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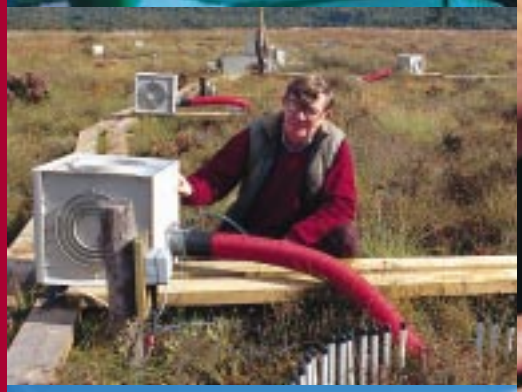

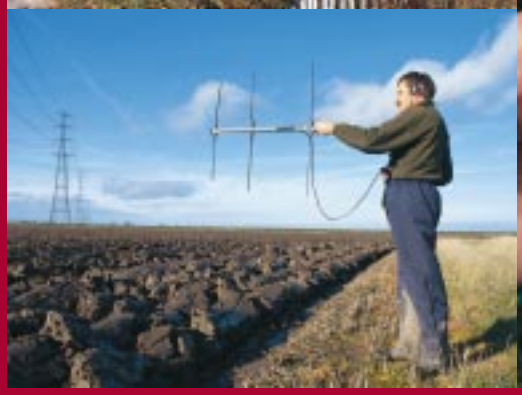

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Frances Dipper

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THE LINCOLNSHIRE AND NORTH NORFOLK MARITIME AREA: A REVIEW OF THE PAST AND PRESENT STATUS OF IT'S SPECIES AND HABITATS

by

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Summary

The area covered in this report includes the whole of the Wash and North Norfolk cSAC plus the Lincolnshire coast as far north as the Humber estuary.

The aim of this desk study was to identify marine and maritime species and habitats that have disappeared or reduced substantially in distribution and extent and to identify the reasons for any such reduction. The data presented are a compilation of readily available existing information. Sources of information include published literature, grey literature, official reports from various organisations and personal communications from various individuals. Priority was given to species and habitats for which UK BAP Habitat or Species action plans have been drawn up.

The information gathered is relatively broad-scale but should be sufficient to allow prioritization of effort aimed at restoration of habitats and species within the area. Further study may then be required for specific habitats or species. For each species or habitat, consideration was given to its general biology, conservation status, present and past distribution, reasons for any observed declines and opportunities for restoration and further research needed.

The Wash, the Lincolnshire coast and the Humber estuary are important spawning and nursery grounds for a number of commercial species. A wide variety of commercial marine species are exploited within the Wash and along the adjacent coasts and landed at ports within the Eastern Sea Fisheries Joint Committee (ESFJC) district. Seven commercial fish species were reviewed all of which make a significant contribution to the local economy. Five of these fish are included in the BAP Commercial marine fish Grouped Species Action Plan for the North Sea: cod, herring, mackerel, plaice and sole. North Sea stocks of these fish (plus hake and saithe) are all considered by the International Council for the Exploration of the Seas (ICES) to be below Safe Biological Limits (SBL). All five species appear to have declined significantly within the study area, although most of the evidence is indirect and derived from landing figures. It is unclear whether the remaining two fish species considered, sprat and bass, have declined or not. Over-fishing appears to be the main cause for decline in commercial species within the North Sea and over-exploitation within the study area has certainly impacted some species. Future improvements in population numbers will only be achieved through local and national fishery management.

Five other species of fish were considered that no longer have any commercial value. They have become so rare in the study area (and throughout Great Britain) that they are no longer exploited to any extent. Sturgeon, shad, smelt and lamprey are all anadromous, migrating up rivers to spawn. Their decline has resulted from over-exploitation and particularly from barriers to spawning migrations. Sturgeon were probably never common in the area but smelt in particular used to have large spawning runs up many of the rivers in the area. Attempts to restore numbers of these species would necessitate providing access to spawning rivers and provision of suitable spawning habitat. The common or blue skate has declined (all round Great Britain) through over-exploitation, to such an extent that it is now very rarely caught. Common skate and shad are the subjects of BAP Species action plans.

Shrimp, crab and lobster are all exploited within the study area. Brown shrimp are extremely important commercially within the Wash. Populations undergo natural fluctuations and it is difficult to ascertain whether there has been a sustained decline in numbers of this species. Research on the biology of this species is currently being carried out and may help to provide some answers. Pink shrimp are far less important commercially in the Wash than they used to be. Declines in landings probably reflect responses to market demands. The crab and lobster fishery in the Wash and along the north Norfolk coast have shown few signs of over-exploitation in the past. However, recent high exploitation levels are causing concern and research into population numbers and dynamics is currently being undertaken by the ESFJC.

Five species of molluscs were reviewed. The native oyster is a BAP species and horse mussel (*Modiolus modiolus*) beds are the subject of a BAP Habitat Action Plan. Native oysters used to be extremely abundant within the Wash and adjacent areas. However, there are currently no known native oyster beds within the study area. Stocks were declining even in the late1800s and there has not been a fishery since around the 1920s. Declines were due to over-exploitation and the effects of introduced pest species and disease. There do not appear to be any *Modiolus* beds within the study area although the species itself is relatively widespread and common and there are no indications that there have ever been such beds in the area. Available evidence suggests that whelk stocks have declined in recent years, probably due at least in part to over-exploitation. Periwinkles have been collected in the area for many decades but there is insufficient data available to see if there has been a decline in numbers or distribution. Razor shells are included in this review because there have been recent attempts to exploit them in the Wash.

Lugworm are included in the review because they are widely exploited as bait. There are indications that there may have been local declines due to over-exploitation and there is possibly some evidence for a more widespread decline within the Wash. However, the life history of this species normally results in rapid re-colonisation after exploitation.

The ross worm *Sabellaria spinulosa* is a widespread and common species within the Wash. There is no concern for the species itself. However, under certain conditions, this tube-building worm forms distinct reefs. It is these reefs that are the subject of a BAP Habitat action plan and not the species itself. Recent research by EN and the ESFJC has been directed towards ascertaining the distribution and condition of reefs within and outside the Wash and North Norfolk cSAC. Further research is required to establish just what constitutes a reef and how stable such reefs are. There is evidence to suggest that within the Wash such reefs may be relatively fast growing and ephemeral. Available information is not sufficient to say whether activities such as trawling have had an effect on any reefs present.

Seagrass beds are the subject of a BAP Habitat action plan. There are currently no extensive seagrass beds within the study area. All three British species occur within the area but mostly as small patches. Historical records are insufficient to say whether there has been a widespread decline in seagrass within the area. There is some evidence of local declines at the time when *Spartina* hybrid species were spreading in East Anglia.

Saline lagoons are the subject of a BAP Habitat action plan. There are a number of important lagoons and lagoon systems scattered along the north Norfolk coast. These support a typical lagoon fauna and flora including the starlet anemone and the lagoon sand shrimp both of which are the subjects of BAP Species action plans. Available data are not sufficient to quantify the historical loss of this habitat. Two lagoons (of unknown conservation interest) are recorded as lost through progression to freshwater habitat. Lagoons within the Blakeney Spit and Cley series have suffered in recent years from repairs to the shingle banks. Others have suffered changing fortunes with degradation (such as drying out) in some years and improvement in others. The starlet anemone, the subject of a BAP Species action plan, appeared to be extinct in Norfolk by 1975 but is now recorded as present again in at least two lagoons.

A summary is provided in Appendix 1 of seven further species that were considered but not included in the review, along with reasons for their exclusion. Mussels and cockles are both important commercial species within the Wash and in recent years have suffered badly from over-exploitation. However, these two species are the subject of other extensive studies collating data on past and present distribution and abundance. It was therefore agreed that these species be omitted from the study.

An extensive bibliography includes cited references plus all publications accessed and considered relevant to the study.

Summary table

Species/Habitat	**Evidence for decline**	**Probable reasons for decline**	**Possibilities for restoration in the study area. Possible interested organisations**
Cod	Yes	Overfishing	Reliant on fishery management. ESFJC, DEFRA, CEFAS
Herring	Yes	Overfishing	Reliant on fishery management. ESFJC, DEFRA, CEFAS
Mackerel	Yes	Overfishing	Reliant on fishery management. ESFJC, DEFRA, CEFAS
Plaice	Yes	Overfishing	Reliant on fishery management. ESFJC, DEFRA, CEFAS
Sole	Yes	Overfishing & by-catch of young in shrimp trawling	Reliant on fishery management & research into by-catch problems. ESFJC, DEFRA, CEFAS
Sprat	Uncertain; probably not		Probably N/A
Bass	Uncertain; yes nationally	Overfishing	Current fishery restrictions may be sufficient. Research local catches. ESFJC, CEFAS
Sturgeon	Yes	Over-exploitation	Unlikely as probably never common in the area.
Common skate	Yes	Overfishing	Unlikely. European effort required. ESFJC, IUCN
Shad	Yes	Barriers to spawning migration; overfishing	Unlikely. Probably never common in the area. EA, CEFAS, CEH
Smelt	Yes	Barriers to spawning migration. Loss of fry and	Possible. Research needed on biology & populations. Reliant on

		young as by-catch?	river improvements (eg access). EA, CEFAS, CEH
Lamprey	Uncertain. Yes nationally	Obstacles to spawning migration	Unlikely. Previous status unknown. Parasite. EA, CEH
Brown shrimp	Uncertain	Possible overfishing	Ongoing research necessary. ESFJC, UEA
Pink shrimp	Uncertain; probably not		Probably N/A
Crab	Not in past. Possibly now		Reliant on ongoing research & fishery management. ESFJC, CEFAS
Lobster	Probably not in past. Possibly now.		Reliant on ongoing research & fishery management. Artificial habitats possible. ESFJC, CEFAS
Horse mussel beds	Unlikely that there were any		Probably N/A although more direct survey required? CEFAS
Native oyster	Yes	Over exploitation	Possible. Explore feasibility? ESFJC, CEFAS
Whelk	Yes	Overfishing	Reliant on further research and fishery management. ESFJC
Periwinkle	Unknown		Probably N/A. Research populations?
Razor shells	Unknown	Potential fishery	Further research needed? Non-native sp ongoing research by CEFAS
Lugworm	Uncertain, possibly locally	Bait digging	Stocks recover well. Management measures known. CEH, angling clubs
Sabellaria spinulosa reefs	Uncertain. Past & present extent of reefs not clear	Possible damage by trawling but natural stability of reefs not clear	Continued research on presence, stability and monitoring methods. ESFJC
Seagrass beds	Uncertain.	Past *Spartina* invasion, disease, physical damage	Possible but extent of past beds not well documented. EA
Saline lagoons	Uncertain but likely	Sea defences, management, natural succession, pollution	Good potential for restoration of existing sites and creation of new. EA, RSPB
Nematostella vectensis	Yes	Linked to lagoon habitat deterioration	Good potential for management of present sites & introductions (?).
Other lagoon species	Uncertain	Uncertain; many species difficult to find & identify	Further survey by experts needed to ascertain distributions

1 Introduction

The aim of this desk study was to identify historic marine and maritime species and habitats which may be candidates for restoration on the Wash and Lincolnshire and north Norfolk coasts. The emphasis is on those species and habitats that are important for biodiversity and for which a Biodiversity Action Plan (BAP) has been prepared, including commercially important species. However, any species or habitats thought to have disappeared or reduced substantially as a result of human activities are included. All UK BAP habitat and species action plans can be consulted on the UK biodiversity website (www.ukbap.org.uk).

The study area, agreed with the EN nominated officer Conor Donnelly, is concentrated on the Wash and North Norfolk Coast Special Area of Conservation (cSAC). However, the limits extend outside the SAC from the mouth of the Humber Estuary to just east of Wells on the Norfolk coast. These limits are shown in Figure 1 along with the limits of the Eastern Sea Fisheries Joint Committee (ESFJC) district to which all landing figures given in the text refer. The ESFJC district runs from Donna Nook in Lincolnshire to Dovercourt in Essex. Details of the exact and seaward limits can be obtained from ESFJC.

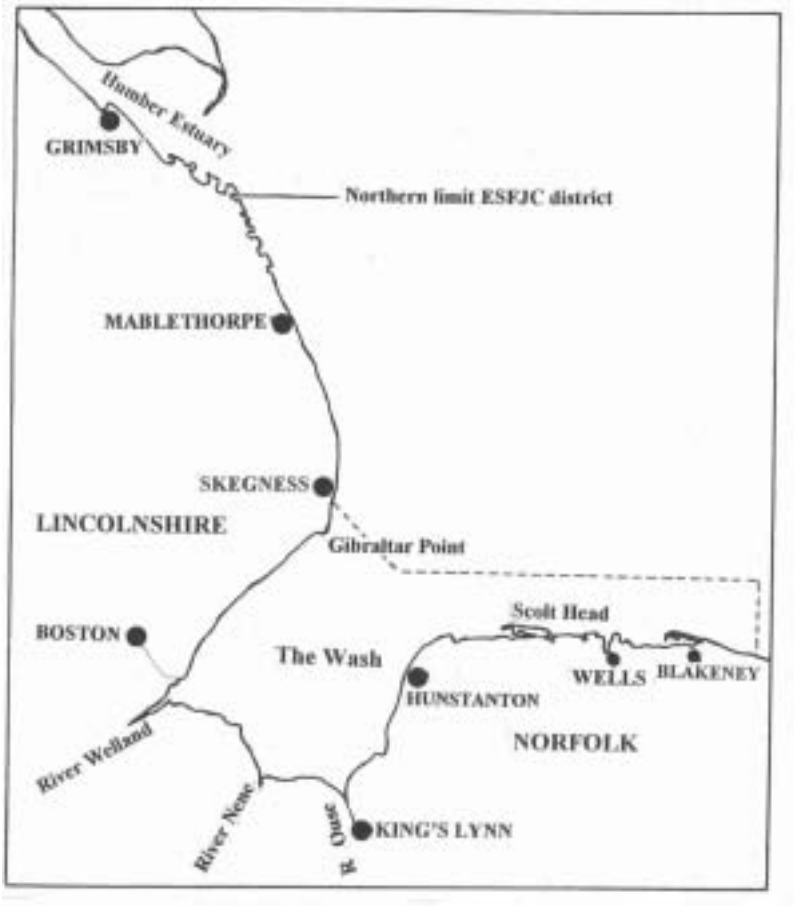

Figure 1. Limits of the study area, the Wash cSAC and the ESFJC district

2 Methods

2.1 Species

A list of species and habitats of known conservation interest was drawn up by consulting UK BAP species lists, Annexes to the EC Habitats Directive and Annexes to the Wildlife and Countryside Act. Species of known past or present commercial importance in the area were added. The list was modified as work proceeded with additions and some deletions (see Appendix 1).

It was decided at an early stage not to include mussels (*Mytilus edulis*) and cockles (*Cerastoderma edule*). A considerable amount of work has been done on these two species within the Wash in recent years and they are the subjects of other contracts funded or partly funded by English Nature.

Saltmarsh is an important habitat within the study area and coastal saltmarsh is the subject of a UK BAP Habitat Action Plan. However, this habitat was not included as this large topic necessitates a separate study. Other BAP habitats present in the study area but not covered in this report are sublittoral sands and gravels, mudflats and sandbars. Changes in the saltmarsh vegetation of the Wash from 1971-1985 have been documented by Hill (1988).

2.2 Sources of information

2.2.1 Cambridge University Library (CUL)

The majority of published literature required was sourced from the CUL. In addition, all volumes of the Transactions of the Norfolk and Norwich Naturalists Society and the Transactions of the Lincolnshire Naturalist's Union were scanned for relevant papers. Mr R. Hamond has recorded the marine intertidal fauna of Norfolk covering most major groups as follows:

Table 2.2.1: Papers by R. Hamond published in Transactions of the Norfolk and Norwich Naturalists Society

Paper	Group
1957	Hydrozoa
1961	Marine fauna
1962	Polychaeta
1963	Marine fauna
1963	Hydrozoa
1965	Amphipoda
1966	Polychaeta
1967	Amphipoda
1969	Fauna offshore
1970	Crustacea
1971	Protozoa, Mesozoa & Porifera
1972	Mollusca

1977	Ctehophora, Scyphozoa, Anthozoa
1991	Echinoderms
1997	Cirripedia, Branchiura and Cladocera

The library has an on-line catalogue that can be searched via the World Wide Web.

2.2.2 Visits and contacts

Two visits were made to the Eastern Sea Fisheries Joint Committee at Kings Lynn where annual reports, research reports and other data were made available. One visit was made to Ecomaris Ltd. to discuss monitoring work done by them for the EA.

The following organisations and individuals were contacted by telephone and e-mail:

- Biological Records Centre Norfolk –John Goldsmith
- Bob Foster-Smith (re. *Sabellaria*)
- Bob Earll, CMS (re. Wash forum)
- CEFAS Lowestoft: Steve Milligan (herring larvae surveys etc); David Palmer (razor shells)
- CEFAS Burnham-on-Crouch; Hubert Rees (*Modiolus*)
- Dick Hamond (Norfolk marine fauna)
- English Nature (Peter Lambley, Norfolk office)
- Environment Agency, Brampton - Mike Best (re. Wash reports)
- Environment Agency, Brampton - Roger Handford,
  Team Leader, Fisheries, Recreation and Biodiversity (re. Smelt)
- Gillian Beckett, BSBI Recorder, VC28, West Norfolk (re. *Zostera*)
- JNCC (library plus loan of publications)
- Norfolk Wildlife Trust
- Peter Maitland (re. shad and other anadromous fish)
- Richard Williams (re. *Nematostella*)
- Richard Barnes, Cambridge University (re. saline lagoons)
- Roger Bamber, Natural History Museum (re. saline lagoons)

2.2.3 World Wide Web

A list of useful websites consulted is given at the end of the Bibliography (Appendix 3). The MarLin website and Fishbase website were always checked for information on each species and reference lists downloaded for checking. A considerable amount of information was available from some sites including the CEFAS site, UKBAP site, and UK marine SACs site.

2.2.4 Bibliographies

Habitats Directive Site Dossiers: Literature Review – July 2001
Lists of references on web sites and in reports

3 Commercial BAP fish species

There are 22 species of fin-fish that are regularly landed at ports within the ESFJC district, including the Wash ports and for which landing statistics are published in the ESFJC Annual Reports. These are shown in Table 3.1.

Table 3.1 Species of fin-fish currently landed within the ESFJC district and for which landing statistics are available in the ESFJC Annual Reports

Species	**Included in commercial marine fish Grouped Species Action Plan North Sea stocks**
Bass *Dicentrachus labrax*	
Brill *Scophthalmus rhombus*	
Cod *Gadus morhua*	YES
Dab *Limanda limanda*	
Dogfish *Scyliorhinus* spp.	
Flounder *Pleuronectes flesus*	
Gurnard (various species)	
Haddock *Melanogrammus aeglefinus*	
Herring *Clupea harengus*	YES
Lemon sole *Microstomus kitt*	
Ling *Molva molva*	
Mackerel *Scomber scombrus*	YES
Monkfish *Lophius piscatorius*	
Mullets (grey) *Mugil* spp.	
Plaice *Pleuronectes platessa*	YES
Skate *Raja* spp.	
Sole (Dover) *Solea solea*	YES
Sprat *Clupea sprattus*	
Turbot *Psetta maxima*	
Whiting *Merlangius merlangus*	
Others	

Five of these fish are included in the Commercial marine fish Grouped Species Action Plan: cod, herring, mackerel, plaice and sole. North Sea stocks of these fish (plus hake and saithe) are all considered by the International Council for the Exploration of the Seas (ICES) to be below Safe Biological Limits (SBL). These stocks are considered priority stocks for the purposes of the action plan and each of these 5 species is described in detail, with reference to the Wash, in the following sections.

Young of all these five species are found within the Wash and the Wash, the Lincolnshire coast and the Humber estuary are important spawning grounds for sole and herring. The Wash is also an important nursery area for cod, plaice, sole and herring. Plaice spawn mainly outside the area in the central and southern North Sea (NERC 1998). Individual species spawning maps are given in Coull *et al* (1998).

Landings of plaice are by far the highest of any fin-fish within the Wash and the rest of the study area.

3.1 Atlantic Cod *Gadus morhua*

3.1.1 Introduction

The cod is such a well-known and popular fish that it was recently the subject of a non-specialist 'biography' (Kurlansky 1997). The title of this book –"Cod: A biography of the fish that changed the world" bears testament to the commercial importance of this species. Given the chance, cod can grow to a considerable size, up to 1.5 m long and 30 kg or more in weight. However, such large fish are now extremely rare. Most are caught in the first few years of their life, many before they mature. Statistics from seine fleets at Grimsby and North Shields, collected between 1958 and 1982, show that 2-year old fish have traditionally predominated in the catch (Macer and Easey 1988). The majority of cod spawn for the first time when they are 3-4 years old at a length of around 50 cm.

Cod spawn throughout the North Sea, although much of the spawning activity is concentrated into specific areas. The Wash and present study area, do not encompass specific cod spawning areas. The main spawning period is January to April and the resultant young fish move down to the seabed around 12 weeks later. Adult cod are voracious hunters and will take sand eels, whiting, haddock, squid and their own young. They also feed on the seabed taking molluscs and crustaceans.

3.1.2 Conservation Status

Assessed as Vulnerable by IUCN. Included in the UK Commercial marine fish Grouped Species Action Plan.

3.1.3 Present distribution and abundance

Cod are widely distributed throughout the north Atlantic including the North Sea. In the Wash it is mainly the juveniles that are found. The MAFF young fish survey (Rogers and Mead 1998) has shown that juveniles are particularly common in the Wash and in the estuary of the River Humber. Cod spawn offshore but the juveniles move into the shallow brackish waters of the Wash in their first and second winters. As they get older, they move progressively out of the Wash, first northerly coastwise and then offshore as large fish (Riley in Doody and Barnett 1987).

ICES considers that the North Sea stock is outside Safe Biological Limits (SBL). The spawning stock has been reduced to levels where the chance of stock collapse is very high. In 1999 it was about 70,000 tonnes, which is less than half the level considered safe (see CEFAS website for more details). With the exception of the 1996 year class, recruitment has been below average since 1987. The 1997 year class was the poorest on record and the 1998, 1999 and 2000 year classes were also relatively poor (www.cefas.co.uk/fsmi/roundfish-cod.htm). Cod stocks in the North Sea are therefore on the brink of collapse with 40-45% of 2-8 year old fish removed every year by fishing (Clarke 2002). Restrictions have now been placed on fishing for North Sea cod (see below).

Landings of cod within the ESFJC district for 2000 were around 800 tonnes and for 2001 were 530 tonnes (ESFJC 2001:Annual report). These landings show a very marked drop from the 1990s when landings were between 1200 to 1900 tonnes (Figure 3.1.2). The ESFJC annual report for 1998 records that codling were abundant throughout much of the year, which was considered unusual.

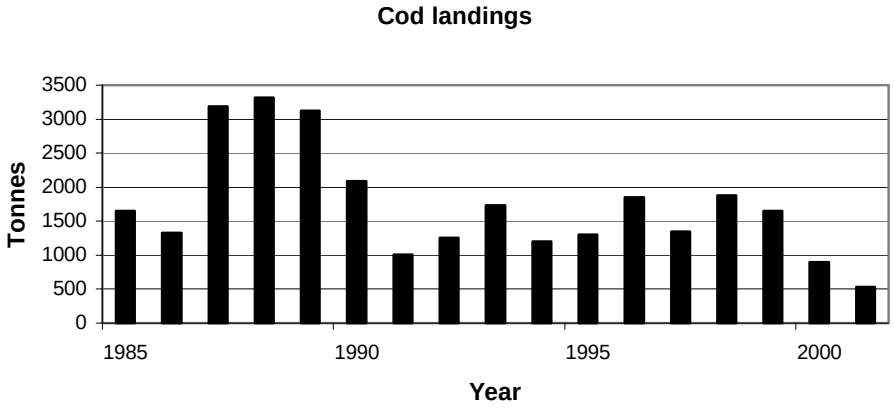

Figure 3.1.2 ESFJC District landings of cod

3.1.4 Past distribution and abundance

Cod were once so abundant it was considered impossible that they could be overfished. No other single fish species has ever been as important as cod for human consumption. However, this has proved not to be the case. In 1992 the Canadian Grand Banks cod fishery in the NW Atlantic finally collapsed and many other stocks are now on the verge of collapse. The UK (Atlantic Northeast) catch of cod has remained high at between 300,000 and 400,000 tonnes since 1950. It peaked at 450,800 tonnes in 1969 but in the past few years it has declined dramatically and stood at only 41,750 tonnes in 2000 (FAO statistics from the Fishbase website).

In the North Sea the abundance of cod rose markedly in the 1970s and the spawning stock biomass in the early 1970s was over 250,000 tonnes (in ICES divisions IV, IIIa (Skagerrak) & VIId). The average annual catch in 1961-1965 was 122,000 tonnes whereas in 1971-1975 it reached 216,000 tonnes (NERC 1998). The reasons for this increase are not fully understood but it has been suggested that it could have been associated with the decline in the abundance of herring and mackerel. East coast herring stocks crashed in the late 1960s. The theory is that without the herring there would have been more planktonic food available to the cod larvae and a decrease in predation of the larvae by herring (Macer and Easey 1988).

Smith (1915) recorded cod as plentiful all along the Lincolnshire coast a ‘great number’ being landed in the autumn.

3.1.5 Reasons for decline

There is no doubt at all that the drastic decline in North Sea (and other) cod stocks is due to overfishing and in particular to the reduction of the spawning stock to a level where it cannot sustain the fishery.

3.1.6 Opportunities for restoration

The spawning stock of cod in the North Sea (and elsewhere) is now very small, and must be allowed to increase if there is to be any future for the fishery. Measures are needed which are designed to increase the survival of immature fish so that more of them can reach maturity and spawn before they are caught. Cod are extremely fecund and both young and adults are omnivorous and versatile in their habitat requirements. The potential for recovery is therefore high given the right conditions. Effective management measures are needed to reduce fishing mortality and especially to reduce the capture of immature fish. Management measures for North Sea cod already include minimum mesh size (100mm), minimum fish size (35 cm) and annual catch quotas but these have not been effective in preventing decline of the stocks. An emergency measure was introduced by agreement between the EU and Norway in 2001. This involves the closure of certain fishing areas (mostly towards the eastern side) between 14 February to 30 April, which covers the main spawning season for cod (see CEFAS web site for more details).

Since juveniles and immature fish are particularly common within the Wash, any measures designed to prevent their capture whether targeted or as by-catch, would be beneficial. Studies on by-catch from the shrimp fishery in the Wash are currently being undertaken by the ESFJC, and these studies should help indicate the extent to which juvenile cod are involved. There is some evidence that by-catch gadoid fish have a low survival rate when returned to the sea (Graham 1996). Therefore support of research into finding out which species are involved and into preventing by-catch in the first place must be beneficial. In the North Sea, cod form an important by-catch in the beam trawl fisheries for plaice and sole.

In 2000 ICES recommended that fishing mortality for North Sea cod be reduced to the lowest possible level in 2001 and that a rebuilding plan be developed and implemented for the spawning stock (CEFAS website as above).

3.1.7 Major References

Macer and Easey (1988)
CEFAS web site

3.2 Herring *Clupea harengus*

3.2.1 Introduction

The herring is a pelagic, shoaling species that once featured in the Guinness Book of records as the ‘most numerous fish’. It is widely distributed in the North Atlantic and forms distinct breeding stocks or races. The stocks spawn in different areas and at different seasons and also differ in physical characters such as the number of vertebrae. There are three major stocks of autumn spawning North Sea herring which are very similar and cannot be separated on physical attributes: the Buchan stock (Shetland-Orkney in July moving to NE coast Scotland); Banks stock (NE coast England late summer moving down to Yorkshire by late September/October);

Downs stock (Southern Bight and eastern English Channel in late November-December). Wash herring form a small, local inshore stock that spawns in spring.

Within British waters, herring are the only commercially important marine bony fish to spawn on the seabed. The eggs are sticky and are attached to small stones and gravel, the need for which largely dictates the distribution of the spawning grounds. Therefore the spawning grounds can be very roughly correlated with the known distribution of gravel deposits. The Wash itself is not a spawning ground but it is an important nursery area, as is the Lincolnshire coast and the Humber. There is a small inshore spawning area along the Lincolnshire coast just outside the Wash used by the spring spawners and larger areas off both the Norfolk and Lincolnshire coasts used by the autumn spawners (see sensitivity map in Coull, Johnstone & Rogers 1998, available on CEFAS website).

The eggs hatch after 2-3 weeks and once the larvae reach around 6 mm long, they swim clear of the gravel and drift in the plankton until they reach 5 cm or so after 4-6 months. They then begin to form into large shoals and move further into the shallow nursery areas. In some areas of the North Sea, the shoals are fished as whitebait along with young sprat. Herring can grow to 43 cm though most landed now are only around 25 cm in length. They mature at 3-9 years old.

Adults migrate considerable distances between spawning and overwintering grounds.

3.2.2 Conservation Status

Included in the UK BAP Commercial marine fish Grouped Species Action Plan.

3.2.3 Present distribution and abundance

The major stocks of herring are found in offshore areas and it is mainly juveniles that are found within the Wash, which is an important nursery area. The young fish survey (YFS) (Rogers *et al* 1998) does not provide any information on juvenile herring because the young (and adults) are pelagic and are not well sampled by the bottom trawls used in the survey. Studies by the ESFJC on by-catch from the brown shrimp fisheries in the Wash similarly provide little information. Herring larvae surveys are undertaken by most North Sea coastal states because they provide a reliable indicator of the size of the spawning stock. Quantitative data from individual surveys undertaken by the MAFF Directorate of Fisheries Research (DFR) are available from CEFAS Lowestoft. However, CEFAS have never conducted herring larvae surveys in the Wash (Steve Milligan *pers.comm* 24/2/03). Young herring would undoubtedly be caught when fishing for sprat within the Wash but landing statistics do not differentiate between them.

Nichols (2001) reports that the stringent management measures for North Sea herring imposed in 1996 are proving increasingly effective and that spawning stock biomass is increasing. There was a very good year class of herring from the 1998 spawning and immediate prospects for the stock are encouraging.

3.2.4 Past distribution and abundance

The dramatic decline of North Sea herring is a well-documented story and one that had considerable repercussions for those thousands of people involved in the herring industry in the 1960s. Herring were abundant throughout East Anglian waters in the 19th century, as shown by

the detailed notes made by Southwell in the late 1800s and documented in the Transactions of the Norfolk and Norwich Naturalists Society. He kept records of the numbers of herring landed at Yarmouth and Lowestoft from about 1871 and he and other workers continued the records until around 1939. Patterson (1897) writes that Yarmouth owed its existence to the herring fishery and that 1000 boats went out from the port, with 11,000 people connected with the industry. He records 20,000 to 30,000 'lasts' of herring being landed per year (a 'last' is 13,200 fish).

The history of the North Sea fishery from the mid-1900s to the present is clearly told in Nichols (2001) and the following account is based largely on his description. Annual landings from the North Sea were high from 1947 to the early 1960s averaging about 650,000 tonnes. The removal of so many fish resulted in a decline in the spawning stock biomass (SSB) from around 5 million tonnes to1.5 million tonnes. Age analysis of the adult stock showed that fewer and fewer year classes were present, a clear sign of overfishing. North Sea landings continued to increase to a peak of over one million tonnes in 1965. Around 80% of the fish caught were juveniles. Not surprisingly, there was a serious collapse in the stocks and in 1975 landings had dropped to around 300,000 tonnes and the SSB to 83,500 tonnes. By 1977 the SSB stood at only 52,000 tonnes. Important spawning grounds, such as around the edge of Dogger Bank and in the central North Sea, were abandoned by the herring. As a result of this collapse, a fishing ban was imposed from 1977 to 1980. The fishery was re-opened in 1981, limited by total allowable catch (TAC). However, problems with the fishery have remained, largely due to very high numbers of juveniles being taken in the small meshed fishery for sprat between 1987-1995. Emergency measures introduced in 1996 and modified through to 1999 have finally resulted in an improvement of the SSB that will hopefully be maintained.

ESFJC district landings of herring have varied from 36 tonnes in 1986 to 140 tonnes in 1993. They have remained below 50 tonnes since 1994. Note that the figures of 115 tonnes (1989) and 35 tonnes (1991) shown here and taken from the relevant annual reports, are shown as 60 tonnes and 180 tonnes respectively in the 1998 onwards annual report ten-year trend histograms.

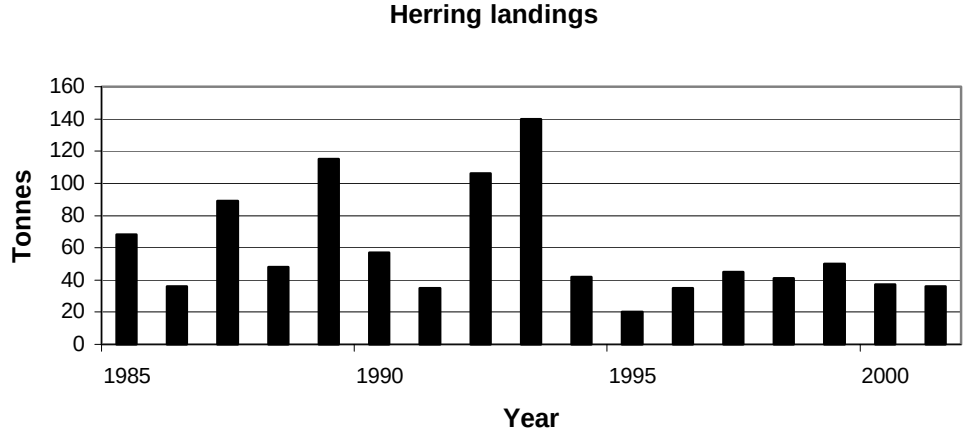

Figure 3.2.2 Landings of herring in ESFJC district

3.2.5 Reasons for decline

The collapse of the herring fisheries in the North Sea in the 1970s and the earlier collapse of the local East Anglian autumn driftnet fishery during the 1950s can both be entirely contributed to overfishing and lack of management of the stocks. The East Anglian fishery was targeted on a stock (Downs stock) that moves south to the Southern Bight and eastern English Channel to spawn and so took mostly fish that had not yet spawned. Some of the English Channel spawning grounds were subject to heavy fishing by bottom trawlers, which destroys spawn and damages the substrate, thus affecting subsequent spawning. North Sea stocks were also subject to high mortality of juveniles in industrial fisheries using small mesh nets and to removal of too many immature fish in the adult fishery, which led to reduction of SSB to very low levels (Nichols 2001).

3.2.6 Opportunities for restoration

At the North Sea level, herring stocks will only be maintained or improved if adequate management of the fisheries is properly implemented. A new management system for North Sea herring has been agreed between the EU and Norway that follows on from the stringent management measures enforced in 1996.

At the local level within the Wash, the number of young herring using the area as a nursery may be affected by pelagic fisheries, such as those for sprat and pink shrimp. However, neither of these fisheries is particularly active at the moment.

Research designed to ascertain the numbers of young herring using the Wash could provide useful information.

3.2.7 Major References

Nichols (2001)

3.3 Mackerel *Scomber scombrus*

3.3.1 Introduction

Mackerel are pelagic schooling fish widely distributed on both sides of the Atlantic. There are two major stocks in British waters, the North Sea stock and the Western stock. Both stocks are migratory, moving to deeper water to overwinter. The North Sea stock spawns over a very wide area of the central and northern North Sea in early summer (May to July). The young fish remain in the vicinity of the spawning grounds until they are 3-4 years old. Growth is rapid during the first year and they become mature when 2 years old at around 29 cm long. Growth slows after this and individuals can reach 20 years old and 66 cm in length. However, 40 cm or less is a more usual size.

Mackerel tend to move inshore in summer and it is at this time that they can be found around the East Anglian coast. The Wash does not act either as a spawning ground or a nursery area for mackerel.

3.3.2 Conservation Status
Included in the UK BAP Commercial marine fish Grouped Species Action Plan.

3.3.3 Present distribution and abundance
Mackerel are not found in abundance within the study area and do not appear to form an important local fishery. Landings into the ESFJC district were only 4 tonnes in 1993 and 2 tonnes in 2001. Mackerel stocks in the North Sea currently remain at a low level.

3.3.4 Past distribution and abundance
Mackerel were once an extremely abundant fish in the North Sea. There were no internationally significant fisheries for them in this area, until the mid-1960s, when the herring stocks began their drastic decline. The fishery developed mainly in the northern North Sea with Norway taking the main catch and international landings in the NE Atlantic rose to 1 million tonnes in 1967 (FAO statistics). Under such intense pressure, the stocks and the fisheries collapsed and in the 1970s, landings dropped to around half this amount with the main Norwegian take from North Sea stocks, dropping to around a quarter of its high of 800,000 tonnes. Landings have remained at these much lower levels ever since.

3.3.5 Reasons for decline
There is no doubt at all that the drastic decline in NE Atlantic (mainly North Sea) stocks was due to overfishing in the 1960s and 1970s.

3.3.6 Opportunities for restoration
Mackerel do not appear to have ever been of great importance as a fishery in the Wash or environs. The Wash acts neither as a spawning or nursery area. Therefore there seems to be little opportunity or need for restoration of this species in this area.

3.3.7 Major References
MAFF (1998) UK DMAP
Lee and Ramster 1981

3.4 Plaice *Pleuronectes platessa*

3.4.1 Introduction
Plaice are the most important flatfish in European fisheries and landings of plaice into the ESFJC district are much higher than any other fin-fish. They are relatively easily caught, mainly by beam trawling in a mixed fishery with sole. They are found mostly on sandy substrata but also in areas of mixed sediment, mud and gravel down to around 120 m depth, although they are commonest at depths between 10-50 m. Plaice eat a wide variety of benthic invertebrates especially worms and small, thin-shelled molluscs.

Within the North Sea there are well-defined spawning grounds, mainly in offshore central and southern areas. These grounds do not extend into the Wash. Spawning occurs from January to mid-March with the peak in January and February. Eggs and larvae drift inshore and the young settle out of the plankton and metamorphose between 90-120 days after fertilization. They

remain in shallow water and intertidal pools for about two years and older fish are found in progressively deeper water. Juveniles live in shallow water all round the coast. The most important nursery grounds are the Waddensee and along the west coast of Denmark, but the Wash is also a major nursery ground as shown by the MAFF/CEFAS Young Fish Survey (YFS) (Rogers *et al* 1998). This survey has also shown that during September 0-group plaice are most abundant in the intertidal zone and over 25% of fish are found in water less than 1m deep.

Plaice can live as long as 30 years although few attain more than about 10 years due to fishing pressures. Females mature at 3-7 years and males at 2-6 years.

3.4.2 Conservation Status

Included in the UK BAP Commercial marine fish Grouped Species Action Plan.

3.4.3 Present distribution and abundance

Plaice are widely distributed throughout northern European waters and the North Sea stock is one of the most important. In the shallow waters of the Wash, young fish are especially common. In the YFS (Rogers *et al* 1998) O-group plaice were found in more than 60% of the sample sites in the Wash and 1-group fish at 40-59% of the sites. In the Humber and the Lincolnshire coast sectors, 40-59% of sites also had 0-group and 1-group fish.

Riley (in Doody 1987) suggests that the Wash contains around 2% of North Sea juvenile plaice in an average year. First year juveniles are found in water above 10 m with the highest abundance at 2m. They stay in the Wash for about 3 years and then most leave for good, moving in a coastwise and northerly direction.

ICES considers that the North Sea stock is outside safe biological limits.

3.4.4 Past distribution and abundance

Landings of plaice into the ESFJC district ports have declined steadily over the past 15 years, from around 10,000 tonnes in 1988 to around 2,300 tonnes in 2001. Prior to 1988, landings had been increasing (Figure 3.4.1). In the northeast Atlantic as a whole, landings were at a high in the late 1960s standing at around 50,000 tonnes. Since then, they have declined to around 24,000 tonnes in 2000 (FAO statistics in Fishbase website).

The spawning stock biomass of plaice in the North Sea, peaked at 493,000 tonnes in 1967 (there was a strong year class in 1963 which matured at this time). It then declined steadily to 300,000 tonnes in 1980. There was a second peak in 1989 due to strong year classes in 1981 and 1985 but since then SSB has declined to a record low of 180,000 tonnes in 1997 (CEFAS website). Since then it has increased again due to another strong year class in 1996, which considerably improved the fishery landings in 1999 and 2000. The strong year classes coincide with cold winters.

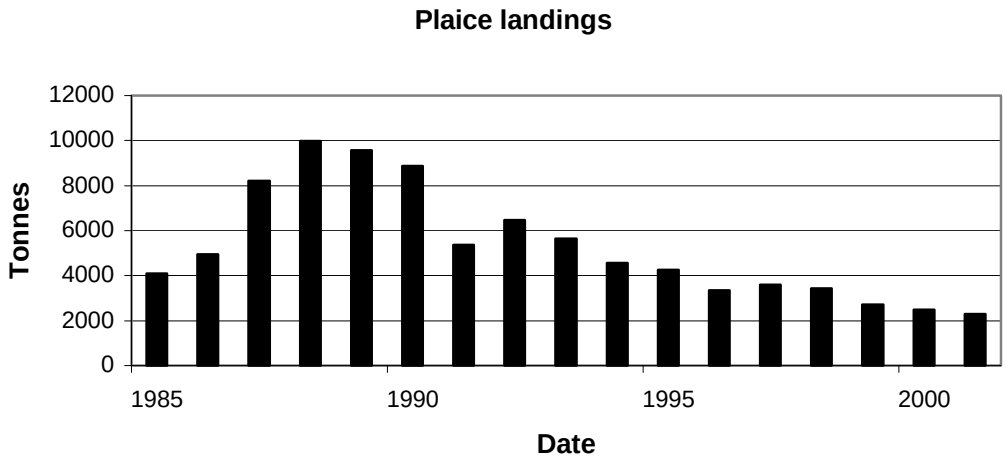

Figure 3. 4.1 ESFJC district landings of plaice

In the early 1900s plaice appears to have been plentiful along the Lincolnshire coast as Smith (1915) records: “large numbers of small size all along the coast and in the Wash and Humber; marketable size in fair quantity off and between Tetney and Sutton-on-Sea”. Patterson (1897) mentions an important fishery off Yarmouth until the 1860s after which it became ‘unremunerative’ possibly due to trawlers fishing on its feeding grounds.

3.4.5 Reasons for decline

Direct evidence showing that plaice stocks have declined within the study area, is in short supply. However, indirect evidence such as plaice landings within the ESFJC district suggests that this is so. Within the Wash, juvenile plaice are caught as a by-catch from brown shrimp beam trawling. The ESFJC 1998 research report states that in their shrimp surveys, dab, plaice and flounder were commonly found as by-catch in low numbers with occasional catches of high numbers. Whilst flatfish appear to survive better than roundfish when sorted by riddling and then discarded back into the sea, survival of juveniles is often poor (ESFJC 1993: research report). As is the case with sole, it is likely that by-catch has contributed to decline in the past. By-catch has been reduced in the Wash by use of selective fishing gear and mortality of by-catch has been lowered by improved methods of riddling but there is still room for improvement.

Flatfish stocks generally provide dependable fisheries if well managed because they are less subject to large natural fluctuations than many other species (Lee and Ramster 1981). Recruitment is fairly consistent each year in North Sea stocks except for the occasional occurrence of strong year classes coinciding with cold winters (CEFAS website).

3.4.6 Opportunities for restoration

Field trials by the ESFJC have shown that modifying fishing trawls to help fish escape whilst retaining shrimp, can considerably reduce by-catch (ESFJC 1993: research report). Support of research into ways of reducing by-catch would be beneficial to plaice and other vulnerable species such as sole. In October 1997, the EU Fisheries Conservation Group agreed that a separator trawl or net with a sorting grid must be used for shrimp gear (ESFJC 1997: research report).

Most sandy beaches and shallow inshore areas are potential nursery areas. It would be useful to analyse the results of ESFJC by-catch studies and MAFF/CEFAS young fish surveys in detail to ascertain which such areas are important for juvenile plaice within the Wash and the rest of the current study area. Areas that appear suitable but are not currently being used, could be looked at to see what factors (natural or artificial) are preventing their use. As an example, populations of plaice in Kattegat and Danish belts decreased in the 1980s and early 1990s due to discharge of nutritive salts.

Current fishery restrictions for plaice in the North Sea, include minimum landing size (27 cm), and minimum mesh size for beamtrawls (100 mm; 80 mm when fishing for sole south of 55º N, which includes the Wash area). There is also a closed area, the plaice box, which covers the main spawning grounds

3.4.7 Key References

CEFAS web site
ESFJC Research report 1993 – Juvenile fish by-catch studies
NERC (1998) UK D-MAP

3.5 Sole *Solea solea*

3.5.1 Introduction

The Dover sole is an important and valuable commercial flatfish. It feeds on small invertebrates especially ragworms, which it catches at night using its sense of smell. Ragworms live in muddy and fine sands, the type of habitat that predominates within the Wash. Sole spawn from April to June in inshore coastal waters especially at the mouths of estuaries and within embayments. The area extending south from the Humber estuary down to Essex including the Wash, is a major spawning ground. The Wash and the Lincolnshire coast are also an important nursery area for this species. Female sole first spawn when 3 years old at around 30 cm long. The young settle out of the plankton 2-3 weeks after the eggs have been fertilized and spend up to 2 years in the nursery areas (NERC 1998) before moving further offshore.

3.5.2 Conservation Status

Included in the UK BAP Commercial marine fish Grouped Species Action Plan.

3.5.3 Present distribution and abundance

The Wash is a particularly important nursery area for juvenile sole and may contain around 1% of all North Sea sole juveniles in an average year (Riley in Doody and Barnett 1987). The MAFF young fish survey (YFS) has shown that young sole are particularly abundant on the coast of East Anglia from 0 to 20 m depth (Rogers *et al* 1998). Three of the MAFF YFS coastal sectors fall into the present study area: the Humber, the Lincolnshire coast and the Wash. The percentage occurrence (number of stations in which young sole occurred / total number of stations, 1981-97) was highest for 0-group fish along the Lincolnshire coast and in the Wash (40-59%). It was between 10-39% for 0-group fish in the Humber and 1-group and 2-group fish in

the Humber, Lincolnshire coast and Wash. Details of spawning and nursery areas for sole can be seen on sensitivity maps in Coull, Johnstone and Rogers, 1998 available on the CEFAS website.

In 1998 the spawning stock biomass of sole in the North Sea was the lowest recorded and stood at around 22,700 tonnes, a considerable decrease from the high of 90,000 tonnes estimated in 1990. However, there was a strong year class in 1996 that is likely to lead to a temporary increase.

3.5.4 Past distribution and abundance

Buckland (1875) reported that the sole fishery based on King's Lynn had diminished by about a half both in numbers and size since around 1870. He attributed much of the decrease to the by-catch of juveniles from the shrimp fishery (see below).

In the early 1900s, sole was apparently abundant along the Lincolnshire coast and in the Wash. Smith (1915) reports small ones in the Humber and much bigger ones in the Wash and that they were numerous all along the Lincolnshire coast (referred to then as *Solea vulgaris*). Exceptionally good fishing ground was found between Somercotes and Sutton-on-Sea (south of Grimsby). In one hour's haul of a shrimp net from the 'Protector' on 27/8/1904, 1732 soles mostly small, were caught within a quarter mile of the shore.

The abundance of sole in the North Sea has varied by at least threefold over the past 50 years, as a result of changes in fishing activity and natural variations in recruitment (Millner and Whiting 1996). Extreme winter weather has also had effects. As a result of the bad winter of 1962/63, spawning stock biomass was reduced by more than half. However, such bad winter events seem to be followed by the occurrence of exceptionally large year classes such as the 1963, 1991 and 1996 year classes (CEFAS website).

Landings of sole into the ESFJC district have declined from around 350 tonnes in 1990 to around 75 tonnes in 2001 (Figure 3.5.2).

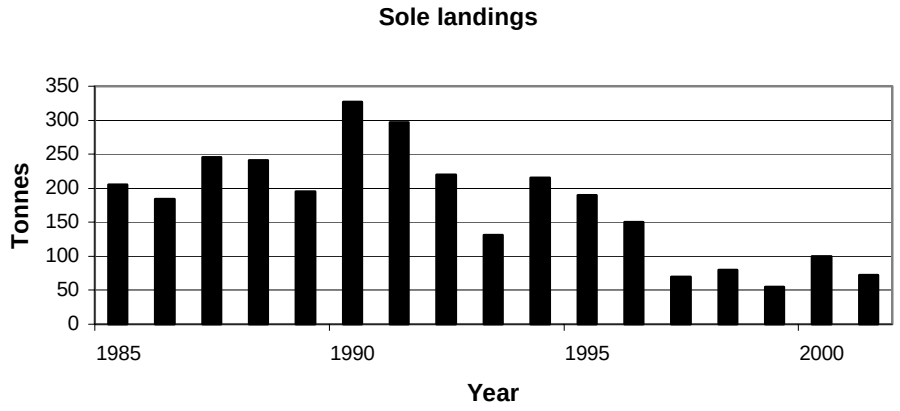

Figure 3.5.2 Landings of sole into the ESFJC district

3.5.5 Reasons for decline

Large areas within the Wash act as nursery grounds for flatfish including sole, plaice, dab and other commercial fish such as whiting. These grounds coincide with commercial shrimping grounds. There is therefore the potential for large-scale mortality of juvenile fish including sole, as by-catch.

Early declines in the sole fishery in this area can probably be attributed mainly to huge numbers of young fish being taken as by-catch from the shrimp fishery, and few of them surviving. Around 130 years ago Buckland (1875) reported that shrimp fishermen were destroying huge numbers of young sole because of the small mesh and design of their nets. He reported that a 'gentleman experienced in the local sea fishery' thought that between 20,000 and 30,000 young soles between 2-4" (5-10 cm) long were being killed every **day** during the summer by the shrimping boats based on King's Lynn.

Whilst by-catch of juveniles may still be a problem, it appears that it is much less so with today's nets and quicker methods of 'riddling' – sorting of the shrimps from the by-catch before the latter is returned to the sea. The ESFJC have been carrying out a monitoring programme on brown shrimp (*Crangon crangon*) since 1993. At the same time they have attempted to monitor the by-catch, with a new programme initiated in 1997. By-catch species are identified and quantities recorded to assess potential impacts on juvenile flatfish populations. The shrimp surveys are conducted using nets with a finer mesh than those used by commercial shrimp boats. However, the numbers and species of by-catch varied widely between stations. The 1998 ESFJC research report states that juvenile sole were rarely caught as by-catch in their surveys.

Sole fetch a premium price and have always been heavily exploited. In the North Sea in general, the numbers of sole taken by fishing has risen gradually since 1960 and peaked in 1996. Recent years have seen around 40% of the population taken by fishing each year (CEFAS website as below). ICES considers that North Sea stocks are harvested outside safe biological limits.

3.5.6 Opportunities for restoration

The importance of the Wash for sole lies mainly in its role as a spawning and nursery ground. North Sea fisheries for sole depend on such areas to provide young fish for recruitment into the fishery. Research on methods to prevent by-catch (of all flatfish) from the shrimp fishery, is therefore of great importance. In October 1997, the EU Fisheries Conservation Group agreed that a separator trawl or net with a sorting grid must be used for shrimp gear (ESFJC 1997: research report).

ICES recommended that fishing mortality on North Sea sole be reduced to a level corresponding to a total catch of less than 17,700 in 2001, in order to maintain the spawning stock biomass at a non-critical level. In 1999 it was around 24,000.

3.5.7 Major References

www.cefas.co.uk/fsmi/flatfish.htm

4 Other commercial fish species

A number of other finfish species (listed in Table 3.1.1) are fished commercially in the Wash apart from those already covered in Section 3.1. Of these, only the sprat, lemon sole and bass are included in this report as they are or have been significantly important fisheries. Bass are not fished in great numbers but are a valuable fish both to commercial fishermen and to anglers.

4.1 Sprat *Sprattus sprattus*

4.1.1 Introduction

Sprats are small, shoaling, pelagic (open water), herring-like fish that are common in inshore coastal waters (10-50 m) especially in summer. The shoals remain close to the seabed during the day but at night they rise to the surface to feed on copepods and other planktonic crustaceans. As winter approaches they stop feeding and aggregate into large over-wintering shoals often in coastal waters, bays and estuaries, including the Wash.

Sprat spawn from May to August over a large part of the southern and central North Sea, mostly offshore. The Wash and adjacent coastal areas are not included in the main spawning grounds shown in Coull (1998), as determined by egg and larval distribution, but some spawning does occur in coastal waters. Sprat are 'serial' spawners releasing eggs in discrete batches.

The eggs and larvae are pelagic and float in the water currents, the larvae gradually drifting inshore as they develop. There are no clearly defined nursery areas and the Wash and North Norfolk coast do not act as specific nursery areas, but young fish are common within the Wash as they are in other estuaries and inlets. Sprat mature at an age of two years and a length of around 12-13 cm. They can live for 5-6 years and reach 17 cm long.

During their first year of life, young fish around 4-8 cm long are fished as 'whitebait' as they become concentrated in patches by coastal currents. Larger fish are also sold fresh, smoked and canned and in bulk as animal feed and fertilizer.

4.1.2 Conservation Status

None. Not currently included in the UK BAP Commercial marine fish Grouped Species Action Plan.

4.1.3 Present distribution and abundance

Data on distribution of sprat within the Wash were collected several decades ago but probably still hold good today. Data collected by MAFF between 1958-1968, using echo surveys and distribution of fishing effort, showed that the sprat concentrate in specific areas and that these remain constant each season. The concentration of fish in these areas appears to be related to topography rather than temperature or salinity patterns (Johnston 1970). The main concentrations reported were:

- well outside the Wash at the southern end of the Inner Silver Pit off the Lincolnshire coast;
- just outside the Wash between the south Inner Dowsing and Lynn Knock;
- inside the Wash in the deeper central channel from Lynn Well to Roaring Middle;

- in some years, concentrations were also found outside the Wash off Wells between Stiffkey and Blakeney overfalls;
- towards the end of the season, when the main channel concentrations have dispersed, the Lincolnshire coast, and occasionally the Humber estuary and Yorkshire coast to Bridlington, provided good fishing in some years.

Riley (in Doody 1987), comments that the Wash is used by 'a local population of sprat thought to be restricted to the Wash and neighbouring coastlines of Norfolk and Lincolnshire, although other sprat stocks are found in most parts of the North Sea'.

4.1.4 Past distribution and abundance

Most information comes from the fishery within the Wash. It appears that sprat have been fished in the Wash from an early date. Smith (1915) reports sprat being caught mainly in stow nets in the lower parts of the Wash, that he had seen 100 tonnes taken at Boston on one tide and that they were not so plentiful at the present time.

Relatively detailed information on the Wash sprat fishery is available for the period 1958-1968, following recommencement of the fishery in 1959 after a lapse of 30 years. During this time the fishery was studied by MAFF using catch data, samples from commercial boats and echo and fishing surveys and the results were published in their Fishery Investigations series (Johnston 1970). The fishery was re-started to help Thames estuary sprat fishermen whose fishery collapsed in the early 1950s. No mention is made in Johnston (1970) as to whether the Wash sprat fishery collapsed 30 years before its recommencement (i.e. around 1930) or simply failed due to lack of market demand. However, when it did recommence, landings were good and the stocks appeared to be healthy.

During the ten years of the MAFF study, the fishery remained healthy with some ups and downs caused by weather and changes in active fishing boats. The main trend was one of increasing effort and catch, with the conclusion that the level of fishing was not having any measurable effect on the stock. The fishery seems to be one dependent almost entirely on recruit stock as evidenced by the fact that the first season's fishery produced very few fish older than 3 years, even though the stock had been unexploited for 30 years. Sprat can live to 5-6 years of age.

Total yearly catches of Wash sprat averaged around 2000 tonnes between 1959 to 1963. Catches then increased in most years, reaching 8,230 tonnes (8,100 tons) in 1968 (Johnston 1970). Landing statistics in the ESFJC annual reports show very low landings of around 15-30 tonnes in the mid-1970s to mid-1980s with occasional highs of several hundred tonnes. Landings remained below around 200 tonnes in the 1990s until in 1998 landings increased to around 1000 tonnes. Landings then dropped down to almost zero in 2000 and back up to around 1,500 tonnes in 2001. The fishery therefore appears to be susceptible to large fluctuations in landings, which do not necessarily reflect the stock abundance (Figure 4.1.1).

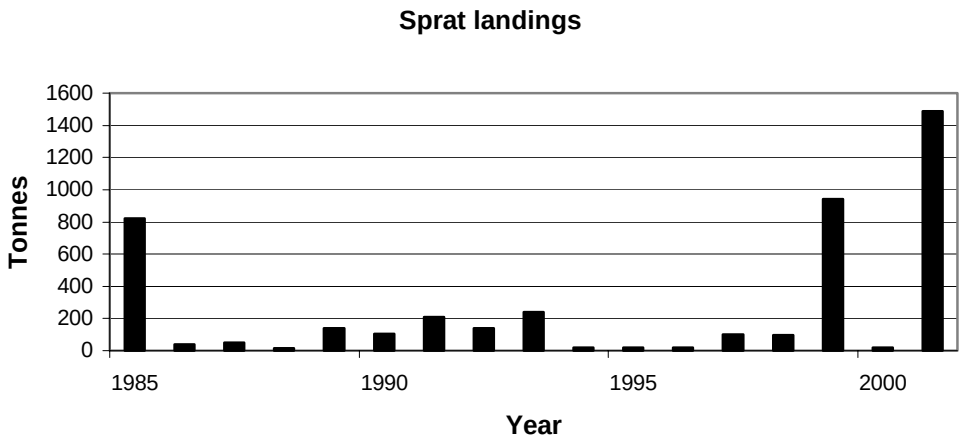

Figure 4.1.1 ESFJC district landings of sprat

4.1.5 Reasons for decline

The landing figures available for the sprat fishery within the Wash and adjacent areas, discussed above, show that the current level of exploitation (1,486 tonnes in 2001) is well below the maximum achieved in the late 1960s (>8,000 tonnes) and well above the minimum recorded in the 1990s (*ca*. 200 tonnes). Looking at the sudden increases and decreases shown in the 3 years of 1998 to 2001, it seems likely that the landings are currently reflecting fishing effort rather than stock availability. Boats may fish for sprat on an opportunistic basis, switching to other targets such as herring as appropriate. For example, the 1993 ESFJC annual report mentions that in the Boston and Fosdyke area, 6 vessels fishing for sprat landed 140 tonnes in January then switched to herring as these came in. The sprat season generally runs from around November to March. Whether the Wash stocks have ever suffered significantly from over-exploitation as the Thames stocks appears to have done in the 1950s, is difficult to say. The Wash stocks appear to be composed mainly of young fish and the fishery depends on the strength of the recruiting year class. Johnston (1970) reports that there is evidence that older and larger fish tend to emigrate into deeper water offshore. However, sprat become sexually mature by 2 years and the stock is not dependent on the reproduction effort of these older fish.

4.1.6 Opportunities for restoration

It is not clear from the available records and literature whether the Wash sprat stocks have been over-exploited. Apart from careful monitoring of landings on a catch-per-unit-effort basis, there seems little opportunity or need for restoration at this time.

4.1.7 Major References

Johnson 1970
Lee and Ramster 1981

4.2 European seabass *Dicentrachus labrax*

4.2.1 Introduction

The bass is a valuable commercial fish and is also of great importance to anglers being a popular sporting fish. In summer bass are found inshore and will enter estuaries and occasionally rivers. In winter they retreat to deeper water. Spawning occurs in spring, the eggs and larvae are planktonic and the young move into estuaries and creeks where they spend their first two years,

before moving out into coastal waters. Large bass can reach 1 m long, but 60 cm and 4 kg is more normal. They can live for at least 20 years. Bass are essentially a southern species and are affected by bad weather. Cold weather in spring and summer can affect spawning and result in a poor year class. The exceptionally cold winter of 1963 extended well into spring and spawning was badly affected. Conversely a warm spring and summer often result in very good year classes. Bass are predatory, feeding on sandeels, other small fish, shrimps and practically anything else that moves.

4.2.2 Conservation Status

None

4.2.3 Present distribution and abundance

Bass can be found in small numbers all round Britain and Ireland. However, most are found around southern England in the Channel, the Thames Estuary and up the west coast of Britain to Cumbria. In winter bass retreat southwards to warmer waters in the south-west. Even in summer they are not a very common fish around East Anglia, possibly because they prefer to live near inshore rocky reefs, which are in short supply in this area. However, they will also concentrate around sand banks where shoals of prey fish such as sandeels congregate. Bass are caught in trawls as far north as Scarborough but the main fishing effort in East Anglia, is south of Aldeburgh in Suffolk.

Landings of bass into the ESFJC district in 2001 were around 3 tons. Young fry and juveniles live in sheltered estuaries and inlets but the Wash does not seem to be an important nursery area. The Young Fish Survey showed negative results for bass at almost all sites within the Wash and along the Lincolnshire and East Anglian coasts (Rogers *et al* 1998). It is not until the Essex estuaries are reached that significant numbers of young fish are found. There are 34 designated bass nursery areas but none lie within the present study area (Pickett *et al* 1995).

4.2.4 Past distribution and abundance

Lowe (1899) commented that bass were not common on the Norfolk coast. Smith (1915) reported that bass were occasionally taken along the Lincolnshire coast and in the Wash. He found a ‘good number’ in Immingham Dock and reported that a small one was caught in the Witham below the docks at Boston.

Bass first appear in the ESFJC landing statistics in their annual reports in the 1980s. Landings remained below 0.5 tonnes in the 1980s except for 1986 when 1.6 tonnes were landed. Since 1990 landings have been between 2 to 5 tonnes. Although the numbers caught are not high, bass are very valuable and the 3 tonnes landed in 2001 were worth over £22,000.

4.2.5 Reasons for decline

The Bass is very vulnerable to over-exploitation because it takes a long time to reach maturity and because it grows slowly in cold British waters, where it is at the limits of its range. The increase in the popularity of sea angling in the 1980s put great pressure on populations. Most bass are caught by rod and line both commercially and for sport. They are also taken by small boats (< 10 m) using gill nets, long lines, beach seines and set nets and by some bigger boats using trawls and seine nets. Fishing restrictions such as minimum landing size, have helped to

ease the pressure on the stocks. A MLS of 26 cm was introduced in 1976 and this was increased to 32 cm in 1981. There are also minimum mesh size regulations with local variations (MAFF 1987).

Bass stocks declined significantly in Great Britain between the 1950s and 1980s especially on the west coast. Landings into the ESFJC district have remained steady since the 1980s. The information readily available is not sufficient to tell whether there has been a decline in local stocks within the study area.

4.2.6 Opportunities for restoration

Further information is needed in order to ascertain whether bass stocks are stable or declining in the study area. This might be obtained on a local level from sea angling clubs and local fishermen. The Wash and its environs do not appear to be of major importance to bass and it is probably not high on the list of priorities for restoration. However, this species is important as a leading saltwater sport fish, a valuable commercial fish and a top predator.

4.2.7 Major References

MAFF 1987
Pickett *et al*. 1995

5 Rare or declining fish

5.1 Sturgeon *Acipenser sturio*

5.1.1 Introduction

Sturgeon occur throughout north-western Europe but in northern Europe is now very rare. In the British Isles, sturgeon are now mere vagrants that are occasionally caught in fishing nets. For example, one was landed at Grimsby in 1986. It lives in shallow inshore areas and is a bottom-living species. It is anadromous, entering rivers and spawning in the lower reaches in deep gravelly areas (6-8 m). The adults leave after spawning but the young remain in the rivers for up to 3 years or so.

5.1.2 Conservation Status

Listed by IUCN as Critically Endangered (A2d)

5.1.3 Present distribution

No recent records from this area.

5.1.4 Past distribution

Although there are no definitive records of sturgeon spawning in British rivers, it seems possible that they may once have done so. Throughout the 19th century, there are many records of sturgeon far up British rivers especially in May and June. However, by the late 1800s sturgeon were already rare around GB. There are a few records from East Anglia from the 19th century. Some of these records are from rivers where there may once have been spawning sites. It would probably be possible to find more details by trawling through ancient ESFJC records, angling records etc but this would be very time consuming. The records found are summarised below:

- Record from unknown source (in FD lecture notes): In 1715 a 7.5' long sturgeon found in Thetford Mill Pool (following bursting of Denver sluice in 1713);
- Record from Patterson (1897) that sturgeon have been taken in the river (at Yarmouth?) and in Breydon water. A 2.4 m (7' 10") fish was stranded on the 'flats' (Breydon) in 1871 and a 2 m (6' 5") fish was landed from the beach in 1894;
- Record from Lowe (1899): Beach fisherman caught one on 7th December 1894 2 m (6'6") long;
- Record from Southwell (1904): *A.sturio var latirostris* – the broad-nosed variety of the sturgeon is much less frequently met with by our fishermen than the normal form; one is recorded by Mr Patterson as brought into Yarmouth on 23rd November 1899;
- Record from Smith (1915): Occasionally in the Humber. They occasionally ascend the Trent as far as the weir above Newark. Brogden says: "It frequently ascends the Welland. One of 18 stone taken at the mouth. They have been taken in the New River, Cowbit Wash and Vernatt's drain".

- Record from Patterson (1924): A 0.9 m (3') fish was netted offshore (Norfolk) in July 1920. There seem to have been far greater numbers in the North Sea for 3-4 years after the war, possibly due to lessened fishing in European rivers;
- Record from 1964 from Heacham (Wash) from Kings Lynn museum (see Dipper 1983) from Dick Jones.

5.1.5 Reasons for decline

Not known for certain but likely to be a combination of overfishing, pollution in estuaries and especially, barriers preventing migration up rivers.

5.1.6 Opportunities for restoration

Not likely to be feasible in the East Anglian area.

5.2 Common or blue skate *Dipturus batis (Raja batis*)

5.2.1 Introduction

Following taxonomic work reported recently, this species now belongs to the genus *Dipterus*. The common skate or blue skate ranges all around British and Irish coasts but has now become rare and is thought to be locally extinct in the Irish Sea. It is the largest European ray and can grow to over 2 m in length. It lives on sandy and muddy bottoms where it feeds on a variety of benthic animals including fish. The adults are usually found between 100m to 200 m and occasionally down to 600 m depth, whilst younger specimens prefer shallower water up to around 30 m. Like most other skates and rays, it is oviparous and lays egg capsules during the summer. An individual may lay up to 40 egg capsules in a season. The slow growth and low reproductive rate mean that the species has very low resilience with a minimum population doubling time of 14 years (www.fishbase.org).

5.2.2 Conservation Status

The IUCN Red List assessment for this species is *Endangered.* It is the subject of a UK BAP Species Action Plan.

5.2.3 Present distribution

The current status of this species within the Wash is unknown but numbers are likely to be very low. Records of skate landings for the ESFJC district do not differentiate between species. The status of the British stocks generally is not known, partly because too few are caught in research cruises to make analysis possible. It is very scarce throughout European waters, is thought to be extinct in the Irish Sea and is extremely rare throughout the central and southern North Sea, western Baltic and western Mediterranean.

5.2.4 Past distribution

Patterson (1897) recorded that this species grew to considerable size in local waters (Yarmouth) and that 'numbers' were taken by long liners.

Smith (1915) records *Raja batis* as a common species along the coast especially between Tetney Haven and Mablethorpe. He reports that small ones were numerous in the Wash and Humber and

occasionally a large one was taken. He also records the roker *Raja clavata* as being more numerous than *R.batis* and of larger average size.

Wheeler (1978) writing in general terms, recorded that the species was relatively common but that very large skate were less commonly reported than in the 1920-1930 period.

ESFJC district landings of skate in general (all species) have shown a steady decline over the last ten years between 1992-2001, from around 617 tonnes (1992) to 184 tonnes (2001). Prior to this period, landings had been increasing (around 375 tonnes in 1989 to around 600 tonnes in 1992) (ESFJC 1998, 2001: annual reports). In 1993, many boats were actively fishing skate and the bulk of fish were caught near the Inner Dowsing Bank, except for a period in May when large numbers (mainly roker) were caught further inshore (ESFJC 1993: annual report). In 2001 boats moved down to Suffolk and don't fish for skate in Wash and Lincolnshire now.

5.2.5 Reasons for decline

The European-wide decline in this species is due to over-exploitation. This species grows slowly, does not mature until it is at least 10 years old and 1.25 m long (for males) and slightly larger for females. This means that in heavily fished areas, most juveniles are caught before they have matured and had a chance to breed. Recovery of stocks is also hampered by the low fecundity of this species.

5.2.6 Opportunities for restoration

Although no longer targeted in areas where it is very scarce around Britain and Ireland, including the Wash, numbers are still taken as by-catch when fishing for other bottom-living species, including other rays. Whether this is the case in the Wash is not known. Tagging records have shown that most individuals remain within a relatively small coastal area for their entire lives.

A first step to restoration within the Wash and adjacent areas would be to ascertain to what extent this species is still being landed along with other targeted rays, at any of the ports within the study area. Ideally all skate and ray species should be recorded separately in landing statistics but this may not be practical. Point 5.1.1 of the Species Action Plan for this species suggests that all skate and ray landings should be made 'skin on' to facilitate species identification and that all species should be recorded in landing statistics.

As an initial step, a programme of regular sampling of skate catches at the bigger markets could be initiated. Another possibility would be to ask fishing boats to look out for this species in their catch and to keep any that are found. A simple identification and record sheet could be prepared. Both market sampling and retention of specimens by fishermen were successfully used in Sabah, Borneo, when searching for rare elasmobranchs in rivers and estuaries (Manjaji, in Fowler, Reed and Dipper 2002). Fishermen could be paid the going market rate for any fish kept for the project. However, there should be no other reward as this would encourage deliberate capture of the species.

5.2.7 Note on the Roker *Raja clavata*

A variety of species are landed within the ESFJC district that are recorded together as 'skate'. However, roker is generally the main species taken by inshore trawlers in most areas including the Wash. This species lives on muddy, sandy or gravelly bottoms (which are widespread throughout the Wash) and feeds on crabs, brown shrimp and various fish. Smith (1915) and other miscellaneous records suggest that this species was common in the past, in the Wash and along the Lincolnshire coast. It now appears that this species has been very heavily fished (hammered was the word used!) in the Wash and environs. This is reflected in the steady decline in 'skate' landings within the ESFJC district (see section 5.2.4 above). Schemes aimed at identifying different skate species in landings as discussed above, would provide useful statistics for this species too.

5.3 Shad *Alosa fallax* & *Alosa alosa*

5.3.1 Introduction

The Twaite shad and Allis shad are members of the herring family that live in shallow coastal waters and estuaries. Both species spawn in freshwater, making spawning runs up large rivers in late spring and early summer to areas above the tidal influence. Optimal habitat requirements within the rivers are not well known. Shad spawn over stony and gravelly areas often adjacent to deep pools. The eggs hatch after a few days. Young twaite shad drop back downriver with the current into the upper parts of the river estuaries where they feed and grow before moving out into open water. Most young Allis shad drop down to the sea during their first year of life although some may remain in freshwater until their second year. Most twaite shad die after spawning although in the UK up to a quarter may survive to spawn a second time. Almost all Allis shad die after spawning.

Twaite shad females mature at about 5 years old and the males at about 3 years when 25-30 cm long. They can live to at least 10 years old and reach a length of around 40 cm. Allis shad mature between 3-4 years old at around 30-40 cm in length and can eventually reach a length of 60-70 cm (age not given).

Twaite shad feed on estuarine zooplankton, shrimps, mysids and small fish when young, whilst adults mostly eat small fish such as juvenile herring and sprat. Allis shad feed on riverbed invertebrates such as crustaceans and midge larvae when young, whilst the adults out at sea utilise small fish and planktonic crustaceans.

5.3.2 Conservation Status

Both species are the subjects of UK BAP Species Action Plans.

Allis shad is protected under schedule 5 of the Wildlife and Countryside Act 1981 and listed on Appendix II of the Bern Convention and Annexes II and V of the EC Habitats Directive.

Twaite shad is listed on Appendix III of the Bern Convention and Annexes II and V of the EC Habitats Directive.

5.3.3 Present distribution and abundance

Both species of shad occur in coastal waters all round the British Isles but are uncommon, especially the allis shad which is moderately rare. The JNCC UK distribution maps for both twaite and allis shad (JNCC web site) indicate populations in some Essex estuaries but none are indicated within the present study area. Ecomaris Ltd. is contracted by the EA to take regular samples in the Wash, and hasno records of this species (*pers comm.* Seamus Whyte 14/2/03). Neither species is known to spawn in any rivers within the study area. Spawning stocks of twaite shad occur in rivers in Wales and on the England/Wales border. The only recently confirmed spawning site for allis shad is in the Tamar Estuary although there is thought to be a spawning population in the Solway Firth area (Jackson and McLeod 2002). The EA run a recording scheme to collate records of incidental catches in England and Wales.

5.3.4 Past distribution and abundance

Twaite shad have declined substantially throughout Europe including the UK. A lack of records and comments from early recorders suggest that the species has never been common in the East Anglian area. However the times and places of the few records there are, suggest that there may have been some spawning in local rivers, although direct references to this have not been found.

Patterson (1892) records that twaite shad are rarely taken around Yarmouth and that he recorded one in Breydon water in April 1891. In his 1887 paper he records allis shad as not uncommon with the herrings. Lowe (1894) in his list of Norfolk fishes, records a twaite shad landed at Yarmouth in April 1893 that was 43 cm (17") long and weighed 2.2 kg (4.75 lbs). Smith (1915) records that 'Twite' shad (*Clupea finta*), are of rare occurrence in the Wash. Dipper (1983) records that the Kings Lynn museum had a frozen twaite shad collected from Snettisham beach in September 1982.

Allis shad appear to have fared even worse than twaite shad and the species is still declining throughout its range on the western coasts of Europe. Like the twaite shad, there are few past records of this species from East Anglia. Patterson (1892) records a number washed up alive (at Yarmouth?) in May 1881. Lowe (1894) records one landed at Yarmouth in April 1893 weighing 2.2.kg (4.75) lbs. Smith (1915) records "shad (*Clupea alosa*) occasionally taken at the mouth of the Welland".

5.3.5 Reasons for decline

Reasons given for the general decline of populations of shad around the UK and Europe include obstructions such as weirs that deny the fish access to upriver spawning grounds, pollution of estuaries and lower reaches of rivers and overfishing especially by local fisheries on spawning populations. Both species of shad have been commercially exploited in the past, but the allis shad in particular is not universally considered good eating. Maitland and Campbell (1992) report that the twaite shad is still fished commercially in some parts of Europe especially using nets in estuaries during the spawning migrations. The twaite shad is also taken by anglers in the UK.

5.3.6 Opportunities for restoration

There is a lack of evidence to suggest that these two species of fish ever spawned in large numbers in rivers within the study area. In addition, rivers within the area are now unlikely to

provide good spawning grounds due to river engineering and pollution. Restoration of these species in this area is therefore probably not appropriate at this time. However, useful data might be collected by encouraging anglers, fishermen etc to report finds to local records centres.

5.3.7 Major References

Jackson and McLeod 2002 (www.jncc.gov.uk/publications/JNCC312)
UK BAP Species Action Plans (www.ukbap.org.uk/asp/UKPlans)
Fishbase (www.fishbase.org.uk)
Maitland and Campbell 1992

5.4 Smelt *Osmerus eperlanus*

5.4.1 Introduction

The smelt is a small (usually 10-20 cm; max. 45 cm) predominantly estuarine fish, belonging to the family Osmeridae and related to salmon and trout (Salmonidae). It is tolerant of a wide range of salinities and is most abundant around the mouths of rivers and in estuaries. Like its larger relatives, salmon and trout, it migrates into large clean rivers to spawn. The spawning run is short, usually just a few days and takes place between February to April in the study area. After spawning the fish drop back downstream and many manage to return to the sea and will spawn again in due course. The eggs are sticky and become attached to stones, gravel and weed on the riverbed. Time to hatching varies from around 20 to 35 days depending on temperature. The young fry are carried down to river estuaries where they start to feed. At first they feed on tiny planktonic animals later progressing to larger planktonic shrimps and small crustaceans. Larger ones eat mainly small fish.

5.4.2 Conservation status

Classified as Data Deficient in the IUCN Red Data Book. Not listed under European or UK legislation but now considered by many to be a nationally rare species (EA 1997).

5.4.3 Present distribution and abundance

The smelt is still a relatively common species in the Wash but its true status both in the Wash and associated rivers, is hard to ascertain. It is not currently targeted as a commercial species here but is caught along with other bottom-living fishes. Therefore there are no fishery statistics available from the ESFJC and it is not mentioned in ESFJC annual reports.

Nationally smelt populations have declined drastically, through poor management of fisheries, pollution and barriers to migration. It is now considered by many to be a nationally rare species (EA 1997). Its current and past status throughout the British Isles is currently the subject of a literature survey for EN by Peter Maitland.

An EA report (1997) states that smelt do occur in the Great Ouse catchment in most years. However, numbers are low and existing data on populations is poor. The EA 1997 report had proposed that the EA carry out a survey specifically to find out the status of the population in the Ouse catchment. However, this has not been done and is unlikely to be (Roger Handford pers comm 28/11/02). Annual epibenthic trawls of the tidal river Great Ouse between the Wash and

Denver sluice between 1984 to 1996, show great variation in numbers caught at each site between years. The lowest total number caught was 9 fish in 1985. The highest was 405 fish in 1993.

In the Great Ouse catchment, smelt are also been recorded on an occasional basis (in routine EA fisheries surveys between 1980-present) in Hundred Foot River, Old Bedford River/Counter Drain, Old Bedford/River Delph, Great Ouse Relief Channel, Ely Ouse, Old West, River Cam, Middle Level Main drain. Occurrences in systems such as the Relief Channel and Middle Level Main Drain are probably explained by fish being attracted by the high flows from the sluice gates. No smelt have been recorded in the Rivers Nar, Babingley, Heacham and Gaywood during surveys carried out between January-April since 1985. Anecdotal evidence collated by Peter Maitland indicates that smelt were still managing to ascend the tidal Ouse and New Bedford rivers in reasonable numbers 10-20 years ago.

Howes and Kirk (1991) compiled their historical review of smelt in the Humber because they were prompted by 'recent records from the Humber'.

5.4.4 Past distribution

Early 19th century references suggest that the smelt were abundant in the Wash in the 1800s and that they formed the basis of a successful and remunerative fishery. The most important river for spawning was the Ouse and there were considerable runs up the Ouse and the Hundred Foot River every year between February to April. 'Enormous quantities' of smelt are said to have been caught in the 'drains and cuts' of the Bedford Level, in the Welland and the Nene (Jenyns 1846, Buckland 1875, Southwell 1886, 1888, Brogden 1899). Howse and Kirk (1991) provide a few other 19th century references to the abundance of smelt in the Ouse and in the Humber estuary in the 19th century, where there were commercial fisheries and along the sandy shallow shores of Lincolnshire. Patterson (1897) records them as very abundant off Yarmouth in the autumn and in Breydon. He describes the water as 'fairly alive' with fry at times in the summer.

In the early 1900s they appear to have been abundant still. Smith (1915) reports smelt as abundant in the Wash and all along the coast (Lincs) but especially in the brackish water of the Humber, Witham, Welland and Wainfleet Haven where large quantities were caught. However, Howse and Kirk (1991) quote reports suggesting that after the First World War smelt were rarely found in the Humber.

In the 1960s there are anecdotal records (collated by Peter Maitland) of smelt in the River Nene at least as far upriver as Peterborough and Wisbech. Talking to local people who have lived in the area and used the rivers for some time, often elicits the response that they used to see lots of smelt during the spring e.g. 'thousands of fish, bucket loads of fish at St Ives staunch (lock)' (pers comm John Hesp).

A lack of other than anecdotal records means that it is difficult to document the decline of the smelt. However, written records suggest that there were problems with overfishing even in the 1800s. These were mainly caused by the removal of huge numbers of fry in 'stow' and 'trim' nets set across the mouths of the rivers and the fisheries for adults on the spawning grounds in the rivers. A circular sent out to local ports in 1882 by a Mr Harding ascertained that many

reported decreases in the amount of smelts taken (Southwell 1888). The Norfolk and Suffolk Fisheries Act of 1877 is mentioned by Southwell (1887) as helping to alleviate such problems.

5.4.5 Reasons for decline

Obstruction to migration: The EA consider that obstructions to migration inhibit access to spawning habitat in the Great Ouse and North West Norfolk rivers. Passage to the upper tidal reaches where the smelt spawn, is obstructed by sluices and gates designed for flood alleviation. Details of impediments in each river are given in EA (1997). The most unimpeded route is up the Hundred Foot Drain (New Bedford River).

Spawning habitat: Smelt need clean, fast flowing water and a gravel or weedy substratum on which to spawn. Such areas are limited. Details of sites thought to be currently in use and areas that are potentially suitable are given in EA (1997).

Pollution: Smelt are very susceptible to pollution and other stresses, both in estuaries and in the rivers where they breed. Past records indicate that in historical times, pollution also had a detrimental effect on stocks. The EA reports that water quality has now improved in the Ouse catchment (EA 1997).

Exploitation: There is no evidence that current exploitation is affecting stock within the study area. A few commercial eel fishermen target smelt in the river systems for sale as pike bait. Most are caught simply as a by-catch. Young smelt are caught and killed in the Wash by shrimp trawlers (ESFJC annual reports) – see pink shrimp section 6.2. In historical times, destruction of fry in nets was significant.

5.4.6 Opportunities for restoration

Since the EA report (1997) was produced, the EA has not undertaken any further research on this species. Their fisheries sampling is restricted to freshwaters and smelt only spend a short time in the rivers. So resources have not been available to monitor the stocks with any degree of quantitative accuracy. They also say that monitoring of populations is complicated by the ecology of the species and its low commercial importance. The EA remains interested in the smelt and if EN were considering further research into its status or distribution in rivers, they would be interested in getting involved (pers comm Roger Handford, EA Team leader, Fisheries, Recreation and Biodiversity 28/11/02).

Smelt are sometimes caught in the Wash and Ouse approaches by fishermen and during EA survey work, both by their own staff and that of sub-contractors such as Ecomaris Ltd. (pers ob). Collation of such incidental catches could provide useful abundance data especially if dedicated surveys are not possible.

The EA (1997) report lists measures that could be taken to help restore this species. Such measures include improving passage to suitable spawning areas and research into the swimming ability of smelt to help designs for fish passes etc. Identification of spawning sites within the Ouse and other rivers is also important. Continued improvement in water quality in the Great Ouse estuary may improve habitat for smelt.

5.4.7 Major References

EA (1997)
Fishbase
Peter Maitland

5.5 Sea lamprey *Petromyzon marinus* and river lamprey or lampern *Lampetra fluviatilis*

5.5.1 Introduction

Lampreys belong to a small group of primitive vertebrates known as the Agnatha – the jawless fish. In the absence of jaws, these long eel-shaped fish have a round sucker-like disc surrounding the mouth, with a number of strong, rasping teeth set into the disc. The adults are parasitic on marine and anadromous fish including salmon, trout, shad, herring and cod. They attach themselves to their host by their mouth sucker and rasp away a hole, so that they can feed on blood, muscle and body fluids. The host fish may survive but many die.

Like salmon and shad, sea and river lampreys are anadromous, spending most of their adult life at sea, but migrating up rivers to reach freshwater spawning grounds. The life cycle of the two species is very similar and they can often be found in the same places. The eggs are laid in spring and early summer in stony and gravelly stretches of rivers where there is a reasonable flow of water. After hatching the larvae disperse downstream and settle in quiet silty areas of the river where they burrow into the sediment. At this stage they are known as ammocoetes, which are blind and feed on micro-organisms, bacteria and detritus. The larval stage lasts up to five years and is followed by a slow metamorphosis into the adult fish-feeding form and migration down to the sea. Young river lampreys often remain in estuaries for a year or two where they feed mainly on herring, sprat and flounders. Little is known of the adult sea-going phase but adult sea lamprey have been taken in both coastal and deep offshore areas and can also be found attached to basking sharks and whales. Mature sea lamprey adults average around 60 cm in length whilst the maximum length is around 90 cm. River lamprey are smaller at around 30 cm. Adults do not feed during their spawning migrations and they die after spawning.

5.5.2 Conservation Status

Both species are listed in Annexes II and V of the EC Habitats Directive. Draft action plans have been produced for both species.

5.5.3 Present distribution and abundance

Both sea and river lamprey occur mainly in coastal waters and estuaries and can be found all round the UK. However, due to their parasitic habits, they are rarely seen and little is known of their distribution at sea. Sea lampreys are reasonably widespread in UK rivers and are common in some areas but scarce and declining in others. River lampreys are more widespread with stronger populations. The UK distribution map given in Jackson and McCleod (2002) shows a record for sea lamprey in the Humber estuary and a record for Suffolk, but none for the Wash or Norfolk. There are records for river lamprey in the Humber, in rivers along the Lincolnshire

coast and north Norfolk but not in the Wash area. The EA run an incidental catch and observation scheme to collate records in England and Wales.

5.5.4 Past distribution and abundance

Past records of lampreys are not very extensive. The following records indicate that both these species were more widespread in the past, within the area:

- Lowe (1884) records one 0.7 m (28.5") long caught in Barton Broad January 18th 1873 attached to a tench;
- Patterson (1897) records lampern as frequent in April (around Yarmouth) when shrimpers and draw nets take many. They ascend the rivers to spawn. He records lamprey as netted now and again on the Breydon;
- Smith (1915) records sea lamprey as fairly frequent in the Wash and Humber;
- Patterson (1924) comments that while at times sea lamprey been found in the Waveney in some numbers, it rarely seems to ascend the Bure. He also noted two 2lb (0.9 kg) fish 74 cm (2'5") long in an eel set at Hickling Broad in May 1921;
- Smith (1915) in his list of fishes from Lincolnshire records river lamprey from the Welland, Glen, Waring River, and Trent. He records that it used to be plentiful in the Freshney and there were a few in the Lud.

5.5.5 Reasons for decline

Sea lamprey are relatively poor at getting around or over any obstacles to migration and have therefore become restricted to the lower reaches of rivers in many places. Here they cannot necessarily find the right conditions for spawning or for larval development. As there are few past or present records of sea lampreys from the present study area, it is difficult to tell whether the species has declined. However, it is likely that it has, especially in the light of the problems faced by other species trying to ascend rivers to spawn in this area, eg smelt. It is not exploited commercially in UK but there are fisheries for it in countries such as Poland and Spain.

River lamprey suffer similar problems to sea lamprey, when trying to ascend rivers to spawn. Wheeler (1978) comments that the species has markedly decreased in numbers since historical times. They have been more widely fished throughout Europe than the sea lamprey. Substantial fisheries for river lamprey existed in the past on large British rivers such as the Severn. It is not known whether there were any local fisheries at one time within the present study area.

5.5.6 Opportunities for restoration

There would seem to be few opportunities to attempt to restore these species. It is not known in which rivers they used to spawn within the study area, or how abundant they were. As both species are parasites, that often kill their host fish, attempts to increase their numbers might meet resistance, although adults only feed whilst at sea and not whilst spawning in rivers.

5.5.7 Major References

www.fishbase.org
Jackson and McLeod 2002
Maitland and Campbell 1992

6 Crustaceans

6.1 Brown shrimp *Crangon crangon*

6.1.1 Introduction

The brown shrimp is a very important faunal element of the Wash, providing a large part of the secondary production within the ecosystem. The health of the stocks is therefore of major concern. The brown shrimp fishery within the Wash is more valuable financially than either the cockle or the mussel (ESFJC 1993: research report) and supports a major (growing) proportion of the Wash fishing industry. In 1996, brown shrimp represented nearly 80% of the income from all Boston and King's Lynn 'shellfish' landings. Closure of mussel beds since 1994 and the widespread failure of cockle recruitment since 1992 have resulted in a focus of effort on the brown shrimp (ESFJC 1996: research report). In addition lack of demand for pink shrimp (*Pandalus montagui*) means that this fishery is no longer significant in the Wash. The only other large fishery for brown shrimp is in Morecambe Bay although it is fished locally in other areas.

The brown shrimp is so called because this is the colour it turns when it is boiled. When alive it is a translucent greyish colour and blends in well with the muddy sand on which it lives and into which it burrows during the day. It feeds at night by crawling over the seabed in search of anything edible including detritus, seaweed, small crustaceans, molluscs, worms and eggs. Spawning occurs throughout most of the year and the female carries the eggs until they hatch. It can reach a length of around 70 mm.

6.1.2 Conservation status

None

6.1.3 Present distribution and abundance

Brown shrimp are common throughout the present study area, wherever there are suitable areas of shallow sands and silt soft enough for them to burrow into.
Information on shrimp population levels in the Wash over the past 10 years or so is provided by the following research programmes:

- Shrimp monitoring has been carried out by the ESFJC on a yearly basis since 1993;
- CEFAS carried out shrimp monitoring between 1995 – 2000 as part of contracted survey work examining the ecological effects of offshore dredging within and outside the Wash, in relation to a beach replenishment scheme on the Lincolnshire coast;
- University of East Anglia has been engaged in research into the biology of *Crangon* for a number of years. Dr Bob James is carrying out a study of long-term trends in shrimp landings and abundance in the Wash using historical ESFJC records.

Unfortunately these limited time series are not sufficient to draw definitive conclusions on population levels in relation to fishing, given wide natural fluctuations and a range of variables. In their 1997 research report, ESFJC recommended that in order to answer the question of

whether the stocks are declining, existing landings figures be examined and compared with the level of fishing effort, extending for 15-30 years back. As far as is known, this has not yet been done.

6.1.4 Past distribution and abundance

Hamond (1970) recorded *Crangon* as abundant in the 1960s, on sand all round the East Anglian coast, being especially numerous in the Wash and off Yarmouth where it was trawled in large quantities. Small specimens were also recorded as numerous in Breydon and in the North Norfolk saltmarshes.

Fishery information/declines: The size of shrimp populations can vary considerably according to the abundance of predators such as whiting and intensity of fishing effort. Natural mortality is estimated to be 20-50% of the adult stock per month (Boddeke 1983). The effect of fishing effort has not been accurately quantified (ESFJC 1994: research report) but annual shrimp landings at Boston and King's Lynn between 1977 and 1993 suggest that stocks in the Wash have diminished. During this period there was a significant increase in fishing capacity, with greater numbers of larger vessels and the introduction of double beam trawls. Despite this increase in effort, annual catch rates have declined since 1987 (Figure 6.1.1) (ESFJC 1993: research report). Abundance in 1995 appeared to be low (ESFJC 1995: research report). After a long depression in *Crangon* numbers throughout 1997 and first half of 1998, a conspicuous increase in catch rates on the ESFJC research programme was seen in the latter part of 1998 (ESFJC 1998: research report).

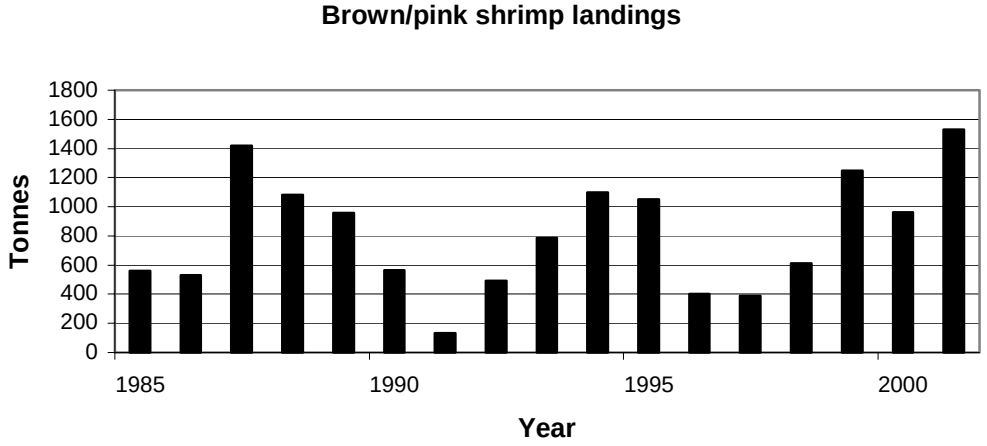

Figure 6.1.1 ESFJC district landings of shrimp (brown & pink). Landings of brown and pink shrimp are not recorded separately, and these statistics are therefore of limited value in the present context.

Research on the population dynamics of brown shrimp at both inshore and offshore stations in the Wash, has been carried out by the ESFJC since 1993 to the present, with the aim of applying more effective management to the stocks and assessing the current condition of the fishery. The results, whilst not sufficient to determine any long-term changes in the population structure and abundance in the Wash, have shown a general fall in abundance. This reflects fishermen's reports that catch rates have been declining and that the average size of individual shrimps in the catch is lower. However, the population has the potential to recover rapidly even from very low levels. One area of concern within the shrimp fishery is an apparent and continued decline in average size of the shrimp as evidenced from grading landings. The ESFJC research data time series is at present too limited to confirm this.

6.1.5 Reasons for decline

Brown shrimp populations fluctuate widely from year to year and natural mortality through predation is high. It is not entirely clear to what extend apparent declines (as measured in landings) in stock are due to fishing. However, the available evidence of declining landings and apparent decline in average size of individuals caught, suggests that fishing is having an effect on stocks.

There are concerns (since 1995) about the effects of aggregate extraction adjacent to the Wash, which may influence the shrimp fisheries as well as the molluscan fisheries. The industry believes that the decline in catches from 1994 onwards (in the ESFJC district *ca*. 1100 tonnes in 1994 to just over 400 tonnes in 1997) was due to marine aggregate dredging especially from Area 107 off the east coast, for beach replenishment material for Lincolnshire beaches. However, in 1999 shrimp catches (pink and brown) rose dramatically to around 1500 tonnes and the increase began well before dredging in Area 107 ceased (ESFJC 2001: annual report).

ESFJC (1996: research report) propose various possible explanations for continuing declines should these prove to be a genuine trend:

- Suppressed primary productivity (eg through decreasing phosphate discharge into the water systems or increased water turbidity) limiting food availability at lower trophic levels;
- Fishing pressure, eg depleting the brood stock (largest individuals of greatest commercial value) as well as the developing brood – resulting in reduced productivity and consequently lower stocks;
- an increase in shrimp predation by starfish and other predators, especially when strong year classes occur.

6.1.6 Opportunities for restoration

Whilst there is probably little that could or should be done directly by EN, support could be given to research efforts by ESFJC and the UEA into population dynamics. The population has the potential to recover rapidly even from very low levels (ESFJC 1995: research report).

The shrimp fishery has issues with the level of by-catch and discard mortality. Regular monitoring by ESFJC of by-catch with their monthly shrimp research surveys would be useful but time and staff limitations currently prevent this. For example, many juvenile smelt are caught

and killed (pers comm 1991 from N.J. Fickling to R.Maitland). The Wash is also an important nursery ground for juvenile gadoids and flatfish such as the commercially important sole. Recent work has been carried out to assess these impacts in economic terms, which highlights the scale of the problem in a tangible way Revill (1998).

6.1.7 Major references
ESFJC annual reports and research reports (1993 onwards).

6.2 Pink shrimp *Pandalus montagui*

6.2.1 Introduction
The pink shrimp *Pandalus montagui*, is found all round the coast of the British Isles and is common in the Wash and along adjacent coastlines. It is so named because it turns bright pink when cooked. There has been a commercial fishery for this species in the Wash for over a hundred years and the pink shrimp, along with the brown shrimp (*Crangon crangon*) also acts as an important food source for white fish species. Pink shrimp eat a wide variety of food including worms, mussel spat, tiny periwinkles, copepods, crustacean larvae, small shrimps and plant material (algae). Unlike brown shrimp, it prefers a firm or hard seabed. Females lay eggs in November-December and carry them until they hatch in the following March –May. The young grow rapidly and mature in the first year, entering the fishery in their second year.

There is an important feeding relationship between pink shrimp and the tube-building worm *Sabellaria spinulosa* (‘ross’) – a BAP priority species (see section 8.2.1). *Sabellaria* lives in colonies consisting of many intertwined tubes and the concentration of worms in one place can therefore be very high. Pink shrimp can live quite happily in areas where there is no *Sabellaria* but probably prefer the *Sabellaria* grounds because they provide a concentrated food source. The shrimps crawl over the colonies and extract the worms from their tubes by probing with their delicate claws. *Sabellaria* can build up into extensive reefs, but in the Wash such reefs may be limited in extent. The distribution of pink shrimps and *Sabellaria* is however likely to be linked in the Wash and the main concentrations of both species coincide. Hamond (1970) found this species to be common off the Norfolk coast wherever there were abundant colonies of *Sabellaria*, but not on otherwise similar shelly and stony ground lacking living colonies.

6.2.2 Conservation Status
None

6.2.3 Present distribution and abundance
The pink shrimp is found over a wide area of the Wash but unlike the brown shrimp, is not adapted to live in purely sandy areas. It is therefore uncommon along the extensive sand banks of the southern inshore areas and eastern side of the Wash. The distribution of major concentrations of pink shrimp can be inferred from the fishery. This is concentrated in the deeper central area of the Wash where the bottom is of mixed, but mainly hard material comprising gravel, sandy mud and stones. These central hard substratum areas are also where high concentrations of *Sabellaria* are found. Warren (1973) reports the main fishery as concentrated in the deepwater channel between Roaring Middle and Burnham Flat (Figure 6.2.1).

Information on the current abundance of this species in the Wash is only available by inference from landings recorded by the ESFJC. At present the fishery is very limited and over the last few years only a handful of small boats have been fishing the shrimp on a regular basis. For example in 1998 only 2 vessels fished on a regular basis concentrating their efforts in the Lynn Deeps and Silver Pits areas (ESFJC 1998: annual report). This compares to around 25 boats in 1972. However, this does not necessarily reflect poor stocks as market forces appear to be currently controlling this fishery. Pink shrimp have become unfashionable and in both their 1993 and 1998 annual reports, the ESFJC refer to limited markets restricting effort (ESFJC 1993, 1998: annual reports). There was also a health scare when it was believed that the shrimp were being infected (via lobsters) with a disease that could cause unpleasant symptoms in humans when the shrimp were eaten (pers comm Colin Trundle ESFJC 14/2/03). This was around the time of the Salmonella in eggs scare but there was never any real proof that this was happening. It was however, sufficient to depress the market.

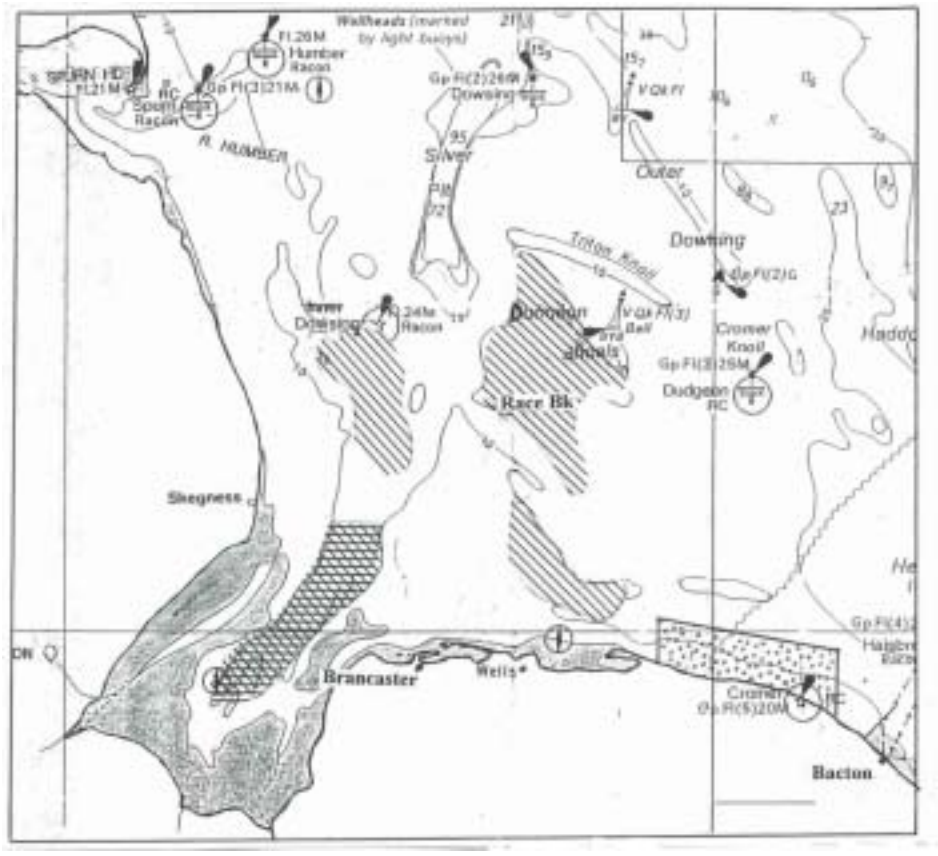

Figure 6.2.1 Main fishing grounds for pink shrimp (Warren 1973), edible crab (traditional inshore area) and whelk (between 1974-1991, from ESFJC undated). Edible crabs are now also fished in the Wash and on Race Bank. Key: xxx = pink shrimp; \\\\\ = whelk; º º º = edible crab.

6.2.4 Past distribution and abundance

Warren (1973) traces the history of the fishery in the Wash as far as is possible and the following information is taken largely from this source. Whilst it is known that there has been a fishery for pink shrimp in the Wash for over a hundred years, the importance of the early fishery is difficult to assess due to a lack of consistent records. MAFF annual statistics published by HMSO go back to the 1920s but lump both brown and pink shrimp together. These statistics indicate that between 1920 and 1970 the total annual landings of 'shrimps' into Boston and King's Lynn, have fluctuated considerably. Wide fluctuations in landings appear to be a normal feature of the Wash shrimp fishery and probably reflect changes in natural abundance of the stock (Warren 1973).

ESFJC annual reports landing statistics also do not separate brown and pink shrimps. In some years, additional information is given for specific ports and this was used by Warren (1973) to compile approximate landings of pink shrimps into Wash port between the 1920s to1970. No attempt has been made here to extract similar data after 1970 as this would have been very time consuming. The information available to Warren was for Boston and King's Lynn between 1925 to 1946, for Boston only between 1944 and 1959 and for King's Lynn only between 1960 and 1970. Thus comparisons are not easy. Weights given below have been converted from cwt to tonnes. Between 1925 and 1935, the average annual landings of pink shrimps into Wash ports (King's Lynn and Boston) were around 711 tonnes (highest 1,067 tonnes, lowest 417 tonnes). In Kings Lynn, landings declined to an all time low in the early 1960s (1.5 cwt in 1961). Between 1960 and 1970 landings at King's Lynn steadily improved to exceed 200 tons. In 1970, around 457 tonnes were landed into Wash ports. Catch-per-unit-effort data available from 1960 onwards, showed considerable variation. In recent years (since the 1980s?) the importance of the fishery has declined.

Whilst the major fishery is within the Wash, Hammond (1970) reports that pink shrimp were also fished commercially off Yarmouth, Gorleston and Caister by Yarmouth shrimpers.

6.2.5 Reasons for decline

No information on fishing effort is available before 1961 in relation to shrimp fisheries in the Wash. It is therefore very difficult to ascertain whether downward trends in landings reflect declines in the stock or changes in the size of the fleet. In the 1970s the Wash pink shrimp fishery was the only remaining one in the country. Fisheries in the Thames and in Morecambe Bay went into decline from about 1950 and commercial landings virtually ceased by the early 1970s. At this time the pink shrimp fishery in the Wash was at its peak and accounted for around half the total shrimp landings in England and Wales. The decline in the fishery since then appears to be market driven. There do not appear to have been any scientific studies on pink shrimp stocks in the Wash and so their status remains unclear.

6.2.6 Opportunities for restoration

The pink shrimp is an important ecological component of the Wash ecosystem. However, there is little information available to provide an accurate assessment of current stocks. Efforts to restore this species are probably not appropriate at the current time particularly in the light of the low level of current exploitation. However, research into populations and stocks within the Wash

would be very useful, especially in relation to the predation of *Sabellaria spinulosa* by pink shrimp.

6.2.7 Major References
Warren, P.J. (1973).
Mistakidis (1957).

6.3 European lobster *Homarus gammarus* (*H. vulgaris*)

6.3.1 Introduction
Lobsters are too well known to require any detailed description. These large decapod crustaceans are found mainly in rocky areas and rough ground where they live in holes and excavated tunnels. They can be found from the lower shore down to around 60 m depth. Mature lobsters can reach 1 m in length but few currently reach this size and a 50 cm maximum is more usual. Females mate when their shell is soft immediately after moulting and the eggs are laid around August-September. They are particularly vulnerable at this time. The developing eggs are carried by the female until they hatch the following late spring to early summer. The larvae are planktonic for 4-6 weeks.

6.3.2 Conservation Status
None

6.3.3 Present distribution and abundance
Information on distribution and abundance of lobsters comes mainly from fishery statistics and research. Lobsters are very important commercially within the ESFJC district and their value can comprise up to 25% of all 'shellfish' landings in the district. They are not as common within the Wash and neighbouring coastlines as they are in areas such as SW Britain, where the substratum is predominantly rocky. There are currently three main lobster grounds: an offshore area worked mainly out of Blakeney and Wells; an inshore area with landings into Cromer and Sheringham; and a newly exploited area in the deeper central parts of the Wash initiated in 1998. Catches in the latter were initially good indicating a healthy local stock. The stock was however, reduced in the small area then being exploited (ESFJC 1998: annual report). Landings of lobster into the ESFJC district in 2001 were 48 tonnes.

The ESFJC has recently (from 1997) been carrying out research, with the co-operation of the fishermen, aimed at investigating the stocks of lobsters, by analyzing landings and by surveys at sea. The latter provide information on immature and berried lobsters that are returned to the sea. Continued steady or increasing landings of lobsters over the years has meant that this fishery has been regarded as successful and relatively stable. However, landings data can be misleading unless collected on a catch per unit effort basis and there are recent concerns that the stock may be declining under continued high levels of fishing mortality. There was a 48% decrease in landings from 1996-1997 at Cromer and Sheringham (ESFJC 1998: research report) and fishermen report declines in the size of lobsters in the inshore fishery. The research is ongoing and aims to gather data on the population structure and spawning stock levels. A long time series

will be needed to provide meaningful data. The ESFJC also has a trial project to assess lobster stocks in Wash using re-capture rates. Trials to assess the practicality of the method have been carried out and the programme will be started properly this year (pers comm Colin Trundle ESFJC).

In 1998 CEFAS initiated an investigation using divers, into numbers of juvenile lobsters with the aim of measuring recruitment. However, practical difficulties constrained the amount of data collected.

6.3.4 Past distribution and abundance

Prior to the research outlined above, little information is available on lobster stocks within the ESFJC district apart from landings data. Landings into the ESFJC district remained at about 10-13 tonnes from 1950 to 1980. In the 1980s landings started to increase and during the early 1990s they increased dramatically and peaked at 80 tonnes (1994). Currently landings have reached a plateau around the 50 tonne mark (Figure 6.3.1).

Hamond (1970) summarized old records of crustaceans in Norfolk but there are few references to lobsters. There has been a commercial fishery for lobsters and crabs in Norfolk since at least the 1800s.

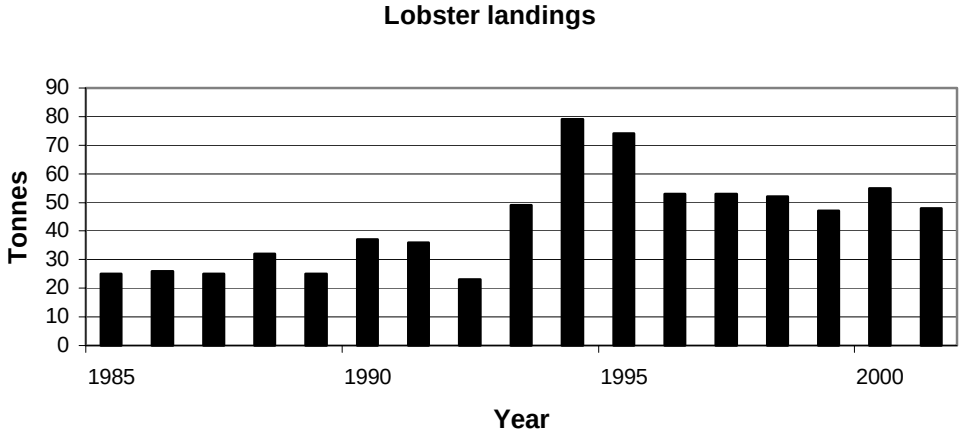

Figure 6.3.1 ESFJC district landings of lobster 1987-1996 (from research report 1997)

6.3.5 Reasons for decline

Lobsters are very slow growing and take between 5-6 years to reach the minimum landing size (MLS) which stood at 85 mm in 1998 (87 mm in 2002(?), 225 mm in 1973). Mature lobsters are therefore prone to over-exploitation. They are extremely valuable and known grounds are heavily fished. The MLS is only just over the length at which the lobster usually mature.

6.3.6 Opportunities for restoration

Restoration and maintenance of lobster stocks within the area depend on controlling the fishery. There is already a minimum landing size in operation and restrictions on landing 'berried' (egg-holding) and soft females. Recently (1998) the ESFJC and the Norfolk lobster industry agreed a voluntary scheme whereby a proportion of large, mature mainly female lobsters are marked (with a V-shaped notch in the tail) and returned to the sea. If caught subsequently they are again released. The idea is too ultimately enhance egg production (ESFJC 1998: research report).

The relatively new fishery within the Wash is probably of most concern in the context of the Wash cSAC. This stock is included in the ESFJC research into the health of the stocks.

Whilst controlling the fishery is very important, there are a number of direct methods for increasing lobster numbers that have been tried in other areas. Lobsters require a rocky habitat and suitable hiding holes, especially for berried females and young. Experimental work on artificial reefs carried out by the Southampton Oceanography Centre has shown that such reefs can provide effective habitat for lobsters in UK waters (Collins and Jensen 1996). Work has also been done on hatchery rearing of lobsters with release of juveniles. Consideration has been given to combining these two techniques by populating artificial reefs with hatchery reared juvenile lobsters.

There is sufficient expertise in artificial reef construction and hatchery rearing of lobsters to make these techniques feasible. However, both are expensive.

6.3.7 Major References

ESFJC research reports 1998-2001

6.4 Edible crab *Cancer pagurus*

6.4.1 Introduction

Edible crabs are the only species of crab exploited commercially for food in Britain, although the shore crab (*Carcinus maenas*) is collected for bait when it is soft after moulting (peeler crabs). The largest numbers are found on rough ground but they can also be found in mixed sediment areas, where they will often excavate deep pits. Female crabs are mostly mature by the time they reach 12.5 cm carapace width, at an age of around 5-6 years. After laying their eggs, female crabs retain them on their swimmerets until they hatch about 7 months later. The larvae are planktonic and past studies on Norfolk crab populations have suggested that young crabs in this fishery are at least partly derived from larvae that drift south from the Yorkshire crab grounds (MAFF 1966). Females are thought to move inshore in spring when their eggs are ready to hatch. The moulting period is mainly in winter and the crabs move into deeper water. So the fishery in Norfolk runs from late March through to early October although it can extend into November and December.

6.4.2 Conservation Status

None

6.4.3 Present distribution and abundance

Edible crabs are widespread and common throughout the study area. However, the fishery for them is concentrated mainly in eastern North Norfolk where the seabed is rough and irregular and where there are outcrops of chalk, large flints and boulders. MAFF (1966) describe the Norfolk crab fishing grounds as extending along 15 miles of coast from Salthouse to Mundesley and extending about 2 miles offshore. Buckland (1875) describes the grounds as extending from Weybourne to Sidestrand, which is essentially the same area (see Figure 6.2.1). Today Norfolk offshore grounds and areas of the Wash and Lincolnshire coast are also fished but the Norfolk inshore grounds remain very important. Crab caught in the Wash have traditionally been considered as of relatively poor quality and often only taken as a by-catch with lobsters. However, in 1998 quite good catches were made suggesting a reasonable stock (ESFJC 1998: annual report, Boston section). The main fishing grounds are therefore to the east of and outside the present study area.

The distribution of crab grounds within the area has not remained entirely constant. In the 1988 ESFJC annual report, the grounds adjacent to the Race Bank and Docking Shoal are described as having slowly changed from primarily whelk grounds to crab grounds over a period of 20 years or so. This has allowed the fishery, which previously only extended west to Cley (see above) to include Wells and Brancaster boats.

Landings into the ESFJC district from 2001 were 1,542 tonnes, the highest on record. In 2001 the ESFJC initiated trial research into edible crab populations alongside their ongoing research into lobsters. The researchers worked for one day on fishing vessels measuring, counting, sexing and looking at the condition of all the crabs caught including those below the MLS, which were then returned to the sea. Continuation of this work should provide more data on the distribution and abundance of edible crabs within the area.

6.4.4 Past distribution and abundance

Crabs have always been common along this coastline. Buckland (1875) talks of the crab fishery as being of ‘immense importance’ to the local inhabitants and of millions of undersized crabs being landed (see below).

Landings of crabs in the ESFJC district have increased steadily over the decades. In the 1950s landings were 150 to 300 tonnes. In the 1970s to mid-1980s they stood at around the 500 to 600 tonne mark. By the 1990s they had topped the 1000 tonne mark and the trend is currently still upwards (Figure 6.4.2).

Hamond (1970) described the edible crab as caught commercially from April to August over the whole of the strip of rocky ground which hugs the coast from Cley to Overstrand and which has its greatest width (about 2 km) off Sheringham and Cromer. He described small crabs as common at West Runton (note – this is still so, pers ob) and as being found in the wreck ‘*Hjordis*’, on the reef and the Freshes Lays and (more rarely) Hunstanton scaup and in holes in the submerged forest at Brancaster. Offshore, apart from rocky ground, he found them widely distributed in small numbers on stony and shelly ground with plenty of other organisms and in whelk pots.

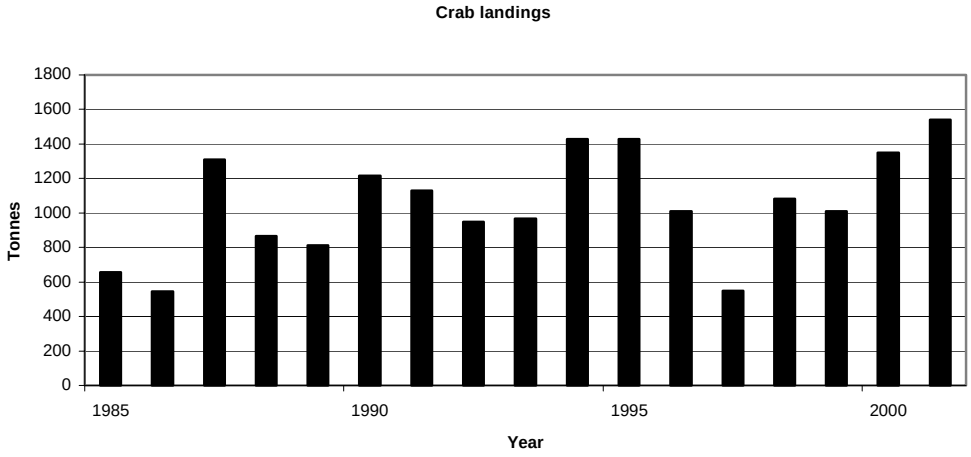

Figure 6.4.2 Landings of edible crab in the ESFJC district

6.4.5 Reasons for decline

Early declines in the Norfolk crab fishery, in the 1800s were investigated by Buckland (1875) and attributed to the taking of immature crabs. He calculated that around three-quarters of a million undersized crabs were being sold in one month at Sheringham plus others that were being used as bait. Minimum landing sizes apply to today's fishery and the taking of juveniles is unlikely to be implicated in any observed declines. Likewise, berried and soft crabs are no longer landed. Landings of crabs (and lobsters) into the ESFJC district have been relatively stable and have not shown the general downward trend that demersal, pelagic and shellfisheries have in the last ten years (Figure 6.4.2). The recent research by ESFJC described above, is designed to provide a better idea of the population structure on the various grounds and so to estimate whether the populations are declining under the current high level of exploitation.

6.4.6 Opportunities for restoration

It is unlikely that the edible crab requires any restoration within the study area at the present time. The research by ESFJC will hopefully provide further information on the current status of the stocks. There have been (still are?) concerns in the past over the effects of aggregate extraction on edible crabs on their offshore grounds. The Race Bank, still an important fishing area and considered to be a breeding ground for crabs, is one example (ESFJC 1993:annual report).

6.4.7 Major References

MAFF 1966
ESFJC 2001 – research report

7 Molluscs

7.1 Horse mussel *Modiolus modiolus*

7.1.1 Introduction

The horse mussel is a large, long-lived bivalve mollusc that can be found from the lower shore down to around 150 m depth. It occurs all round the British Isles usually in areas of mixed and muddy sediments. The main conservation interest of this species is that it forms dense beds that have a high biodiversity of other species associated with them. It is the habitat not the species, which is the subject of a UK BAP Action Plan. The MNCR marine biotope classification includes several *Modiolus* biotopes:
SCR.Mod – sheltered *Modiolous* beds;
SCR.ModCvar – *Modiolus modiolus* beds with *Chlamys varia*, sponges, hydroids and bryozoans on slightly tide-swept very sheltered circalittoral mixed substrata;
SCR.ModHAs - *Modiolus modiolus* beds with fine hydroids and large solitary ascidians on very sheltered circalittoral mixed substrata;
CMX.ModMx – *Modiolus modiolus* beds on circalittoral mixed sediment;
CMX.ModHo – Sparse *Modiolus modiolus*, dense *Cerianthus lloydi* and burrowing holothurians on sheltered circalittoral stones and mixed sediment;
MCR.ModT – *Modiolus modiolus* beds with hydroids and red seaweeds on tide-swept circalittoral mixed substrata.

7.1.2 Conservation Status

Modiolus modiolus beds are the subject of a UK BAP Habitat Action Plan

7.1.3 Present distribution

Modiolus modiolus is a very common species throughout the study area. However, there are no records of true beds of *Modiolus* either in the Wash or along the adjacent coasts and it is unlikely that any do occur. Occasional beds occur between Berwickshire and the Humber but none are known south of the Humber on the east coast (and the Severn on the west coast) (BAP Habitat Action Plan).

The remote acoustic surveys carried out by Foster-Smith (1997, 1999) predicted extensive areas of sediment containing *Modiolus*, some distance off the Norfolk and Lincolnshire coasts, but never in the Wash (Figure 7.1.1). He commented that *Modiolus* beds, if they exist, were elusive and their contribution to the diversity of the Wash remains an unknown quantity. During his Lincolnshire and north Norfolk survey, the biotope was under sampled and was identified on the basis of live specimens being taken in grabs together with stones during ground-truthing. The biotope was assigned as CMX.ModMx.

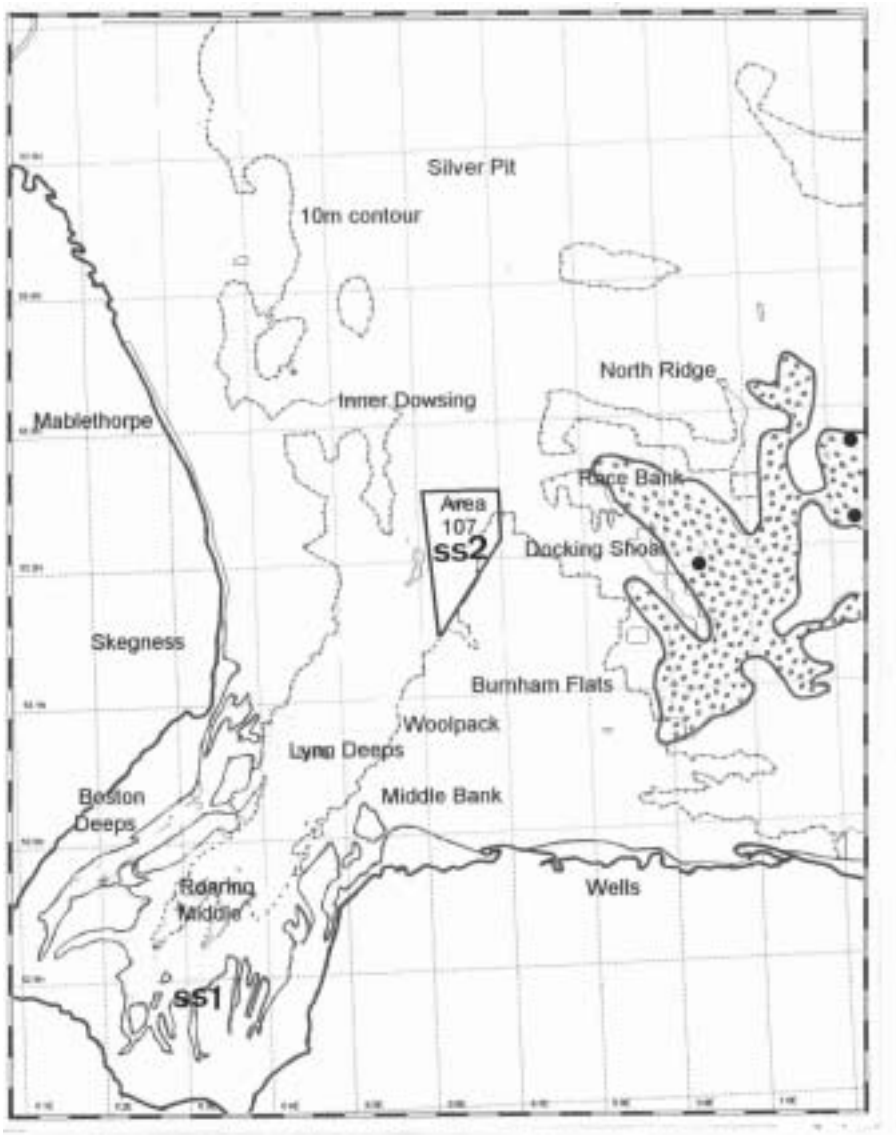

Figure 7.1.1 Distribution of epifaunal *Modiolus modiolus* biotopes predicted from acoustic and ground truth data (modified from Figure 9.5 in Foster-Smith & Sotheran 1999); and areas where *Sabellaria spinulosa* reefs have been positively identified using drop down video. Key: º º º = predicted *Modiolus*, • = ground truth *Modiolus*, SS = *Sabellaria spinulosa* (SS1 transient reef ESFJC pers comm., SS2 Foster-Smith & White 2001)

Within the Wash, dead *Modiolus* shells are commonly dredged up during surveys, but records of live specimens are few and far between. Single individuals of *Modiolus modiolus* were collected in day grab samples from only 3 out of 66 sites throughout the Wash during the NRA Wash survey in 1991. Smaller (unidentified) *Modiolus* species were collected at 51 out of 66 sites in

greater numbers (NRA 1991). Benthic sampling surveys undertaken by Ecomaris Ltd. (for the EA) between 1991-1999 show a similar lack of *Modiolus* (Bailey et al 2001). Fowler (1987) suggests that *Modiolus* may be widely distributed within the Wash but as scattered individuals almost completely buried in sediment and therefore fairly secure from dredging and so not often sampled.

Modiolus can also occasionally be found in the intertidal region and immediately below. Within the Wash, there is a long narrow promontory called "the Scaup", situated north of the Lighthouse at Hunstanton, which is exposed a spring tides. Hamond (1963, 1972) recorded *Modiolus* as very common there, living just below ELWST at the seaward (northern) tip. As far as is known this is still the case.

CEFAS Lowestoft laboratory have never worked on *Modiolus* (Peter Walker pers comm) but the Burnham laboratory apparently have some data collected between the Humber and Skegness. The contact for this is Hubert Rees but no information has so far been received.

7.1.4 Past distribution

No early records of *Modiolus modiolus* occurring in any numbers in the Wash or adjacent areas, have been found. The early Wash surveys by the NCC in the 1980s again showed that dead shells were common in the Wash but very few live specimens were taken. In the 1982 survey, a few live *Modiolus* were dredged up in Roaring Middle area but in much more extensive 1985 and 1986 surveys, only dead shells were found (Dipper 1982, Dipper et al 1989, Fowler 1987).

7.1.5 Reasons for decline

There is no evidence to suggest that there were ever any extensive *Modiolus modiolus* beds either within the Wash or along the north Norfolk coast. It is not possible from the information found during this study, to say whether *Modiolus* numbers have declined within the area.

Dead *M .modiolus* shells are dredged up in the Wash and along the north Norfolk coast in much larger numbers than live specimens. This is probably a reflection of the fact that the live shells live partly embedded in the sediment and are not easily removed by the types of dredges and grabs employed (eg bucket dredge, Baird dredge, Day grab), whilst the dead shells are easily scooped up. However, it is possible that the dead shells represent the remains of a much larger previous resource in the way that native oyster shells do within the Wash.

M. modiolus beds have been badly damaged in Strangford Lough and off the IOM by scallop dredging. This type of fishery does not occur in the Wash but many other types of trawling and dredging do, including bottom trawling for whitefish and flatfish, shrimp trawling, cockle and mussel dredging. Oyster dredging was widespread within the Wash prior to the collapse of the fishery around the 1870s. There is therefore always a possibility that *Modiolus* numbers could have been reduced by these activities.

7.1.6 Opportunities for restoration

The lack of evidence for the existence of previous beds of horse mussels within the study area, means that, unlike the common mussel, it is probably not a suitable candidate for restoration within the area.

It would be useful to know exactly what the *Modiolus* 'beds' identified by Foster-Smith off the north Norfolk coast consist of. These areas were identified as *Modiolus* biotopes when grabs were taken as part of the ground truthing exercise following acoustic survey. Only a few sites were dredged. Further survey using divers/video or suitable grabs designed to be effective on hard ground would ascertain the extent and composition of these habitats. This would contribute to section 5.2.1 of the BAP HAP: Identification of the resource within protected areas.

7.1.7 Major References

Foster-Smith 1997, 1999

7.2 Native or flat oyster *Ostrea edulis*

7.2.1 Introduction

Ostrea edulis is the only species of oyster native to the British Isles. It is widely distributed around the coast with the main stocks now in the west coast of Scotland, the south-east and Thames estuary, the Solent, the River Fal and Lough Foyle (Jackson, 2001). Oysters require a stable substratum to which to attach are therefore found on hard bottoms of rock, firm sediment, hard silt and muddy gravel with shells. In exploited beds the habitat is improved by the use of 'cultch' – mostly broken shells (often old oyster shells). The normal lifespan is around 5-10 years though they may live to 15 years or more. They take around 4 years to reach marketable size.

7.2.2 Conservation Status

Subject of a UK BAP Species Action Plan. Oysters are subject to UK shellfisheries conservation legislation.

7.2.3 Present distribution

There are no known extant native oyster beds within the study area. Further south, there are still natural stocks in the Thames estuary and cultivated stocks in various estuaries along the south Suffolk, Essex and north Kent coasts (Doody et al 1993).

7.2.4 Past distribution

There has not been a recorded oyster fishery in the Wash since around 1920. Live oysters are very rarely found. Only one or two live oysters were found during several hundred experimental trial hauls made by the ESFJC over the decade between about 1977-1987 (Aldous 1987). General sublittoral surveys undertaken by the NCC in the 1980s recorded no live oysters (Fowler 1987).

In 1875, Frank Buckland produced a report on the fisheries of Norfolk with a number of references to Wash fisheries including oysters. At that time there were reportedly seven principal

natural beds in the 'Lynn fishery' plus other small patches. The largest was around seven miles long and half a mile wide (Buckland 1875). Although the location of the beds is not given, reference is made to the fact that oysters do not generally fatten in the Wash except on the 'Gore bed', and a bed called the 'Roaring Middle'. Fattening grounds at Heacham Harbour and space to make fattening reservoirs in the neighbourhood of Lynn, are also mentioned.

Even then there were reports of declines. Buckland records the local bailiff (a Mr Harding) as saying there had been a spat fall in 1868 but no spat fall for the 'past two years' (presumably 1873-74). Buckland reported that 39 boats from King's Lynn were engaged in the oyster fishery in the 'last season' (presumably 1874-75) dredging up around 700,000 oysters. The oyster and mussel fishery in the Lynn Deeps was first regulated in 1872 and a closed season was introduced by byelaw around 1875 with no fishing allowed between June to August. Sometime in the 1870s the Boston and Lynn Corporations are reported to have prohibited oyster fishing for 3 years, due to a decline believed to be due to over-fishing. When the fishery re-opened there were few oysters to be found (Aldous 1987).

Buckland (1875) also reported on the oyster fishery at Wells. He stated that oysters, 'were abundant 20 to 30 years ago all over the back of Burnham flats to the easternmost limits of the ground, and between Haisborough (Buckland's spelling) and Wells to the west, a distance of about 25 miles'.

Hamond (1972) summarised information available from old references. He reported that there was a flourishing fishery off north Norfolk that ceased for unexplained reasons in 1908 and another off Yarmouth that ceased in 1905 due to over-fishing (Patterson 1905). The north Norfolk oysters lived in submarine depressions in a relatively small area located by means of shore marks, which were a jealously guarded secret. Hamond (1972) searched for oysters using what marks were remembered locally and found none in Blakeney Deeps. He reports records of one taken live about a mile off the beach at Blakeney in 1934 and another about 1.5 miles SE of the Blakeney overfalls Buoy in 1966. Hamond (1969) carried out extensive dredging off the north Norfolk coast and reported that, at many of the dredge sites, masses of dead *Ostrea* shells were brought up between 1949 to1967. Between Wells Bar and Blakeney Bar, off the Point, where the sand grades off seawards into the muddier deposits of Blakeney Deeps, there is a narrow strip of clean sand in 5 fathoms (9 m) with abundant dead water-worn shells of *Ostrea* (Hamond 1963).

7.2.5 Reasons for decline

The reason for the early decline in the Wash in the 1870s is unknown. It could have resulted from over-fishing, pollution, predation, infestation, disease or a combination of these factors (Aldous 1987). There was a huge increase in demand for oysters in general, with the advent of the railways, as this meant that supplies could reach London in good condition from relatively distant places. Buckland (1875) talking to local oyster fishermen concluded that the loss of oysters around Wells was due to sand floating about and smothering the oysters. However, there seems no doubt that overexploitation has been the main cause for the decline of native oyster beds in general in the East Anglian region. Natural fluctuations in spatfall caused by unfavourable currents and the death of adult stocks during extreme winters have compounded the

problem. Stock levels on the east coast were particularly badly hit by the winter of 1963. The commercial beds were also neglected during the war years.

Further declines have been caused by the introduction and spread of several non-native species including the slipper limpet *Crepidula fornicata* and the oyster drill *Urosalpinx cinerea.* The slipper limpet was introduced to Essex between 1887-1889 in association with imported American oysters *Crassostrea virginica*. It spread rapidly and is now present throughout the Wash and along the north Norfolk coast and extends as far north as Yorkshire (Eno 1997). The first record of live *Crepidula* in the Wash was from Dipper et al (1985) although it may well have been present before this. *Crepidula* competes with oysters for space and food and deposits mud in the form of pseudo-faeces that change the substratum to a muddy state unsuitable for oyster spat settlement.

The oyster drill was first recorded from the Essex oyster grounds in 1927 and again came in with imports of *Crassostrea virginica* (Eno 1997). It eats native oysters feeding on the young and spat and can have a devastating effect on commercial oyster beds.

The east coast fisheries in general were amongst the richest in Europe during the 18th and 19th centuries. An indication of this is given by the fact that in 1864, 5,000 million flat oysters were sold in Billingsgate. The average landings from the east coast were 28.4 million between 1903-1914 and only 8.9 million in 1975-1985.

7.2.6 Opportunities for restoration

In theory restoration of beds of native oysters within the study area, should be relatively easily attainable. The biology and breeding are well known and the expertise for establishing or re-establishing beds of oysters is readily available. There are cultivated beds of native oysters in Suffolk and Essex estuaries including the Deben, Colne, Crouch, Roach and Blackwater. There are also much larger cultivated beds of Pacific oysters in the same areas. At present a small number of Pacific oysters are cultivated in some creeks and harbours along the north Norfolk coast (Doody et al 1993) and in the Wash such as at Cley Hole near the entrance of the Welland and Haven Rivers (pers comm ESFJC 11/2/03). However, in practice restoration efforts face a number of difficult problems, arising from potential disease, predators and competitors and lack of suitable habitat. Efforts are being made in other areas to re-introduce oysters onto old, derelict grounds (Jackson 2001) which may provide useful guidance.

The slipper limpet *Crepidula fornicata* is a major problem when trying re-establish native oyster beds. It has rendered large areas of former oyster habitat unsuitable for spat settlement and will inevitably invade new beds that are laid out. Control methods and biology of this pest have been studied by the MAFF (CEFAS). The oyster drill *Urosalpinx cinerea* is now less of a problem than it was because it proved susceptible to TBT in anti fouling paint in the 1970s and it shows only slow and limited natural dispersal (Eno 1997). There are however, a number of indigenous species that prey on oysters of which the most important are starfish *Asterias rubens* and the sting winkle *Oceanebra erinacea*.

There are limitations imposed on translocation of oysters (implemented in Great Britain through the Fish Health Regulations 1997) since this can be the mechanism for the spread of diseases

such as the copepod mussel parasite *Mytilicola intestinalis* which has been recorded in native oysters from the SW and E coasts of Britain. Native oysters are also susceptible to the disease bonamiasis that has caused huge mortalities in France and is present in some English populations. It is caused by a parasitic protozoan *Bonamia ostreae*.

Crassostrea gigas is widely cultivated in the intertidal along the North Norfolk coast and within the Wash, both in cultivated beds and on trestles and trays. The 1993 ESFJC reported that a pilot project to grow *Crassostrea gigas* on trestles in Cley Hole in the Wash was successful (see above). This indicates that conditions for oyster growth are good within the study area.
In the current study, it has not proved possible to identify any clearly defined sites where native oyster beds once thrived. It is likely that there were never many such sites along the north Norfolk coast, unlike the Suffolk and Essex coasts. It also appears from Hamond (1972) that there are now few if any people remaining that remember the locations of the small natural beds that once occurred off the Norfolk coast. The account given by Buckland (1875) suggests that extensive beds were once present in the Wash and the names of some are given.

Since there are now no self-regenerating native oyster fisheries in the area, the only way to establish new beds would be to find areas with suitable habitat, prepare new beds and persuade local fishermen to cultivate these using hatchery reared spat. There are several possibilities:

- Creeks and inlets along the north Norfolk coast, especially those currently or previously used to cultivate Pacific oysters. In 1993 there were 8 small-scale cultivators of Pacific oysters, with fisheries at Thornham, Titchwell, Brancaster, Burnham Norton, and Blakeney (ESFJC 1993: annual report). In 1998, five fishermen were reported as growing-on Pacific oysters at Brancaster (ESFJC 1998: annual report);
- offshore sites along north Norfolk - suitable sites might be identified either by field survey and/or by trying to trace the location of previous oyster areas as tried by Hamond in 1972 (with only limited success);
- suitable sites within the Wash using the places mentioned by Buckland as a starting point.

Re-establishing oyster beds within the Wash would probably be politically and physically difficult and expensive.

There is a national closed season from 14 May to 4 August during the breeding season although there is some dispensation for cultivated stocks.

7.2.7 Major References

An extensive list of references for *Ostrea edulis* is given in Jackson (2001). Information on locations and landings of Pacific oysters are given in the ESFJC annual reports.

7.3 The Whelk *Buccinum undatum*

7.3.1 Introduction

The common whelk or buckie is a large, marine snail that occurs all round the coasts of Britain and Ireland. It ranges from the intertidal down to around 1,200 m depth and is normally found in areas of mixed sediment with shells. Whelks are carnivorous and feed on worms, bivalve

molluscs, including cockles and mussels and carrion. Their predilection for carrion means that they are easily caught in baited pots. The main fishery within the study area remains based around Wells and Blakeney where it has been since at least the 1960s.

7.3.2 Conservation Status

None

7.3.3 Present distribution

Whelk are commonly found both in the shelter of the Wash and other smaller Norfolk estuaries and outside in the open sea and along the coast. There are no records of their disappearance from the area but there are suggestions in the literature of past over-exploitation in the Wash.

Whelks are still fished along the Lincolnshire and Norfolk coasts. Grounds fished between 1974-1991 are shown in Figure 6.2.1 (from informal map in ESFJC undated, compiled from annual reports). However, other areas are now also fished especially when stocks are low. In 2001, the north Norfolk fishery took place from the Outer Dowsing and the Cromer Knoll areas with landings into both Wells and Blakeney. These areas are outside the boundary of the Wash ans North Norfolk cSAC. The fishery started around April and finished in September. Experimental laboratory work has shown that whelks do feed in the winter but do not do so at very low temperatures (MAFF 1967). As whelks are caught by using baited pots, winter fisheries in bad winters are likely to be poor. Landings within the ESFJC district for 2001 were low at 196 tonnes (ESFJC 2001: annual report). Landing statistics include the 'red' or 'almond' whelk *Neptunea antiqua*, which may make up 0.1 to 10% of the catch.

7.3.4 Past distribution and abundance

Most of the information on whelk abundance and distribution in East Anglia, comes from fisheries reports. Buckland (1875) suggests that a fishery for whelk started out of 'Lynn' (Kings Lynn) around 1871. Four years later, when compiling his report, Buckland was told that the fishermen had already exhausted the fishery within the Wash itself and were going ten to twenty miles out to sea to catch the whelks. Old hand-written ESFJC ledgers from 1923 to 1940 give some figures for whelks landed into Kings Lynn, which probably came from the Wash, for example 2,190 cwt (111 tonnes) in 1928. This is not far short of the amount currently being landed into the district as a whole. It is not clear when the Wash whelk grounds were last productive. There is a note in ESFJC records that one fisherman tried the old whelk grounds in the Wash in 1977 but had only limited success (ESFJC undated).

Landing figures given in ESFJC annual reports show that during the 1950s and 1960s landings were between 700 to 2,000 tonnes. The highest landings were in the 1970s (2,885 tonnes in 1975). During the 1980s and 1990s landings declined in a somewhat erratic manner and are now at a low level around the 200 tonne mark (little more than in the 1920s) (Figure 7.3.1).

Hamond (1963) writes that the area for some miles around the NE, SE and SW sides of the South Race Buoy (offshore N of Blakeney Deeps) provides the chief whelk grounds in about 8 fathoms (14.6 m). Other grounds he mentioned were inside the SE Docking Buoy, further out near the Dudgeon and NE of Blakeney Overfalls, on grounds N of Sheringham Shoal. All these fall within the fishing areas shown in Figure 6.2.1. These areas have bottoms of stiff clayey mud or

rough ground with a high percentage of silt. He reports that these grounds were worked in summer, with a winter fishery in the Blakeney Deeps. In the mid 1960s, Wells was the most important port for whelk landings in the whole of Great Britain (MAFF 1967). Landings for Wells alone were 12,663 cwt (643 tonnes) in 1962 and 17,615 cwt (895 tonnes) in 1965 (MAFF 1967). For all the ports from Brancaster to Felixstowe the figures were 1,057 tonnes and 1,468 tonnes respectively.

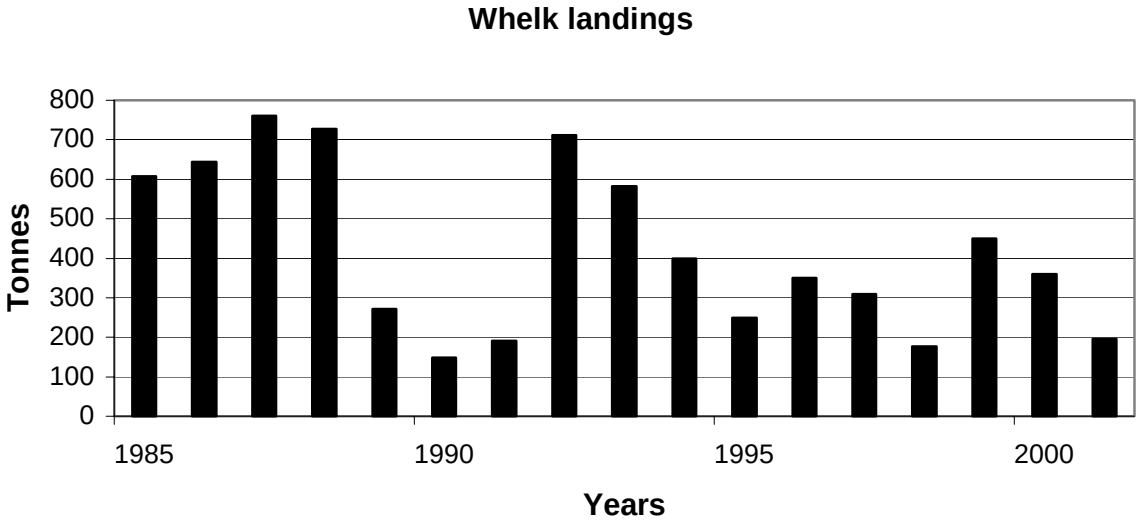

Figure 7.3.1 Landings of whelks into the ESFJC district

7.3.5 Reasons for decline

The early decline in the Wash reported by Buckland (1875) was, in his opinion, partly due to the fact that huge numbers of immature whelks were caught and not, at that time, returned to the sea. He recommended that the whelks be riddled out at sea and the small ones released.

It appears from the landing statistics available, and from notes in the ESFJC annual reports that stocks have declined quite drastically between the 1970s, when there were very high landings and the present day. Whereas ports such as Wells once had a thriving whelk industry, this is no longer so. There are notes in the ESFJC (undated) whelk report that for various years in the 1980s and 1990s, landings had decreased whilst demand was still high. In 1982 there was a comment that the continued decline of the whelk fishery off the Norfolk coast was causing concern and that new or re-vitalised grounds were being sought. In 1986 Wells and Brancaster whelk fishermen were unable to meet demand.

However this fishery is also prone to ups and downs as shown by variable landings between successive years. This is reinforced by statistics given in MAFF 1967 where a comparison of landings between different ports in 1962 and 1965 is given. This shows that in some ports such as Grimsby and Whitstable, landings declined significantly whilst at Wells and Brancaster, they went up. Therefore apparent declines may not always be a true reflection of the stock abundance,

but may be influenced more by the number of active boats in the fishery, by weather and by market demands.

Many marine animals spawn in spring when temperatures are rising. In contrast whelk start spawning around November when the temperature drops below about 9ºC (MAFF 1967). Therefore it is the winter fisheries that might impact on the spawning stock. There are both winter and summer fisheries within the area. In Whitstable (Kent) and in the River Crouch, whelks spawn when they reach around 51mm (2") long at an age of 2-3 years (MAFF 1967). The young emerge directly from the egg capsules and so are not widely dispersed. Therefore fishing pressure could easily cause local declines if sufficient stock are not left for the winter spawning or if large numbers of immature shells are taken, as happened in the 1800s. However, there is now a national minimum landing size of 45mm for whelks. In the ESFJC (undated) whelk report, a continued absence of juvenile whelks on the grounds off the Lincolnshire coast was noted.

It is likely that the decline in whelk stocks, particularly on the inshore grounds, is due to a combination of factors including heavy fishing pressure. Natural cyclical changes may also be involved such as changes in substratum and food availability.

7.3.6 Opportunities for restoration

The fishery is currently at a low level and is mainly carried out some distance offshore outside the Wash, since the inshore grounds are not currently very productive. It would be useful to obtain a detailed picture of both old and new whelk grounds and to ascertain which fall within the Wash and North Norfolk cSAC. No suggestions are made here as to whether attempts to re-vitalise these grounds would be possible or desirable. It would be useful to know how long it has taken exhausted grounds to recover in the past. Whether such information exists is not known. Since whelks do not have planktonic larvae, natural re-colonization could be very slow.

7.3.7 Major References

MAFF (1967)
ESFJC (undated) Whelks 1974-1991
ESFJC Annual Reports

7.4 Common or edible periwinkle *Littorina littorea*

7.4.1 Introduction

Periwinkles are gastropod molluscs - marine snails – that are widely distributed around the British Isles. The common periwinkle is the largest species reaching a height of 52 mm – large enough to be harvested for food. They are most abundant on rocky shores but can be found anywhere that provides a reasonably firm substratum and the fine algae such as *Ulva* and *Enteromorpha* on which they feed. Although primarily intertidal, they can be found down to 60 m depth. Breeding occurs mainly in spring and summer from February to May but there is some breeding throughout the year. The egg capsules and larvae are planktonic for around 4-7 weeks. Most adults die before they reach 4 years old.

7.4.2 Conservation Status
None

7.4.3 Present distribution and abundance
No specific information has been found on the abundance of periwinkles within the study area. It is known that they are collected by hand on an *ad hoc* basis by fishermen and local residents but there does not currently seem to be a specific fishery for them. In Scotland and Ireland winkle fisheries are worth around £5 million per year. They were common along the Norfolk coast in the 1970s (see below) and are likely to still be so today. The author's own casual observations would support this.

7.4.4 Past distribution and abundance
There are records of an early fishery for periwinkles within the Wash. Old handwritten ledgers held by the ESFJC (1923-1947) show that periwinkles were being collected from 'Lynn and Boston beds' in the 1920s and 1930s with landings into Kings Lynn of between 50 to 100 tonnes a year. There is no mention of periwinkles in the 1942-1947 period. Periwinkles appear in the ESFJC annual reports from 1951 to 1960. During this time none were landed into the district in 1951, the maximum landing was 4.5 tonnes in 1955 and by 1960 landings had again gone down to zero. Periwinkles do not appear in later ESFJC records (1961-1976 not seen). Notes in the annual reports record the decline of the fishery during the 1950s but also state that in 1959 the fishery was more or less non-existent but that supplies were still available. The demise of this fishery may therefore have been due to a lack of markets and lack of interest by fishermen rather than a decline in numbers of periwinkles.

Hamond (1972) recorded this species as very common along the entire Norfolk coast on all sorts of substrates apart from wave-beaten clean sand; especially plentiful in Breydon, West Runton and all over western half of Blakeney Harbour, in which eggs and larvae are abundant in plankton from March to September.

7.4.5 Reasons for decline
It is not possible to say whether periwinkle numbers have declined within the study area. The demise of the Wash fishery and any fishery that may have occurred along the Norfolk coast may have been market led.

7.4.6 Opportunities for restoration
There is currently probably no requirement or opportunity to restore this species. It was included in the review because it is collected for food and because there was a past fishery for it. It might however, be useful to set up a recording project for this species, probably on a volunteer basis. It has been suggested that periwinkles would make a very suitable indicator species for detecting pollution. Periwinkles accumulate trace elements and other compounds, which consequently change their behaviour (Jackson 2002).

7.4.7 Major References
Jackson 2002 (www.marlin.ac.uk)
ESFJC ledgers 1923-1947; annual reports 1950-1960

7.5 Razor shells *Ensis* spp.

7.5.1 Introduction

Razor shells are bivalve molluscs with long shells that resemble a cut-throat razor in shape – hence their name. They live in deep burrows in fine sand and fine muddy sand at extreme low water in the intertidal zone and in the shallow sublittoral down to around 40 m depth. There are three British species: *Ensis arcuatus, Ensis siliqua* and *Ensis ensis* and all three can be found in the study area. In recent years, a fourth species *Ensis directus* (see 7.5.7 below) has been found in the area especially in the Wash. This is an introduced species that has spread around the southern North Sea from its point of introduction in the German Bight in 1978. It reached the English Channel by the end of the 1980s (Eno et al 1997).

7.5.2 Conservation Status

None

7.5.3 Present distribution and abundance

There are few specific records of the abundance of *Ensis* spp. within the study area. *Ensis siliqua* is probably the most common and widespread species but in the Wash *Ensis directus* now seems to be present in large numbers. This alien species has not necessarily ousted the native species but may have found itself a niche in sediments unsuitable for the former (pers comm Seamus Whyte, Ecomaris; see also note on *E.directus* in section 7.5.7). After storms, razorshells are often washed ashore in large quantities at places such as Hunstanton (pers ob) and Titchwell beach (Hume 2003) indicating that there are locally dense beds. Which species are involved is not known.

In 1989 the ESFJC carried out a survey to establish whether razorshells were present in the Wash in commercial quantities. The survey was carried out on Sunk Sand and Long Sand at extreme low tide by ‘stamping’ on the sand. This causes the razors to dig down to escape capture and results in keyhole-shaped depressions appearing in the sand which can be counted. They recorded densities from 1-5 per square metre (ESFJC 1989: annual report).

In 1998 there was some limited fishing for razor clams on a trial basis using deep penetrating suction dredge techniques. RSPB, EN and others were seriously concerned that the fishing method could cause considerable damage to non-target species as well as the razors themselves. A prohibition on fishing with this method was very quickly put into place (ESFJC 1998: annual report).

Further work on evaluating the resource within the Wash has therefore not been continued. Effects of mechanically harvesting razor shells are summarised at www.ukmarinesac.org.uk/activities/fisheries/f1_5_2.htm

7.5.4 Past distribution and abundance

Hamond (1963, 1972) lists a number of records of *Ensis* spp. within the study area:

- Moderate numbers of *E.siliqua* at Brancaster (Broad cape of shore at LW springs on the west side of the channel between Scolt Head Island and the mainland);
- Sands down east side of Wells bar: almost barren except for a few *E.siliqua*;
- *Ensis ensis*: formerly common (in mid 1800's) but rare nowadays. *Ensis siliqua*: common, dead shells common from Blakeney to the Wash, living specimens at most exposed shores (Wells Bar, Holkham, Brancaster). In Norfolk waters neither species much exceeds 13 cm and it is unknown whether either reaches sexual maturity here.

7.5.5 Reasons for decline

It is not known whether native *Ensis* species have declined in the study area. Hamond (1972) suggests that *Ensis ensis* was common in the 1800s but is rare today. Razor shells are dug for bait and for consumption but the extent of this practice along the North Norfolk coast is not known.

7.5.6 Opportunities for restoration

Few references to any decline in distribution or abundance of *Ensis* spp. have been found so restoration is probably not currently necessary or feasible. The impact, if any, of the spread of the American razor shell on native species of *Ensis* (and other species) could be usefully studied. There are likely to be other records of *Ensis* available from sources such as Biological Records Centres, mollusc mapping schemes and the Conchological Society that might usefully be collated.

7.5.7 Note on *Ensis directus* from CEFAS

The following information was received from David Palmer, CEFAS, Lowestoft Laboratory (pers comm 6/3/03). He has papers in preparation on growth of *E. directus* and on distribution and survival:

"I have been carrying out a study of the distribution, growth and mortality of the introduced razor shell, *Ensis directus* within the Wash and North Norfolk candidate SAC. This species has been the target of our research because it constituted almost all the catches in the small scale, experimental fishery that was undertaken in 1998. This fishery led to the ban on fishing for razor shells (along with some other bivalve species) within the cSAC. It is fortuitous that the high abundance and relatively small size of this species renders it reasonably easy to sample in the field.

So far we are able to say that populations of this species are highly dynamic. Massive spat-falls have occurred in some years, only to be followed by almost complete mortality. Survival beyond the first year is sporadic, although occasional very prolific year-classes can survive to adulthood as evidenced from our first survey in 1999 when the 1994 year-class was found to be very abundant. In the Wash this species appears slow growing, taking four or five years to reach 100mm shell length. They also appear to be somewhat short lived, the oldest specimens so far sampled being seven years old. In one study area the 1994 year-class seems to have died, in situ in the winter of their sixth year. Such mass mortalities have also been reported from the Dutch Wadden Sea. By contrast, the native species *E. siliqua* and *E. arcuatus* can live in excess of twenty years, although mass strandings, following severe storms, have been reported for these species.

In general *E. directus* seems to prefer more estuarine conditions than the native *Ensis.* We found the densest populations in quite muddy sediments, often on the sides of channels between banks. We have a record of all the infauna taken in the samples from our first survey. Species diversity was low in the survey area whether *E. directus* was present or not and the razor-shells constituted 95% of the total infauna biomass.

We know less about the native species. *Ensis siliqua* has occurred in some of our samples, but the grab we use does not penetrate deeply enough to sample them effectively. You may be interested to know that we have confirmed the presence of the species *E.minor* in the area. Externally this species is almost identical to *E. siliqua* and in the past has not been separated from it. It has recently been confirmed from a number of sites around the UK".

7.5.8 Major References

None

8 Worms

8.1 Lugworms *Arenicola marina* and *Arenicola defodiens*

8.1.1 Introduction

Lugworms are polychaete worms that live in burrows on sandy and muddy sand shores and in the shallow sublittoral. There are two species, the blow lug (also called lobworm and yellowtail) *A. marina*, and the black lug *A. defodiens*. The latter has only recently been distinguished from *A. marina*. Both species live in burrows and produce faecal casts that allow their numbers to be counted easily. Black lug are larger and live in J-shaped burrows at low spring tide levels and below. Blow lug live in U-shaped burrows and extend further up the shore.

The life history of lugworms is summarized in Fowler (1999) and the following description is based on this reference. Lugworms can live for up to six years and breed several times during their life, starting when they reach two years old. All the worms on a beach will spawn within a few days of each other but populations on other beaches spawn on different days. Most spawning occurs in November to December but can occur throughout the winter months and some populations spawn in the summer. The resulting larvae remain in the adult burrows for a short period before migrating down the shore to just below the low water mark. Here they live in dense beds for about 6 months until they reach around 10 mm long. They then swim in a mucus tube to the upper shore where they form dense beds of juveniles just below the strandline. The latter provides a good source of organic material for them to feed on. They move down to the adult beds near the low water mark and beyond, when they are maturing at about 2 years old.

Lugworms are extremely common but have been included in this report because they are heavily exploited as bait.

8.1.2 Conservation Status

None

8.1.3 Present distribution and abundance

Lugworms are widely distributed and common throughout the study area, which has many suitable muddy sand beaches. Yates et al (2002) sampled invertebrates at regular transect sites throughout the Wash. They reported densities of lugworms were 40-50% lower in 1998 and 1999 than when similar surveys were done in 1986. However, these results should be taken in the context of the report as a whole and should be analyzed or discussed further with the authors if the apparent decline is considered serious.

The ESFJC (Colin trundle, pers comm) say that bait digging seems to be increasing and there is more in Lestrange estate, Snettisham, but no real problems. Lincolnshire is well dug (at N end near the Humber estuary).

8.1.4 Past distribution and abundance

There is some evidence of past over-exploitation in the Wash area. A newspaper article (date unknown) reported bait diggers coming to the Wash area to dig lugworms. A good digger used to

get up to 5000 worms in a day, now 1000 is good. The diggers are now taking smaller worms that they would have previously left, thus depleting stock for the future (article held by MSB at the EN Grantham office called The Wash/Bait digging S78 W01.05).

Hamond (1963) reported *Arenicola* and *Cardium* as both being very scarce in Blakeney Harbour, The Strond due to excessive digging.

8.1.5 Reasons for decline

Lugworm beds may be very heavily exploited and there are some references and anecdotal reports that refer to declines in numbers. However, most populations are able to recover quite quickly because the dug areas are re-populated from un-exploited populations low on the shore and in the sublittoral. In addition maturing juveniles will move down the shore from the higher-level juvenile beds.

8.1.6 Opportunities for restoration

Most exploited populations will recover naturally provided the juvenile beds high on the shore are not dug. Many areas have bye-laws restricting bait digging at particular sites or times. These bye-laws are aimed as much at protecting non-target species such as cockles and at preventing amenity problems, as they are at conserving the lugworms themselves. The extent of such bye-laws in the study area has not been examined.

Attempts are being made to farm these worms for bait in UK although their relatively slow growth and complex life cycle does not make them ideal candidates. Fowler (1999) states that both species should soon be available from bait farms.

8.1.7 Major References

Fowler 1999
Yates et al 2002

8.2 Ross worm *Sabellaria spinulosa*

8.2.1 Introduction

Sabellaria spinulosa is a small, tube-building polychaete worm that is normally found in rather turbid waters, where the high sediment load provides sand grains for tube building. Throughout most of its range it lives as small encrustations on pebbles, rocks, shells and kelp holdfasts. It is a wide-ranging and common species. Under favourable conditions it can form extensive, thin crusts that may only be a seasonal phenomenon. In a few areas, proper reefs are built up, from masses of intertwined tubes, forming distinct, raised structures on the seabed.

The conservation interest in *Sabellaria* reefs lies in the assumption that such reefs increase biodiversity. There is good evidence to support this assumption (see below). *S. spinulosa* grows in areas with strong tidal currents that carry heavy loads of suspended sand. Such habitats are not very favourable to many other species, until the *S. spinulosa* stabilizes the sand and provides shelter and food with its intricate network of tubes. As with other biogenic reefs (such as *Serpula* reefs in Scottish sea lochs), it is logical to assume that well developed reefs are more productive

and diverse than poorly developed reefs. The problem with *S. spinulosa* reefs within the Wash, is that it is not yet clear how stable these structures are, whether they are essentially ephemeral or require many years to grow and develop (Foster-Smith and Southeran 1999). The small amount of information available suggests that such reefs as there are within the Wash, come and go within a relatively short time-scale (see section 8.2.3 below).

This extract taken from section 7.2.2.1 of Foster-Smith and Sotheran (1999) supports the assumption that *Sabellaria* reefs are associated with high biodiversity: "The tube dwelling polychaete *Sabellaria spinulosa* was associated with diverse communities even when this species was found in low abundances. However, the highest species diversity of all samples was found associated with *Sabellaria* reefs. …*Sabellaria spinulosa* formed colonies that ranged from a low-lying, loose arrangement of tubes to large colonies. These colonies were associated with a large number of mobile carnivorous polychaetes and other surface feeders. Mysid shrimps, swimming crabs, edible crabs and even lobsters were seen in association with these reefs." In Foster-Smith and White (2001) this relationship is shown for several different data sets and there appears to be a clear trend for dense *Sabellaria* to be associated with high species diversity.

Within the Wash and surrounding areas, *Sabellaria* has been identified as a component of several different and interrelated biotopes. The major biotopes within the Wash have been described by Foster-Smith and Sotheran (1999), using a combination of remote acoustic techniques, grab samples and remote video.

8.2.2 Conservation Status

Sabellaria reefs are the subject of a UK BAP Habitat Action Plan

8.2.3 Present distribution

In 2000 a joint project between EN and the ESFJC was initiated, with the aim of establishing the spatial and temporal distribution of *Sabellaria spinulosa* reefs within the area of the Wash and North Norfolk Coast cSAC. The work was undertaken by the SeaMap Research Group, Newcastle University (Foster-Smith and White 2001). The same group had previously carried out broadscale mapping of habitats and biota, including *Sabellaria* biotopes, within the Wash and along the coasts of north Norfolk and Lincolnshire (Foster-Smith et al 1997, 1999). These surveys are based on the use of remote acoustic ground discrimination systems, which can predict the likely distribution of various biotopes with varying degrees of accuracy. Direct observations using drop-down video and grab sampling are used to 'ground truth' the results.

Sabellaria spinulosa has been recorded throughout the Wash and is also commonly found along the north Norfolk coast. However, most surveys have reported it as encrustations on shells and stones or as fist-sized or smaller clumps on sediment (NRA 1994, Dipper et al 1989). This accords well with the *Sabellaria/Lanice* biotope (CMX.SspiMx) described in the recent surveys mentioned above. In this biotope, *S. spinulosa* is common to abundant, in the form of low encrustations over cobble or small clumps together with loose gravel. The sand mason worm *Lanice conchilega* is usually present and there is a diverse infauna and epifauna. This biotope has been recorded using grab samples and video, mainly within the deeper central channel of the outer Wash and well outside the Wash. Acoustic techniques have predicted its presence in a wide band extending up the Lincolnshire coast and well offshore.

Ground truth samples using grabs have identified the presence of super-abundant *S. spinulosa* along the deep channel running from the Wash towards Docking Shoal. However, the only site where substantial and extensive reefs have been confirmed (using drop-down video) is within the licensed sand extraction area 107 (see Figure 7.1.1). This lies just outside the Wash ans North Nprfolk cSAC. Super-abundant *S. spinulosa* has also been found within the Wash (between Roaring Middle and Lynn Deeps) but there is so far no visual (video) confirmation that this is in the form of reefs. Problems of bad weather and poor visibility prevented much planned video work during all the surveys (Foster-Smith & Sotheran1999).

In 2000 two trial sites were surveyed (Foster-Smith & White 2001), one in the deep channel outside the Wash within the licensed gravel extraction area 107 and the other within the Wash in the channel off the east side of Longsands. Direct observations using video confirmed that *S. spinulosa* reef existed in Area 107 where it had previously been identified (Foster-Smith et al 1997). Grab samples recorded high numbers of worm tubes. However, video at sites off Long Sand showed little evidence of *S. spinulosa* and grab samples recorded only low to moderate densities.

In 2002 the ESFJC confirmed the presence of an area of *Sabellaria spinulosa* reef on the west side of the Teetotal Channel (see Figure 7.1.1). The presence of the reef had been predicted using acoustic techniques and was then confirmed with drop down video. The site was re-visited a few months later and the reef structures were no longer present. The reef structures were situated on the edge of a fairly steep sand bank (pers comm Colin Trundle ESFJC and Seamus Whyte, Ecomaris Ltd).

Therefore it appears that *S. spinulosa* is undoubtedly abundant in some areas within the Wash notably between Roaring Middle and Lynn Deeps and acoustic techniques predict the possibility of reefs throughout the deeper outer channel. Other areas on the edges of sand banks well within the Wash, including Long Sand and the Teetotal Channel between Seal Sand and Thief Sand appear to have at least transitory reef structures.

8.2.4 Past distribution

The Wash: There is very little information available on the distribution of *Sabellaria spinulosa* within the Wash, prior to the recent surveys by EN with ESFJC (Foster-Smith 2001). No past records of *Sabellaria* reefs have so far been found. Warren (1973) when discussing the feeding relationship between pink shrimp (*Pandalus montagui*) and *S. spinulosa* stated that no *Sabellaria* reefs were known to exist in the Wash. He also commented that in 'recent years' ross (*S. spinulosa*) had only been found in small clumps in the Wash, in predominantly sandy areas towards the offshore end of the fishery (ie in the outer reaches towards Burnham Flats). Whilst this implies that it might have been found in larger clumps at an earlier date, nothing has so far come to light in the literature. Fowler (1987) also found no past records of reefs. It is possible that anecdotal evidence might be obtained from shrimp-fishing families etc.

Sublittoral surveys of the Wash carried out by NCC in the 1980s identified some sites where *S. spinulosa* was the dominant organism in fist-sized colonies, but did not identify reefs as such. These areas were adjacent to the peripheral sandbanks of the Wash and in the outer reaches of

the survey area, where coarser sediments were found and sand scour was likely to occur. The highest densities were found on the edges of Roger Sand and Long Sand (north side of the Wash) and towards the middle of the mouth of the Wash to the east of Lynn Knock (53 03.00'N 0 30.60'E) where *S. spinulosa* was the dominant element in the dredge. The latter site falls within the area running from the Wash towards Docking Shoal where super-abundant *S. spinulosa* was found (grab samples) by Foster-Smith and Sotheran (1999).

North Norfolk: There are some past records of *Sabellaria spinulosa*, from dredgings made in the 1950s (Hamond 1963, 1969), but again all these are of clumps with no reference to reefs. Hamond comments that the deeper part of the northern slope, just west of the Blakeney Overfalls Buoy is especially noticeable for an abundance of *Sabellaria spinulosa*. Other records are listed in Table 8.2.1.

Table 8.2.1 Records of *Sabellaria* from Hamond

Records of *S. spinulosa* from Hamond 1963 & 1969	**Date of survey and reference**	**Comments**
Site D10 53º 04' 30'' N. 01º 01' E	August 1955 (Hamond 1963 and 1969)	Dredge: Masses of "ross" covered with small colonies of *Bortylloides*, *Bicellariiella* and *Bugula avicularia*.
Site D19 53º 04' 18'' N.00º 58' 36'' E	September 1958 (Hamond 1963)	Dredge full of small shingle coated with *Sabellaria*
Site D5 53º 03'N 01º 02'E	June 1955 (Hamond 1969)	1955 Muddy dredge full of *Mya* and *Modiolus* shells and colonies of *Sabellaria*
Site D8 53º03'30"N 00º58'E	July 1955 Hamond 1969	Slightly dirty sand with abundant fist-sized lumps of *S.spinulosa* and with masses of *Flustra*

8.2.5 Reasons for decline

The question of whether *S. spinulosa* reefs have declined within the Wash is, at present difficult to answer. Such reefs have only recently been identified from the area and so no direct comparisons can be made with early records. In addition there is evidence to suggest that reefs may be naturally 'patchy' and not a great deal is known about the temporal stability of *S. spinulosa* reefs (Foster-Smith et al 2001, Holt et al 1995). Hiscock (pers. com. 15/3/03) says: "Concern about decline in *Sabellaria spinulosa* 'reefs' (mounds raised above the seabed) is being confused by concern about non-reef-forming *Sabellaria spinulosa*. *Sabellaria spinulosa* is a widely occurring, fast settling and growing species, often forming crusts that are not rare, threatened or in decline".

Sabellaria 'reefs' are relatively fragile and are easily broken. The Habitat Action Plan for *Sabellaria spinulosa* reefs identifies physical disturbance from fishing activities as having the greatest impact. Dredging for oysters and mussels, trawling for shrimp or fin-fish, net fishing and

potting can all cause physical damage to reef communities. All these activities are carried out extensively in the Wash and adjacent areas, and have been for many decades. Therefore it is possible that some areas of reef could have been destroyed or damaged without anyone ever knowing they existed. Reisen and Reise (1982) recorded a significant decline in the *Sabellaria spinulosa* reefs in the Wadden Sea since the 1920s when they re-surveyed sites. They attributed this decline to shrimp trawling. Recent experimental studies are reported by Vorberg (2000) the results of which suggested that trawling was unlikely to destroy the reefs (Note: this paper has not been seen by the author).

8.2.6 Opportunities for restoration

Techniques for surveying and monitoring *S. spinulosa* reefs are still under development by the SeaMap Research Group, for English Nature and the ESFJC (Foster-Smith and White 2001). A summary of *S. spinulosa* distribution and abundance within the Wash is currently being prepared by Dr Bob Foster-Smith (pers comm). It is important to ascertain for certain where and whether true stable long-lived reefs occur within the Wash.

Further research on the stability of *S. spinulosa* reefs and exactly what constitutes a reef, may be needed before there can be any discussion as to whether it is either desirable or feasible to attempt restoration of *Sabellaria spinulosa* reefs within the Wash. With the lack of early data, it is very difficult to identify former habitat for the purposes of initiating recovery of *Sabellaria* reefs.

It might be possible to set up an exclusion area outside the Wash where known reef exists, such that it is not disturbed by trawling. This could then be monitored alongside a similar nearby area that currently has no reef, has probably been trawled but does have *S. spinulosa* present. The latter could be monitored for any signs of reef development or recovery over a number of years. *S. spinulosa* are known to settle preferentially where tubes already exist. It might also be useful to ascertain whether the areas of reef known to exist in the licensed extraction area 107 have been trawled by shrimp boats and how much they have been disturbed by aggregate extraction.

8.2.7 Major References

Foster-Smith and White (2001)
Foster-Smith and Sotheran (1999)
Foster-Smith, Sotheran and Walton (1997)
NRA (1994)
Dipper, Irving and Fowler (1989)

9 Plants

9.1 Eelgrass or seagrass *Zostera* spp.

9.1.1 Introduction

Seagrasses are the only group of flowering plants (angiosperms) that are truly marine. They grow rooted in sandy and muddy seabed sediments in sheltered areas, either in small patches or as extensive beds. Two intertidal species occur around UK coasts dwarf eelgrass *Z. noltii*, found on the upper and middle shore and the narrow-leaved eelgrass *Z. angustifolia*, found on the middle and lower shore. A third species, eelgrass *Z. marina*, is found in shallow sublittoral areas and is occasionally exposed at low spring tides. However, recent preliminary DNA sequencing work indicates that *Z. marina* and *Z. angustifolia* may be variants of a single species.

Zostera is an important food for Brent geese and wigeon. The plants also increase the biodiversity of sand and mud flats by acting as a habitat for epiphytic algae and hydroids and as foraging and nursery grounds for mobile animals including various crustaceans and fish. The extensive root systems of these plants also help to stabilise the shoreline and so reduce erosion.

9.1.2 Conservation Status

Seagrass beds are the subject of a UK BAP Habitat Action Plan. All three UK species of *Zostera* are considered to be scarce.

9.1.3 Present distribution

It appears that no extensive seagrass beds currently exist along the north Norfolk coast shoreline. It is unlikely that there are or were any extensive beds of sublittoral *Z. marina* within the study area as the waters of the Wash and surrounding areas are very turbid. Recent confirmed records of *Zostera* in Norfolk are limited to 4 sites identified during the 1993 MNCR survey from Brancaster to Blakeney (Hill et al 1996) and a number of spot records from 1997 contained in a list collated by the Botanical Society for the British Isles (BSBI) recorder for Norfolk (currently Gillian Beckett). These are shown in Tables 9.1.1 and 9.1.2. No recent records of *Zostera* in the Wash and along the Lincolnshire coast have so far been unearthed though it is likely that patches of *Zostera* occur in conjunction with the saltmarsh fringing the area. BSBI records mention that there are records for Wolferton and Snettisham on the Wash coast.

Table 9.1.1 Records of *Zostera* spp. from the 1993 MNCR survey

Site	**Grid Ref.**	**Extent of *Zostera* habitat**	**Notes**
Off Brancaster. Cockle Bight, Scolt Head Island	TF794465	0.25 km^2	Muddy sand with ephemeral algae & *Arenicola*, mud with bivalves & patches of *Zostera* & pioneer saltmarsh. Small patches of *Z.noltii*
Opposite Wells Lifeboat Stn.	TF918456	0.5km^2	Mud with *Scrobicularia* & *Zostera. Z.noltii* common in pools between patches of mussels in upper shore sandy mud

Blakeney. Cley Channel S of the Marrams	TG034454	0.1km^2	Fine sandy mud with *Scobicularia* & *Zostera. Z.noltii* common on waterlogged mud on upper shore with *Enteromorpha*
Breydon Water			Outside scope of this report

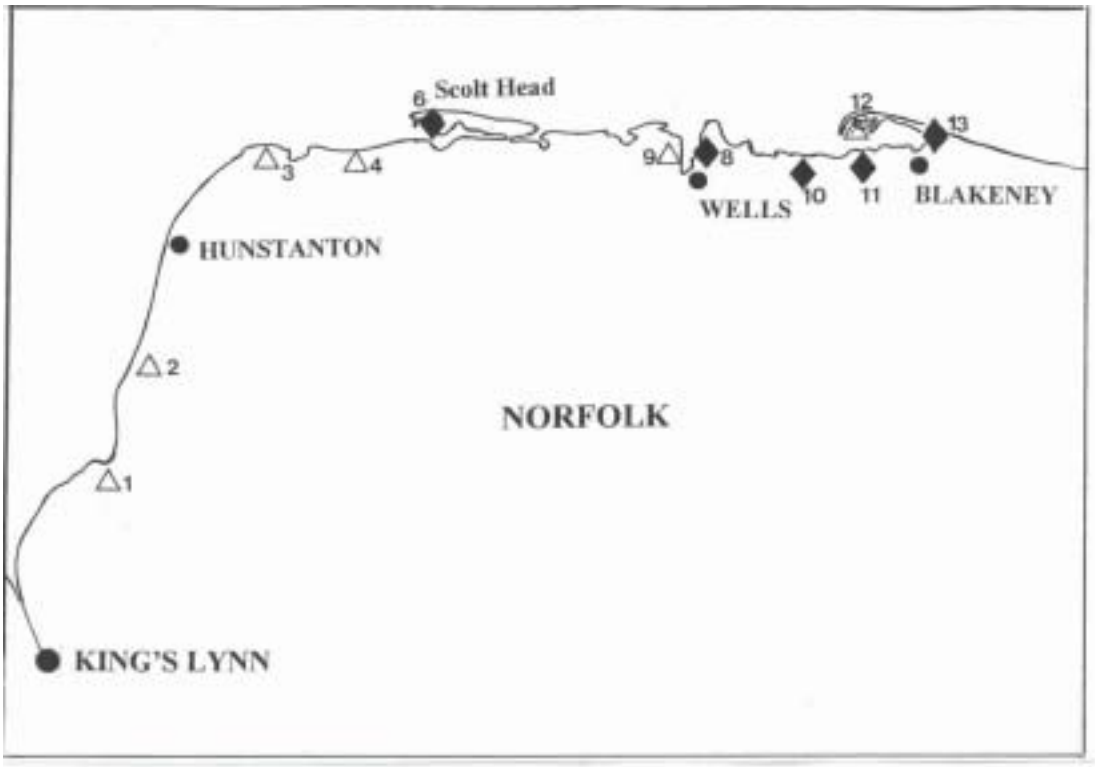

Figure 9.1.1 Records of *Zostera* in North Norfolk. Key: Open triangles = pre-1990s record, closed diamonds = records from pre and post 1990s. Refer to Tables 9.1.2. and 9.1.3 for site and date details.

9.1.4 Past distribution

Nearly 30 years ago *Zostera noltii* was reported in NERC (1976) and Probert (1981) as being limited to the 'lime-rich flats of the Welland outflow and Freiston shore'.

Hamond (1963) reports that 'around 10 years ago' (so presumably around 1953) at Blakeney, there were "on the eastern half of the Strond, which extends between mid-tide level and high water neaps, large mudflats covered with widgeon-grass (*Zostera* spp.) which have since been greatly reduced by the phenomenal growth of *Spartina townsendii*. This covers the entire upper part of the shore on the west side of Morston Creek, from which it extends westwards on both sides of the *Zostera*, covering Seven Foot Knoll on the one side and the entire frontage of the Meols on the other, the latter as far west as the shingle spit running out to the Freshes Stake".

Table 9.1.2 Records of *Zostera* from Gillian Beckett, BSBI recorder, West Norfolk

Date	Grid Ref.	Place	Notes
Z. angustifolia			
1958	TF74	Titchwell, in the lagoon	EL Swann & CP Petch. Det.TG Tutin
1955	TF 802467	Scolt Head Is., Cockle Bight Pit	DS Ranwell
1955	TF 84	Scolt Head Is., Norton Creek	DS Ranwell
1966	TF 802467	Scolt Head Is., Norton Creek	DS Ranwell & A. Malloch
1830	TF 84	Burnham Overy	S Bolton (Hb. Lucy Allen)
1907	TF 94	Wells (identity not certain)	F.Long (Hb.NWH)
1968	TF 94	Wells-next-the-Sea	EL Swan. 'Abundant with swans feeding upon it'
1970	TF 921456	Wells	BRC No data
1997	**TF 9144, 9244**	**Wells outer harbour**	**James McCallum (EN survey)**
1977	TF 9744	Stiffkey, Patch Creek	James McCallum (EN survey)
1961	TF 94	Morston	RSR Fitter (in litt)
1995	**TF 994462**	**Morston**	**Alan Lewis**
1977	TF 9846	Blakeney Point	James McCallum (EN survey)
1956	TG 04	Blakeney Harbour, S side	JF Peake (Hb NWH det.TG Tutin)
1977	TG 0345	Cley Channel	James McCallum (EN survey) VC27
Z.marina			
1951	TF 63	Wolferton	EL Swann
1951	TF 7044	Hole-next-Sea	CP Petch. 'lost after 1953'
1834	TF 74	Kirby Trimmer	Norfolk flora 1866
1964	TF 74	Brancaster	CP Petch
1932	TF 74	Scolt Head	VJ Chapman
1954	TF 74	Scolt Head	CP Petch
1964	TF 74	Scolt Head, creek nr Missel marsh	CP Petch & EL Swann
1887	TF 94	Wells	F Long (Hb.NWH)
1956	TF 9145	Wells (listed as Holkham), Abraham's Bosom	DS Ranwell
1954-70	TF 912455	Wells boating lake, Abraham's Bosom	CP Petch
1977	TF 901405	Wells, Abraham's Bosom	ET Daniels, conf. EL Swann
1994	**TF 922455**	**Wells mudflats**	**PR Banham 'doing well'**
1954	TF 94	Morston	RS Fitter (in litt.)
1949	TG 0345	Cley Channel	EL Swann (Hb. in Hb.NWH)
Z.noltii			
1972	TF 63	Wolferton	EL Swann
1975	TF 6330	Wolferton	R Jones, conf & comm SM Coles
1975	TF 6432	Snettisham	R Jones, conf & comm SM Coles
1954	TF 74	Titchwell	EL Swann
1955	TF 7946	Scolt Head Is.	DS Ranwell
1954	TF 84	Brancaster, nr the Nod	CP Petch
1966	TF 800465	Scolt Head Is.	A Malloch (Hb.Lanc.)
1975	TF 902455	Wells, Abraham's Bosom	DS Ranwell
1994	**TF 922455**	**Wells**	**PR Banham 'doing well'**
1997	**TF 9144, 9244**	**Wells outer harbour**	**James McCallum (EN survey)**
1997	**TF 9744**	**Stiffkey**	**James McCallum (EN survey)**
1954	TF 94	Morston	RSR Fitter (in litt.)
1915	TF 94, TG 04	Blakeney	FW Oliver
1949	TG 0345	Blakeney, Cley Channel	EL Swann
1997	**TG 0234**	**Cley Channel**	**James McCallum (EN survey)**

9.1.5 Reasons for decline

During the 1920s-1930s a 'wasting disease' destroyed many seagrass beds around British coasts. Since there are few records of the occurrence of *Zostera* around the Wash and East Anglia prior to this epidemic, it is not known if the disease had an effect in this area.

Hamond describes a reduction in the extent of *Zostera* on mud flats around Blakeney by the encroachment of the sterile hybrid cord grass *Spartina* x *townsendii* in the 1950s (note that this could have been *Spartina anglica*, a fertile species that arose from the hybrid by a doubling of its chromosomes). Although documented information on the spread of hybrid *Spartina* in eastern England is sparse, there is no doubt that there was a rapid expansion during the 1950s and 1960s. In the late 1950s *Spartina* stands were almost continuous around the Wash (Goodman et al 1959) and it is likely there was also considerable growth in suitable areas along the north Norfolk coast. However, by the early 1970s there had been a dramatic reduction, as shown by a study of aerial photographs of the region (Doody 1984, Randerson 1975). It is therefore possible that other unrecorded beds of *Zostera* were also affected by *Spartina* and have not re-grown.

Other factors affecting seagrass beds that could be active in the study area include grazing by wildfowl, physical disturbance from construction of sea defences and land re-claim and bait digging. Table 9.1.3 and Figure 9.1.1 are summaries of the records in Tables 9.1.1 and 9.1.2. Since the records have not been collected consistently and most records are of presence/absence, no clear declines are apparent. However, there are some sites such as Scolt Head Island where the grid references indicate that *Zostera* spp. have been present since at least the 1950s.

Table 9.1.3 Summary of sites and dates of *Zostera* spp. records (see Tables 9.1.1 and 9.1.2 for full records)

	Date	**1800s**	**1900-1949**	**1950s**	**1960s**	**1970s**	**1990s**
	General site name						
1	Wolferton			TF63		TF63 TF6330	
2	Snettisham					TF6432	
3	Holme			TF7044			
4	Titchwell Lagoon			TF74			
5	Brancaster			TF84	TF74		
6	Scolt Head Island		TF74	TF802467 TF74 TF7946	TF802467 TF74 TF800465		TF794465
7	Burnham Overy		TF84				
8	Wells, marshes	TF94	TF94		TF94	TF921456	TF9144 TF9244 TF922455 TF918456
9	Wells, Abraham's Bosom			TF9145 TF912455	TF912455	TF912455 TF901405 TF902455	
10	Stiffkey					TF9744	TF9744
11	Morston			TF94	TF94		TF994462
12	Blakeney		TF94 , TG04	TG04		TF9846	
13	Cley Channel		TG0345			TG0345	TG0234 (?) TG034454

9.1.6 Opportunities for restoration

The past extent of seagrass beds within the study area is very poorly documented and so it is not clear how much of the resource has been lost. Neither wasting disease nor *Spartina* spread are likely to be currently limiting any potential natural regeneration of *Zostera* beds. However, *Zostera* spreads mainly by vegetative means rather than seeds (which have a poor germination potential). Therefore natural spread and regeneration may be limited by distance to the nearest extensive beds.

The highly dynamic nature of the mud and sand flats and adjacent saltmarsh areas along the Norfolk coast might make it difficult to undertake a planting programme for this species. Trials on large-scale transplantation within the UK have so far had limited success but the techniques have potential and are developing (www.ukmarinesac.org.uk/communities/zostera). References to worldwide transplantation attempts are reviewed in Davison (1997).

The health and extent of known *Zostera* sites in north Norfolk should be monitored. The MNCR survey was carried out 10 years ago and these sites could usefully now be re-visited. A survey of the site in Morston Creek described by Hamond (1963), would ascertain whether there are any remnants exist of the *Zostera* bed present in the 1950s. There is a 1995 record of *Zostera* in Morston in Table 9.1.2

9.1.7 Major References

Norfolk Habitat Biodiversity Action Plan (see norfolkbiodiversity.org)
Seagrass beds Habitat Action Plan
www.ukmarinesac.org.uk/zostera

10 Lagoons and lagoon species

10.1 Saline lagoons - Habitat

10.1.1 Introduction

Coastal lagoons vary in their salinity, size and position and have been classified according to the way saltwater reaches them (JNCC 1996, Sheader & Sheader 1989). In this review all types of true saline lagoons and lagoon-like habitats are treated together but consideration is mainly given to those previously identified as of conservation interest.

Saline lagoons support a characteristic invertebrate fauna that is very similar throughout the UK (and Europe). However, individual lagoons vary as to how many and which species they support. Lagoons within the present study area support several rare and protected species (detailed below) including the starlet anemone *Nematostella vectensis*. Holkham Salts Hole and Abrahams Bosum support particularly good populations of the lagoon cockle *Cerastoderma glaucum* and several of the Blakeney Spit lagoons support the lagoon mysid *Paramysis nouveli*. There are also scattered records of the lagoon mud snail *Hydrobia neglecta*.

Saline lagoons of conservation interest in England, are listed and described in Downie (1996). This is an update of Laffoley 1992, which itself was based on the overviews of lagoons produced by Barnes (1988) and by Sheader and Sheader (1989). The actual surveys on which these overviews were based were carried out in the 1980's as part of the Nature Conservancy Council's national lagoon survey of Great Britain: Barnes carried out a survey of East Anglian lagoons in 1984; Sheader and Sheader surveyed Humberside and Lincolnshire lagoons in 1985 to 1986; Irving surveyed remaining lagoons along the south west shoreline of the Wash, in 1987. Subsequent to Downie's list, Bamber (1997) has re-surveyed lagoons in North Norfolk as part of an assessment of saline lagoons within SACs.

10.1.2 Conservation status

True saline lagoons are rare both on a national and European scale (Downie 1996). They are listed as a 'priority habitat type' under Annex I of the Habitats Directive. Saline lagoons are the subject of a UK BAP Habitat Action Plan.

10.1.3 Lagoon resource

The current total saline lagoon resource in England is estimated to cover about 1200 ha, comprising 177 lagoon sites (Saline Lagoons Habitat Action Plan). Within the current study area, Downie (1996) lists two lagoon systems (comprising 6 lagoons) in N and S Humberside, one in Lincolnshire, and five lagoon systems (comprising 9 lagoons) in Norfolk. These are listed in Table 10.1.1 below.

Using Downie's figures, the total lagoonal areas of conservation interest are: N & S Humberside 27.7 ha, Lincolnshire 1.75 ha, Norfolk 33.35 ha. In total this represents 5.2% of the total England resource. If all lagoons and lagoon-like habitats are included in the figures (ie Tables 10.1.1 & 10.1.2 together) then the total is around twice this amount.

Table 10.1.1. The saline lagoons and saline ponds that fall within the study area, that are considered worthy of conservation by Downie (1996).
(Legend: NWT-Norfolk Wildlife Trust; NT-National Trust; EN –English Nature; RSPB-Royal Society Protection Birds)

Sites	**Grid Ref. and area (hectares)**	**Status & owner/mgt**	**BAP and protected spp.**	**Latest Survey date & refs.**
Humberside				
1. Easington Lagoons Easington Ditch lagoon	TA 410177 TA 390173 (12.7 ha)	Lagoon SSSI + others	None	1984 Sheader & Sheader 1985
2. Killingholme Pools (1-3), Immingham	TA 167198 (1) TA 168196 (2) TA165196 (3) (15 ha)	?owner Ponds	*Alkmaria romijni*	1990 Bamber 1990 Sheader & Sheader 1986
Lincolnshire				
3. Humberston Fitties, Cleethorpes	TA 336048 (1.75 ha)	? owner Saltmarsh pond	*Gammarus insensibilis*	1986 Sheader & Sheader 1986
Norfolk				
4. Snettisham	TF 649306 (18 ha)	RSPB Lagoon SSSI	*Gammarus insensibilis*	2000 Barnes 2000 Barnes 1985
NW Norfolk salt-	**marsh relict lagoons**:			
5. Broad Water, Holme	TF712446 (4.4 ha)	NWT (wardened nature reserve) Sluiced pool SSSI + others	None	1996 Bamber 1996 Barnes 1985
6. Holkham Salts Hole	TF 886451 (0.6 ha)	EN (wardened nature reserve). percolation pool. SSSI, NNR + others	None	1996 Bamber 1997 Barnes 1985 Hunt 1971 Pantin 1960s
7. Abraham's Bosom	TF912452 (1.6 ha)	Private owner Percolation pool. SSSI + others	Previously *Nematostella vectensis* (Williams 1987). Not recorded by Barnes (1985) or Bamber 1997	1996 Bamber 1997 Barnes, 1985 Williams 1973 & 1987
8. Blakeney Spit Lagoons:				
- Half Moon Pond	TG 049453 (0.1 ha previously 0.4 ha)	NWT Percolation pool	*Nematostella vectensis* present in 1996. Absent in 1976, 1987 (Williams). Present prior to 1975	1996 Bamber 1996 Barnes, 1985 Williams, 1973, 1976, 1987
- Arnold's Marsh Lagoon	TG 062448 (3.4 ha)	NWT Trust reserve	None	1996 Bamber 1996 Barnes 1985
- Salthouse Broad	TG 068446 (4 ha)	Private Percolation pool	*Nematostella vectensis* *Gammarus insensibilis*	1996 Bamber 1997 Barnes 1985
- Little Eye	TG 078444 (0.5 ha)	NT ? Isolated pool	None	1996 Bamber 1997

				Barnes 1985
- Gramborough Hill West	TG 083443	NT? Percolation pool	*Gammarus insensibilis*	1996 Bamber 1997 Barnes 1985
- Gramborough Hill East	TG 087442 0.45 ha (both together)	NWT Isolated pool	*Gammarus insensibilis*	1996 Bamber 1997 Barnes 1985

Table 10.1.2. Other sites identified as lagoons and coastal saline ponds but not included in Downie (1996).

Site	**Grid Ref**	**Status & owner/mgt**	**BAP & protected spp. Notes**	**Latest survey date & Refs.**
Humberside:				
9. Barton Pools (1-4) South Humberside clay pits	TA 045233 TA 050234 TA055236 TA058236 (total: 48.9 ha)	? ?percolation	*Alkmaria romijni* (pool 3) Very low salinities with predominantly freshwater communities.	1986 Sheader & Sheader 1986
10. Welton Waters pools. N Humberside	SE 958250 57 ha	Low salinity sluiced clay pits	Listed in Bamber & Barnes 1995	?
Lincolnshire	**lagoons:**			
11. Northcoates lagoon, Louth Lincolnshire	TA 375034 3 ha	? owner Sluiced pond	High salinity (33-40%0) with no exclusively lagoonal species but good example of its kind	Sheader & Sheader 1986
12. Gibralter Point landward and seaward ditches	TF 562587 TF 562586		Landward is very low salinity and seaward almost fully saline.	Sheader & Sheader 1986
13. New March Drain, Skegness, Lincs.	TF 550551 to 467509 5 ha	? owner sluiced drain	Man-made with unremarkable fauna typical of upper saltmarsh channel	Sheader & Sheader 1986
14. Butterwick pond, Boston, Lincs	TF 411434		Small, low diversity expected by Sheader & Sheader to infill	Sheader & Sheader 1986
15. Wyberton Marsh 'square' pond, Lincs.	TF 367386 ca. 0.3 ha	? private		Irving 1987
16. Lawyer's Farm Pool	TF 417333	? private < 1 ha	*Gammarus insensibilis* Impoverished fauna compared to other saline lagoons	Irving 1987
17. RAF Holbeach sea bank	TF 444324 ca. 30 m^2	? private Percolation pool	Very shallow, rather species poor	Irving 1987
18. Oldershaw Farm Pool	TF 453303	?private	Eutrophic	Irving 1987
19. Snettisham Pits		RSPB	Not really a lagoon	Barnes 2000
20. Heacham 'Harbour' (nr Snettisham)	TF 654350	Not included in Downie (1996) list due to 'comments received'	Former estuary; not really a lagoon	Smith and Laffoley 1992, Barnes 1985

8. Blakeney Spit	**Lagoons:**			
- New Moon Pond	TG 053452	NWT Percolation pool	*Gammarus insensibilis* Incl. in Norfolk saline lagoons action plan	1996 Bamber 1996
- Seahorse pond	TG 058449	NWT Percolation pool	Incl. in Norfolk saline lagoons action plan	1996 Bamber 1996

10.1.4 Status and history - Humberside lagoons

Killingholme pools and Easington lagoons are included in Downie's 1996 list as considered worthy of conservation. Barton pools were not but *Alkmaria romijni* was recorded in Barton pool 3 and Sheader and Sheader (1986) considered this pool as worthy of conservation. There have been no known recent surveys of these lagoons. Therefore their current status is unknown.

10.1.5 Status and history – Lincolnshire lagoons

The only Lincolnshire lagoon considered as worthy of conservation and so listed in Downie (1996), is Humberstone Fitties, Cleethorpes. As far as is known this has not been re-surveyed since 1986. Sheader and Sheader (1986) describe it as a small lagoon on the NW edge of Tetney saltmarshes. Salinity in 1986 was 19-20 $^{0}/_{00}$ with no freshwater input but a 1 km long seawater channel. Species diversity was high and there was a population of *Gammarus insensibilis* – currently still the northernmost record as far as is known. Sheader and Sheader (1986) considered it an important site that should be conserved possibly in conjunction with Tetney Marshes and Northcoates lagoon, situated at the SE end of the site.

There are numerous other small saline ponds, drainage ditches etc along the Lincolnshire coast described in Sheader and Sheader (1986) and Irving (1987). The more lagoon-like of these are listed in Table 10.1.2 above but none of these appear to hold much of interest. *Gammarus insensibilis* was recorded by Irving (1987) from Lawyer's Pool but the pool held little other of interest. There have been no recent surveys of saline lagoons in this area.

10.1.6 Status and history – North Norfolk lagoons

The majority of saline lagoons that are of conservation interest in the context of the present study, are situated along the North Norfolk coast. Nine lagoons are listed in Downie (1996) as of conservation interest. These have all been re-surveyed relatively recently (1996) by Bamber. The descriptions given below highlight changes and are based on Bamber's work. Reference should be made to Bamber for detailed descriptions. Most of the lagoons have been the subject of past surveys, especially by Barnes (1985) with other records as far back as the 1960s. Unfortunately Barnes (1985) does not describe the lagoons in any detail in his report to the NCC although further details might be available on raw data sheets if these can be located.

Three lagoons, Broadwater, Holkham Salts Hole and Abraham's Bosom, are saltmarsh relict lagoons situated between Hunstanton and Wells. These were all re-surveyed by Bamber. The remaining lagoons are strung out behind the shelter of Blakeney Spit. These are percolation lagoons retained between the seaward shingle ridge and the reclaimed saltmarsh along Blakeney Spit. Bamber reports that these lagoons were affected by bad seawater flooding in February 1996 and have been impacted by re-construction work on the shingle ridge using heavy machinery. He re-surveyed the 6 lagoons studied by Barnes in 1984 (Table 10.1.1) plus 2 new ones (Table

10.1.2). He also noted a group of lagoons north of Salthouse village that had been severely impacted or destroyed during the shingle ridge re-construction.

Broad Water
This lagoon has been less well studied than Holkham Salts Hole or Abraham's Bosom but appears not to have changed significantly between the most recent survey by Bamber in 1996 and the earlier 1984 survey by Barnes. Water flow is controlled by a sluice gate and Bamber (1996) reports that around 1993 the regime was changed. Instead of allowing the lagoon to drain regularly, the sluice was kept closed and a depth of water of 1 m maintained. In 1996 the sediments supported a comparatively diverse infauna of polychaetes, chironomids, *Corophium volutator* and various molluscs including *Cerastoderma glaucum*. It is not known what the current water regime is.

Holkham Salts Hole.
This lagoon is an almost circular, saline spring-fed percolation pool. It has the longest recorded history. Pantin (in Hunt 1971) recorded the species present in this lagoon between 1962 and 1966. Hunt (1971) described this site as an interesting saline lagoon. He also made a species list and concluded that there had been very little change in the flora and fauna since Pantin made his collections. Barnes survey in 1984 indicated that this lagoon was the richest in East Anglia in terms of fauna (Barnes 1985). The most recent survey by Bamber (1997) indicates that this lagoon remains in good condition and supports a diverse fauna. A long-lived population of the cockle *Cerastoderma glaucum* is of particular interest. This lagoon appears to have remained stable and in good condition since at least the 1960s.

Abraham's Bosom and Creek.
Williams (1973 and 1976) describes this site as supporting populations of the rare anemone *Nematostella vectensis*, prior to around 1973. Barnes (1985) describes the north end of Abraham's Bosom as heavily polluted and anoxic, the middle region as covered in *Enteromorpha* and the south east corner as healthy.

In 1986 Williams rediscovered a thriving population of *Nematostella vectensis* in the adjacent Abraham's Creek and describes the habitat as being greatly improved by the "cutting of a wide ditch from the north west corner of Abraham's Bosom to join Abraham's Creek about 100 m from its original sole connection with Abraham's Bosom". This resulted in improved water circulation and increased oxygenation of the mud (Williams 1987).

In the most recent survey Bamber (1997) describes the sediment as colonized by a diverse fauna dominated by the lugworm *Arenicola marina* and the cockle *Cerastoderma glaucum* but he did not find *Nematostella vectensis*. Like Barnes (1985) he also describes the northern quarter as degraded and anoxic and states that the lagoon has not changed significantly since Barnes' survey. He does not mention Abraham's Creek.

Half Moon Pond (Blakney Spit).
This small lagoon used to support a thriving population of the rare anemone *Nematostella vectensis* (Williams 1973, 1976). In 1975 it dried up and the population of anemones was lost. Barnes (1985) lists the pool as species poor with no fringing vegetation. The most recent survey

by Bamber in 1996 showed that whilst the area of the pool had diminished (from 0.4 to 0.1 ha), a dense population of *Nematostella* was again present plus a dense *Ruppia* bed.

Arnold's Marsh lagoon (Blakeney Spit)
This, the largest of the Blakeney Spit lagoons was reported as in reasonable condition by both Barnes (1985) and Bamber (1987).

Salthouse Broad (Blakeney Spit)
Few details are given by Barnes (1985) but Bamber (1997) found *Nematostella vectensis* present at the southern edge and a generally sparse but diverse fauna. The northern edge had bulldozer scrapes along it.

Little Eye (Blakeney Spit)
Bamber (1997) records that this small lagoon was degraded during reconstruction work on the shingle ridge after the 1996 floods. At the time of his survey the lagoon had shrunk to 0.2 ha and was only 5-10 cm deep. Barnes in his 1984 survey recorded an area of 0.5 ha and a depth of 40 cm. Otherwise it remained the same as before with a sparse estuarine infauna including the crustaceans *Paramysis nouveli* and *Idotea chelipes*, but no longer *Corophium volutator*.

West Gramborough Hill (Blakeney Spit)
This small, very shallow lagoon showed evidence of bulldozer damage in 1996 and Bamber (1997) suggests that its future might be in doubt due to the incursion of the seaward shingle ridge. Small clumps of *Ruppia* and *Chaetomorpha* supported *Gammarus insensibilis*, other crustaceans and the spire shell *Hydrobia ventrosa*.

East Gramborough Hill (Blakeney Spit)
Observations by Bamber (1997) suggest that this lagoon has also been degraded. It is a saltmarsh creek relict lagoon amidst grazing marsh and its banks are subject to damage by cattle. Bamber also records that *Phragmites* recorded by Barnes in 1984 remains only as dead stumps. Small numbers of *Gammarus insensibilis* were present in clumps of *Chaetomorpha*.

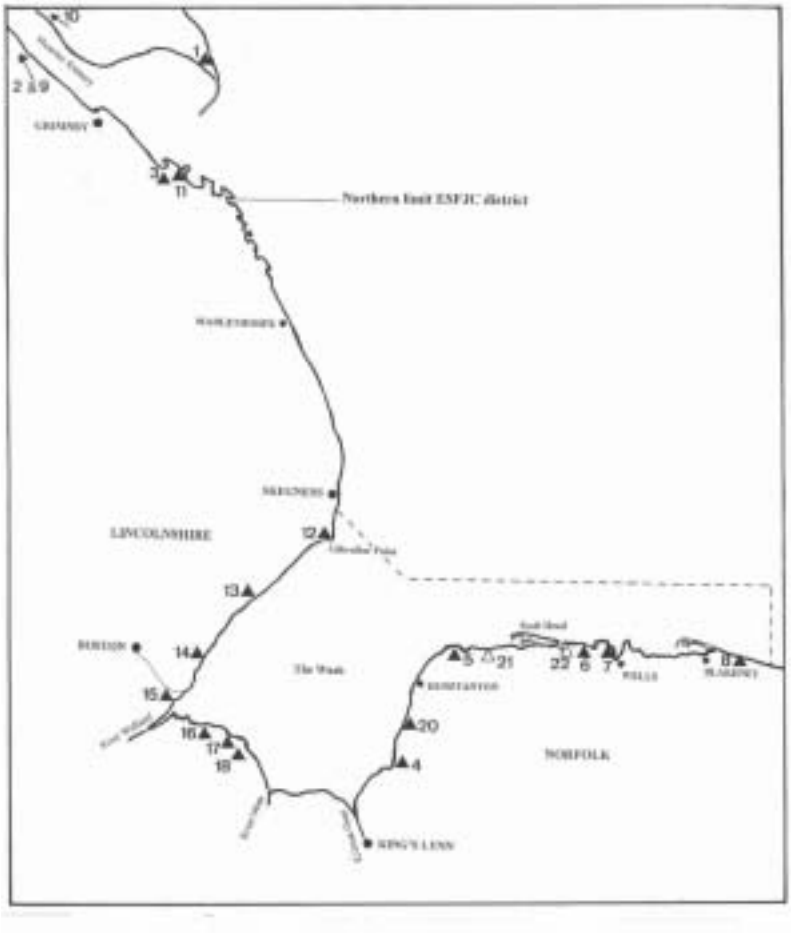

Figure 10.1.1 Location of lagoons. Grid references are given in Tables 10.1.1 and 10.1.2. Detailed location maps are given in Bamber 1997, Downie 1996 and Irving 1987.

10.1.7 Resource decline- Former lagoons

It is difficult to estimate the extent to which the saline lagoon habitat has declined within the study area. However, there are some records in the literature of lagoons that are no longer extant. These are listed in Table 10.1.3 below.

Table 10.1.3 Lagoons recorded as lost

Site	Grid ref.	Decline	Former interest	References
Titchwell lagoon, Scott Head	TF 765448	Drained in 1971	*Rare species	Williams 1972
Overy Staithe	TF 855450	Now freshwater, occluded by reeds		Barnes 1985
Weybourne Hope	TG 109436	Now freshwater occluded by reeds		Barnes 1985

*Titchwell lagoon was described by Williams (1972) as similar to Holkham Salts Hole which supports a wide range of brackish fauna. The anemone *Haliplanella luciae* (an introduced species) was abundant between 1961-1970 (the only known location?). The 'species group' of *Gammarus insensibilis* was frequent in 1969 and 1970. Other species included *Hydrobia neglecta, Cerastoderma glaucum* and *Modiolus modiolus* (unusual in brackish water).

In addition a number of other lagoons have become degraded and have shrunk in extent as detailed above. The reasons for the decline of saline lagoon habitats in general include drying out, infilling, eutrophication, pollution and rubbish dumping. Many are naturally transient and subject to natural succession towards freshwater habitats. All of these are implicated in the loss of lagoons within the study area. However, coastal defense works are of particular significance within the East Anglian region, particularly in relation to expected sea level rise in this area and to maintenance of shingle ridges.

10.1.8 Other lagoon-like sites

Table 10.1.2 lists those sites identified by Sheader and Sheader (1986) and Irving (1987), as being brackish lagoons or saline ponds, but not included in Downie (1996) as being worthy of conservation. Two sites, Barton Pool 3 and Northcoates lagoon were considered by Sheader and Sheader as worthy of conservation. Irving visited 19 sites of which he found 11 were brackish but only 4 were regarded as approaching true saline lagoons, with salinities ranging from 20ppt to 33ppt. Two sites, Wyberton Marsh 'square' pond and Lawyer's Farm pool were considered by Irving as worthy of further study.

10.1.9 Opportunities for restoration

Database: Knowledge of the resource is vital before any consideration is given to re-creation or restoration of lagoon habitats in the area. This report brings together the majority of published and unpublished information. It would be useful for EN to produce a database from this, of lagoons of conservation importance within the Wash and North Norfolk cSAC (and adjacent coasts?). This could be regularly updated and distributed to bodies and individuals who own or manage the sites, plus the EA and others engaged in coastal works. Conservation organisations do not always know what data is available for their lagoon sites (pers comm with NWT) and EN does not always know if or when additional survey/monitoring work has been carried out by other bodies. A simple questionnaire for reporting observed changes could be sent regularly to site owners/managers to encourage them to report such work. Members of the public visiting NWT, RSPB etc sites could also fill in forms.

Surveys: Although the majority of current lagoon sites considered worthy of conservation within the present study area, are already afforded some protection through their inclusion in SSSIs and other designated areas, they are still subject to degradation. This is a dynamic region and as the flooding in 1996 showed, is subject to seawater inundation, as well as adverse impacts from tourism (eg caravan parks) and pollution. It is therefore always going to be important to monitor the condition of these lagoons. Regular surveys should therefore be implemented at set time intervals in order to identify any significant loss of habitat and to provide the basis for future management and improvement of the resource and of those BAP species dependent on this habitat (see below).

The Norfolk lagoons were last surveyed 7 years ago (Bamber 1997). Lagoons in Lincolnshire and Humberside have not been surveyed since the 1980s (with one or two exceptions – see Tables 10.1.1 & 10.1.2). Those considered to have had at least some interest (eg Barton Pool 3, Wyberton Marsh 'square' pond and Lawyer's Farm pool), should be re-surveyed from the perspective of whether it might be possible to upgrade and improve them to a condition where they would be worthy of conservation.

Habitat creation: The Saline Lagoons Habitat Action Plan has as one of its objectives, the creation of new saline lagoon habitat to at least keep pace with projected losses. Pye and French (1993) suggested that a minimum target for re-creation should be 120 ha in the next 20 years (ie to 2013). Bamber (1997) suggests that the numerous lagoons behind Blakeney Spit are "individually replaceable *in situ* insofar as any sufficient excavation in this area is likely to create the appropriate habitat for a percolation lagoon". Some of the current sites (Seahorse, Little Eye and E Gramborough) currently have little merit and consideration could be given to their improvement. Some sites such as Half Moon Pond, seem to be subject to (natural?) changes of water regime which affect populations of important species such as *Nematostella vectensis*. Maintaining a dynamic sequence of lagoons by survey, management and re-creation would seem appropriate.

10.1.10 Priority BAP saline lagoon species

The Annex to the saline lagoons habitat action plan states lists the following species as priority species under the UK Biodiversity Action Plan:

- starlet sea anemone *Nematostella vectensis*
- Ivell's sea anemone *Edwardsia ivelli*
- lagoon sandworm *Armandia cirrhosa*
- the hydroid *Clavopsella navis*
- lagoon sand shrimp *Gammarus insensibilis*
- the lagoon seaslug *Tenellia adspersa*
- Baltic stonewort *Chara baltica*
- bearded stonewort *Chara canescens*
- foxtail stonewort *Lamprothamnium papulosum*
- bird's nest stonewort *Tolypella nidifica*

Of all these species, the starlet sea anemone (*N.vectensis*), the lagoon sand shrimp (*G.insensibilis*) and possibly the lagoon seaslug (*T. adspersa*) (see section 10.4) are recorded as occurring in saline lagoons or ponds in the study area. One other nationally rare or nationally scarce brackish water species, protected under the Wildlife and Countryside Act 1981, occurs in lagoons within the study area: the tentacled lagoon worm *Alkmaria romijni*.

10.1.11 Major References

Bamber 1997
Barnes (1985).
Downie (1996).
Irving (1987).
Sheader and Sheader (1986)
Smith and Laffoley (1992)
Bamber and Barnes (1995)

10.2 Starlet anemone *Nematostella vectensis*

10.2.1 Introduction

The starlet sea anemone *Nematostella vectensis* is a small anemone that occurs in isolated, brackish lagoons and sometimes saltmarsh pools, brackish ponds and ditches, in England and North America. It normally lives with its column buried in the mud, attached to small stones or gravel and its tentacle crown exposed. It is sometimes found attached to plants such as *Ruppia* or *Zostera* or lying freely on the mud surface.

10.2.2 Conservation Status

Listed as vulnerable by IUCN/WCMC and rare on the GB Red List. Protected under schedule 5 of the Wildlife and Countryside Act 1981. Subject of a UK BAP Species Action Plan.

10.2.3 Present distribution

The UK BAP states that this anemone is known only from a few localities on the south and east coasts of England: the Isle of Wight, Hampshire, Dorset and along the East Anglian coast. In East Anglia, this species is currently (taken from Bamber 1997) known to occur in two Blakeney Spit pools -Half Moon Pond and Salthouse Broad. It was also previously known from Abraham's Bosom in NW Norfolk (Figure 10.2.1). However, this small anemone is easily overlooked and seems to be prone to population fluctuations. The Norfolk Wildlife Trust has written a species action plan for this species using distribution information from Bamber (1997) and a draft Norfolk biodiversity action plan for saline lagoons (see www.norfolkbiodiversity.org). In these, it is stated that *Nematostella* is known to be present at Half Moon pond, Cley and Salthouse Broad. It is assumed that 'Cley and Salthouse' Broad are one site as no other reference can be found to Cley Broad. The Norfolk Wildlife Trust has not itself done any surveys of its lagoon sites (pers comm Helen Baczkowska and Reg Land 7/2/03).

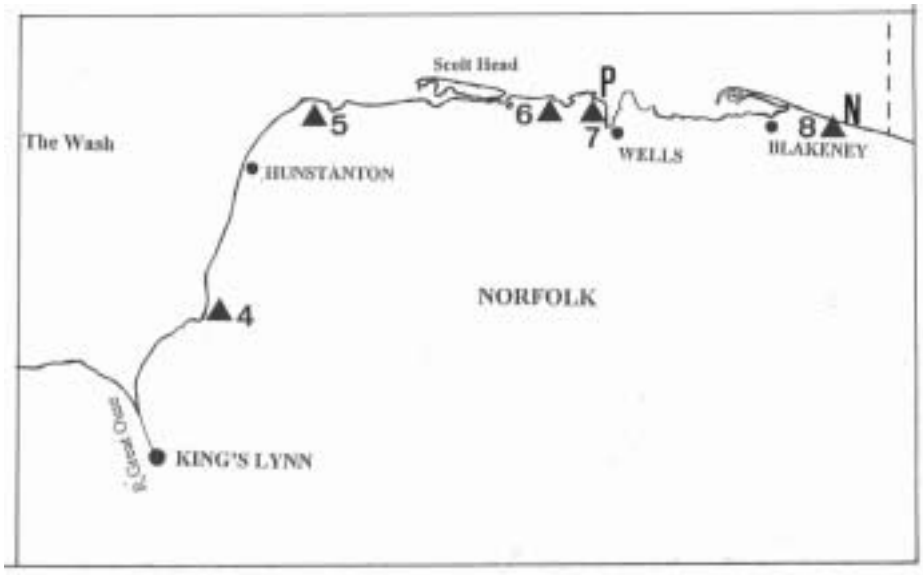

Figure 10.2.1 Past and present distribution of *N.vectensis.* Key: **N** = current record, **P** = past record not found in latest survey (Bamber 1997). Refer to Table 10.1.1 for details of sites.

10.2.4 Past distribution

Three sites were known in Norfolk during the early 1970s but by 1975, the anemone was thought to be extinct in the county. In 1986, one of the sites at Wells (Abraham's Creek) was found by Williams (1987) to once again have a thriving population. A supposed population at Stiffkey marshes turned out to be young specimens of *Sagartia troglodytes* var. *ornata*. The location of these pools is given in section 8.1 of this report, where all saline lagoons and ponds in the study area are listed.

- *Half Moon pond*, Cley: sometime prior to 1975 the anemone was very numerous at this locality. This pond dried up in August 1975. Ten anemones were moved over the sea wall over the road and their position marked with a white oak post (pers comm Ray Williams 3/12/02). Williams (1987) says he has not seen these again since December 1975 and he did not know if the pond had been re-colonised.

  Nematostella was not recorded in this pond or any of the other 'Blakeney Spit' pools by Barnes during his 1984 coastal saline lagoons survey (Barnes 1985). Recently Bamber (1997) has recorded a thriving population in this lagoon.

- *Abraham's Bosom and Abraham's Creek*, Wells: the anemone was always less common at these two sites than in Half Moon pond. It was thought to have become extinct in about 1973 (Williams 1973, 1976). In 1986, Williams rediscovered a thriving population in Abraham's Creek. He reported (Williams 1987) that the condition of the habitat had been greatly improved over the previous few years by cutting a ditch from the NW corner of Abraham's Bosom to join Abraham's Creek about 100 m from its original sole connection with Abraham's Bosom. This had improved the water circulation and increased the oxygenation of the mud.

  Nematostella was not recorded by Barnes in Abraham's Bosom during his 1984 survey of coastal saline lagoons (Barnes 1985). He states that the north end was heavily polluted. Bamber (1997) did not find *Nematostella* in Abraham's Bosom. Neither he, Barnes (1985) or Downie (1996) mention Abrahams Creek.

10.2.5 Reasons for decline

The main reason for decline is the isolation of the anemone's habitats by seawall construction and marsh reclamation, resulting in relict populations and preventing natural spread across marshes. Isolated brackish ponds and lagoons are very vulnerable to drying out (eg Half Moon pond), eutrophication, pollution and rubbish dumping.

10.2.6 Opportunities for restoration

Before any action can be taken with this species, it is necessary to re-check its current status within the area since the last survey was in 1996 (Bamber 1997). Saline lagoons where it is known (or suspected) to have occurred should be re-visited and surveyed, (see Table 8.1.1 for locations) viz:

- Half Moon Pond

- Check site that Williams marked with white post, near Half Moon pond; he thinks the post may still be there *(*pers comm)
- Salthouse Broad
- Abraham's Bosom and Abraham's Creek

This is compatible with the BAP Species Action Plan point 5.5.1. 'Promote surveys to determine the full extent of the species' distribution'.

Those sites that do still hold thriving populations should be carefully monitored to ensure their continued existence. The re-discovery of the population in Abraham's Creek in the early 1980s, following improvements in habitat, and the re-appearance of the anemone in Half Moon Pond after a prolonged absence, suggest this species will re-colonise or resurrect itself, given the opportunity. Consideration could be given to re-introduce the anemone to Abraham's Bosom after improvement of the habitat if necessary. This is compatible with the BAP Species Action Plan point 5.5.2: "Seek to identify former sites suitable for re-introduction".

After this, consideration could be given to introducing the species to new localities where its specific habitat requirements are met. Williams has carried out extensive ecological studies on this species that may provide sufficient information to facilitate re-introduction (Williams 1976). Sheader et al (1997) discuss conservation management of this species. It would be useful to identify whether there are habitat corridors for the species to spread to other sites.

10.2.7 Major References

Williams, 1973, 1976, 1987
Hamond and Williams 1977
Bamber 1997
Sheader et al 1997

10.3 Lagoon sand shrimp *Gammarus insensibilis*

10.3.1 Introduction

The lagoon sand shrimp is a small amphipod crustacean found in saline lagoons, associated with floating mats of the green alga *Chaetomorpha linum* and other macrophytes. Morphologically it is very similar to the more familiar *G. locusta*.

10.3.2 Conservation status

Protected under schedules 5 and 8 of the Wildlife and Countryside Act 1981. Subject of a UK BAP Species Statement in Saline Lagoons Habitat Management Plan. Listed as 'rare' in the British Red Data Book and regarded as 'Nationally scarce' in a review of benthic marine species (Sanderson 1995).

10.3.3 Present distribution and abundance

All known records of this species from the current study area are listed in Table 10.3.1 below. The most recent record is from Snettisham Pits, recorded by Barnes (2000). The remaining records are from Bamber (1997) and previous to that, surveys carried out from 15 to 30 years

ago. This species is also found in lagoons along the south coast as far west as the Fleet in Dorset and in Essex and Suffolk. Southern England is probably the northern limit of its range, as it has its centre of distribution in the Mediterranean. Details of lagoon sites outside the current study area, are given in Sheader and Sheader 1987 and the BAP Species Statement (they are not identical).

Table 10.3.1 Records of *G. insensibilis* within the study area (for details of lagoons, see Section 8.1).

Site details	Comments	References
3. Humberstone Fitties lagoon, N Lincolnshire.	Listed as present	Sheader & Sheader 1986, 1987
16. Lawyer's farm lagoon, Lincolnshire (Wash)	Recorded as present	Irving 1987
21. Titchwell lagoon Norfolk (Wash)	The 'species-group' frequent from 1969-70. Lagoon drained in 1971. Not found by Barnes (2000) in RSPB seawards 'lagoon' at Titchwell which is not a proper lagoon but more a large tidal pool.	Williams 1972
4. Snettisham, Norfolk (Wash)	Not included in list of sites on BAP Species Statement. Recorded as present in clumps of *Chaetomorpha*	Barnes 2000
8. W & E Gramborough Hill lagoons, Blakeney Spit, Norfolk	Present	Bamber 1997 Not in Barnes 1985
8. New Moon lagoon, Blakeney Spit, Norfolk	Present	Bamber 1997
8. Salthouse Broad, Blakeney Spit, Norfolk	Present	Bamber 1997

10.3.4 Past distribution and abundance

This species was only described in 1966 and so all records are combined under 'present distribution' above. *G.insensibilis* is very similar morphologically to the widespread and common *Gammarus locusta* with which it has been confused in the past. However, the latter only occurs in fully saline conditions.

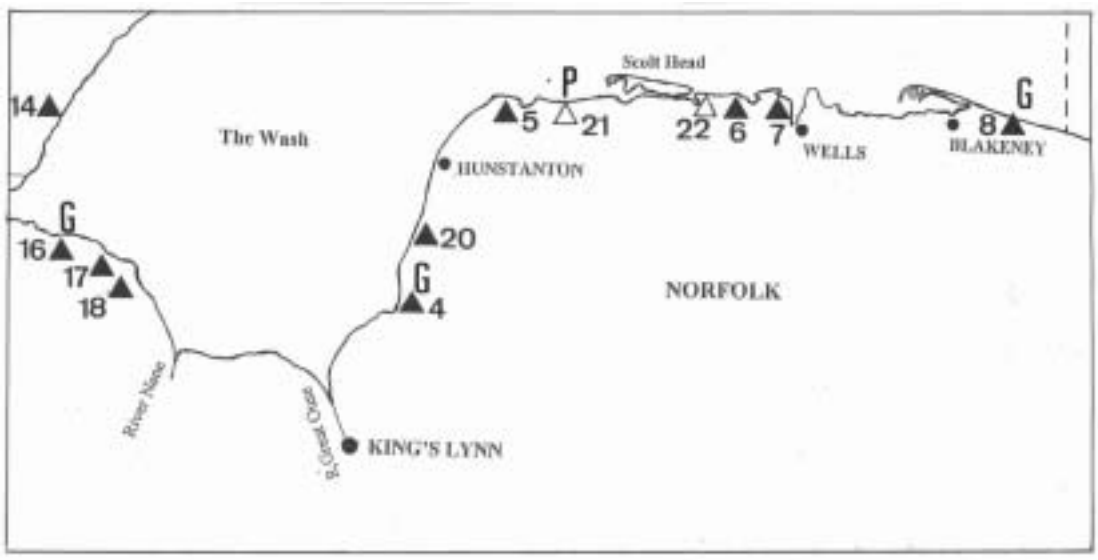

Figure 10.3.1 Saline lagoons where *G.insensibilis* has been recorded. Key: **G** = current record, **P** = past record lagoon now gone (refer to Table 10.3.1 for dates and 10.1.1 for details of sites). Site 3, Humberstone Fitties in North Lincolnshire, is not shown.

10.3.5 Reasons for decline

There are too few records to ascertain whether this species has declined or not.

10.3.6 Opportunities for restoration

Sheader and Sheader (1987) describe the characteristics of lagoons where *G.insensibilis* has been recorded. These are reproduced below and could form the basis for determining suitable sites for introduction/re-introduction if deemed appropriate. This species is difficult to recognise and may be present in other saline lagoons within the study area. When Bamber (1997) re-surveyed north Norfolk lagoons, he found this species in four lagoons where it had not previously be recorded. Re-survey of lagoons not visited by Bamber would help to sort out how widespread this species is within the area.

Characteristics of lagoons where *G. insensibilis* has been recorded:

- Regular tidal input through sea channel or culvert (in most cases);
- Small tidal range;
- Freshwater input (other than rainfall) low or absent;
- Salinity high, 10-58 $^{0}/_{00}$, usually 15-35 $^{0}/_{00}$, with seasonal variation;
- Water retained at low tide by a sill or barrier. In all lagoons, relatively little of the sediment surface is exposed to the air at low tide;
- Sediments variable, ranging from organic muds, to shingle with various admixtures of sand and silt-clay.

10.3.7 Major references

Bamber 1997
Sheader and Sheader 1986, 1987

10.4 Other lagoon species

10.4.1 Introduction

Ten species of plants and animals found only or predominantly in saline lagoons, are listed as priority species under the UK Biodiversity Action Plan (see Annex to the saline lagoons habitat action plan). Three of these species, the anemone *Nematostella vectensis*, the lagoon sand shrimp *Gammarus insensibilis* and the lagoon seaslug *Tenellia adspersa*, are known to occur or have occurred in lagoons within the present study area. *N. vectensis* and *G. insensibilis* are described in separate sections (10.2; 10.3 above). *T. adspersa* is described below along with a number of other characteristic lagoon species of interest in the context of this report.

10.4.2 Lagoon seaslug *Tenellia adspersa*

Tenellia is a tiny, and rather drab seaslug only about 7 mm long. In older literature it is recorded as *Tenellia pallida*, now considered a pseuonym. It is euryhaline, that is it can withstand a wide variety of salinities, but is normally found in brackish localities. It feeds on hydroids especially *Cordylophora lacustris* and *Laomedea* spp. and so is only found where sufficient hydroid food is present. Available information on this species is summarised in a Species Statement appended to the UK BAP Saline Lagoons Habitat Management Plan. It is protected under schedule 5 of the Wildlife and Countryside Act 1981, is listed as 'Insufficiently known' but at least 'Rare' in the British Red Data Book and classified as 'Nationally rare' in a review of benthic marine species (Sanderson 1995). The BAP Species Statement lists two sites in Norfolk (Snettisham Pits lagoon and "a creek near Dersingham") as records for the species. There are a few other records outside the current study area. The origin of the Norfolk records has not yet been traced as no references are given in the species statement.

This small species is easily overlooked and may prove to occur more widely than the current records suggest. Picton and Morrow (1994) report that there are few British records but suggest that it is probably widely distributed in estuarine conditions.

10.4.3 Tentacled lagoon worm *Alkmaria romijni*

The tentacled lagoon worm is a small polychaete worm up to 5mm long that is common around continental eastern North Sea coasts in suitable habitats. In Britain it is distributed along the southern shores of the North Sea as far north as the Humber estuary and in the English Channel and north to Pembrokeshire. There is no UK BAP Species Action Plan for this species, but it has been classified as 'Nationally rare' and is protected under schedule 5 of the Wildlife and Countryside Act 1981. However, Gilliland and Sanderson (2000) suggest that in the light of new records it should now be considered as 'scarce' not 'rare' in a national context. Previously thought to be restricted to lagoons it is now known to occur also in sheltered estuaries in shallow, muddy sediments, where it builds mud tubes that stick up above the sediment surface. White (2002) in a summary of known data, reports that it has been recorded from 27 sites around UK, most of which are in estuaries with a few in lagoons. Gilliland and Sanderson (2000) provide details of 34 reliable UK records. Within the present study area, Sheader and Sheader (1986) recorded it from two sites (Killingholme Pool 1 and Barton Pool 3) within the Humber estuary and so on the northern edge of the area. Gilliland and Sanderson (2000) also record it from several sites within intertidal areas of the Humber Estuary. They also list it as occurring in

Breydon Water, Great Yarmouth, south of the present study area. It is therefore possible that with careful searching it might be found in other lagoons within the study area. Its small size makes it easily overlooked.

The status and importance of this species in saline lagoons within the study area is not fully known but should be the subject of further research if/when lagoons in the area are re-surveyed

10.4.4 Spire snail *Hydrobia neglecta*

Hydrobiids or spire shells are tiny marine and freshwater snails often found on mud flats and in saltmarshes. Most species are tolerant of a wide variety of salinities. The commonest species *Hydrobia ulvae*, can be found in enormous numbers on wet mud and sand banks in estuaries and other sheltered places as well as in saline lagoons. Two other species *H. ventrosa* and *H. neglecta* are particularly associated with saline lagoons that have soft bottoms and vegetation. There are records of *H.ulvae* and *H.ventrosa* from many East Anglian and Lincolnshire coast lagoons as well as drainage ditches and other brackish areas. *H. ventrosa* in East Anglia is known over a salinity range from 1-36 $^{0}/_{00}$ (Cherrill and James 1985) although it prefers lower salinities from 6-25 $^{0}/_{00}$.

H. neglecta appears to have a much more restricted distribution and lives in lagoons and similar areas with salinities between 10-30 $^{0}/_{00.}$ It was only described in 1963 and so has not always been recognised as a distinct entity. All three species are difficult to distinguish especially by non-specialists. Therefore it may be more widespread than current records indicate. It is listed by Barnes (1985) in his report on East Anglian lagoons and as possibly present (dead shells) by Irvine (1987) in Lincolnshire lagoons.

The status and importance of this species in saline lagoons within the study area is not fully known but should be the subject of further research if/when lagoons in the area are re-surveyed.

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Annex 1. Species considered but not covered in this report

A1. Houting *Coregonus oxyrinchus*

The Houting is a whitefish (family Coregonidae) that lives in estuaries and low salinity areas such as the Baltic. It is anadromous ascending large rivers to spawn. It underwent a severe decline in the last century (1900s) as a result of over-fishing, pollution and barriers in its spawning rivers. It is listed in the IUCN Red List as Data Deficient. This species was considered because it has been recorded from within the study area. The first British record was received by Day (cited in Smith 1915) in 1877 when he was sent a specimen collected from Lincolnshire. However, it has never been known to spawn in the British Isles and so should really be regarded as a vagrant. Houting was originally distributed in the southern North Sea and western Baltic Sea. It has occurred in British waters a few times on the south-east coast but it is now believed that the North Sea population is extinct (Wheeler 1978). None have been recorded here for many decades but it was a one time taken regularly along the south-east coast of England and in Essex estuaries such as the Colne (Maitland & Campbell 1992).

A2. Lemon sole *Microstomas kitt*

Lemon sole are one of a number of flatfish caught commercially in the Wash. Plaice and sole are by far the most important and are covered separately in this report because they are both included in the UK BAP Commercial fish action plan and are commercially valuable. Lemon sole was recorded by Smith (1915) as frequent in the Wash and along the Lincolnshire coast and at times, common in the Humber. Lemon sole are caught in sufficient numbers in the Wash to be recorded in landing statistics but this is not a BAP species and time prevented its inclusion.

A3. Salmon *Salmo salar*

There is some evidence to suggest that salmon may once have run up rivers in and around the Wash. Brogden (1899) says they were taken almost annually in the flounder nets at the mouth of the Welland. However, this species is not currently found in any rivers within the study area. East Anglian rivers are not prime sites for salmon and trout and it is unlikely that restoration attempts would be successful. Salmon were not part of the site selection rationale for the Wash ans North Norfolk cSAC. Therefore this species has not been covered.

A4. *Macoma balthica*

This bivalve shell is found in estuaries and sheltered locations. It was considered because there was some suggestion that it might be exploited commercially. However, time constraints prevent its inclusion. There are a number of past records of this species in Hamond (1972) who considered it common: found under Ludham Bridge in River Ant in 1906 – many paired empty shells indicating it had lived and died there when the river was more saline. Scolt Head. Blakeney Harbour, live ones numerous in the sandbank south of the Watch House and in the floor of Pinchen’s Creek and in small numbers in Freshes Lays.

A5. Lagoon cockle *Cerastoderma glaucum*

The lagoon cockle is found in brackish water including lagoons, in southern Britain including East Anglia. It is not a UK BAP priority species and is therefore not listed in the Annex to the Saline lagoons Habitat Action Plan. Unlike *Nematostella vectensis* there are no immediately obvious references referring to a decline in this species within the study area and it so it was not included since time was limited.

A6. Ragworm and white ragworm (various species)

Ragworms are listed in Fowler (1992) as popular bait species in the East Anglia region. True ragworms belong to the family Nereididae (Nereidae) and the two most important bait species are *Neanthes (Nereis) virens* and *Hediste (Nereis) diversicolor*. White ragworm are also known as catworms. There are several similar species all of which belong to the family Nepthydidae and the most familiar of which is probably *Nepthys hombergii*. True ragworms are usually found in estuarine conditions. They live in permanent burrows and so are easier to exploit than white ragworm. They breed only once in their lifetime and then die.White ragworm live close to the low water mark in clean sand beaches and are errant predators that wander through the sand. They can breed several times during their life. There appears to be little readily available information on the status and exploitation of ragworms in East Anglia and time precluded a detailed search.

A7. Cord grass *Spartina* spp.

Four species of cord grass occur in UK although only the small cord grass *Spartina maritima* is native. *S. alterniflora* is an introduced species from America whilst *S. x townsendi* and *S. anglica* are hybrids derived from the native and introduced species. The history of *Spartina* spp. in eastern England has not been well documented in spite of the fact that at one time the hybrid species occupied several thousand acres in the Wash. The available past information is summarised by Doody (1984). The current distribution of *Spartina* species within the study area would be best researched in conjunction with changes in saltmarsh distribution and abundance, which is outside the scope of this report.

A8. Samphire or glasswort *Salicornia* spp.

There are around 9 species of samphire that grow in saltmarshes around the UK. Most are annuals and pioneer species growing on bare mud around the edges of creeks and saltmarshes. In the East Anglia region they are harvested for food although not in the quantities they used to be. There are a number of rare species. Like *Spartina*, it is felt that the current distribution of *Salicornia* species within the study area would be best researched in conjunction with changes in saltmarsh distribution and abundance, which is outside the scope of this report.

Records of *Salicornia* within Norfolk have been obtained from Gillian Beckett, BSBI recorder, West Norfolk. These include *S. ramosissima, S. europaea, S. dolichostachya, S. obscura, S. fragilis, S. pusilla* and *Sarcocornia perennis*.

Bird and Wain (1963) map changes in saltmarsh vegetation including *Spartina* and *Salicornia* since 1953. The spread of hybrid *Spartina* affected the distribution of *Salicorni-Aster* marsh.

A9. Mussels (Mytilus edulis) and cockles (Cerastoderma glaucum)

Mussels and cockles are both very important commercial species within the Wash and in recent years have suffered badly from over-exploitation. However, these two species are the subject of other extensive studies collating data on past and present distribution and abundance. It was therefore agreed that these species be omitted from the study.

Annex 2. List of major surveys carried out in the Wash and along the North Norfolk and Lincolnshire coasts.

1. 2000-2001. Studies on *Sabellaria spinulosa* using remote acoustic techniques, grabs and video.
References:
Foster-Smith and White 2001

2. 1998-1999. Surveys of Wash intertidal sediments and macro-invertebrates carried out by CEH (ITE) for EN. Sites along line transects all round the Wash. Over 100 sites mostly re-visiting sites previously sampled by ITE in 1986.
References:
Yates et al (2002)
Goss-Custard et al (1988)

3. 1996-1999. BMP project (broadscale mapping) in1996-1997. Video, grabs and trawls to ground truth acoustic maps (ie sample stations were chosen to investigate different acoustic ground types).
References:
Foster-Smith et al (1997).
Foster-Smith and Sotheran (1999).

4. 1991-1993. NRA survey based on grab samples taken on a regular grid. Carried out by Unicomarine. Macro-invertebrate samples analyzed. Wash zone report
References:
NRA (1994).
Bailey et al 2001

5. 1999. Ecomaris Ltd. Subtidal benthos surveys in the Wash for EA. Benthic grab samples on a regular grid at the same sites as the EA 1991 and 1993 surveys.
Bailey et al 2001
Whyte 2001

6. 1993. JNCC MNCR survey 459 Intertidal Brancaster to Blakeney . 35 sites surveyed.
References:
Hill et al 1996 (summary)
MNCR database

7. Date? JNCC MNCR survey 689 Intertidal Hunstanton to Brancaster sediments. 5 sites.

8. 1987. Intertidal survey of chalk shores of North Norfolk and Flamborough Head carried out by the Natural History Museum, London for NCC
References:
George et al 1988

9. 1985-1986. NCC CSD sublittoral surveys of the Wash using divers, grabs, dredges and trawls on irregular grid.
References:
Dipper et al (1989).
Dipper (1983)

10. 1981. NCC survey of shores of Lincolnshire and East Anglia. Basic survey plus literature review
References:
Probert 1981

11. 1976. NERC & Central Water Planning Unit survey of Wash shores for feasibility study to assess the likely impact of freshwater storage reservoirs.
NERC 1976

Annex 3. References and Bibliography.

All references cited in the text plus all references consulted are included. A small number of references that were not consulted are also included, as they may be useful in further studies. These are marked with an asterisk (*).

ALDOUS, J.R., 1987. The commercial sea fisheries in the Wash. In*: P.Doody & B.Barnett*, eds. The Wash and its environment, 93-96. Peterborough, Nature Conservancy Council.

Anon 2000. Wash & North Norfolk Coast European marine site: English Nature's advice given under Regulation 33(2) of the Conservation (Natural Habitats etc) Regulations 1994. Peterborough: English Nature.

Anon 1999. UK Biodiversity Group. Tranche 2 Action Plans. English Nature for the UK Biodiversity group, Peterborough.

BAILEY, M. 2001. Long term biological monitoring in the Great Ouse estuary. *Porcupine Marine Natural History Society Newsletter* **9**, pp. 29-33.

BAILEY, M., BAMBER, R.N., COAD, P. and WHYTE, S.G. 2001. *Analysis of sublittoral benthic samples from the Wash Estuary 1991-1999*. Contract report by Ecomaris Ltd. For the Environment Agency, Anglia Region.

BAMBER, R., BATTEN and BRIDGEWATER 1990. The brackish ponds at Killingholme. Unpublished (TEC/L/0288/R90)

BAMBER, R.N. 1997. Assessment of saline lagoons within Special Areas of Conservation. Peterborough: *English Nature Reports* No. 235 Contractor: Fawley Aquatic Research Laboratories Ltd.

BAMBER, R.N. and BARNES, R.S.K. 1995. Chapter 3.4 Coastal lagoons. *In*: J.H. BARNE *et al, eds.Coasts and seas of the United Kingdom. Region 6 Eastern England: Flamborough Head to Great Yarmouth.* Peterborough: Joint Nature Conservation Committee.

BANNISTER, R.C.A. 1978. Changes in plaice stocks and plaice fisheries in the North Sea. *Rapp.P.-V.Reun.CIEM* **172,** pp. 86-101.

BARNES, R.S.K. 1985. Coastal saline lagoons of East Anglia, U.K. (Contractor: University of Cambridge, Department of Zoology, Cambridge.) *Nature Conservancy Council CSD Reports*, No. 600.

BARNES, R.S.K. 1987. Coastal lagoons of East Anglia, UK. *J Coast. Res.* **3**(4), pp. 417-427.

BARNES, R.S.K. 1988. The coastal lagoons of Britain: an overview. (Contractor: University of Cambridge, Dept. Zoology). *Nature Conservancy Council, CSD Reports* No. 933.

BARNES, R.S.K. 2000. Saline lagoon invertebrate surveys, Havergate, Titchwell and Snettisham. August/September 2000. Unpublished report to RSPB.

BIRD, E.C.F. & WAIN, J. (1963). Changes at Blakeney Point since 1953. *Transactions of the Norfolk and Norwich Naturalists' Society* **20**, 1-?

BLOOMFIELD, E.N. 1908. Fauna and flora of Norfolk. Additions to Part 10: marine algae. *Transactions of the Norfolk and Norwich Naturalists' Society*, **8,** pp**.** 809.

BODDEKE, R. 1983. The life cycle of the brown shrimp and the Dutch shrimp fisheries. Biological research, Marine Fishery, Haringkade 1, Ijmuiden, Holland (Paper presented at the Walne Memorial lecture for 1983).

BROGDEN 1899. Fishes of the Lincolnshire Wash and Fenland. *Naturalist*, **24**, pp.357.

BUCKLAND, F. 1875. Report on the fisheries of Norfolk, especially crabs, lobsters, herrings and the Broads. Ordered by The House of Commons to be printed 11 August 1875.

*BUTCHER, R.W. 1933. Report on the present condition of eelgrass on the coasts of England. MAFF report.

*BUTCHER, R.W. 1934. On the present distribution of *Zostera marina* in England. *J. du Conseil Perm. Explor. Mer* **9**, pp. 45-65.

*CHERRILL, A.J. and JAMES, R. 1985. The distribution and habitat preferences of four species of Hydrobiidae in East Anglia. *Journal of Conchology*, **32**, pp. 123-133.

CLARKE, B. 2002. *Marine Conservation Society Good Fish Guide*. Ross-on-Wye: Marine Conservation Society.

Collins, K.J. ans Jensen, A. C. (1996). Artificial Reefs. *In*: C.P. SUMMERHAYES and S.A. THORPE eds. *Oceanography. An Illustrated Guide.* London: Manson Publishing.

COULL, K.A., JOHNSTONE, R., and ROGERS, S.I. 1998. *Fisheries Sensitivity Maps in British Waters*. Published and distributed by UKOOA Ltd. (on CEFAS website).

DAVIDSON, D.M., 1997a. The genus *Zostera* in the UK: A literature review identifying key conservation, management and monitoring requirements. Report to the Environment & Heritage Service, D.O.E. (N.I.), Belfast.

DIPPER, F. 1983. Preliminary one day sublittoral survey of the Wash by diving and dredging. *Nature Conservancy Council CSD Report,* No. 474.

DIPPER, F.A., IRVING, R.A. and FOWLER, S.L. 1989. Sublittoral survey of the Wash by diving and dredging (1985 &1986). *Nature Conservancy Council CSD ReportS* No. 976.

DOODY, P. 1984. *Spartina* on the east coast of England. *In*: P. DOODY Ed. *Spartina anglica* in Great Britain. *Nature Conservancy Council Focus on Nature Conservation Report* No. 5.

DOODY, J.P., JOHNSTON, C. and SMITH, B. eds. 1993. *Directory of the North Sea coastal margin.* Peterborough*:* Joint Nature Conservation Committee.

DOODY, P. & BARNETT, B. eds. 1987. *The Wash and its environment. Report of a conference held on 8-10th April 1987 at Horncastle, Lincolnshire*. Peterborough: *Nature Conservancy Council Research and Survey in Nature Conservation,* No. 7.

DOWNIE, A.J. 1996. Saline lagoons and lagoon-like ponds in England: an update of the lagoons and lagoon-like sites recommended for conservation. Peterborough: *English Nature Science report* No. 29.

DYER, M. & GRIST, N. 1987. The ecology of the Great Ouse and Nene estuaries. *In*: P. DOODY & B. BARNETT EDS. *The Wash and its environment,* 138-147. Peterborough: Nature Conservancy Council Research and Survey in Nature Conservation, No. 7.

Dyer, M.F. & Grist, N.C. 1986. *Great Ouse estuary ecological study II. Biological surveys*. (Contractor: University of Hull, Institute of Estuarine and Coastal Studies, Hull.) Unpublished report to the Water Research Centre Environment.

EARLL, R.C. ed. 2001. Shellfish and bird populations in the Wash - population declines in the 1990s. Review of the research and proceedings of the Wash Forum conference. Wash Forum, 63pp.

EASTERN SEA FISHERIES JOINT COMMITTEE (undated). *Whelks*. Landings & Reports from ESFJC Files 1974-1991. Unpublished report.

EASTERN SEA FISHERIES JOINT COMMITTEE (1993, 1994, 1995). Brown shrimp (*Crangon crangon*) research in the Wash. Research reports 1993, 1994, 1995.

EASTERN SEA FISHERIES JOINT COMMITTEE (1952-1978;1985-1994; 1998; 2001). Annual Reports.

ENO, C., CLARK, A. & SANDERSON, W.G. 1997. *Non-native marine species in British waters: a review and directory*. Peterborough: Joint Nature Conservation Committee.

ENVIRONMENT AGENCY 1997. The status of the smelt in the Great Ouse and North West Norfolk rivers. Unpublished report.

FOSTER-SMITH, R.L., SOTHERAN, I. & WALTON, R. 1997. Broadscale mapping of habitats and biota of the sublittoral seabed of the Wash. Final report of the 1996 Broadscale Mapping Project survey. Peterborough: *English Nature Research Reports* No. 238

FOSTER-SMITH, R.L. & SOTHERAN, I. 1999. Broadscale remote survey and mapping of sublittoral habitats and biota of the Wash and the Lincolnshire and the North Norfolk coasts. Peterborough: E*nglish Nature Research Reports* No. 336.

FOWLER, S.L. 1987. The sublittoral ecology of the Wash basin. *In*: P. DOODY & B. BARNETT Eds. *The Wash and its environment*, pp. 148-153. Peterborough: Nature Conservancy Council Research and Survey in Nature Conservation, No. 7.

FOWLER, S.L. 1992. Survey of bait collection in Britain. Peterborough: *Joint Nature Conservation Committee Report* No 107.

FOWLER, S.L. 1999. *Guidelines for managing the collection of bait and other shoreline animals within UK European marine sites*. Prepared for the UK Marine SACs Project. Published on www.ukmarinesac.org

FOWLER, S.L., REED, T.M. & DIPPER, F.A. 2002. Elasmobranch biodiversity, conservation and management. Proceedings of the international seminar and workshop, Sabah, Malaysia, July 1997. *Occasional Paper of the IUCN Species Survival Commission* No.25. 258pp

FRID, C.L.J. 1988. The marine fauna of the north Norfolk saltmarshes and their ecology. *Transactions of the Norfolk and Norwich Naturalists' Society*, **28**(1): 46-50.

FRID, C.L.J. 1989. A preliminary survey of the sublittoral chalk reefs of North Norfolk. *Transactions of the Norfolk and Norwich Naturalists' Society*, **28**(3): 243-246.

FRID, C.L.J. 1987. The sublittoral chalk reefs of North Norfolk: a preliminary survey. Contractor - University of East Anglia. *Nature Conservancy Council CSD Report* No. 789.

GEORGE, J.D. & PLATT, H.M. 1988. Benthic communities and the crab fishery of north Norfolk. (Contractor: British Museum (Natural History), London.) Unpublished report to Anglian Water Authority.

GEORGE, J.D., FINCHAM, A.A., TITTLEY, I and PRICE J.H. 1988. The macrobenthos of chalk shores in North Norfolk and around Flamborough Head (North Humberside). Contractor British Museum (Natural History). *Nature Conservancy Council CSD Report* No. 833

GILLILAND, P.M. and SANDERSON, W.G. 2000. Re-evaluation of marine benthic species of nature conservation importance: a new perspective on certain 'lagoon specialists' with particular emphasis on *Alkmaria romijni* Horst (Polychaeta:Ampharitidae). *Aquatic Conservation:Marine and Freshwater Ecosystems* **10**, pp. 1-12.

GOSS-CUSTARD, J.D., YATES, M.G. *et al*. 1988. Wash birds and invertebrates. (Contractor: ITE) Unpublished report to DoE and NCC. Vol 1 & Vol 2

*GOULD, D.J., DYER, M.F., STARKE, G.T.C.S. & COOPER, V.A. 1986. The Great Ouse estuary ecological study. III. The status of the fisheries of the Wash and Great Ouse estuary. Unpublished, Water Research CeNtre Environment. (Report No. 1077-M/1/EV/8511)

GRAHAM, N. 1996. Reduction of by-catch in the brown shrimp (*Crangon crangon*) fisheries of the Wash and Humber Estuary. University of Humberside, School of Applied Science and Technology. (Quoted in ESFJC research report 1996).

*GRAY, A.J. (1977). Further ecological studies on the Wash. Progress report on the first year's rsearch (March 1976-March 1977). Compiled from reports by S. McGorty, S.M. Coles and R. Scott. Unpublished, ITE.

*GRAY, A.J. (1977). Further ecological studies on the Wash. Final report. (Research March 1976-March 1978). (Contractor: ITE). Unpublished report to Central Water Planning Unit.

GURNEY, R. (1923). A sea anemone (*Sagartia luciae* Verrill) in brackish water in Norfolk. *Transactions of the Norfolk & Norwich Naturalist's Society*, **11**, pp. 434-437. *(=Haliplanella lineata; summarised in Probert 1981. No mention of any interest species.)*

HAMOND, R. 1957. Notes on the hydrozoa of the Norfolk coast. *J. Linn. Soc. London (Zool)*, **43,** pp. 294-234

*HAMOND, R. 1961. Marine fauna in Norwich and its region. Jarrold & Sons, Norwich.

*HAMOND, R. 1962. On some Polychaeta from the coast of Norfolk. *Annals and Magazine of Natural History.Ser13*, **5**, pp. 567-576.

HAMOND, R. 1963. A preliminary report on the marine fauna of the North Norfolk coast. *Transactions of the Norfolk and Norwich Naturalists' Society*, **20** (1), pp. 2-31.

*HAMOND, R. 1963. Further notes on the Hydrozoa of the Norfolk coast. *Annual Magazine of Natural History*, **13**, pp. 659-670.

*HAMOND, R. 1965. On some amphipods from the coast of Norfolk. *J Mar. Biol. Ass. UK* **45**, p.153

*HAMOND, R. 1966. The Polychaeta of the coast of Norfolk. *Cahiers de Biologie Marine*, **7**, pp. 383-436.

*HAMOND, R. 1967. The Amphipoda of Norfolk. *Cahiers de Biologie Marine*, **8**, 113-152.

HAMOND, R. 1969. On the Norfolk marine area and the offshore stations worked within it. *Transactions of the Norfolk and Norwich Naturalists' Society*, **21**, pp. 209-228.

HAMOND, R. 1970. The leptostracan, euphausiid, stomatopod and decapod Crustacea of Norfolk. *Transactions of the Norfolk and Norwich Naturalists' Society*, **22** (2), pp. 90-112.

HAMOND, R. 1971. The marine protozoa, mesozoa and Porifera of Norfolk. *Transactions of the Norfolk and Norwich Naturalists' Society*, **22**, pp. 83-89.

HAMOND, R. (1972). The marine mollusca of Norfolk. Transactions of the Norfolk and Norwich Naturalists' Society, 22(4), 271-306

HAMOND, R. 1991. The echinoderms of Norfolk. *Transactions of the Norfolk and Norwich Naturalists' Society*, **29**(1), pp. 33-51.

HAMOND, R. 1997. The Cirripedia, Branchiura and Cladocera of Norfolk. *Transactions of the Norfolk and Norwich Naturalists' Society*, **31**(1), pp.52-62.

HAMOND, R. and WILLIAMS, R.B. 1977. The Ctenophora, Scyphozoa and Anthozoa of Norfolk, with additional notes on the Hydrozoa. *Transactions of the Norfolk and Norwich Naturalists' Society*, **24**, pp. 58-74.

HARMER, F.W. 1872. The marine mollusca of the Norfolk coast. *Transactions of the Norfolk and Norwich Naturalists' Society*, 1871 -2, pp. 42-46.

HART, T.J. 1930. Notes on the Crustacea Malacostraca of the region round Blakeney Point, Norfolk. *Transactions of the Norfolk and Norwich Naturalists' Society* **13** (1) pp. 25-34.

HILL, M.I. 1988. Saltmarsh vegetation in the Wash. An assessment of change from 1971 to 1985. *Research and survey in Nature Conservation* No. **13**. Peterborough:Nature Conservancy Council.

HILL, T.O., EMBLOW, C.S. & NORTHERN, K.O. 1996. Marine Nature Conservation Review Sector 6. Inlets in eastern England:area summaries. Peterborough: Joint Nature Conservation Committee. (Coasts and seas of the United Kingdom, MNCR series.)

HISCOCK, K., ed. 1998. Marine Nature Conservation Review. Benthic marine ecosystems of Great Britain and the north-east Atlantic. Peterborough: Joint Nature Conservation Committee. (Coasts and Seas of the United Kingdom. MNCR series.) Chapter 6: Eastern England (Bridlington to Folkstone).

HOWES, C.A. and KIRK, B. R. 1991. A review of the smelt (*Osmerus eperlanus* L.) in the Humber and Tees estuaries, their tidal tributaries and the tidal waters of Lincolnshire. *Naturalist* **116**, pp. 27-32.

HUME, R. 2003. Titchwell. *RSPB Birds Magazine* Spring 2003, pp. 80-86.

HUNT, O.D. 1971. Holkham Salts Hole, an isolated salt-water pond with relict features. An account based on studies by the late C.F.A. Pantin. *J. Mar. Biol. Ass. U.K.* **51**, pp. 717-741.

*INGLIS, C.C. and KESNER, F.J.T. 1958. Changes in the Wash as affected by training walls and reclamation works. Institution of Civil Engineers. Proceedings **11**, pp. 435-466.

IRVING, R. 1987. A survey of coastal saline lagoons: Boston Haven to the River Nene, Lincolnshire, 1987. Field report. (Contractor: R. Irving). *Nature Conservancy Council CSD Report*, No.761.

JACKSON, A. 2001. *Ostrea edulis*. Native oyster. Marine Life Information Network:Biology and Sensitivity Key Information Sub-programme (on-line). Plymouth:Marine Biological Association of the United Kingdom. www.marlin.ac.uk

JACKSON (2002). *Littorina littorea*. Common periwinkle. Marine Life Information Network:Biology and Sensitivity Key Information Sub-programme (on-line). Plymouth:Marine Biological Association of the United Kingdom. www.marlin.ac.uk

JACKSON, D.L. and McLEOD, C.R. (eds.) 2002. Handbook on the status of EC Habitats Directive interest features: provisional data on the UK distribution and extent of Annex I habitats and the UK distribution and population size of Annex II species. Version 2. *JNCC Report* No. 312. www.jncc.gov.uk/publications/JNCC312

JOHNSON, P.O. 1970. The Wash sprat fishery. *Fishery Investigations, Series II*: **26**, pp. 1-77 (Pt 4)

KURLANSKY, M. 1997. *Cod. A biography of the fish that changed the world.* London: Vintage.

LEE, A.J. and RAMSTER, J.W. (eds.) 1981. *Atlas of the Seas around the British Isles*. MAFF.

LOWE, J. 1884. Fauna and flora of Norfolk (additions to part IV Fishes). *Transactions of the Norfolk and Norwich Naturalists' Society* **3**(5), pp.677-682.

LOWE, J. 1894. Fauna of Norfolk - Fishes. *Transactions of the Norfolk and Norwich Naturalists' Society* **5**(5), pp. 634-642.

LOWE, J. 1899. Fauna and flora of Norfolk - Fishes. *Transactions of the Norfolk and Norwich Naturalists' Society* **6**(5), pp. 495-500.

MACER, C.T. and EASEY, M.W. 1988. The North Sea cod and the English Fishery. *MAFF Laboratory Leaflet* No 61, Lowestoft.

MAITLAND, P.S. and CAMBELL R.N. 1992. *Freshwater Fishes*. London:Harper Collins.

MILLNER, R.S. and WHITING, C.L. 1996. Long term changes in growth and population abundance of sole in the North Sea from 1940 to the present. *ICES Journal of Marine Science*, **53**, pp.1185-1195. (Abstract on CEFAS website).

MINISTRY AGRICULTURE FISHERIES & FOOD (1966). The Norfolk crab fishery. *MAFF Laboratory Leaflets (new series)* No. 12

MINISTRY AGRICULTURE FISHERIES & FOOD 1967. Whelks. *MAFF Laboratory Leaflets (new series)* No. 15

MINISTRY AGRICULTURE FISHERIES & FOOD 1987. The bass (*Dicentrarchus labrax*) and the management of its fishery in England and Wales. *MAFF Laboratory Leaflet* No. 59, Lowestoft.

MINISTRY AGRICULTURE FISHERIES & FOOD 1988. Cod - see Macer and Easey 1988

MNCR database. Survey No. 459 1993 MNCR littoral survey from Brancaster to Blakeney (data included in Hill *et al*. 1996)

NATIONAL RIVERS AUTHORITY 1994. Wash Zone report Part 1. A monitoring review. Unpublished, NRA, Anglian Region, Central Area.

NATIONAL RIVERS AUTHORITY 1994. Wash zone report Part 2.: Analysis of macroinvertebrate samples from a survey of the Wash in August 1991. Report prepared for the NRA, Peterborough by Unicomarine Ltd.

NATURAL ENVIRONMENT RESEARCH COUNCIL 1969. The ecology of the Wash and the implications of the proposed barrage schemes. NERC: unpublished report.

NATURAL ENVIRONMENT RESEARCH COUNCIL (1975). Saltmarshes. See Randerson 1975.

NATURAL ENVIRONMENT RESEARCH COUNCIL 1976. The ecology of the Wash. A report of studies undertaken as part of a feasilbility study of the proposals to construct reservoirs of fresh water storage in the Wash. *NERC publications series C* No. 15.

NATURAL ENVIRONMENT RESEARCH COUNCIL 1998. UKDMAP. Third Edition July 1998. An atlas of the seas around the British Isles. (CDROM).

NATURE CONSERVANCY COUNCIL 1976. The Wash Water Storage Scheme feasibility study. Report on the ecological studies: Part III - Conservation implications and recommendations. (Contractor: NCC). Unpublished report to Central Water Planning Unit.

*NEWAN, L.F. and WALWORTH, G. 1919. A preliminary note on the ecology of part of the south Lincolnshire coast. *Journal of Ecology* **7**, pp. 204-210.

NICHOLS, J. 2001. Saving North Sea herring. Publications section CEFAS web site www.cefas.co.uk

*PANTIN, C.F.A., HOLLICK, F.S.J., JOYSEY, K.A. and BIDDER, A.M. 1960. The marine invertebrate fauna. In: J.A. STEERS ed. *Scolt Head Island*. (2nd ed.) Cambridge: W. Heffer and Sons.

PATTERSON, A. 1891. Some marine notes from Yarmouth. *Transactions of the Norfolk and Norwich Naturalists' Society* **5**(3), pp. 323-328.

PATTERSON, A. 1924. Fauna and flora of Norfolk - Fishes. *Transactions of the Norfolk and Norwich Naturalists' Society* **11**(5), pp. 592-600.

PATTERSON, A. 1897. The marine and fresh-water fishes of Great Yarmouth and its neighbouring coasts, rivers and broads. *Zoologist, 4th series*, **1**, pp. 539-567.

PERRINS, J. and BUNKER, F. 1998. Biotope survey of the littoral sediments of the N. Norfolk coast candidate SAC. *English Nature Research Reports* No. 285

PICTON, B.E. and MORROW, C.C. 1994. *A Field Guide to the Nudibranchs of the British Isles.* London:Immel Publishing.

PICKETT, G.D. *et al.* (1995). An appraisal of the UK bass fishery and its management. *MAFF Laboratory Leaflet* No. 75.

POTTS, G.W. and SWABY, S.E. 1993. Review of the status of estuarine fishes. Final report to English Nature (Being an assessment of the fishes of 22 estuaries and coastal ecosystems carried out between December 1992 and February 1993). *English Nature Research reports* No. 34.

PROBERT, P.K. 1981. Report on the shores of Lincolnshire and East Anglia. A biological survey of the littoral zone. Unpublished, NCC. (Internal Report).

*RANDERSON, P.F. 1975. The saltmarshes of the Wash. Wash Feasibility Study Ecological Report Scientific Study D. Natural Environment Research Council.

*REVILL A. 1998. The biological and economic impacts of discarding by the UK (East coast) brown shrimp fishing fleet – Executive Summary. University of Lincolnshire and Humberside (Grimsby).

RIESEN, W. and REISE, K. 1982. Macrobenthos of the subtidal Wadden Sea: revisited after 55 years. *Helgolander Meeresuntersuchungen*, **35**, pp. 409-423.

ROBERTSON, J.A. 1938. The sprat and sprat fishery of England. *Fishery Investigations London Ser. 2*, **16**(2) 103pp.

ROGERS, S.I., MILLNER, R.S. and MEAD, T.A. 1998. The distribution and abundance of young fish on the east and south coasts of England (1981 to 1997). *Sci.Ser., Tech. Rep.*, CEFAS, Lowestoft, (108), 130pp. (Downloaded from CEFAS web site).

SANDERSON,W.G. 1995. Chapter 5.4. Rare seabed species. *In:* J.H. BARNE, S.S. KAZNOWSKA, J.P. DOODY, N.C. DAVIDSON *eds. Coasts and seas of the United Kingdom. Region 6 Eastern England:Flamborough Head to Great Yarmouth*, pp. 91-93. Peterborough: Joint Nature Conservation Committee.

SHEADER M. and SHEADER, A. 1985. New distribution records for *Gammarus insensibilis* Stock, 1966 in Britain. *Crustaceana* **49,** pp. 101-105.

SHEADER, M. and SHEADER, A. 1985. A survey of coastal saline lagoons. North Humberside to Tyneside, 1985: Final report. (Contractor: University of Southampton, Dept. Oceanography, Southampton). *Nature Conservancy Council CSD Report* No 753.

SHEADER, M. and SHEADER, A. 1986. A survey of brackish coastal lagoons. South Humberside to Boston Haven, Lincs. Final report. (Contractor: University of Southampton, Dept. Oceanography, Southampton). *Nature Conservancy Council CSD Report* No 812.

SHEADER, M. and SHEADER, A. 1987. The distribution of the lagoonal amphipod *Gammarus insensibilis* Stock in England. *Porcupine Newsletter* **3** (No 9) , 220-223 (old series)

SHEADER, M. and SHEADER, A. 1989. Coastal saline ponds of England and Wales:an overview. Peterborough: *Nature Conservancy Council CSD Report No. 1009*.

SHEADER, M., SUWAILEM, A.M. and ROWE, G.A. 1997. The anemone, Nematostells vectensis, in Britain: considerations for conservation management. *Aquatic Conservation: Marine and Freshwater Ecosystems*, **7**, 13-25.

SMITH, A. 1915. The fishes of Lincolnshire. *Transactions of the Lincolnshire Naturalist's Union* **3**, pp. 239-256.

SMITH, A. 1919. Lincolnshire Crustacea. *Transactions of the Lincolnshire Naturalist's Union* **5**, pp. 42.

SMITH, A. 1919. Marine shells of the Lincolnshire coast. *Transactions of the Lincolnshire Naturalist's Union* **5**, pp. 63-78.

SMITH, B.P. and LAFFOLEY, D. 1992. Saline lagoons and lagoon-like habitats in England. Ist ed. *English Nature Science* No. 6. Peterborough: English Nature.

SOUTHWELL, T. 1887. On the smelt fishery in Norfolk waters. *Transactions of the Norfolk and Norwich Naturalists' Society* **4**(3), pp. 338-343.

SOUTHWELL, T. 1888. Further notes on the smelt fishery in Norfolk waters. *Transactions of the Norfolk and Norwich Naturalists' Society* **4**(4), pp. 481-486.

SOUTHWELL, T. 1904. Fauna and flora of Norfolk - Fishes. *Transactions of the Norfolk and Norwich Naturalists' Society* **7**(5), pp. 741-

WARREN, P.J. 1973. The fishery for the pink shrimp Pandalus montagui in the Wash. Lowestoft: *MAFF Laboratory Leaflet (New Series)* No 28.

WHEELER, A. 197). *Key to the Fishes of Northern Europe*. London: Frederick Warne.

WHITE, N. 2002. *Alkmaria romijni.* Tentacled lagoon worm. MarLin:Biology & Sensitivity Key Information Sub-Programme (on-line). Plymouth:MBA UK www.marlin.ac.uk

WHYTE, S. 2001. Subtidal benthic surveys of the Wash in the 1990s. *Porcupine Marine Natural History Society Newsletter*, **9,** November 2001, pp. 33-37.

WILLIAMS, R.B. 1972. Notes on the history and invertebrate fauna of a poikilohaline lagoon in Norfolk. *Journal Marine Biological Association U.K.*, **52**, pp. 945-963.

WILLIAMS, R.B. 1973. The significance of saline lagoons as refuges for rare species. *Transactions of the Norfolk and Norwich Naturalists' Society*, **22**, pp. 387-392.

WILLIAMS, R.B. 1975. A redescription of the brackish-water sea anemone Nematostella vectensis, with an appraisal of congeneric species. J*ournal Natural History*, **9**, pp. 51-64.

WILLIAMS, R.B. 1976. Conservation of the sea anemone *Nematostella vectensis* in Norfolk, England and its world distribution. *Transactions of the Norfolk and Norwich Naturalists' Society*, **23**, pp. 257-266.

WILLIAMS, R.B. 1983. Starlet sea anemone: *Nematostella vectensis* Stephenson, 1935. *In*: The IUCN invertebrate red data book pp. 43-46.

WILLIAMS, R.B. 1987. The current status of the sea anemone *Nematostella vectensis* in England. *Transactions of the Norfolk and Norwich Naturalists' Society*, **27**(5), pp. 371-374.

WILLIAMS, R.B. 1988. The current status of the sea anemone *Nematostella vectensis* in England - A correction. *Transactions of the Norfolk and Norwich Naturalists' Society*, **28**(1), pp. 51-61.

WILLIAMS, R.B. and BEALE, C.J. 1977. A note on Holkham lake, Norfolk. *Transactions of the Norfolk and Norwich Naturalists' Society*, **24**, pp. 83-84.

*YATES, M.G. *et al*. (1998). Environmental assessment of increased Ely Ouse abstraction: final report Vol 2. 1996-97 surveys of sediment, invertebrates and birds. Report to Binnie, Black and Veatch for Essex and Suffolk Water. 60 pp.

*YATES, M.G. *et al.* 1993. Sediment characteristics, invertebrate densities and shorebird densities on the inner banks of the Wash. *Journal of Applied Ecology*, **30**, pp. 599-614.

YATES, M.G. *et al*. (2002). Littoral sediments of the Wash and North Norfolk Coast SAC: The 1998 and 1999 surveys of intertidal sediment and invertebrates. *English Nature Research Reports* No. 470. Peterborough: English Nature.

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Bottom left: Radio tracking a hare on Pawlett Hams, Somerset.
Paul Glendell/English Nature 23,020
Main: Identifying moths caught in a moth trap at Ham Wall NNR, Somerset.
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