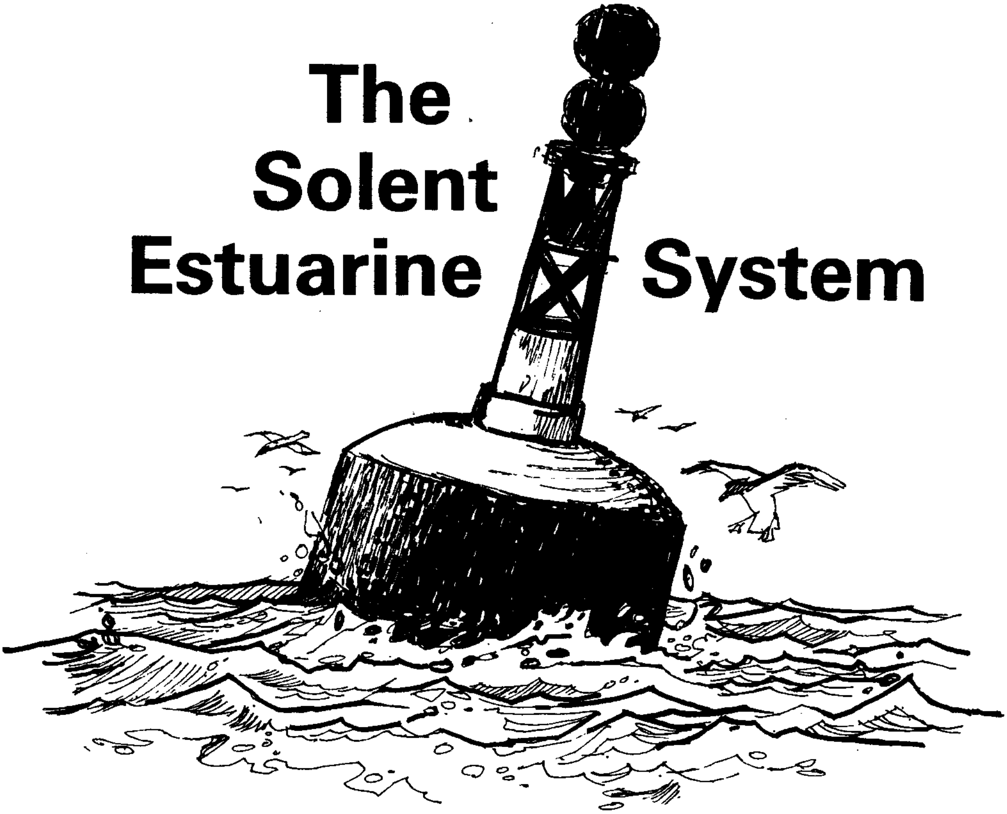
The Solent Estuarine System



An Assessment of Present Knowledge

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THE SOLENT ESTUARINE SYSTEM

Contents

PREFACE

This review of the Solent is the fifth in a series on major UK estuarine systems to be published by the Natural Environment Research Council. Its preparation is the result of an initiative by Dr J. D. Burton of the Oceanography Department, Southampton University, following several meetings of an *ad hoc* group of scientists with active interests in the region. I am pleased to acknowledge the valuable role played by Dr Burton in suggesting the composition of the review and acting as local editor.

Geographically, the text covers the Solent proper, Spithead, Southampton Water, the harbours of Portsmouth, Langstone and Chichester, as well as the major estuaries entering the system. The individual contributions range widely across the physical and biological sciences and provide an up-to-date assessment of the scientific knowledge of the area. The review represents the first attempt to draw together information on such a diversity of subjects since the *Survey of Southampton and Its Region* was published by Southampton University Press for the British Association for the Advancement of Science in 1964. In fact, this volume still provides useful and valid information on several topics which it has not been possible to include in the present review. This is particularly true for the sections on weather and climate and on the zooplankton of Southampton Water.

The format for this review of the Solent is slightly different to that for the previous publications in the series in that the contributors have, in general, gone into greater detail and in some cases provided extensive information which has not appeared elsewhere. It is to be hoped that this publication will be of use to the scientific community and to all with an interest in the Solent, and will serve to identify some of the gaps in our knowledge of this most important estuarine system.

R. J. H. Beverton
Secretary of Council

Satellite photograph of the Solent Estuarine System, taken by Landsat 2 on 23 September 1978.

PROCESSES AND IMPACTS IN THE SOLENT

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Introduction

The modern conformation of the Solent is derived from the postglacial transgression of the sea into the Tertiary and Quaternary 'Solent River' system. It has been postulated that this system flowed eastwards along the modern bed of the Solent and its present day remnants are represented by the rivers Frome, Avon, Stour, Test, Itchen, Hamble, Meon, Medina, Eastern Yar and Western Yar. The postglacial transgression separated the Isle of Wight from the mainland and drowned the lower reaches of the tributary streams. Where these had flowed in confined valleys, the narrow estuaries of the Keyhaven, Lymington, Beaulieu, Test, Hamble, Yar and Medina and Wootton Creek were formed. Where the streams flowed in broad, unconfined valleys, the extensive complex intertidal basins of Portsmouth, Langstone, Chichester, Brading and Newtown Harbours resulted. The margins of Portsmouth, Langstone and Chichester Harbours were extended by subsequent wave attack to form cliffs up to four metres high although where historically recent reclamation has occurred, these are now replaced at the harbour margins by sea walls. The three harbours are essentially a single biological system comprising connected tidal basins that are drained at low water by systems of channels which unite in each case to form narrow, common exits to the Solent.

The approximate areas of the main intertidal sediments in the Solent are given in Table 1. Those sediments accumulated in the estuaries and harbours mainly comprise fine silts and organic matter which may be up to eight metres deep in places on the upper shore. Their upward growth has been locally assisted by the formation of mixed saltmarsh and, more widely, by the rapid growth of *Spartina* marshes since the late nineteenth century. However, over the surface of some mudflats, angular flint gravel occurs and similar material outcrops along channel and creek beds and as beaches at high water mark. There are probably also extensive subsurface spreads beneath the superficial muds. More exposed beaches lacking the protection of a wide intertidal zone tend to be dominated by washed flint pebble, and the bed of the Solent in the littoral zone includes extensive deposits of similar material interspersed with clays and sands. The longshore drift tends to form shingle spits across estuary and harbour mouths as at Hurst, Calshot and Needs Ore Spits. At the harbour mouths, the strong currents resulting from the incursion and exit of large volumes of water deflect the spits into the harbours. In Chichester and Langstone Harbours these are of sand on the eastern side of the inlets and shingle on the west, whilst outside the harbour entrances there is a similar disposition of sand and shingle bars which are submerged at high sea. Hurst Spit is still migrating into the Solent and overwhelming the intertidal zone which it shelters, and the conformation of the others has changed significantly in historically recent times, probably at least partly in response to more general changes in the morphology of the intertidal area.

Mud is replaced by sands at more turbulent sites, the most extensive sandflats being off Ryde and Bembridge on the Isle of Wight shore, and around the mouths of Langstone and Chichester Harbours, where they include the extensive off-shore bank known as the East Winner.

Significant ecological and geomorphological changes have occured in the Solent in recent times and the most important and dramatic of these are outlined below.

Table 1: Approximate area of main intertidal sediments in the Solent

Type	*Area* (hectares)
Mudflats (with intermixed flint)	5465
Sandflats	729
Mixed saltmarsh	430
Spartina marsh	2470

Mixed saltmarsh accretion and erosion

As long as there is a net gain in the silt budget of an intertidal system, the level of the sediments will tend to rise until the point is reached where colonisation by saltmarsh plants occurs. Subsequent development of the marsh is aided by the ability of the plants to trap silt and by colonisation by plant communities characteristic of different elevations in the tidal range. Most of the Solent saltmarshes evidently developed during a period when the physical character of the Solent was somewhat different from today and most can perhaps be regarded as relict features.

The upper levels of the saltmarshes support a mixed plant community dominated by sea plantain, *Plantego maritima*, sea lavender, *Limonium vulgare*, sea meadow grass, *Puccinellia maritima*, sea purslane, *Halimione portulacoides* (which occurs in monospecific stands along the margins of internal drainage creeks) and locally thrift, *Armeria maritima*, and golden samphire, *Inula crithmoides*. At lower levels this grades into a *Halimione/Spartina/Salicornia* community, the *Spartina* having invaded the marshes since the end of the nineteenth century. The marshes terminate abruptly in mud cliffs up to two metres high and are subject to active wave erosion at high water except in the few localities where they are continuous with and protected by more recently developed *Spartina* marsh at a lower level in the tidal range.

There is abundant map evidence from which to demonstrate the general recession of the mixed saltmarshes in the Solent since the eighteenth century. In Langstone Harbour, for example, maps of 1600, 1716, 1773, the military survey of 1797-1810 on which the first Ordnance Survey was based, and the more recent Ordnance Surveys of the nineteenth and twentieth centuries, show that the area of saltmarsh has declined steadily, presumably through erosion, a process clearly discernible today. How long erosion had been going on prior to 1600 is conjectural, but it seems likely that saltmarsh development in Langstone Harbour and elsewhere was of considerable antiquity. The 48ha of saltmarshes that remain represent only relics of formerly extensive tracts which at their greatest extent probably occupied a large proportion of the upper, northern part of the harbour. Only the 80ha of mixed saltmarsh in the Western Yar estuary are known to be of recent origin. This marsh dates from the early nineteenth century and appears to have been caused by the construction of a breakwater and roadbridge across the estuary mouth. However, the Yar saltmarshes are also now subject to erosion of their terminal cliffs.

Spartina marsh development and recession

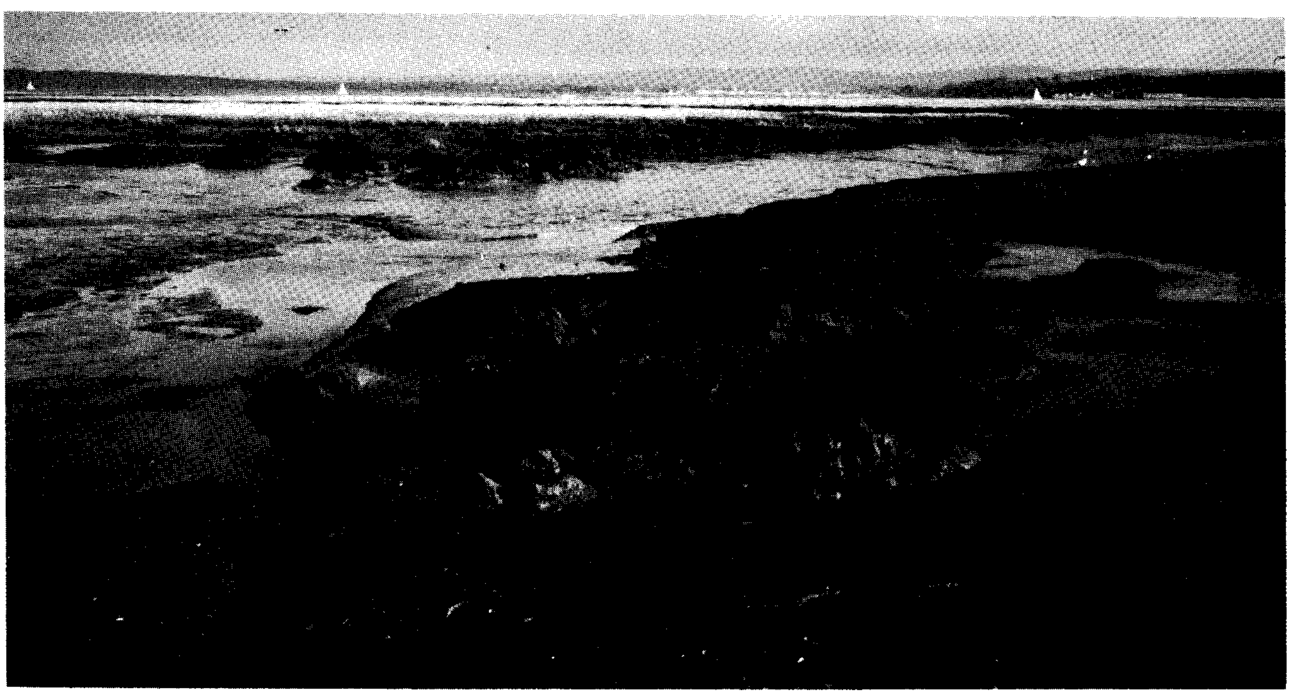
The *Spartina* marshes date from the late ninteenth century. The origins of the invasive forms of *Spartina* lie in the hybridisation of the native *Spartina maritima* with a North American species, *S. alterniflora,* which was accidentally introduced into Southampton Water in the second half of the nineteenth century. Male sterile *S. towsendii* was first recorded at Hythe in 1870. Subsequently a doubling of the chromosome number appears to have occurred to produce fertile tetraploid *S. anglica,* which proved to possess a remarkable capacity for colonising intertidal muds. The initial clumps gained a hold on level expanses of mud at a somewhat lower level in the tidal range than the existing saltmarshes, and thereafter spread to form continuous monospecific swards. Upward sediment accretion was rapid so that in maturity the marsh surface is elevated up to two metres above that of the mudflats, and the internal drainage systems comprise narrow, steep-sided creeks. *Spartina* marsh formation began in most of the estuaries and harbours of the Solent in the last decade of the nineteenth century, assisted by planting in the Beaulieu Estuary in 1898 and in Newtown Harbour as late as 1933 (Hubbard and Stebbings, 1967). Perraton (1953), who examined the saltmarshes of Langstone and Chichester Harbours, postulated a natural succession from bare mud, through *Spartina* to *Halimione/Spartina* marsh and finally to mixed saltmarsh, but it is evident from map evidence alone that the *Spartina* marshes have developed independently of or have invaded mixed saltmarsh of much earlier origin.

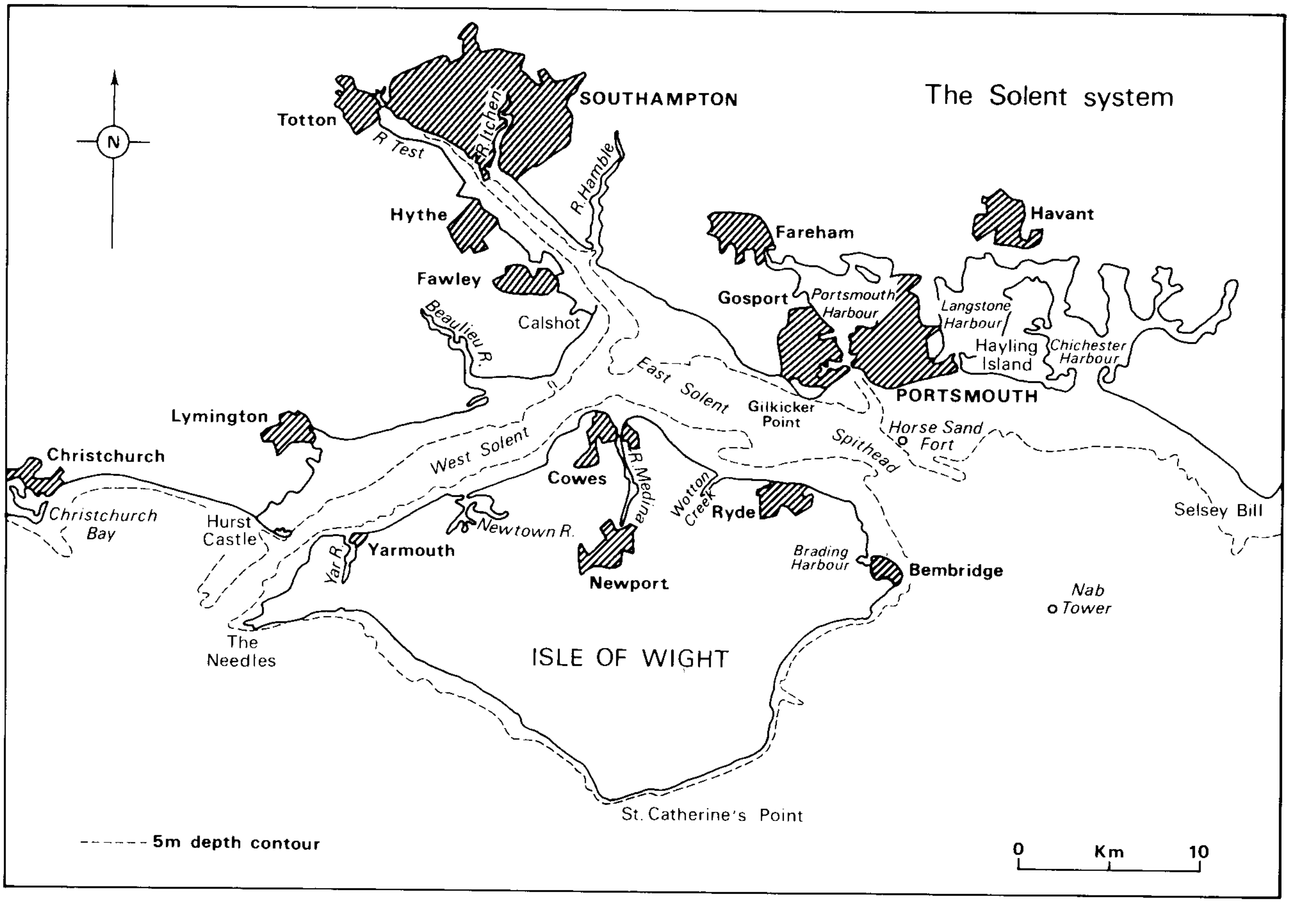
In the Solent, lateral and vertical growth of *Spartina* marsh has ceased. The *Spartina* plants are dying and other saltmarsh plants are failing to colonise successfully the resulting bare platforms of accreted mud which are thus slumping and eroding. Concurrently, the terminal cliffs of the marshes are subject to erosion by wave attack which in some very exposed sites (eg the mouth of the Beaulieu Estuary) is making dramatic incursions. In more sheltered sites the margins of the marshes have also become scarred by deep trenches which appear to be caused by run-off from the marsh surface. It is now difficult to reconstruct the chronology of die-back but it was occurring in the western Solent as long ago as the early 1950s and in Langstone Harbour by the early 1960s. Perraton (1953) clearly considered the marshes still to be invasive. Further west, in Poole Harbour, marsh recession may date from as early as the 1920s (Hubbard, 1965). The process of *Spartina* die-back is imperfectly understood but it has been suggested that it may be a result of progressively poorer aeration associated with decreasing particle size of the sediments accreting round the plants in the mature phase of marsh development (Goodman, 1959). However, it remains necessary to explain the rapid destruction of the marsh edges. In addition, there is no evidence for *Spartina* recolonisation of the lowered mud levels left after marsh break-up, and it is not inconceivable that further genetic changes in the *Spartina* population may be involved.

Changes in intertidal profiles

There is abundant evidence, mainly cartographic, that there has been a considerable net loss in the area of intertidal sediments in the Solent since at least the eighteenth century. Successive maps, commencing with the surveys carried out around the turn of the nineteenth century on which the first Ordnance Survey was based, show a progressively narrowing intertidal zone. Where earlier maps are available, it is possible to trace this process further back into the eighteenth century. The change is most apparent on the shores of the main body of the Solent. Along the northwest shore between Stone Point and Hurst Spit, the intertidal zone has been halved in width since the beginning of the nineteenth century. Although the change has been less dramatic in the

Eroded spartina *marsh*





harbours, low water channel widths have clearly increased. This is successively demonstrated for Newtown Harbour by the surveyor's drawings for the first Ordnance Survey made in the 1790s, the Tithe Map of 1840, the 1:10,560 OS surveyed in 1862-3, an estate map of 1885, the revised 1:10,560 map published in 1908, and the present edition of the OS. These collectively give a picture of the gradual drowning of the harbour and the nearby Solent foreshore sediments. The disappearance of the 'high muds' from the north shore of the Isle of Wight was described by Colenutt (1938), who recorded: "the gradual disappearance of the ..... high mud banks of soft silt which westwards of Quarr formerly clothed the foreshore down to low water mark".

Although no measurements are available to support the hypothesis, the narrowing of the intertidal zone has probably been accompanied by a lowering of the profile of the remaining muds and possibly by a change from a generally convex to a generally concave section. Certainly this is the impression derived from familiarity with the Solent since the early 1950s and it is supported by an examination of the toes of sea walls throughout the Solent which show that the sediment has been lowered by up to one metre during the life of the present structures. It is difficult to derive a chronology, however, since the dates of sea wall repairs are in most cases difficult to retrieve. Particularly marked changes appear to be occurring between Lymington and Keyhaven, where sediment loss since 1970 has in places been of the order of 0.5 m and the masonry footings of a seventeenth or eighteenth century salt works dock have been exposed. These must originally have been established at some depth in the sediment. A lowering of the intertidal profile would also accentuate cliffing at the margins of mixed saltmarsh and *Spartina* marsh alike and increase their vulnerability to wave attack. It is thus likely to be the proximate cause of the present phase of marsh retreat. The underlying cause of changes in the morphology of the intertidal zone is presumed to be a change in isostatic balance such as has been invoked by Kirby (1969) for similar phenomena in the Medway Estuary.

Nutrient enrichment

The Solent receives a large volume of sewage effluent, and nutrient enrichment has had observable effects on the ecology of some of the Solent's component intertidal systems. This has been most thoroughly investigated in Langstone Harbour (Dunn 1972, Portsmouth Polytechnic, 1976), where it has been shown that enhanced nutrient levels arising from increased effluent discharge since the 1950s have stimulated the growth of the green algae *Enteromorpha* and *Ulva.* The area of muds covered by algae has greatly increased. Many areas are anaerobic and support an impoverished infauna, although the weed blankets themselves support abundant animal life. However, these weed mats break up or become incorporated in the mud in autumn and winter and the fate of their fauna is unknown. The increased algal cover and its annual cycle of growth may have important implications for secondary consumers, especially birds, an aspect which has been considered by Tubbs (1977). The algae provide an important food resource for some species, notably Brent geese, *Branta bernicla,* but potentially may reduce the carrying capacity of the harbour for others, notably mud probing waders. Algal blanketing of muds since the late 1950s is also apparent in Portsmouth Harbour and locally in Chichester Harbour, and in both cases there is a clear correlation in location and time with increased discharges of sewage effluent. Dense blankets have also appeared since the early

1960s between Fawley and Calshot in Southampton Water, although here the explanation is less clear and no thorough investigation has been carried out.

The decline and recolonisation of Zostera

Eelgrasses (*Zostera* spp.) were reputedly abundant on the muds and in the shallow estuaries and intertidal channels of the Solent, until they were virtually wiped out in the 1930s when *Zostera* populations on both sides of the Atlantic were attacked by a disease associated with, if not caused by the mycetazoan *Labyrinthula*. Recolonisation of the Solent seems to have commenced from small residual populations in the early 1960s. *Zostera marina* beds which grow in a zone between low water neaps and a little below low water spring tides, now occur irregularly on firm, sandy substrates from Bembridge Ledges to Newtown Harbour on the northern shore of the Isle of Wight, and at Calshot on the mainland shore. Extensive beds of the smaller forms *Z. angustifolia* (or *Z. marina* var *angustifolia*) and *Z. noltii* have become established in Portsmouth, Langstone and Chichester Harbours. Recolonisation began first in about 1960 in Langstone Harbour, where there were relict beds. After 1968, the spread became very rapid and by 1977 the beds occupied about 470ha of mudflats. In Chichester Harbour, where the first patch was found in 1974, there were about 130ha by 1978. The early chronology of recolonisation in Portsmouth Harbour is unknown, but by 1976 there were about 80ha. *Zostera* beds, and the substrate in which they root, support a notably rich fauna and the leaves themselves are an important food of Brent geese and wigeon, *Anas penelope*. Thus, the spread of *Zostera* can be seen as a significant enrichment of the Solent system. The Langstone Harbour beds alone are thought to be the most extensive in England south and west of Maplin Sands in Essex.

Introduced species

Spartina alterniflora is by no means the only alien species to have been introduced accidentally to the Solent. Of comparable antiquity is the now common slipper limpet, *Crepidula fornicata*, which was apparently imported in the 1880's with oysters from North America. Probably the most recent species to appear is the Japanese brown alga *Sargassum muticum* which was first found at Bembridge Ledges in 1973 and is now well established in a number of localities. It is presumed to have been introduced by shipping or as packing for imported oysters. Experiences from the west coast of North America, where it spread rapidly in the 1940s from British Columbia to California, suggested that *Sargassum* might become dominant in the Solent to the exclusion of other brown algae and *Zostera marina*, as well as causing considerable fouling problems for small craft. Efforts to eliminate it have failed and its future status in the intertidal zone remains problematical. However, early fears on rate of spread and interspecific competition may be unfounded (Farnham *et al.*, 1973; Gray and Jones,1977).

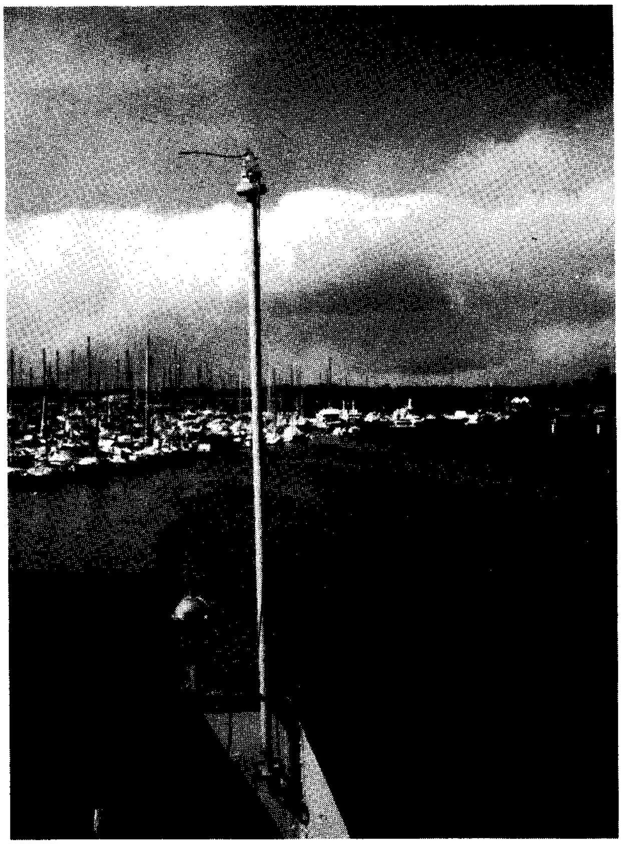
Further local modifications in the flora and fauna of the Solent have been associated with the cooling water discharges from Marchwood and Calshot Power Stations on Southampton Water. Such examples serve to illustrate the vulnerability to ecological change of an estuarine system supporting industry and both commercial and naval ports.

Reclamation and development

Imposed on this pattern of ecological and morphological change, is the impact of man's direct demands on the system. Of greatest concern is the reclamation of intertidal areas since this involves the destruction of parts of the system. Areas of mudflats and saltmarsh were reclaimed for agriculture from at least the sixteenth century until the beginning of the nineteenth and lie behind seawalls today. The first reclamation of about 80ha of mudflats for docks at Southampton took place in the 1930s. This was followed by another 160ha for the New Docks between 1927 and 1933 and about 100ha for the Container Port in the 1960s. Roughly 350ha have been reclaimed and filled since 1930 on the western shore of Southampton Water, partly to accommodate the Fawley Refinery and Calshot Power Station. The British Transport Docks Board has statutory powers to permit further reclamation for dock expansions at the mouth of the Test Estuary and a further 250ha of the intertidal area between Fawley and Hythe are reserved for possible industrial development by the South Hampshire Structure Plan. Further east, Portsmouth and Langstone Harbours have also recently lost parts of their intertidal zones. For example, 240ha were reclaimed in Portsmouth Harbour in the early 1970s for motorway construction, refuse tipping and as a reserve of uncommitted land, and in Langstone Harbour, 72ha were used for refuse tipping between 1960 and 1975. There have also been more recent proposals in both harbours for intertidal reclamation.

The popularity of the Solent for small boat sailors generates demands for marina construction which often involve the loss of intertidal areas. There are currently five marinas on what were formerly intertidal mudflats and at least a further three have been proposed.

Lymington Marina



Exploitative activities include the dredging of shingle from the bed of the Solent, which may conceivably have contributed to erosion along the north shore of the Isle of Wight (Hydraulics Research Station, 1977), and commercial fishing. The oyster industry in particular is currently enjoying a period of prosperity based on the latest in a succession of peaks in the oyster population, each of which appears in the past hundred years or more to have terminated with over-fishing. The effects of unrestrained oyster dredging on the bed of the Solent and on the other organisms which inhabit it are largely unknown and are potentially a matter of concern to biologists.

Finally, attention must be drawn to the implications should substantial quantities of oil be found in the English Channel and brought ashore in the Solent area. Service industries and oil (or gas) transportation, storage and processing are all likely to have significant impacts on the region and large scale proposals for shore development and further reclamation will require a careful assessment of their environmental effects.

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