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SURVEYS OF HARBOURS, RIAS AND ESTUARIES IN SOUTHERN BRITAIN
AVON AND ERME ESTUARIES

Report

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SURVEYS OF HARBOURS, RIAS AND ESTUARIES IN SOUTHERN BRITAIN

PREFACE TO REPORTS

The marine inlets of southern Britain are almost all formed from drowned valleys. They vary in shape, size, depth and salinity according to their historic and present hydrographic influences. All are more-or-less sheltered from wave action and have therefore been the focus of many urban and port developments. Some support or have supported important fisheries and several are currently being developed for shellfish and fin fish farming. Many of these inlets are known to include marine or estuarine habitats and communities which are rarely encountered in the British Isles. Some are already known as rich areas for marine life. However, little is known of the ecosystems present within many of these areas and new and potential developments make description and comparison urgent if scientific interests are to be taken into account during planning. Therefore the Nature Conservancy Council has commissioned the Field Studies Council to undertake studies of the area over an initial three year period from 1985 to 1988.

There are 24 inlets included in the study. Some are already well documented and may need little survey work. Others require a considerable amount of field work and analysis of data.

Our work consists of both a review of available information and field work.

The aims of the information review are:

1. To describe the areas in terms of their physical attributes.

2. To review the results of previous marine biological and related studies both published and unpublished.

3. To review fisheries, boating activities, port operations, diving activities, educational activities, research studies and other marine resource usage.

4. To catalogue available information.

Items of published and unpublished information are entered onto computer files and can be retrieved by area or subject. A paper copy of each entry is maintained in a loose-leaf file ordered by area.

Where field work is carried out, it aims to:

1. Collect information on the habitats present and the abundance of species in those habitats at sites selected to include a wide range of different shore and seabed types, areas of known conservation importance, or where rare species are or might be present.

2. Collect photographs of the habitats, communities and species present.

For each area where surveys are undertaken, the following reports are produced:

Volume 1 - Report of field surveys
Volume 2 - Species distribution records
Volume 3 - Field data
Volume 4 - Catalogue of photographs

Keith Hiscock
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SURVEYS OF HARBOURS, RIAS AND ESTUARIES IN SOUTHERN BRITAIN AVON AND ERME ESTUARIES

SYNOPSIS

The Avon and the Erme are situated on the south coast of Devon and open into Bigbury Bay. The Avon estuary runs through a narrow valley for 7 km from Aveton Gifford to Bantham and Bigbury-on-Sea at its entrance. The Erme estuary runs through a slightly broader valley for 6.5 km from Sequer's Bridge to Wonwell Beach at its entrance. Both estuaries have been infilled with sediment, and at low water their channels are very narrow and shallow. The estuaries are predominantly sedimentary with broad sandy beaches at their entrance and sand penetrating some way into the estuaries. The sediments in the Erme remain very sandy for a considerable distance upstream. Bedrock shores are present at their entrances and some upper shore bedrock is present in the upper Avon estuary.

The Erme estuary is very secluded and remains almost completely natural throughout. The quiet and unspoilt character of this estuary is maintained by the management of the Flete Estate which owns it and the adjacent land. The Avon estuary is less secluded, but marine and estuarine habitats and communities are also almost completely natural. The beaches and sand dunes at the entrance to the Avon are very popular with holiday makers, and watersports at Bantham are also popular during summer months. Commercial fishing operations are minimal and neither estuary has many boat moorings.

Three intertidal sites in the Erme and four in the Avon were surveyed during this survey. Descriptions are given of these and lists of species found are tabulated. In comparison to most other inlets surveyed in this series of studies the Avon and Erme have a very limited diversity of habitats and communities. Inparticular there is a relative lack of stable hard substrata and a small area of subtidal habitat. The rocky shore platforms at the entrance to the Avon are semi-exposed and include good overhanging, underboulder and lower shore rock pool habitats with extremely rich communities. Bedrock communities at the entrance to the Erme were not as rich but were typical of semi-exposed shores in South Devon. The sandy shores at the entrance to both estuaries contained communities characteristic of wave-exposed open coast beaches. Inside the estuaries the lower shore was influenced by freshwater and species present were characteristic of low and very variable salinity. The middle and upper shore communities were typical of estuarine habitats, but generally low in species diversity.

The scientific interest and conservation importance of the area has been assessed using standard criteria and the conservation importance of habitats and communities in the area has been provisionally graded as Local or Regional importance

1. INTRODUCTION AND HISTORICAL PERSPECTIVE

The Avon and Erme estuaries are situated on the south Devon coast just to the west of the Kingsbridge estuary (see Fig.1, which folds out of the back of this report). They are both small, shallow and relatively unspoilt. The Avon is tidal for some 7 km to the bridge at Aveton Gifford (OS Grid Ref. SX 69 47); the Erme is tidal for 6.3 km to Sequer's Bridge (OS Grid Ref. SX 632 519).

Aveton Gifford is a small market town founded in the late 13th century. Bigbury-on-Sea and Bantham (once the site of an ancient pre-Roman camp), at the entrance to the estuary, are small habitations which rely on summer tourism. Burgh Island, just outside the entrance, is an impressive rock that looks like a smaller version of St. Michaels Mount and has a chapel on its summit which dates back to 1411. During the 18th and 19th centuries the port at Bantham, at the entrance to the Avon, was quite busy, with many small boats carrying limestone, coal and farming materials. There are a number of old limekilns on the side of the estuary where the imported limestone was burnt to make fertilizer for local agriculture.

The Erme is a particularly unspoilt estuary, due in large part to its ownership by the Flete Estate which manages the area so as to preserve its natural beauty and peaceful character. Public access to many parts of the estuary are restricted and there are no recreational, fishing or industrial developments on its banks. During the 18th and 19th century the estuary was more navigable and used by small vessels to carry coal, grain and lime to and from the small villages of Holbeton, Ermington and Kingston (Hoskins, 1972; Wills, 1985).

2. PHYSICAL CONDITIONS

2.1. Geology and topography

The predominant rock types outcropping in both the Avon and the Erme are of Lower Devonian origin, particularly Dartmouth Slate, Meadfoot Slate and Staddon Grits. Outcrops are found at the entrance to both estuaries, and on the upper shore in places throughout the estuaries. The Meadfoot Slate at the entrance to the Avon is bedded vertically, and forms wide platforms intersected by gullies. Alluvial sediments of both terrigenous and offshore origin form the main surface substrata in these estuaries. (British Geological Survey, 1985)

Both estuaries are cut into high and steep sided valleys, with some vertical cliffs at the entrances. The Erme is relatively straight and broad, with just one minor tributary. The Avon is more winding and has an S-shaped bend before in opens out into Bantham beach. It also has three small tributaries.

2.2. Hydrography

2.2.1. Bathymetry and tidal heights. The Admiralty charts do not give much detail of depths or tidal heights for either estuary. However, both estuaries are very shallow; the channels being easily walked across (wearing waders) at low tide. At high water small boats may navigate the Erme for about three quarters of a mile, and the Avon for the 4 miles up to Aveton

Gifford. The channels are liable to change their course through the sandy beaches at their mouths (Admiralty, 1977).

2.2.2. Temperature. No records of temperature taken in the Avon and Erme have been found. Offshore mean surface temperatures range from 8.5°C in the winter to 16°C in the summer. (Lee and Ramster, 1981).

2.2.3. Freshwater input and salinity. For its size the Avon has a considerable freshwater flow, with a catchment area of 102.3 km^2. It has been shown that the Avon has, in recent geological history, captured much of the freshwater input that used to run into the Kingsbridge Estuary (G.Hobbs, pers. comm.). The gauging station at Loddiswell (Grid Ref. SX 719 476) records an average daily gauged flow of 3.122 m^3/s, with daily maxima and minima of 39.680 and 0.158 m^3/s respectively. Salinity measurements for the estuary are not available.

Freshwater flow to the Erme is not as great, with a catchment area of just 43.5 km^2. The gauging station at Ermington (Grid Ref. SX 642 534) records an average daily gauged flow of 1.624 m^3/s, with daily maxima and minima of 21.441 and 0.081 m^3/s, respectively (South West Water Authority, 1979). Salinity measurements for the estuary are not available.

2.2.4. Tidal Streams. Tidal stream strengths are not known for either estuary, but streams in Bigbury Bay are weak (Admiralty, 1977). The currents of Bantham surf beach are quite dangerous, and a life-saving club operates in the bay (Devon Conservation Forum, 1978).

2.2.5. Exposure to wave action. The mouths of both estuaries are exposed to strong wave action and swell from the prevailing south-westerly winds. However, due to the topography of the bottom and the wide midshore platforms of rock and sand, this wave energy is quickly lost. Bantham Beach at the entrance to the Avon is a surf beach, but the midshore rock platforms on either side of the entrance are only semi-exposed.

2.3. Substratum types

Both estuaries have wide beaches of well sorted mobile sand at their mouths through which the narrow river channels wind their way to the sea. Bedrock shores are present on both sides of the mouths to each estuary. The sediments in the Avon gradually become more mixed and muddier with increasing distance from the mouth and form muddy shingle shores in the upper estuary. In the Erme, however, the upper estuarine sediments remain very sandy, but the channel bed in the lower and middle reaches has mixed shingle and cobbles on sand.

At the entrance to the Erme there used to be a peninsula of accumulated sand and gravel that reached across the mouth, leaving a gap on the east side, and known as Mothecombe Back. At some time during the late 19th century this disappeared, but there may be remains of the gravel deposits on the seabed.

Little (1984) carried out analyses of sediment grain sizes at stations along transects across Bantham Sands and Aveton Gifford saltmarshes. At Bantham sands the sediment was described as fine-grained sand throughout the width of the transect. At Aveton Gifford saltmarshes the uppershore saltmarsh sediment consisted of fine mud, silt and clay, but became sandier on the lowershore, and near the channel on one transect was of unconsolidated gravel with coarse sand.

3. HUMAN INFLUENCES

3.1. Sewage and storm drains

There are 13 sewage discharges into the Avon estuary, the largest being at Aveton Gifford Sewage Treatment Works (STW) which has a average flow rate of 357 m^3/day, all of which receives full biological treatment. Of the other discharges all are from one or a few houses each with flow rates no greater than 4 m^3/day. The Erme receives two discharges. One from Holbeton STW with an average flow of 114 m^3/day after primary settlement treatment, and one small discharge from Flete House (pers. comm. South West Water). The South West Water Authority gives both estuaries quality classifications of A (Good), with maximum points for biological, aesthetic and chemical quality.

3.2. Industrial effluents and pollution

There are no known major industrial effluent inputs into either the Avon or the Erme estuaries. However, the River Erme does pass through Ivybridge which has a large population and some industry. It is not known if there is any significant effluent input into the Erme from these sources.

A few studies of trace metal concentrations in biological tissues and sediments have included sites (detailed locations not given) in the Avon and the Erme. Bryan and Hummerstone (1973) determined concentrations of zinc and cadmium in Hediste diversicolor, sediments and interstitial water from both estuaries. Concentrations in all samples were low, and worms from the 'uncontaminated' Avon were used as 'controls' in further experiments on heavy metal concentrations in other estuaries. Langston (1980) found low concentrations, in relation to sites elsewhere, of arsenic in sediments, Fucus sp., Hediste diversicolor and Scobicularia plana from the Avon. Luoma and Bryan (1982) found average concentrations of silver, cadmium, cobalt, and copper in Hediste diversicolor and Scrobicularia plana from the Erme. Bryan et al. (1980) measured concentrations of 13 metals in sediments from the upper and middle Erme estuary and the middle Avon estuary. No metal was found to be in notably high concentration.

Bryan et al. (1986) took samples of dog whelks, Nucella lapillus from the entrances to both the Erme and the Avon to look for incidence of 'imposex'. As in all other samples from the south Devon coast, there was a high incidence of the condition, and population structure of the dog whelks is likely to be affected. The cause of imposex in dog whelks has been shown to be the chemical tri-butyltin, used in anti-fouling paints. Concentrations of the tri-butyltin in the waters of the Erme and the Avon were not available, but are not likely to be very high as numbers of boats are low.

3.3. Port/Harbour facilities and users

Neither estuary has either a port or harbour, but both contain some moorings, which dry at low tide, and are used by mostly pleasure craft. There are a few quays, particularly in the Avon, which are also mostly used by pleasure craft. There is a small passenger ferry operating at fixed times during summer months from Bantham.

The shores and maritime habitats at the entrance to the Avon are heavily utilised by holiday makers. Bantham beach is a popular surfing beach and the dunes at Bantham suffer considerably from trampling by tourists, and need continual repairs (Devon Conservation Forum, 1978).

3.4. Educational and research usage

The rocky shore at Bantham, on the east side of the entrance, and the saltmarsh below Easton Ford are used for teaching by groups from the Field Studies Centre at Slapton. Bantham Rocks is a 'classic' site for rocky shore ecology studies. Lewis (1964) (see Figure 34, p. 127) described the zonation of communities there, and McCarter and Thomas (1980) also included it in their description of the distribution of animals and plants on rocky shores in the South Hams area.

Sites in both the Erme and the Avon have been used for the collection of samples of sediments and biological tissues for analysis of metal concentration (See Section 3.2).

3.5. Utilization of fish stocks

Angling for bass, flat fish and mullet, and bait digging for lugworm, ragworm and sand eels is popular in some places in the Avon where access is reasonable. There are no other present fisheries for shellfish or finfish, although salmon netting was carried out near Bantham until 1981 (Wills, 1985).

3.6. Established nature conservation importance

The whole of the Erme estuary from Sequers Bridge to the entrance, including the bed of the estuary, is notified as a Site of Special Scientific Interest (SSSI) for its estuarine, saltmarsh, freshwater and oak-hazel woodland habitats. The notification mentions the extensive sandflats at the entrance and colonisation by seaweeds (Fucus spiralis and Enteromorpha sp.). The estuary and the river is a spawning run for sea trout (Salmo trutta) and is frequented by the european otter. Although small, the estuary is frequented by fairly large numbers of wildfowl, with 160 mallard, 50 teal, and 30 wigeon recorded. Waders are not found in large numbers (Prater, 1981). The estuary has been owned by the Fleet Estate for more than a hundred years.

The Avon has no established nature conservation importance. However, a high diversity of waders and wildfowl are recorded for the estuary. These include wintering greenshank, spotted redshank, green sandpiper and common sandpiper. 150 curlew, 50 teal and 45 mute swans are also recorded (Prater, 1981).

4. PREVIOUS MARINE BIOLOGICAL AND RELATED STUDIES

There have been very few previous marine biological studies carried out in either the Avon or the Erme estuary. The rocky shore at Bantham Rocks, at the mouth of the Avon, has been studied by a number of workers. Lewis (1964) illustrates the zonation of this shore and divides it into five zones - a Littorina belt on the steep upper shore; a fairly bare Monodonta / Patella / F.spiralis belt on the gradually sloping upper middle shore platform, which is abraded by coarse sediment; a broad Ascophyllum belt on the middle shore platform, a lower shore Laurencia / F.serratus belt; and a Laminaria belt in the sublittoral fringe. McCarter and Thomas (1980) also described the zonation of a variety of typical shore species from Bantham Rocks. Lists of species recorded from the site by groups from Slapton Field Centre show that the communities there are fairly rich, but the lists do not include any unusual species (G.Hobbs, pers. comm.).

Other shores in the Avon have also been the subject of studies by students on field courses from Manchester University and Slapton Field Centre. In particular, the saltmarshes just south of Aveton Gifford have been used extensively for project work.

Research workers from the marine laboratory at Plymouth have collected and identified marine fauna and flora from the two estuaries on a few occasions only. The Plymouth Marine Fauna (Marine Biological Association, 1957) includes a few records from such occasions. Dr G.M.Spooner used sites in the Avon and the Erme in his studies on the distribution of amphipods in estuaries in the 1940's and many of his records are listed in the Marine Fauna. Gammarus species were a major part of this work (Spooner, 1947).

5. SURVEY AIMS AND METHODS

5.1. Introduction

The aims of the field survey were:

1. To collect information on the habitats present and on the abundance of species in those habitats at sites selected to include a wide range of different shore and seabed types, areas of known or likely nature conservation importance, or where rare or unusual species might be present.

2. To collect photographs of the habitats, communities and species present.

Sites were chosen for fieldwork on the basis of information given on Ordnance Survey maps. Intertidal fieldwork was carried out on 14th May 1987.

Survey methods for both intertidal rocky shores were based on techniques already developed for use in NCC surveys. Checklists were used throughout to ensure recording to a consistent style and, for species abundance data, in a form ready for recording on computer files. All species have been assigned alphanumeric codes from Howson (1987) which are used throughout.

5.2. Rocky shores

At each site selected for survey, the team determined the sort of work which would be carried out. On most shores this was a systematic description of the abundance of species in the main habitats/communities present at different heights on the open shore. Records were also made from habitats such as overhangs, gullies, rockpools and under boulders. Recording from unusual habitats took precedence over recording on the open shore if time was limited. On some shores time permitted only a brief survey, or it was appropriate to note that the shore was very similar to one previously surveyed and detailed records were not taken. Using tidal height predictions made for half hour intervals through the day, the height of sea level above chart datum was established and a cross staff used to level the shore at each 0.5 m interval so that a record could be made of the height of the main zones. The botanist and zoologist decided on the location of each of the distinctly different habitats to be surveyed, which normally included the lower shore (LS), lower midshore (LMS), midshore (MS), upper midshore (UMS), upper shore (US) and splash zone (Spl) as well as the other habitats. The quantity of each species was recorded according to the appropriate abundance scale (Appendix 1). Specimens were collected where necessary for identification.

Sketches of the site location and site profile, or of any other important features, were prepared and photographs of the shore and of species present were taken from various angles. Data was later transferred to the Intertidal Habitat Recording Sheet and plant and animal recording sheets.

5.3. Sediment shores

At each site selected, the shore habitats present were recorded for the Intertidal Habitat Recording Sheet. Core samples for later macrofaunal analysis were taken at one or more stations at each site. Stations were placed so as to represent the major habitats observed. Lower shore habitats, which might be expected to have a greater diversity and abundance of species, were generally sampled in preference to upper shore habitats. 4 x 0.01m^2 cores were taken at each station and sieved over a 0.5 mm mesh. Samples were sieved on the shore by 'puddling' at the water's edge where possible. Samples were transferred to kilner jars, and formalin together with eosin stain added on return to the accommodation.

5.4. Data analysis and presentation

5.4.1. Species coding. All species have been assigned alphanumeric codes according to Howson (1987) (except for lichens, angiosperms, insects and 'others' which have been assigned codes devised in house). Taxonomic nomenclature is also according to Howson (1987). Species listings are arranged in taxonomic order.

5.4.2. Abundance of conspicuous species. Records of the abundance of conspicuous species in separate habitats at each site were entered into the data management program described by Hobbs (1985) (modified to use the new species codes). Print-out from these files has enabled a clear view of the distribution and habitat preferences of each species. Inspection of site records has been used to identify the different habitats and communities encountered during survey and to classify them. The abundance of species in examples of those habitats has been tabulated directly from field records with addition of any laboratory identifications.

5.4.3. Sediment samples. Preserved sediment samples were further washed over a 0.5 mm mesh sieve to remove formalin and remaining fine sediment. The samples were each spread out in a white tray, covered with water, and biological material extracted. Intertidal core samples were exhaustively sorted and numbers of individuals of each species were counted.

6. RESULTS

6.1. Introduction

The location of sites surveyed is listed in Table 1 and illustrated in Fig.1. Seven intertidal sites were surveyed and sampled.

The communities of conspicuous species present are described below. Table 2 lists species sampled from intertidal sediments. Photographs from the shore (two sets) are held by the Nature Conservancy Council. Specimens of algae and animals are held at the Oil Pollution Research Unit.

Habitats and communities are separated on the basis of wave exposure and substratum type. As far as possible, descriptions of habitat/community types

are comparable with those recorded in similar situations in reports for other surveys in the Harbours, Rias and Estuaries study.

6.2. Description of intertidal habitats and communities

6.2.1. Introduction.

THE AVON ESTUARY

6.2.2. Semi-exposed broken bedrock platform at Murrays Rock (Site 1). On the south-east side of Burgh Island, at the entrance to the Avon estuary, is an intertidal reef of broken bedrock with very rich and diverse communities and habitats. The main habitats are described under the following headings.

Midshore broken bedrock platform. This extensive habitat was dominated by Ascophyllum nodosum, Fucus vesiculosus and F. serratus with an undergrowth of foliose red algae, barnacles (mostly Chthamalus montagui and Balanus perforatus) and Patella vulgata. The red algae included Abundant Laurencia pinnatifida with Common Ceramium shuttleworthianum and Mastocarpus stellatus and a variety of other species recorded as Frequent or Occasional. Encrusting red algae, particularly Corallinaceae indet., was also Abundant on the barer patches of rock, and upon it were Abundant spirobid worms. A wide variety of algae and animals were present on the fucoids. In particular, Polysiphonia lanosa was Abundant on the A. nodosum, and Dynamena pumila was Abundant on the F. serratus. Other species living on algae included Lomentaria articulata, Ceramium rubrum and Gibbula umbilicalis. Dogwhelks, Nucella lapillus, and the brittle star Amphipholis squamata were Frequent under the algae, and a variety of sponges, anemones, molluscs and other animals were also present.

Lower shore shaded vertical and overhanging rock. The sides of the platform, including the walls of the gullies which transect the platform, provide extensive areas of overhanging and shaded vertical rock with very rich assemblages of algae and animals. Laminaria digitata was Common, and other algae included Plumaria elegans, Lomentaria articulata, Dumontia contorta, Cladostephus spongiosus, Polysiphonia urceolata, Cryptopleura ramosa and Fucus serratus. Under the algal canopy the rock was covered in encrusting coralline algae and spirorbid worms. Balanus perforatus and Dynemena pumila were Common, and Halichondria panicea was Frequent. A variety of other animals were present in low abundance.

Lower shore underboulder communities. There are a few boulders by the sides of the platform, the undersurfaces of which were dominated by Verruca stroemia, spirorbid worms and Halisarca dujardini. Other species included Actinia equina, Anomiidae indet., Pomatoceros sp. and Cryptosula pallasiana. Mobile species living under the boulders included Porcellana platycheles and Gibbula cineraria.

Midshore Rockpools. There are a large number of rockpools on the platform, many of which are both deep and large. A high diversity of algae were present in these pools with 43 taxa recorded. Algae found in abundance and not noted elsewhere in the estuary included Mesophyllum lichenoides, Calliblepharis jubata, Delesseria sanguinea, Furcellaria lumbricalis and Himanthalia elongata. Other algae found to be particularly common in these pools included Corallina officinalis, Polyides rotundus, Polysiphonia sp. and encrusting coralline algae. The anemones Actinia equina and Bunodactis verrucosa, and the top shell Gibbula cineraria were Frequent. A notable occurrence here was of the rarely recorded red algae Pterocladia capillacea.

6.2.3. Lower shore bedrock dominated by **Audouinella** turf at Murray's Rock. Along the edge of the platform adjacent to the sand isthmus that connects Burgh Island to the mainland, the lower and lower-middle shore rock is sand scoured and was dominated by Audouinella sp. turf with Common Enteromorpha and a few other algae in low abundance. Except for a few Pomatoceros sp. no animals were recorded.

6.2.4. Lower and middle shore clean sand at the entrance to the estuary. The extensive sandy beach of wave exposed clean sand between Burgh Island and the mouth of the estuary was mostly smooth and unmarked by lugworm casts, but contained some rich communities of typical exposed beach polychaetes. These included Scolelepis tridentata, Nephtys sp. and Magelona mirabilis; and sand eels Ammodytes sp. were also Frequent.

Along the banks of the main channel that runs through this beach the sediment is much coarser and very mobile. No fauna was visible and just one prawn (Pontophilus norvegicus) was found in core samples.

6.2.5. Lower and lower-middle shore mud and shale gravel at Easton Ford. The banks of the estuary are not broad and this habitat is therefore not extensive. The infaunal community was dominated by the ragworm Hediste diversicolor and the bivalve Scrobicularia plana, which were both Abundant. Core samples from this sediment found typical upper estuarine communities of worms and crustacea.

6.2.6. Middle and upper-middle shore steep bedrock and boulders at Easton Ford. The steep rocky shore here is affected by freshwater run-off down the cliffs that run along the sides of the estuary. They were covered by filamentous green algae with some Fucus vesiculosus and F. spiralis, and on the upper shore there was some Verrucaria maura.

THE ERME ESTUARY

6.2.7. Lower shore broken bedrock platform at Red Cove. The shore at this site consists of a very broken bedrock platform with boulders on the upper-middle shore and a steep cliff behind. It is more exposed than Murray's Rock at the entrance to the Avon, but is only semi-exposed due to the shallow offshore topography. The surveyors concentrated on the lower-shore and the major habitats are described under the following headings.

Upward facing surfaces of lower shore broken bedrock platform. This fairly extensive habitat was dominated by Laurencia pinnatifida, Fucus serratus and Patella sp.. Barnacles, Chthamalus montagui and Semibalanus balanoides, and dogwhelks, Nucella lapillus were also Abundant and there were Frequent patches of mussels. A few other species of algae and animals were also recorded in low abundances, but diversity was not high.

Lower shore overhanging rock. Some of the overhangs on this shore are almost a metre high. They were dominated by Laurencia pinnatifida and Lomentaria articulata, with Balanus perforatus, Actinia equina, encrusting coralline algae and wide variety of other red algae and animal species.

Lower and middle shore pools. There are extensive pools on this shore, with both rock and sand bottoms, and frequently with boulders in them. The middle shore pools were richest, presumably due to the effect of sand and pebble scour on the lower shore. Many species of red algae were found in these pools, including Abundant Dumontia incrassata and Corallina officinalis,

Common Mastocarpus stellatus and Ceramium rubrum. Filamentous green algae was also Abundant in many pools, and large numbers of shore crabs Carcinus maenas were aggregated under and around the boulders. The under surfaces the boulders were covered in Pomatoceros sp. tubes, and a small variety of other animals were present in the pools.

6.2.8. Lower shore bedrock dominated by **Audouinella** at Red Cove. As at Murray's Rock, at the entrance to the Avon, there are areas of lower shore rock at Red Cove that were sand scoured and dominated by Audouinella sp. turf and Enteromorpha sp.. The community here was not as poor in species as that at Murray's Rock and included Abundant Mastocarpus stellatus and Common Ahnfeltia plicata, Ceramium rubrum, Chondrus crispus and Cladostephus spongiosus. However, no animals were recorded.

6.2.9. Lower and lower-middle shore sand plain at Wonwell Beach. The extensive sand plain at the entrance to the estuary was rippled and waved, and consisted of clean mobile sand. Not much infaunal life was found, but the spionid worm Scolelepis squamata was found in fairly dense patches, and lugworms were Rare. Cores taken from rippled fine sand some 200m upstream of the sea contained small numbers of worms and crustacea characteristic of wave exposed sediments, including Bathyporeia pilosa and Eurydice pulchra.

6.2.10. Lower shore shingle and cobbles at Wonwell Beach. The lower shore banks and the river channel bed consist of shingle and cobbles on sand. The stream was very low in salinity and the lower shore communities were very poor in species. The shingle and cobbles were colonised by Fucus ceranoides, Enteromorpha sp., Porphyra sp. and other green algae.

6.2.11. Lower middle shore fine sand with mud Below Tor Wood. The sediment flats in the upper estuary, near the saltmarsh areas, are still very sandy with some mud. Hediste diversicolor was Abundant and core samples held large numbers of oligochaetes. The only other species recorded was one specimen of Pontophilus norvegicus.

7. DISCUSSION

7.1. Distribution of habitats and communities

This survey was the first to describe the communities and habitats found in the Avon and Erme estuaries. Both estuaries are very shallow and sandy, and these features are the underlining influence on most of the habitats and communities present. The lack of a deep channel bringing seawater into the estuary means that at low water the water in the estuary will have a very low salinity, and after heavy rainfall may be almost freshwater. During the flood tide, however, saltwater will enter the estuary, and at high water during periods of dry weather the water in the estuary may be almost fully marine. The communities present on the bottom of the channel and on the lower shore will therefore experience a considerable variation in salinity. Further up the shore, however, the influence of the freshwater stream will be reduced. The distribution of the communities up the shore is explained by this pattern of salinity change. The lowershore communities of algae on shingle at Wonwell Beach are characteristic of low and variable salinity, being dominated by Fucus ceranoides and Enteromorpha sp. A few metres up the shore, however, where the salinity will usually be greater and less variable, the mobile sand contained polychaetes and crustacea like Scolelepis squamata and Bathyporeia pilosa which one would not expect to find in conditions of very low salinity.

The predominantly sandy nature of the estuaries limits the diversity of habitats and communities, particularly in the Erme which remains very sandy throughout. Upstream from the mouths of both estuaries, stable hard substrata is almost completely lacking, although there is upper shore bedrock in the upper reaches of the Avon. Shingle, presumably derived from this bedrock, is found on the lower shore in this area, but was apparently not colonised by algae or barnacles. This may be due to excessive siltation or lack of stability.

7.2. Comparison with other marine inlets

With the possible exception of the Looe estuary no other inlets surveyed in this series of Harbours, Rias and Estuaries surveys have been as small, shallow or sandy as the Avon and the Erme. Comparison with these estuaries, which have almost completely different characters, is difficult. Comparison between some habitats, however, is attempted.

The semi-exposed lower shore bedrock communities at the entrance to the Avon are very different to those recorded from other inlets, and are very rich. Where the sand scoured the lower shore, however, the communities were similar to those found in the Kingsbridge estuary and other inlets. The lower shore bedrock at Red Cove, at the entrance to the Erme, was similar to the sheltered bedrock at Cellar Beach in the Yealm, but not as rich in species. No Sargassum muticum was found at Murray's Rock or Red Cove, but dogwhelks, which were not recorded from the Yealm, were abundant.

Inside the entrances to both the Erme and the Avon the intertidal habitats are all considerably affected by freshwater. The presence of Fucus ceranoides on cobbles and shingle near the entrance to the Erme shows the extent of this influence. The infaunal communities found in the muddy shingle shores in the upper Avon estuary are similar to upper estuarine communities in many other inlets, and the upper shore bedrock communities are typical of sheltered bedrock influenced by freshwater run-off.

7.3. Comparison with previous marine biological studies

There have been no previous marine biological studies in the Erme estuary and those studies in the Avon have been confined to Bantham Rocks, which was not looked at during this survey. Murray's Rock, on the opposite side of the entrance to Bantham Rocks, appears to be a very similar shore with similar zonation patterns.

7.4. Recommendations for future work

This survey was necessarily short and fairly cursory. Both estuaries deserve some further study to describe the distribution of sediment facies. It would also be interesting to describe the communities on any lowershore hard substrata in the upper and middle reaches of the Avon estuary.

8. ASSESSMENT OF SCIENTIFIC INTEREST AND MARINE NATURE CONSERVATION IMPORTANCE OF THE AVON AND ERME ESTUARIES.

8.1. Introduction

The assessment of scientific interest and nature conservation importance has been undertaken through a general evaluation which follows the criteria

outlined by Mitchell (1986) (Section 8.2) and by ranking the conservation importance of the habitats and communities encountered and of species considered to be of conservation interest (Section 8.3). The conclusion of these exercises is given in Section 8.4. The criteria used here to assess conservation importance are applied in the manner outlined in the NCC 'Handbook for the Preparation of Management Plans' (1st edition, February 1983) but defined in relation to northeast Atlantic marine ecosystems. The definitions were first used in the management plan for the Lundy marine nature reserve and have subsequently been used for the Skomer marine nature reserve management plan and to evaluate marine ecosystems in the Isles of Scilly and the area of Bardsey and the Lleyn Peninsula. They are to be used for each area included in the Surveys of Harbours, Rias and Estuaries but are provisional until comparison of the majority of areas is possible.

8.2. General evaluation

8.2.1. Avon Estuary

1. Naturalness. The habitats and communities in this area are considered to be natural.

2. Representativeness. The Avon estuary is not representative of inlets on the south coast of England, but has similarities with the sandy estuaries of the north coast of Devon and Cornwall and the south coast of Wales. The habitats and communities, which are predominantly sedimentary, are also mostly unrepresentative of South Devon. Some of the rocky shore communities at Murrays Rock have similarities with other open coast shores.

3. Rarity. The marine habitats and communities found in the Avon are not particularly rare, and no species of any rarity were recorded.

4. Diversity. The small area of subtidal habitat and the predominantly sandy sedimentary character means that there is a low overall diversity of both habitats and communities in this estuary. The rocky shore at Murrays Rock, however, has a high diversity of middle and lower shore habitats, communities and species.

5. Fragility. The habitats and communities in this estuary are not likely to be sensitive to disturbance.

6. Size. The area of shore and estuary bed is 180 ha. The length of coastline, measured at HWOST, is 13 km.

7. Situation. There are no existing protected areas adjacent to the Avon estuary.

8. Recorded history. With the exception of studies on the rocky shore communities at Bantham Rocks, no previous studies of the marine communities or habitats have been carried out in the Avon.

9. Research and education potential. The rocky shore at Bantham is already well used by educational groups, and would probably benefit from a rest. The rocky shores at Murray's Rock would make a good, and interesting, replacement. Access to the muddy shores and saltmarsh near Easton Ford is good, and the saltmarsh is already used by educational groups.

Specimens of estuarine worms and animals are frequently used by research workers, and there is a plentiful supply. The estuary, with its low numbers of boats, possibly presents a useful comparitive area for the study of the concentration and effects of TBT in estuaries.

10. Restoration potential. Not relevant.

11. Intrinsic appeal. The entrance to the estuary, with its broad sandy beach, Burgh Island and the sand dunes, is an attractive area, and is popular with holiday makers.

12. Vulnerability. Trampling by holiday makers is already having a serious effect on the sand-dunes at Bantham. Trampling may also be having an effect on the rocky shore communities at Bantham Rocks.

13. Urgency. There is no urgency to protect the marine habitats and communities in this area.

14. Feasibility. Not known.

8.2.2 Erme Estuary

1. Naturalness. The habitats and communities in this area are considered to be natural.

2. Representativeness. The Erme estuary is not representative of inlets on the south coast of England, but has similarities with the sandy estuaries of the north coast of Devon and Cornwall and the south coast of Wales. The habitats and communities, which are predominantly sedimentary, are also mostly unrepresentative of South Devon. Some of the rocky shore communities at Red Cove have similarities with other open coast shores.

3. Rarity. The marine habitats and communities found in the Erme are not particularly rare, and no species of any rarity was recorded.

4. Diversity. The small area of subtidal habitat and the predominantly sandy sedimentary character means that there is a low overall diversity of both habitats and communities in this estuary.

5. Fragility. The habitats and communities in this estuary are not likely to be sensitive to disturbance.

6. Size. The area of shore and seabed in the Erme estuary is 170 ha. The length of coastline, measured at HWOST, is 13 km.

7. Situation. The whole estuary is an SSSI and is privately owned by the Flete Estate, who manage it so as to preserve its natural character.

8. Recorded history. No previous studies of the marine communities or habitats have been carried out in the Erme estuary.

9. Research and education potential. As access and parking is very limited, and the whole estuary is privately owned, it does not have much potential for research or educational usage.

10. Restoration potential. Not relevant.

11. Intrinsic appeal. The whole estuary, with its steep wooded banks, saltmarshes, broad sandy beach and completely unspoilt character is scenically very attractive.

12. Vulnerability. There are no known developments threatening the habitats and communities in this estuary.

13. Urgency. There is no urgency to protect the marine habitats and communities in this area.

14. Feasibility. The owners of the Flete Estate are keen to preserve the natural quality of the estuary and may therefore consider any further protection of the marine habitats favourably.

8.3. Identification/confirmation of important features

Features of littoral and sublittoral ecosystems in the Avon and Erme Estuaries are evaluated here in terms of their International, National, Regional or Local importance. Table 3 lists the main habitat/community types encountered during the survey; the separation of habitat type is according to Section 6. The rating of importance is made broadly according to the following definitions.

International. Communities which are outstandingly good examples of their type in the Northeast Atlantic. Communities recorded at only a very few locations in the Northeast Atlantic.

National. Communities which are outstandingly good examples of their type in Britain. Communities recorded in only a very few marine inlets or estuaries in Britain. Both of these definitions refer to communities which are or are likely to be widely occurring in other inlets and estuaries in the Northeast Atlantic.

Regional. Communities which are present in inlets and estuaries elsewhere in Britain but which are outstandingly good examples of their type in the inlet or estuary under consideration or are as good examples as similar communities present elsewhere in Britain. Communities recorded at only a few locations in inlets and estuaries in southwest Britain.

Local. Communities which are widespread in inlets and estuaries in southwest Britain with as good or better examples at several other locations.

8.4 Conclusion

Both estuaries have a rather low diversity of marine habitats with limited nature conservation or scientific importance, although the rocky shore platforms at the entrance to the Avon are extremely rich and might benefit from some protection against excessive trampling. There are no known developments that might affect the quality of these estuaries, and the Erme, which is scenically very attractive, is already protected by SSSI status.

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TABLE 1

List of sites surveyed
(see Fig.1 for locations)

Site No.	Site Name	OS Grid Ref. SX	Samples	Algae List	Animals List	Habitat Form	Date Surveyed
ERME ESTUARY							
1	Red Cove	614 468		AEL	DR	DR/AEL	14.5.87
2	Wonwell Beach	613 471 to 619 476	1 x (4,0.01m²)	DC/AEL	DC	DC	14.5.87
3	Below Tor Wood	6235 4880	1 x (4,0.01m²)		JM	JM	14.5.87
AVON ESTUARY							
1	Murray's Rock	650 438		AEL	DR/DC	DR/AEL	14.5.87
2	Bigbury Sands	655 440	1 x (4,0.01m²)		JM	JM	14.5.87
3	Easton Ford	683 467	1 x (4,0.01m²)	JM	JM	JM	14.5.87
4	Below Mount Folly	662 444		AEL	DR	DR	14.5.87

TABLE 2

Taxa recorded from intertidal cores

Abundances are quantitative (Nos./0.04m²) for combined cores at each station. See Table 1 for list of sites and samples taken, and Fig.1 for location of sites.

Code	Name of taxa	A2	A3	E2	E3
NEMERTEA					
G 0	Nemertea indet.			1	
ANNELIDA					
P 810	*Hediste diversicolor*		41	1	7
P 1317	*Pygospio elegans*		1		
P 1326	*Scolelepis squamata*			1	
P 1351	*Streblospio shrubsoli*		4		
P 1909	*Ampharete grubei*		1		
P 2417	Oligochaeta indet.		24	1	69
CRUSTACEA					
S 746	*Bathyporeia pilosa*			6	
S 754	*Haustorius arenarius*			1	
S 1027	*Corophium volutator*		3		
S 1340	*Cyathura carinata*		2		
S 1422	*Eurydice pulchra*			10	
S 2344	*Pontophilus norvegicus*	1			1
MOLLUSCA					
W 2097	*Scrobicularia plana*		1		

TABLE 3 A

Classification, description and evaluation of the conservation importance of habitats / community types present in the Avon Estuary.

Classification (based on section 6.2)	Description	Provisional suggested importance
1. Semi-exposed broken bedrock platform at Murrays Rock (Section 6.2.2)	This platform, with criss-crossing gullies and extensive rock pools was colonised by very rich assemblages of algae and animals.	Regional
2. Lower shore bedrock dominated by **Audouinella** turf at Murray's Rock (Section 6.2.3)	Low diversity communities of algae, typical of sand-scoured habitats, were found here	Local
3. Lower and middle shore clean sand at the entrance to the estuary (Section 6.2.4)	The infaunal communities of worms and crustacea are characteristic of wave exposed sandy beaches.	Local
4. Lower and lower-middle shore mud and shale gravel at Easton Ford (Section 6.2.5)	Upper estuarine communities dominated by Hediste diversicolor and Scrobicularia plana were found in this habitat.	Local
5. Middle and upper-middle shore steep bedrock and boulders at Easton Ford (Section 6.2.6)	The communities of green and brown algae found here are characteristic of freshwater influenced habitats.	Local
6. Lower shore broken bedrock platform at Red Cove (Section 6.2.7)	The communities of algae and animals at this site are similar to other semi-exposed sites and not especially rich in species.	Local
7. Lower shore bedrock dominated by Audouinella at Red Cove (Section 6.2.8)	Low diversity assemblages of algae, typical of sand-scoured habitats, were found here. Diversity was greater than similar communities at Murray's Rock (see 2 above)	Local

TABLE 3 B

Classification, description and evaluation of the conservation importance of habitats / community types present in the Erme Estuary.

Classification (based on section 6.2)	Description	Provisional suggested importance
8. Lower and lower-middle shore sand plain at Wonwell Beach (Section 6.2.9)	The infaunal communities of burrowing worms and crustacea were typical of wave-exposed sandy beaches, and very low in diversity.	Local
9. Lower shore shingle and cobbles at Wonwell Beach (Section 6.2.10)	The brackish water communities of brown and green algae are not usually found so close to the sea but are similar to communities found in upper estuarine habitats	Local
10. Lower middle shore fine sand with mud Below Tor Wood (Section 6.2.11)	These very sandy habitats were colonised by Hediste diversicolor and oligochaetes.	Local

APPENDIX 1

Abundance scales used for intertidal species

1. Live barnacles (except B. perforatus) (record adults, spat, cyprids separately); Littorina neritoides Littorina neglecta

7 Ex	500 or more per 0.01 m², 5+ per cm²
6 S	300–499 per 0.01 m², 3–4 per cm²
5 A	100–299 per 0.01 m², 1–2 per cm²
4 C	10–99 per 0.01 m²
3 F	1–9 per 0.01 m²
2 O	1–99 per m²
1 R	Less than 1 per m²

2. Balanus perforatus

7 Ex	300 or more per 0.01 m²
6 S	100–299 per 0.01 m²
5 A	10–99 per 0.01 m²
4 C	1–9 per 0.01 m²
3 F	1–9 per 0.1 m²
2 O	1–9 per m²
1 R	Less than 1 per m²

3. Patella spp. 10 mm+, Littorina Littorea (juv. & adults), Littorina mariae/obtusata (adults), Nucella lapillus (juv., < 3 mm)

7 Ex	20 or more per 0.1 m²
6 S	10–19 per 0.1 m²
5 A	5–9 per 0.1 m²
4 C	1–4 per 0.1 m²
3 F	5–9 per m²
2 O	1–4 per m²
1 R	Less than 1 per m²

4. Littorina 'saxatilis', Patella < 10 mm, Anurida maritima, Hyale nilssoni and other amphipods, Littorina mariae/obtusata juv.

7 Ex	50 or more per 0.1 m²
6 S	20–49 per 0.1 m²
5 A	10–19 per 0.1 m²
4 C	5–9 per 0.1 m²
3 F	1–4 per 0.1 m²
2 O	1–9 per m²
1 R	Less than 1 per m²

5. Nucella lapillus (> 3 mm), Gibbula sp. Monodonta lineata, Actinea equina, Idotea granulosa, Carcinus (juv. & recent settlement), Ligia oceanica

7 Ex	10 or more per 0.1 m²
6 S	5–9 per 0.1 m²
5 A	1–4 per 0.1 m²
4 C	5–9 per m², sometimes more
3 F	1–4 per m², locally sometimes more
2 O	Less than 1 per m², locally sometimes more
1 R	Always less than 1 per m²

6. Mytilus edulis, Dendrodoa grossularia

7 Ex	80% or more cover
6 S	50–79% cover
5 A	20–49% cover
4 C	5–19% cover
3 F	Small patches, 5%, 10+ small individuals per 0.1 m², 1 or more large per 0.1 m²
2 O	1–9 small per 0.1 m², 1–9 large per m²; no patches except small in crevices
1 R	Less than 1 per m²

7. Pomatoceros sp.

5 A	50 or more tubes per 0.01 m²
4 C	1–49 tubes per 0.1 m²
3 F	1–9 tubes per 0.1m²
2 O	1–9 tubes per m²
1 R	Less than 1 tube per m²

8. Spirorbinidae

5 A	5 or more per cm² on appropriate substrata; more than 100 per 0.01 m² generally
4 C	Patches of 5 or more per cm²; 1–100 per 0.1 m² generally
3 F	Widely scattered small groups; 1–9 per 0.1 m² generally
2 O	Widely scattered small groups; less than 1 per 0.1 m² generally
1 R	Less than 1 per m²

9. Sponges, hydroids, Bryozoa

5 A	Present on 20% or more of suitable surfaces
4 C	Present on 5–19% of suitable surfaces
3 F	Scattered patches; < 5% cover
2 O	Small patch or single sprig in 0.1 m²
1 R	Less than 1 patch over strip; 1 small patch or sprig per 0.1 m²

10. Flowering plants, lichens, lithothamnia

7 Ex	More than 80% cover
6 S	50–79% cover
5 A	20–49% cover
4 C	1–19% cover
3 F	Large scattered patches
2 O	Widely scattered patches all small
1 R	Only 1 or 2 patches

11. Algae

7 Ex	More than 90% cover
6 S	60–89% cover
5 A	30–59% cover
4 C	5–29% cover
3 F	Less than 5% cover, zone still apparent
2 O	Scattered plants, zone indistinct
1 R	Only 1 or 2 plants

Other animal species: record as percentage cover or approx. numbers within 0.01, 0.1 or 1 m²

APPENDIX 2

Catalogue of Photographs taken in 1987

All the slides are given a code starting with 'AVON' or 'ERME' followed by 'INT' (Intertidal) and a sequential number.

Number	Subject	Site	Date
ERME/INT/1	View north along shore	Red Cove (E1)	14.5.87
ERME/INT/2	View down shore	Red Cove (E1)	14.5.87
ERME/INT/3	View up shore	Red Cove (E1)	14.5.87
ERME/INT/4	Underside of boulder	Red Cove (E1)	14.5.87
ERME/INT/5	View east across shore	Wonwell Beach (E2)	14.5.87
ERME/INT/6	View north across shore	Wonwell Beach (E2)	14.5.87
ERME/INT/7	View south across shore	Wonwell Beach (E2)	14.5.87
ERME/INT/8	View north along shore	Wonwell Beach (E2)	14.5.87
ERME/INT/9	View west across shore	Wonwell Beach (E2)	14.5.87
ERME/INT/10	View west down shore	Wonwell Beach (E2)	14.5.87
ERME/INT/11	View north along shore	Wonwell Beach (E2)	14.5.87
ERME/INT/12	View up shore	Wonwell Beach (E2)	14.5.87
ERME/INT/13	View west down shore	Wonwell Beach (E2)	14.5.87
ERME/INT/14	View west down shore	Wonwell Beach (E2)	14.5.87
ERME/INT/15	View south along shore	Below Tor Wood (E3)	14.5.87
ERME/INT/16	View up shore	Below Tor Wood (E3)	14.5.87
ERME/INT/17	View down shore	Below Tor Wood (E3)	14.5.87
AVON/INT/1	View down shore	Murray's Rock (A1)	14.5.87
AVON/INT/2	View up shore	Murray's Rock (A1)	14.5.87
AVON/INT/3	View along shore	Bigbury Sands (A2)	
AVON/INT/4	View up shore	Bigbury Sands (A2)	14.5.87
AVON/INT/5	View down shore	Bigbury Sands (A2)	14.5.87
AVON/INT/6	View down shore	Easton Ford (A3)	14.5.87
AVON/INT/7	View up shore	Easton Ford (A3)	14.5.87
AVON/INT/8	View north along shore	Easton Ford (A3)	14.5.87
AVON/INT/9	Hediste diversicolor burrows in mud	Easton Ford (A3)	14.5.87
AVON/INT/10	View west along shore	Below Mount Folly (A4)	14.5.87
AVON/INT/11	View up shore	Below Mount Folly (A4)	14.5.87

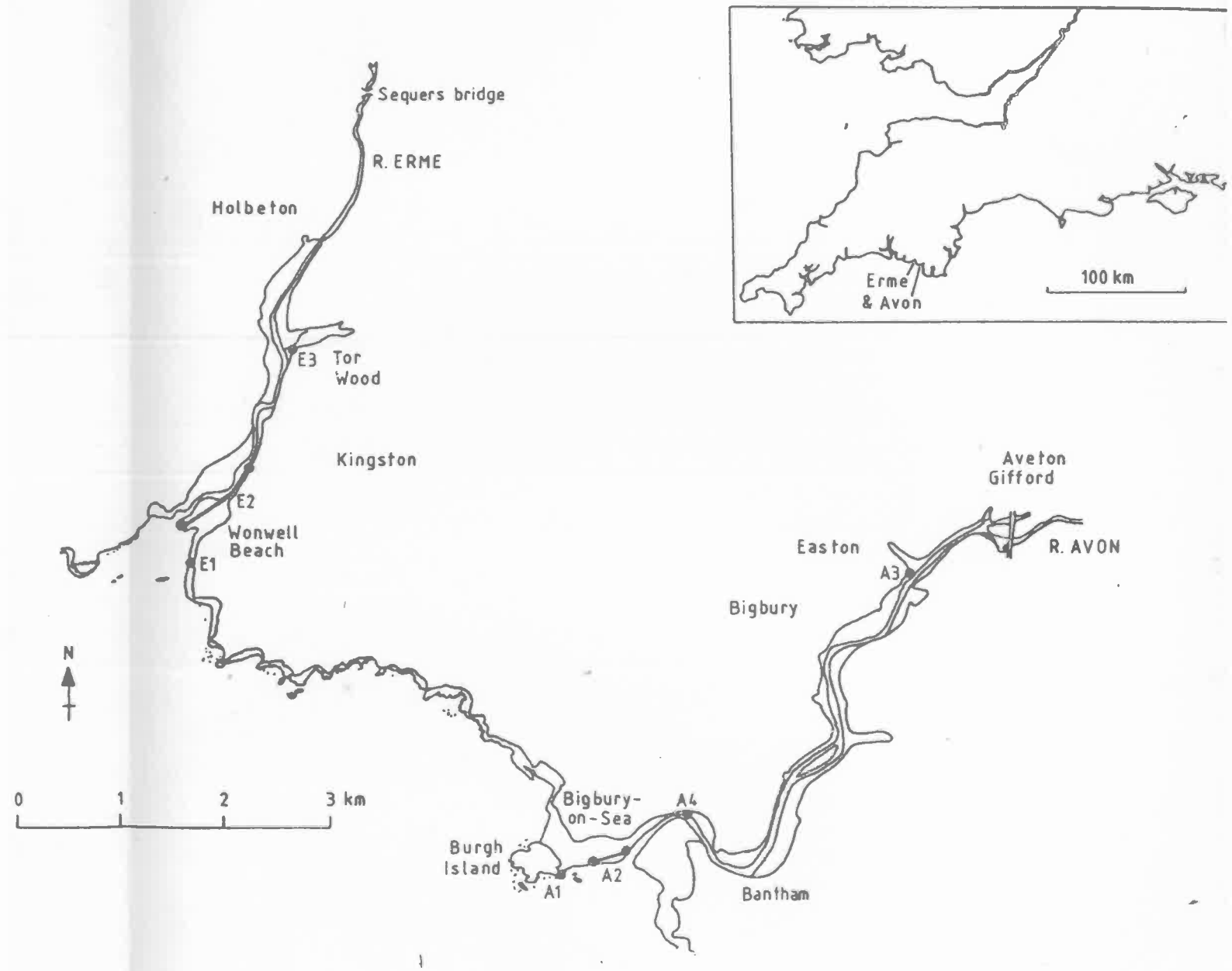

Fig. 1. Location of places mentioned in text and sites surveyed.