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BROAD SCALE BIOLOGICAL MAPPING OF PLYMOUTH SOUND AND ESTUARIES 1997

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C O N T E N T S

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NON-TECHNICAL SUMMARY

In July 1996, an existing data review exercise and a broad scale mapping survey of Plymouth Sound and Estuaries was carried out for English Nature. This report presents the results of the survey. The data review exercise was carried out to supplement the survey work and to provide historical information on the site. Data were collated from various sources including the Harbours, Rias and Estuaries Report for the Plymouth Area, the Marine Nature Conservation Review (MNCR) Sectors 8/9 Western Channel Draft Report and Devon Wildlife Trusts' Marine Survey Report. Data for intertidal areas were also collated from the Nature Conservancy Council (NCC) Coastwatch data and the saltmarsh review carried out by Charman in 1982.

The mapping was carried out using acoustic techniques validated by ground-truthing, which involved diving and remote survey using drop-down video and grab-sampling to collect sediment and infaunal samples. Maps of the predicted distribution of biotopes were prepared using Geographic Information Systems (GIS).

The intertidal zone was also mapped in two specific locations, which were agreed with English Nature in advance. These two areas were St. Johns Lake and the area between Bovisand and the entrance to the Yealm. Data was collected during site visits to the shore and biotopes where determined based on the MNCR intertidal biotope manual (Version 6.95) (JNCC, 1995).

Habitat diversity was high throughout the site, ranging from sheltered muddy habitats within the Tamar Estuary Complex to more exposed rocky shores at Wembury and Bovisand, and there was a high diversity of species in most habitats. One habitat was discovered near the Breakwater which had only previously been recorded at Portland Harbour. This was a muddy substrate supporting *Virgularia mirabilis*, the sea pen. A regional variation of a rockpool biotope was found in the intertidal zone near Wembury, which comprised of rock pools with *Sargassum muticum, Bifurcaria bifurcata, Himanthalia elongata* and other algal species. This biotope is subject to consideration by the MNCR team.

SECTION 1 INTRODUCTION

1.1 In order to effectively manage marine sites it is essential to have information on the types of habitat and species which occur within the site boundaries. Such information is necessary to allow conservation interests to be matched to management regulations. This information can be used to determine the relative magnitude and scale of conflicts, potential or real, between the conservation interest which has resulted in a site being proposed as a marine Special Area of Conservation (SAC) and the uses to which that site is being put, or may be put in the future. It was, therefore, proposed that a baseline mapping survey of the habitats within the Plymouth Sound and Estuaries candidate SAC (cSAC) was carried out. This was to include the sublittoral habitats and agreed areas of the littoral zone.

The objective of the survey was to undertake broad scale habitat and biota mapping, particularly in the subtidal zone, for the areas highlighted by English Nature for this cSAC. The aim being to produce maps at an appropriate scale to demonstrate the relative distribution of the features for which the site has been put forward.

In order to carry out this mapping a technique of acoustic survey, known as RoxAnn, was used. This technique provides cost effective, rapidly acquired data. RoxAnn is the name of the processor which samples a return echo from an echo sounder. In addition to depth, RoxAnn records a measure of the roughness and hardness of the seabed. From these data a picture of the seabed is built up. The data then require groundtruthing in order to assign the values from RoxAnn to a particular biotope or biotope grouping. Groundtruthing was carried out by diving and remote sampling using video and grab sampling techniques. The remote sensing department at Newcastle University have used this system effectively in the past. Discussion was held with this department throughout this project regarding methodology and results.

The intertidal zone was also mapped in two specific locations, which were agreed with English Nature in advance. These two areas were St. Johns Lake and the area between Bovisand and the entrance to the Yealm. Data was collected during site visits to the shore and biotopes where determined based on the MNCR intertidal biotope manual (Version 6.95) (JNCC, 1995).

An existing data review was carried out to supplement these data and to provide historic records of habitats and species. A large amount of survey work has been carried out in the Plymouth area and is collated in various forms. These data were reviewed to provide a background to the survey work and to supplement areas which were not covered in detail.

The survey area for the study is shown in Appendix 1.1 and is known as the Plymouth Sound and Estuaries candidate Special Area of Conservation. The candidate site has been selected to go forward for designation under the EU Habitats Directive. Further information on this proposed site is given in Appendix 1.1, which lists the reasons for its proposal and a site description. The features, listed in Annex 1 of the above Directive, for which this cSAC has been identified are:

- estuaries
- large shallow inlets and bays
- sandbanks which are covered by sea water all the time.

Mapping effort was concentrated on areas specified by English Nature as follows:

- Wembury Bay and the entrance to the Yealm
- Cawsand Bay
- Jennycliff Bay
- the area below Plymouth itself
- Torpoint Area.

Thereafter the following two areas were to be given priority, again as requested by English Nature:

- the Tamar as far as Wearde Quay
- the Lynher as far as Earth Island.

SECTION 2 DATA REVIEW

2.1 BACKGROUND

A vast amount of data already exist on the Plymouth area, ranging from specific studies on individual species or communities to large scale descriptions of the general area. The site is used as a study area by the Plymouth Marine Laboratory and for studies associated with the Marine Biological Association. In addition, the area is frequently used for studies by students from Plymouth University. The available data on the Plymouth area was collated and reviewed by Hiscock and Moore in 1986 as part of the NCC's Harbours, Rias and Estuaries Programme, providing a comprehensive review of work undertaken and describing the diversity of habitats and species found.

Hiscock and Moore's study reviewed available literature and involved discussions with scientists who had previously carried out survey work. Survey work was also undertaken as part of the programme's surveys of Southern Britain to collect information on the vast range of habitats present and on the abundance of species in those habitats. Survey sites were selected to include a wide range of different shore and seabed types; areas of known or likely nature conservation importance; and areas where rare or unusual species may have been present.

The MNCR Sectors 8/9 (Western Channel/Bristol Channel) report (Smith J and Moore J, 1996) was available, in Draft form, for review and included a description of Plymouth Sound and Estuaries in terms of physical and biological characteristics. The report provided details of previous survey work carried out within this area and summarised the results. It also provided a list of biotopes for marine inlets in Sectors 8/9.

2.2 INTERTIDAL HABITATS

During their data review, Hiscock and Moore (1986) surprisingly found very limited data on the hard intertidal areas of Plymouth. However, the survey work carried out as part of their study rectifies this to some extent by including extensive survey work in the intertidal zone.

The particular intertidal areas which were reviewed as part of this current English Nature study were the areas between Bovisand and the Yealm Estuary and St. John's Lake.

The Hiscock and Moore study looked at two sites at Bovisand and four sites in St. John's Lake. Intertidal rocky habitats were surveyed by visual assessment of the abundance of species in the main habitats/communities present at different heights on the open shore. Records were also made of habitats such as overhangs, gullies, rockpools and under boulders. Sediment shores were sampled, as far as conditions and time allowed, using core samplers and by digging over larger areas. Samples were sieved using 0.5 mm, 1.0 mm and 5.0 mm mesh sieves. Intertidal habitats and associated communities were generally separated into distinctive types. Each survey site was assigned to one of the types and the species and habitats were described in detail for each one. Each distinctive type was then assigned a provisional, suggested, conservation importance in terms of local, regional, national or international importance.

Devon Wildlife Trust also undertook extensive survey work within Plymouth Sound and approaches in 1993. This included intertidal survey work in the area between Bovisand and the Yealm. The aim of this survey was to fill gaps in the existing knowledge for this diverse and important area. Thirty six intertidal and 24 subtidal sites were visited and a total of 22 habitats were described. For intertidal survey, sites were restricted to hard substrates. Sites were visited during low spring tides and the presence and abundance of species was recorded. The main features of physical, biological and conservation interest were established.

Bovisand to the Yealm

The site at Bovisand Beach, sampled as part of the Hiscock and Moore study, revealed a very sparse fauna, with only 11 species recorded and only in low numbers.

Work carried out as part of the above study, found that rocky shores within Plymouth Sound, in general, were fairly rich in species. In addition, rockpools were present at several sites and included a fairly wide variety of typical rockpool species. The presence of large amounts of *Sargassum muticum* in upper midshore pools was described as being notable.

The Devon Wildlife Trust report (1993) also identified the shores at Wembury and beneath HMS Cambridge as being of high diversity, particularly due to the pools at Wembury which had a rich underboulder community.

St. Johns Lake

Hiscock and Moore found that the intertidal mudflats in St. John's Lake included quite a wide variety of species which were typically estuarine. They did not find *Zostera* beds although they did report that extensive areas were recorded by Spooner and Moore in 1940.

Hiscock and Moore carried out a comparison of their survey results with data from previous surveys. They found that for intertidal sediments the fauna in 1986 was relatively reduced, particularly in the Tamar. They state that "in St. John's Lake the most obvious apparent loss was that of *Hydrobia ulvae*, which was only recorded as present at one site where a dense patch of *Entermorpha* sp. provided a favourable habitat. The lack of *Zostera* beds, where once they were abundant, is likely to be a contributory factor. A comparable diversity of polychaetes and bivalves, however, was recorded, although Spooner and Moore did not record *Streblospio shrubsolii*."

2.3 SUBTIDAL HABITATS

The presence of the Marine Biological Association on Plymouth Hoe has led to the collation of a wealth of data on marine species within Plymouth Sound, the publication of the Marine Fauna of Plymouth Sound (Marine Biological Association, 1957) being of particular note. However, relatively little of these data are of much use for mapping purposes. A notable exception being the description of substrate and species occurring at 19 sediment areas within the sound by Ford (1923). Dart (1985) also provides descriptions and diagrams of the substrate, seabed profile and obvious epibiota found at 20 popular dive sites within the sound.

The first all encompassing survey of the distribution of subtidal flora and fauna within the sound was conducted by the Field Studies Council Oil Pollution Research Unit (OPRU) in 1986 (Hiscock and Moore, 1986). In this study diving was used to record hard substrate habitats and epibiota, while a towed pipe dredge or diver-operated suction sampler was used for soft substrates. Habitats and their associated communities are described, and the sites at which these habitats were recorded are listed. Detailed species lists are provided for each habitat, with species abundance being recorded using semi-quantitative abundance scales.

A diving survey of a further 24 subtidal areas within the sound, using similar recording techniques, was conducted by the Devon Wildlife Trust in 1993 (Devon Wildlife Trust, 1993).

Fourteen subtidal sediment stations within Plymouth Sound and the upper reaches of the Tamar Estuary were sampled by the National Rivers Authority (NRA) in 1992, including 11 that lay within the area considered by this study. The data from those sampling stations were included in a report on the 1992 survey produced for the NRA by the Cornish Biological Records Unit (Neil, 1995). This report gives the location, describes the sediment characteristics and gives detailed data on species and numbers recorded.

The data from the above reports have been referred to for comparison with, and to supplement, the groundtruthing biotope data collected for the purposes of mapping subtidal biotopes within the sound. It was not, however, used for groundtruthing the RoxAnn data. This was because the accuracy of position fixing for most of the above data was not known, and in no instances was it considered likely to be better than within + or - 50 m of the recorded position.

SECTION 3 METHODOLOGY

3.1 INTERTIDAL SURVEY

3.1.1 Survey work and mapping were carried out following the methodology given in Richards *et al* (1995), as closely as possible. Intertidal surveying was carried out from a rigid hull inflatable boat. Position fixing was carried out using a Differential Global Positioning System (DGPS).

The intertidal areas surveyed were between Bovisand and the entrance to the Yealm Estuary and St. Johns Lake in the Tamar Estuary. These areas were selected as they either appeared to be less well studied than other areas or had been found to have a changing fauna when comparison was made between previous surveys.

For hard substrates the survey involved driving the boat adjacent to the shoreline and visually assessing changes in habitat type. Each different habitat type was then surveyed by a shore visit. Biotopes were recorded during each shore visit and any new biotopes described. Photographs were taken to illustrate the habitats or biotopes surveyed.

Soft sediment habitats were sampled by taking core samples at selected locations within the intertidal zone. It was planned to float the boat up with the tide to take samples at appropriate levels just ahead of the water level and a short distance from the boat. This was possible for the first sample, but in practice was not possible for all locations and therefore the methodology adopted for the remaining sites was to take samples in shallow water.

Samples were taken using 7 cm diameter cores to a depth of between 10-15 cms. The samples were then transferred to buckets together with formalin, labelled appropriately and sealed for transfer to the laboratory. At the laboratory, samples were sieved using a 0.5 mm mesh and fauna identified and counted under a binocular microscope.

On the shore, the littoral biotopes were identified using the MNCR Intertidal biotope manual (Version 6.95) (Connor *et al.*, 1995). This document was initially compared to the classification of benthic marine biotopes for the marine inlets of the south west (Sectors 8/9) and it was found that the MNCR Version 6.95 was more appropriate for this particular survey.

Data Interpretation

Aerial photographs were available and were reviewed prior to mapping being carried out. These were used to determine approximate habitat boundaries and to initiate the mapping phase of the work. Maps at a scale of 1:10,000 were used for the first draft. Biotopes were defined based on the above survey work and with reference to previous survey work carried out in the specific areas (Hiscock and Moore, 1986 and Devon Wildlife Trust, 1993). This working map was then annotated with survey data and a biotope map compiled for input to the GIS.

As with the majority of biotope mapping studies carried out previously, the scale of mapping was considered to be important. The scale used was a compromise between showing enough detail to be appropriate to satisfy the objectives of the study and producing a sensible number of maps to represent the site. A scale of 1:10,000 was used which meant that biotopes which covered areas of about 20 m x 20 m or larger could be mapped effectively. Biotopes smaller than this are added as target notes onto the map, for example, rockpools.

The colours used for mapping were as given in A Field Guide for Seashore Mapping (Foster-Smith and Bunker, 1996). The colours represent various lifeforms and symbols can be used to split the lifeforms into further divisions based on the recorded biotopes.

3.2 SUBTIDAL SURVEY

3.2.1 Acoustic mapping

The subtidal areas were mapped between 4 - 7 July 1996 from the vessel 'Portland Surveyor' (length 10 m draught 1 m). Wind/wave conditions were favourable, although a stiff westerly wind and associated breakers prevented access to the shallow areas between Bovisand and the Mewstone.

Mapping was undertaken using a RoxAnn echo-sounder signal processing system. The transducer was hull-mounted at about 1 m below water level. Trials were carried out using the system to ensure low ambient noise and reproducible results. Three 200 khz echo-sounders were trialed; a survey-quality sounder and two fishing sounders (with beam widths of 8-10°). Best results were obtained with one of the latter - a Furuno model. The only problems encountered during the survey were attributable to high water column noise levels in certain localities characterised by strong tides/turbulence. Where possible 'close' noise was manually blanked out. All other bad data were subsequently removed during processing for records with obviously erroneous depth data, identified by shallow, consistent-value returns punctuated by windows revealing the true bed.

Vessel position was fixed using a Del Norte local Differential Global Positioning System (DGPS). Remote stations were established on Plymouth Hoe, the Tamar road bridge and in HMS Cambridge at Wembury. Nominal accuracy was ± 1 m. Differential loss occurred occasionally, both due to topographical effects and to interference from the emissions from naval vessels. On these limited occasions accuracy was reduced to ± 50 m. Positions were logged in easting and northing to OSGB (SN) 80 datum.

RoxAnn values (E1 (roughness index), E2 (hardness index), depth, position and time) were logged on a PC at 1 s intervals (position update frequency) and results displayed using SEARANO software.

Recorded depth data were accurate to ± 0.2 m. Tidal data for Devonport were subsequently collected for the survey period from the Queen's Hydrographer for the Navy (see Table in Appendix 4.2.2(a)). These data can be used in future, if required, to correct logged depths and produce accurate maps or block diagrams of local bathymetry; for the purposes of this survey, depth contours were derived from the current admiralty chart (reported to local chart datum).

The survey area was subdivided into ten areas as shown in Figure 3.2.1. Each was surveyed on an east-west aligned line system, often with a single tie line for Quality Control purposes. The nominal line spacing was 200 m, but areas 1 (Wembury), 3 (Cawsand Bay), 6 (Jennycliff Bay), 7 (Hoe) and 8 (Torpoint) were surveyed at 50 m line spacing according to the contract requirements.

During the two days following the acoustic survey the data were processed for quality control purposes and also for an initial appraisal of the distribution of substrate types for groundtruth station identification. SGPLUS statistical software was used to examine relationships within the data, determine cluster locations within the E1/E2 plots and define the range of values encountered. Sampling stations were subsequently defined on the basis of this quick analysis, attempting to cover the range of conditions encountered within each of the 10 areas examined.

3.2.2 Subtidal Survey: Groundtruthing

The RoxAnn survey data, when processed, provided maps identifying areas of similar hardness and roughness characteristics (refer to Appendix 3.2.2 for maps and Section 4.2.1 and Appendix 4.2.1(a) for further explanation of maps). In order to link this with actual biotopes, sites covering the range of RoxAnn values exhibited had to be surveyed and each RoxAnn value linked to a specific biotope or biotope groupings. Three distinct methods were employed in order to provide as much detail about the biotopes present as possible. These were SCUBA diving, grab-sampling and video. These methods were used in two consecutive phases of this study: first, a combined diving and video programme covering 34 stations; this was followed by a combined grab-sampling and video programme covering a further 57 stations. Figure 3.2.2 shows the location of survey sites. Both the above programmes were undertaken from the vessel 'Portland Surveyor'. Position fixing was achieved by Del Norte local DGPS; a local reference station was established at several locations around the sound in order to provide complete coverage.

The diving and video programme concentrated primarily on areas expected to be hard substrate, while the grab-sampling and video programme was focused mainly on areas expected to be of soft or mixed substrate. Interpretation of the preliminary RoxAnn track data is, in essence, achieved by surveying sufficient stations, lying along RoxAnn survey tracks, to cover the entire range of RoxAnn E1/E2 values recorded. However, given that RoxAnn is evaluating only two characteristics of the seabed, it is not possible to distinguish between all biotopes purely on the basis of their RoxAnn characteristics. Consequently, additional stations were required to be surveyed in order to take account of varying environmental conditions (i.e. depth, wave exposure, currents, salinity and turbidity) which could alter species composition, and so biotope type, on a particular substrate.

Diving and Video

For this phase of the survey a combination of SCUBA diving (using visual assessment, stills photography and hand-held videography) and drop-down video was employed.

Stills photographs were taken using Nikonos IVa and Nikonos III cameras and Fuji Velvia (iso 50) slide film; hand-held video footage was recorded using a Sony V800 Hi8 within an Amphibico housing with 50-100 W lighting where appropriate. The drop-down video consisted of a housed Sony camcorder mounted within an aluminium cradle, fitted with 100 W lighting. This was linked by video signal umbilical to a surface colour monitor. All video footage was logged; a real-time code was also burnt into the video image. From observations and notes recorded during dives, or from the video record, a brief description of each site was compiled.

Grab-sampling and Video

This phase of the survey work combined grab-sampling for particle size analysis and benthic infauna with drop-down video, recording seabed form and larger epibiota. A Day (0.1 m^2) grab was used; the drop-down video was as described for the diving and video programme. At each station the video was deployed first, and the seabed viewed and recorded. If the substrate appeared suitable for grabbing, the grab was then deployed. Once aboard, the grab contents were noted and photographed. A small amount of the grab sample was taken for particle size analysis (PSA), the remainder was sieved through a 0.5 mm sieve and the retained material was stored in labelled buckets and preserved in seawater with 10% formalin. The content of these buckets were subsequently rapidly analyzed (i.e. the retained material was spread out in large trays and all conspicuous macrofauna or flora picked out). This was then identified as far as possible without conducting microscopic examination of large numbers of individuals.

Particle size analysis of the sub-samples was conducted by Sediment Analysis Services. Sieving was conducted at 0.5 phi intervals, from -2 to +4 phi. This enabled the percentage gravel (>2 mm), sand (2 mm - 63 microns) and mud (<63 microns) to be described. The data were subsequently used, in conjunction with visual assessments, to provide accurate descriptions of the substrate (see Appendix 4.2.2(a) for details of sediment size distribution.

3.3 MAPPING

3.3.1 Initial digitisation of maps was undertaken in EasyCAD. Maps were then transferred from the EasyCAD system in DXF format and brought into MapInfo, so that they could be developed to be compatible with English Nature's mapping systems. Within MapInfo, scales were checked and annotation and symbology developed. Symbology was based on the standard established in the Field Guide for Seashore Mapping (Foster-Smith and Bunker, 1996). Hardcopy output was produced at appropriate scales for plotting within the A3 format.

SECTION 4 RESULTS AND DISCUSSION

4.1 INTERTIDAL MAPPING

Figures 4.1(a) and 4.1(b) show the intertidal biotope maps produced for the selected areas within the proposed Plymouth Sound and Estuaries SAC. Appendix 4.1(a) provides a list of the photographs taken in the intertidal zone. A description of the intertidal biotopes found during the survey together with their MNCR codes (and where possible, their equivalent south west biotope codes) are given below. Appendix 4.1(b) provides a key to the biotopes, taken from Connor *et al.*, 1995.

4.1.1 Bovisand to the Yealm Estuary

The biotopes found along this stretch of coast are mapped on Figure 4.1(a) and are detailed below in Table 4.1(a). The maps show the biotopes and lifeforms which were found in this area. Where biotopes were found in close proximity the mapping was carried out to show the dominant biotope grouping with a target note explaining which biotopes were found within that area. Biotope mapping for this stretch was determined using survey data and previous data from the Devon Wildlife Trust Marine survey (1993).

Table 4.1(a) Plymouth Sound and Estuaries Littoral Biotopes - Bovisand to the Yealm Estuary

Life Form Description	Biotope Level 1	Biotope Level 2	MNCR Code (Connor *et al.*, 1995)	Updated Equivalent MNCR biotope Code (Connor *et al.*, 1996)
Lichen or algal crusts, films or very short turf	VER	VER.B	LRK.VER.B	Ver.B
Lichen or algal crusts, films or very short turf	LPYG	LPYG	LRK.LPYG	BPat.Lpyg
Faunal crust	BP		LRK.BP	BPat
Brown algal shrubs	FSP		LRK.FSP	Fspi
Brown algal shrubs	FVES	FVES.BP	LRK.FVES	Fves
Algal turf	RED	RED.LAU	LRK.RED.LAU	R.Osm
Algal turf	RED	RED.MAS	LRK.RED.MAS	R.Mas
Brown algal shrubs	FSE	FSE.RED	LRK.FSE.RED	Fser.R
Brown algal forest	LDIG	LDIG.T	LRK.LDIG.T	Ldig.T
Brown algal forest	LDIG	LDIG.LDIG	LRK.LDIG.LDIG	Ldig.Ldig
Brown algal forest	SPOL	SPOL	LRK.SPOL	Spol
Algal/faunal turf	RSP		LRK.RSP	S.R
Algal turf	ENT	ENT.ARB	LMXD.EPH	EphX

Life Form Description	Biotope Level 1	Biotope Level 2	MNCR Code (Connor *et al.*, 1995)	Updated Equivalent MNCR biotope Code (Connor *et al.*, 1996)
Algal turf	POR		LRK.EPH	Eph.Por
Barren, mobile sediment and strandline	BAR		LMXD.BAR	BarSh
Barren, mobile sediment and strandline	BAR		LSND.BAR	BarSnd
Brown algal shrubs	FK	FK.BEP	LRK.FK.BEP	Fk
Brown algal shrubs	FK	FK.SP	LRK.FK.SP	Fk.Snd
Short fauna turf	BSP		LRK.BSP	Fser.Bo
Short fauna turf	BASP		LRK.BAS	S.ByAs

The rocky shore was relatively uniform with distinct rocky shore zonation between the upper supralittoral zone and the shallow sublittoral. Upper shore zones were characterised by lichens dominated by *Verrucaria* sp., but with areas of yellow and grey lichens present. There was a wide band of eulittoral rock characterised by barnacles and *Patella vulgata*. Depending on the degree of exposure and tidal area the zone then extended into fucoid covered rock with *Laminaria* spp. in the shallow sublittoral or rock covered with *Ascophyllum nodosum*. There was a wide diversity of red algae in most areas and rich underboulder and overhang communities wherever these habitats occurred. As indicated by the target notes on Figure 4.1(a), there were a large number of different types of rockpools reflecting the varying conditions around this stretch of coastline. Wembury Ledge provided an interesting site with a wide diversity of red algal species and interesting underboulder and overhang communities.

This stretch of coastline has a high diversity of rockpool communities ranging from shallow pools dominated by corallinacea crusts and deep pools with *Sargassum muticum* and fucoids. These rockpools warrant a more extensive survey to fully investigate their extent and species composition. The biotope category for the rockpools containing *Sargassum muticum* and fucoids has been classified, for the purposes of this report, as LRK.SAR. The classification of the rockpool biotopes is under review by the MNCR team. The above rockpool may be a regional variation of one of the fucoid rockpools, this requires verification from the MNCR team once the review has taken place.

Target Notes Associated with Figure 4.1(a)

The following target notes indicate less extensive biotopes present within the larger biotopes. These biotopes relate to areas which were too small to map (eg. rockpools and discrete areas of underboulder communities).

Number	Target Note (Connor *et al.*, 1995)[1]
1	LRK.CHL(G); LRK.COR(Cor); LRK.RSP(S.R)
2	LRK.COR; LRK.SAR.[2]; LRK.FK(FK)
3	LRK.COR; LRK.SAR.[2]; LRK.FK; LRK.BSP(Fser.Bo); LRK.BAS(S.ByAs);
4	LRK.FK; LRK.BAS; LRK.BSP; LRK.COR
5	LRK.CHL; LRK.FK.SP(Fk.Snd); LRK.COR; LRK.SAR[2]
6	LRK.CHL; LRK.ENT(Eph.Ent); LRK.COR; LRK.FK; LRK.FK.BEP(Fk)
7-9	LRK.BAS; LRK.RSP; LRK.COR

1 Updated equivalent biotope code (Connor *et al.*, 1996) given in brackets, where first occurs in table

2 For the purposes of this report this rockpool type has been classified as LRK.SAR.

The rockpools found which did not appear to correspond to the MNCR biotopes are described below, in terms of the conspicuous species present. These rockpools were recorded in previous surveys carried out along this stretch of coast. They were large deep rocky pools dominated by Corallinacea and *Sargassum muticum* but with other algal species present including *Bifurcaria bifurcata* and *Himanthalia elongata*. (For the purposes of this report this rockpool type has been classified as LRK.SAR.). The MNCR team will be reviewing the classification of rockpool biotopes. The rockpools found along this stretch of coast may be a regional variation of an existing biotope but this cannot be determined without further work and results of the MNCR rockpool classification. In previous surveys these rockpools have been described (Devon Wildlife Trust, 1993) and noted for their interest. The above survey noted the presence of *Cereus pedunculatus* in more sheltered pools, and a thick turf of *Mesophyllum lichenoides* was often found.

4.1.2 St. John's Lake

The results of the core sampling survey work are shown in Appendix 4.1.2.

The results of this survey work, together with the aerial photographs and the results of the data review have been used to determine the littoral biotopes for St. John's Lake. The biotopes are based on the above and the boundaries are, therefore, not definitive, due to the limitations of data. They do however provide a general impression of the habitats and conspicuous species present. The limitations of the data relate to the following:

- the timescale which has elapsed since the detailed saltmarsh survey, which was last carried out in 1982; as saltmarshes can change in area relatively quickly the extent of saltmarsh shown on the map may have changed

- the current survey work was only carried out by boat and it was, therefore, difficult to map habitats and species at higher tide levels due to the shallow slope of the mudflats and the speed at which the tide flooded in

- survey work for the biotope analysis was restricted to eight survey locations; the extent of habitats has therefore been estimated by using the features on the map and the expected extent of habitat related to position on the shore.

The biotopes mapped for St. John's Lake are given in Table 4.1(b).

Table 4.1(b) St. John's Lake Biotopes

Life Form Description	Biotope Level 1	Biotope Level 2	MNCR Code (Connor *et al.*, 1995)	Updated Equivalent MNCR biotope code (Connor *et al.*, 1996)	Western Channel Sector 8/9 Code (Smith, J. and Moore, J., 1996)
Semi-permanent burrows in cohesive sediment	HM	HM.NEP	LMUD.HM.NEP	HedMac.Nhom	LS9
Semi-permanent burrows in cohesive sediment	HM	HM.MAN	LMUD.HM.MAN	HedMac.Man	LS10
Faunal bed	MYT	MYT.AR	LMXD.MYT	MytX	LM5
Brown Algal Shrubs	FSE	FSE.FSE	LRK.FSE	Fser	LR17

For the purposes of mapping, saltmarsh has been divided into *Spartina* swards (classified under the Habitats Directive as community 15.12), and upper marsh (which generally falls within community 15.13 of the Habitats Directive relating to Atlantic saltmeadows (92/43/EEC).

The results show St. John's Lake to be relatively uniform. There are, however, some areas of broken shell banks. These have not been mapped, but are shown as a target note, as the exact locations and extent were not known and have not been identified from other reports. The biotopes for these areas are likely to fall within LMXD.EPH.

The mud biotopes described are characteristic of areas which, particularly in summer, have a covering of green algae such as *Enteromorpha* spp. or *Ulva lactuca*. Large areas of green algae were seen covering the intertidal flats at low tide during the survey work.

In relation to the results of previous surveys the findings from this current study reiterate those of Hiscock and Moore (1986), (ie. showing a surprising lack of *Hydrobia ulvae* despite the presence of *Enteromorpha* covering a large area of the mudflats). *Zostera* was not found, but it may be that it covers a discrete area which was not surveyed due to time and tidal limitations. *Streblospio shrubsolii* was identified as being present by Hiscock and Moore, although it had not been found in previous surveys. This species was found in the current study, indicating a possible stabilisation of species and communities over the last few years.

4.2 SUBTIDAL MAPPING

4.2.1 Acoustic Mapping

Considerable effort was made to ensure the accurate calibration or 'ground truthing' of the RoxAnn signal. In terms of data collection, emphasis was placed on accurate position fixing, so as to minimise variability (relocation errors) in areas of rapidly changing substrate. Grab samples were collected within 10 m of the sampled RoxAnn location, video records were collected whilst drifting past within a similar radius (although this was more difficult to control) and dives were conducted within ~50 m of the sample site.

To complement this, during data processing the RoxAnn track for approximately 25 - 50 m on either side of the sampling position was examined (± 20 s). The mean and standard deviation of the E1, E2 and depth values were calculated and are presented in the table in Appendix 4.2.2(a), and plotted as means with error bars in Figures 1, 2 and 3 in Appendix 4.2.1(a). This exercise helped the calibration procedure enormously, giving confidence to those calibration points with low standard deviations (a tight range of E1 and E2 values), and allowing samples with very large deviations to be recognised as often containing two or more distinct substrate types.

Four general observations could be made from an appraisal of the overall data:

1. RoxAnn data are not clearly related to the particle-size of the substrate (the sediment characteristic(s) most commonly used by biologists in habitat descriptions of soft sediment substrates).

2. The Roughness Index (E1) correlated poorly with the particle size data. With a 10° beam the system is typically (~ 10 m water depth) measuring roughness elements within about a 2 m circle, and thus differentiates well between the faceted surfaces of rock, the intermediate roughness of rippled sands and gravels and the smoothness of mud.

3. Approximately 50% of the variability in the Hardness Index (E2) could be modelled in a multiple regression using % gravel, % mud and volume sampled by the grab (% sand is calculated as 100 - (% gravel + % mud)). This index therefore relates mostly to the particle size AND the degree of compaction of the substrate; a recently mobile sand can have the same hardness value as a mud.

4. As a result of these and other factors, it was not possible to define a single relationship between RoxAnn parameters and substrate characteristics which apply to the whole area surveyed.

To enable a classification of substrate/habitat types, the 10 surveyed areas were divided into three main regions, determined specifically for this report, as shown in Figure 3.2.1, and described below:

OFFSHORE, the Wembury, outer Sound and Breakwater areas, characterised by a high degree of exposure to open sea wave climate and modest tidal current (Figure 1 in Appendix 4.2.1(a)).

INSHORE, the Cawsand Bay, inner Sound, Jennycliff Bay and Hoe areas, characterised by lesser wave exposure and in certain areas, stronger tidal currents (Figure 2 in Appendix 4.2.1(a)).

ESTUARY, the Torpoint, Hamoaze and Lynher areas, characterised by low levels of wave energy, strong tides in the channel areas and a turbidity maxima (Figure 3 in Appendix 4.2.1(a)).

The precise boundaries between these areas are impossible to define, and classifications from one area may equally apply in the margins of an adjacent area.

The substrate-type 'polygons' it has been possible to define are described in Table 4.2.1 below. When viewed with contoured values of E1 and/or E2 (see maps in Appendix 3.2.2) superimposed it is possible to gain a detailed picture of the variability of the basic physical characteristics of the sea and estuary bed.

Brief descriptions relating to these regions are given in Table 4.2.1 below.

Table 4.2.1 Brief Description of Regions Described in Report

OFFSHORE (see Figure 1 Appendix 4.2.1(a))
Rock outcrop; much of the offshore area comprises clean-swept rock with only localised areas of mantling lag deposit (stable, winnowed deposits of gravels, cobbles and boulders (red points).
Rock outcrop with kelp forest; characterised by high E1 values, possibly associated with the rugged relief of major rock outcrops (brown points).
Sands; fine and medium-fine sands irregularly mobile under wave action (green points).
Mud; local mud deposit in the lee of Plymouth breakwater (blue points).

INSHORE (Figure 2, Appendix 4.2.1(a))

Rock outcrop; largely free of dense kelp stands except in shallow sublittoral areas (red points).

Lag deposits; mantling the margins of the rock areas, apparently more extensive than in the offshore area (brown points).

Sands and gravels; a variety of fine, medium and coarse sands and gravels, some temporarily stable and burrowed others more recently mobile, as shown by wave-formed ripples and megaripples (green and purple points).

Muds; occupying areas on the eastern and northern sides of the Sound. Sample 26 is an unusually compacted anaerobic mud, and is interpreted as old seabed exposed in a dredged area (blue points).

ESTUARY (Figure 3, Appendix 4.2.1(a))

Rock outcrop; very localised extends, mostly in the narrows (red points).

Lag deposits; highly encrusted (stable) cobble and boulder deposits occurring in association with rock areas (purple points).

Muddy gravels; highly varied in nature, includes lithological gravels, shell/culch, live mussel beds and human debris, all with a mud matrix (brown points).

Mud; varying from very stiff anaerobic mud in the port areas to very fluid mud on banks in the Lynher (blue points).

4.2.2 Subtidal Biotope Mapping

Subtidal biotopes were mapped using the RoxAnn derived substrate/habitat maps in conjunction with relevant data from other sources. These were: (a) the more detailed descriptions of the grab, video and dive groundtruthing stations; (b) site descriptions within reports of previous surveys; (c) knowledge of the distribution of species within the Sound in respect to physical environmental conditions; and (d) local knowledge of specific sites.

From RoxAnn derived data, six distinct substrate/habitat types were identified. These are listed below:

1. Areas of extensive bedrock of rugged relief
2. Areas of mixed substrate: sand with slates, cobbles or boulders; and sand with bedrock outcrops or areas of gravel
3. Lag deposits of cobbles, stones or gravel
4. Sand
5. Upper estuary muddy gravels or mud and shell debris
6. Mud.

Using the additional data, the RoxAnn-defined substrate/habitat types were further described, and in some cases split, into nine broad categories which are mapped on Figures 4.2.2(a) and 4.2.2(b). These are listed below in Table 4.2.2. Appendix 4.2 provides a list of the photographs taken in the subtidal zone. Data has been provided on the biotopes which were broadly identified during the dive surveys. This is not intended to be an exhaustive list and is based on "best fit" biotopes. A separate appendix to this report contains the field data relevant to the dive sites.

Table 4.2.2 Description of Categories used in Mapping

Category	More detailed description	Typical biotope codes or codes representing some of biotopes present (Connor *et al.*, 1996)
Areas of lower infralittoral and circalittoral bedrock	These are areas of bedrock or stable boulder, where the predominant epibiota consists of red algae (lower infralittoral) or animal species (circalittoral) Within the lower infralittoral, a very wide range of red algae may occur, normally in conjunction with animal species from the associated circalittoral community. In the Inner Sound this zone is very narrow, if distinguishable at all. In the Outer Sound it will cover a depth range of several metres. In the Outer Sound, circalittoral rock will typically support a very diverse faunal turf. Communities vary considerably, but will typically include numerous sponge species (notably erect axinellids), hydroids (few or many from a wide range, especially *Plumularia* sp., *Nemertesia* sp., *Sertularia* sp.), large and colonial anthozoans (eg. *Alcyonium digitatum, A. glomeratum* near extreme outer boundary, *Eunicella* sp., *Parazoanthus axinellae, Corynactis viridis, Actinothoe sphyrodeta*). Bryozoan low turf species (*Crisia* sp., *Bugula* sp.) and the massive species *Pentapora foliacea* are generally common. Within the Inner Sound, species assemblages vary considerably from site to site with factors such as tidal streams, sediment scour and salinity range influencing their distribution. Circalittoral rock is frequently dominated by sponges (esp. *Halichondria bowerbanki, Suberites* sp.) and tunicates (esp. *Dendrodoa* sp.) or dense *Nemertesia* sp.. *Polydora* sp. are often dense on limestone.	**Outer Sound** ECR.Axi MCR.ErS.Eun MCR.ErS **Inner Sound** ECR.CuSH

Table 4.2.2 continued

Category	More detailed description	Typical biotope codes or codes representing some of biotopes present (JNCC ver.96.7)
Areas of upper infralittoral bedrock or stable boulder, supporting kelp forest	This category is widespread in the middle of the Sound, South of Plymouth Breakwater, and along the eastern side of the Outer Sound. Upward facing surfaces are generally covered in dense *Laminaria hyperborea*. Such reefs are frequently honeycombed with deep gullies where red algal or animal species dominate.	EIR.LhypFa.Ft EIR.LhypFa MIR.Ldig
Areas of lower infralittoral and circalittoral mixed substrate	This consisted of areas of low bedrock ridges or broken bedrock slabs and slates amongst areas of mud, sand, gravel, cobbles, slates or boulders. Within the Outer Sound, these areas, which generally occur between 13 and 17m below chart datum, support varying amounts of foliose red algae, with *Nemertesia* sp. and *Alcyonium digitatum* often common on ridges. Small Axinellids, *Eunicella* sp. and *Pentapora* sp. may occur on more extensive rock outcrops. Within the Inner Sound, these areas varied from supporting dense growths of sponges, *Nemertesia* sp. and tunicates to *Balanus crenatus, Pomatoceros* sp. and encrusting bryozoans (essentially similar to upper estuarine muddy gravels and cobbles) depending on hard substrate stability, scour etc.	**Outer Sound** MCR.ErSPenPol MCR.ErS.Eun MCR.ErS ECR.AlcMaS **Inner Sound** ECR.CuSH
Areas of upper infralittoral mixed substrate	This includes areas of sand with slates, cobbles or boulders (frequently supporting ephemeral algae such as *Chorda* sp. and *Desmarestia* sp.); sand plains with occasional bedrock outcrops which may support foliose red algae, *Chorda* sp. and/or kelp. It also includes areas of gravel waves and megaripples.	IGS.Mob CGS.AfilEcor EIR.LsacSpol MIR.Lhyp MIR.Lhyp.PK MIR.LsacChor MIREphR

Table 4.2.2 continued

Category	More detailed description	Typical biotope codes or codes representing some of biotopes present (JNCC ver.96.7)
Sand	A broad band of sand extends across the western side of the mouth of Plymouth Sound, from which a narrow band extends North past Penlee Point into Cawsand Bay, which is predominantly sand. This varies from areas of muddy fine sand, recorded in central Cawsand Bay to megarippled coarse sand and gravel. Fine sand was recorded in deeper water to the South, within this Pectinaridae tubes, *Dosinia* sp. and *Echinocardium cordatum* were recorded. *Amphiura* sp. were frequently common on the surface. Relatively impoverished fine sand, and impoverished coarse sand were also recorded in the Outer Sound. Scallops were observed in wave troughs in some of these areas. *Dosinia exoleta* was common in parts of South Cawsand Bay. Within Cawsand Bay and sand patches between Panther and Tinker Shoals, considerable amounts of ephemeral algae (particularly *Desmarestia*) grew attached to shell fragments (and coal slag which was common in ripple troughs in Cawsand Bay). Patches of dense *Corymorpha* sp. were also found in Cawsand Bay. *Amphiura* sp. were common throughout this area. In Wembury Bay, areas of *Zostera* sp. were found in fine sand near the mouth of the Yealm. *Echinocardium cordatum* and *Spisula* also occurred near here. Coarser, impoverished sand was found between reef areas in central Wembury Bay.	CGS.AfilEcor IGS.Zmar IGS.Mob IGS.Sell
Mud	A number of suites of species were recorded within areas of mud. It was not possible to identify consistent differences in mud habitat and corresponding changes in species composition. Large areas of mud occurred North and East of Plymouth breakwater. *Melinna* sp. worms were a common feature of this mud, however abundance varied markedly from a few to thousands per $10cm^3$. *Turritella* shells were also common, with live *Turritella* occurring in patches. Large burrows were frequently observed, possibly due to thalissinid shrimps or gobies. One *Upogebia stellata* was recorded in mud off Torpoint. Low densities of the small razor shell *Phaxas pellucidus* were recorded in shelly mud within Jennycliff Bay. *Acanthocardia* sp. and *Astarte sulcata* were also recorded in some muddy areas.	No appropriate codes

Table 4.2.2 continued

Category	More detailed description	Typical biotope codes or codes representing some of biotopes present (JNCC ver.96.7)
Upper estuarine muddy gravels and cobbles	This habitat (or range of habitats) varies from supporting a fairly diverse and abundant suite of macrofaunal species to being quite impoverished. Species recorded in these areas include: encrusting sponges, *Balanus crenatus, Anomia* sp., *Pomatoceros* sp., encrusting bryozoa indet., *Bugula* sp., *Halecium halecinum, Nemertesia* sp., *Perophora listeri, Styela clava, Corella* sp., *Metridium* sp., *Sagartia troglodytes, Pagurus bernhardus, Asterias rubens.*	No appropriate codes
Upper estuarine areas of boulder, cobble, (mussel) shell debris or live mussels	These areas are similar to the above, with the addition of large amounts of dead mussel shells and (in some areas) patches of live mussels. They were found downstream of the intertidal mussel bed near Jupiter Point. Species differed from the upper estuarine muddy gravels and cobbles in the reduced abundance of epifaunal species (presumably due to the shells being more transient than cobbles and stones) and the increased abundance of megafaunal scavengers (*Carcinus* sp., *Buccinum* sp. etc.).	No appropriate codes
Live mussel beds	A dense bed of *Mytilus* sp. was recorded off Jupiter Point. In addition to mussels, vagile scavengers, foliose red algae, *Styela clava* and a few *Ostrea edulis* were recorded.	SIR MytT

More detailed descriptions of specific sites are given within the target notes linked to particular areas or sampling stations.

In addition, the detailed station descriptions from grab-sampling, video and dive records, plus a composite station description, are given in Appendix 4.2.2(a).

The description of sandbanks, as defined in the Habitats Directive (see Appendix 4.2.2(b)), would include all the 'sand' areas (although it should be noted that the area inside the dotted line shown on Figure 4.2.2(a), is generally deeper than 20m). Much of the upper and lower infralittoral and ciracalittoral mixed substrate will also consist of sand, and so fall within the definition of sandbanks. It is not possible to categorise this further based on the findings of this study.

A description of the subtidal biotope codes used in this report are given in Appendix 4.2.2(c).

Target Notes Associated with Figure 4.2.2(a) and 4.2.2(b)

Number	Target Note
1	Steep limestone bedrock with sponges and tunicates; gravel, cobbles and boulders at base
2	Mixed sediments, silty sand with stones; rock outcrops with kelp
3	Coarse shell, sand/shell gravel; stones heavily encrusted with *Pomatoceros*, bryozoans and hydroids
4	Silty sand with *Zostera* sp.; tubicolous worms (*Myxicola, Lanice, Megalomma vesiculosum*) and *Cerianthus*
5	Stiff mud with burrows. Abundant *Melinna* sp., holothurian *Leptopentacta elongata* occasional
6	Soft mud with burrows
7	Mud with terrigenous material. *Melinna* sp. superabundant, numerous *Dosinia* sp.
8	Shell gravel, impoverished infauna, ephemeral algae
9	Coarse sand with shell fragments and small stones. Some attached algae
10	Soft mud with burrows, abundant *Melinna* sp.
11	Stiff mud with dense *Melinna* sp.
12	Mud with burrows, few *Melinna* sp.
13	Coarse sand and shell gravel; *Laminaria saccharina, Chorda*, filamentous algae
14	Shallow, slightly silty fine sand with drift algae. *Echinocardium* sp. and *Spisula* sp.
15	Fine sand with *Zostera* sp. and *Lanice*
16	Fine sand with burrows; some stones with attached foliose algae
17	Megarippled medium/fine sand and shell gravel; impoverished fauna
18	Medium/coarse sand, impoverished; bedrock outcrops with kelp
19	Slightly silty fine sand; shell fragments; ampharetid worms; stones with algae
20	Medium/fine sand; *Dosinia* sp., *Lanice* sp.; shells with ephemeral algae
21	Muddy fine sand with burrows; some stones with filamentous algae
22	Gravel waves; isolated rock outcrops with kelp

Number	Target Note
23	Gravel waves; isolated rock outcrops with kelp
24	Rippled sand, slate gravel, few slate bedrock outcrops with faunal turf including *Nemertesia* sp., *Alcyonidium diaphanum, Bugula turbinata*
25	Featureless sand, shells with some ephemeral algae
26	'Panther Shoal' and 'Knapp Shoal': Slate bedrock ridges topped with kelp; steep sided gullies. Gully sides are animal and red algae dominated, bases filled with sand and slates
27	Soft mud with burrows; *Turritella, Melinna* sp., few *Virgularia mirabilis*
28	Steep sided, limestone bedrock topped with *Corda filum*; deeper rock with kelp forest
29	Fine sand with burrows, *Amphiura* sp. and *Dosinia* sp.; some ephemeral filamentous algae
30	Infralittoral slate bedrock ridges and gullies topped with kelp. Gully walls with foliose red and brown algae and echinoderms (*Echinus, Marthasterias, Holothuria, Pawsonia*)
31	Circalittoral slate bedrock ridges with *Alcyonium digitatum, Eunicella, Pentapora, Holothuria*
32	Fine, silty sand with burrows and *Amphiura* sp.
33	Bedrock outcrops with foliose red algae and sand patches
34	Broken bedrock: red algae, *Nemertesia* sp., *Pentapora*, few *Eunicella*
35	Gravel waves with few stones and scallops in troughs
36	'Tinker Shoal': as 26
37	Sand with slates, foliose red algae on slates. Few small bedrock outcrops with kelp
38	'Queen's Ground': sand and occasional bedrock outcrops with kelp
39	Live mussel bed with attached foliose red algae and hydroids and encrusting bryozoans
40	Mud, gravel and mussel shells, surface iron crust. Stones heavily encrusted with *Pomatoceros,* bryozoans, hydroids (*Halecium halecinum*) and *Perophora listeri.* Terebellid worms amongst stones
41	Mud with heavily encrusted shells and stones, shell gravel, coal slag and terrigenous material. Hydroids (including *Halecium* sp.), encrusting bryozoa, few *Corella*, few errant polychaetes
42	Soft mud overlying stiff, anaerobic mud. Few Ampharetid worm tubes only

Number	Target Note
43	Soft mud with fine sand, few pebbles, abundant worm tubes. *Parvocardium* sp., hydroids, encrusting bryozoa, tunicates (*Diplosoma listeriamum, Aplidium, Corella*)
44	Iron-encrusted shell gravel and small stones amongst stiff mud *Pomatoceros, Balanus crenatus*, encrusting bryozoans on stones and shells. Few *Crepidula*
45	Shell gravel and isolated boulders. Few *Melinna* sp., few errant polychaetes, *Halecium halecinum* common
46	Stiff mud with fine sand, encrusted stones, shell fragments, numerous artifacts. Abundant Ampharetid worms, few *Ophiura* sp.
47	Bedrock ridge covered in sponges (*Hymeniacidon/Halichondria*?) and abundant *Nemertesia* sp.
48	Mud and fine sand. Superabundant *Mellina* sp.
49	Cobble-sized slate and limestone plates, few boulders. *Asterias*, cobbles heavily encrusted with *Balanus crenatus, Pomatoceros, Anomia, Corella,* sponges
50	Mud and fine sand. Superabundant *Melinna* sp., *Lanice, Amphiura* sp., *Acanthocardia* sp., few errant polychaetes
51	Steep, tideswept limestone bedrock. Dense covering of sponges, hydroids and tunicates (esp. *Halichondria bowerbankia, Dendrodoa*)
52	Steep bedrock with dense sponge, *Nemertesia* sp. and tunicate covering

4.2.3 General Area Description

The Outer Sound

The eastern side of the outer sound, from the mouth of the Yealm to Andurn Point, is characterised by extensive areas of exposed slate and limestone infralittoral bedrock, and kelp forest. At the mouth of the Yealm itself lies a fan of silty sand characterised by *Echinocardium cordatum* and *Spisula*; a bed of *Zostera marina* lies within the northern half of this sand area.

Immediately to the south of the breakwater lies more kelp-dominated bedrock; Knap and Panther Shoal to the West and Tinker Shoal to the East. Between these reefs lie areas of sand, slates and occasional bedrock outcrops.

Further south, beyond the 15 m below chart datum contour, lies a band of lower infralittoral and circalittoral mixed substrate. This mainly consists of low rock ridges and broken bedrock interspersed with bands of sand or gravel. Stable rock in this area supports varying amounts of diverse red algae, including *Calliblepharis ciliata, Bonnemaisonia asparagoides, Cryptopleura ramosa* and *Delesseria sanguinea*; Axinellid sponges; *Alcyonium digitatum;* and *Eunicella* and *Pentapora.*

Cawsand Bay is predominately shallow sand, with a few rock outcrops towards the northern edge. The southern perimeter is clean sand, with *Amphiura* species but otherwise a relatively impoverished infauna. The centre of the bay is quite muddy, with burrows and ampharetid worms.

The Breakwater to The Narrows

An area of soft well-burrowed mud extends northwards from the breakwater. The mud close to the breakwater supports an extremely rich infauna, with very high densities of *Melinna* sp. worms and *Turitella*. Low densities of the seapen *Virgularia mirabilis* also occur near the breakwater. Until now this species was known from only one site on the British coast between the Irish Sea and Northumberland, namely Portland Harbour. The mud further north is quite variable, with consistency and abundance of infauna changing significantly over short distances.

From Cawsand Bay to The Narrows, the western side of the centre of the sound consists of mixed substrate. Sand with slate gravel, slate cobbles and occasional bedrock outcrops cover much of this area. Towards mid-channel the amount of sand and gravel increases. East of The Bridge, relatively high densities of the tiny urchin *Echinocyamus pusillus* were found (station 21) (refer to Appendix 4.2.2(a)). This is generally considered an offshore species, although it is easily overlooked.

A band of silty sand with *Zostera marina* lies to the north of Drake's Island. Beyond this, Drake's Channel consists of coarse mixed sediment and heavily encrusted small stones.

Steep limestone bedrock, covered with a rich epifaunal turf of sponges, hydroids and ascidians, lines the northern side of Drake's Channel.

Off The Hoe, the seabed is composed of burrowed mud. The burrowing holothurian *Leptopentacta elongata* was found here.

On either side of The Narrows (Devil's Point and Wilderness Point), limestone bedrock drops away steeply to around 30 m below chart datum. This bedrock is very tideswept and densely colonised by filter-feeding species; the sponge *Halichondria bowerbankii* covers large expanses while the tunicate *Dendrodoa* is also abundant.

The bed of the main channel through the narrows consists of varying mixtures of muddy gravel, cobble-sized limestone plates and boulders and rock outcrops. Encrusting, scour-tolerant species such as *Pomatoceros* sp, *Balanus crenatus* and encrusting bryozoans were very much in evidence here.

The Hamoaze and the entrance to the Lynher

Through the Hamoaze upstream to Bull Point, there is little hard substrate, the bed consisting mainly of muddy gravels or anoxic mud with relatively little infauna. The solitary tunicate *Styela clava* is common, growing on stones or shells.

Mud and muddy gravel continue into the Lynher. A mussel bed extends into the channel off Jupiter Point (station 57). Red algae and hydroids cover the mussels while a few European oysters occur within the bed. Extending from this bed, the channel is carpeted with heavily encrusted mussel shells covering soft mud.

SECTION 5 FINDINGS AND RECOMMENDATIONS

5.1 FINDINGS

- The Plymouth Sound and Estuaries candidate SAC is a highly complex area in terms of its physical and biological habitats. There are a wide range of habitats varying from sheltered muddy habitats within the breakwater in Plymouth Sound to exposed rock habitats in the outer sound.

- The mapping of habitats was complicated by the detail of the biotope classifications, particularly for sublittoral habitats. The biotopes classified by the MNCR appear to be based on detailed survey work and/or quantitative analysis of infauna. For a study of this size it was not possible to go into such detail for each area based on remote sampling, including grab-samples and video records. It was, therefore, difficult to differentiate between certain biotopes for the purposes of mapping. Data was provided however on the biotopes which were broadly identified in each grouping and this is represented in tabulated form.

5.2 RECOMMENDATIONS

- It is recommended that further work is undertaken on intertidal mapping, particularly to define saltmarsh areas and *Zostera* beds. Such areas can change dramatically in a short space of time and regular monitoring is recommended, even if it just comprises photographic survey.

- Interesting habitats were found in the Tamar Estuary, particularly the rocky areas which occur in the estuary quite a distance upstream. These habitats warrant further investigation to determine their species composition and conservation importance.

- Other interesting areas which could be investigated further include the narrows off Eastern Kings Point and Devils Point. These deeper rocky areas could be of interest for their rocky species composition.

REFERENCES

CHARMAN, K. 1982. Saltmarsh survey maps from English Nature.

CONNOR, D.W., BRAZIER, D.P., HILL, T.O., HOLT, R.H.F., NORTHEN, K.O., & SANDERSON, W.G. 1996. *Marine Nature Conservation Review: marine biotopes. A working classification for the British Isles. Version 96.7.* Peterborough, Joint Nature Conservation Committee.

CONNOR, D.W., HILL, T.O., LITTLE, M.C., and NORTHEN, K.O., 1995. MNCR Intertidal biotope manual version 6.95. JNCC Report No. 249.

DART, P., 1985. The dive sites in and around Plymouth Sound. Unpublished report.

DEVON WILDLIFE TRUST, 1993. Marine Survey Report. Plymouth Sound and Approaches.

FORD, E., 1923. Animal communities of the level sea-bottom in the waters adjacent to Plymouth. *Journal of the Marine Biological Association of the United Kingdom.* 37, 473-482.

FOSTER-SMITH, R.L and BUNKER, F, 1996. *A fieldguide for phase 1 seashore mapping.* English Nature, Peterborough.

HABITATS DIRECTIVE, 1995. Council Directive on the conservation of Natural Habitats and of wild fauna and flora (92/43/EEC). UK list of possible Special Areas of Conservation (SACs) and selection guidelines.

HISCOCK, K and MOORE, J., 1986. Surveys of Harbours. Rias and Estuaries in Southern Britain. Plymouth Area including The Yealm. A report to the NCC from the Field Studies Council OPRU FSC/OPRU/36/86.

MARINE BIOLOGICAL ASSOCIATION, 1957. The Marine Fauna of Plymouth Sound. The Marine Biological Association of the UK, Plymouth.

NEIL, C. J., 1995. Survey of the benthic macroinvertebrate infauna of the Tamar Estuary. Cornish Biological records report for The National Rivers Authority. CBRU, Institute of Cornish Studies, Redruth, Cornwall.

RICHARDS, A., BUNKER, F. and FOSTER-SMITH, R 1995. *Handbook for Phase 1 survey and mapping.* Bangor, Countryside Council for Wales (CCW Report, No. 95/6/1).

SMITH, J. and MOORE, J., 1996. (Draft Report) MNCR Sectors 8/9 Western Channel. Plymouth Sound and associated estuaries.

SPOONER, G. M. and MOORE, H. B. 1940. The Ecology of the Tamar Estuary. An account of the macrofauna of the intertidal muds. J. Mar. Biol. Ass. UK 24, 383-430.

FIGURES

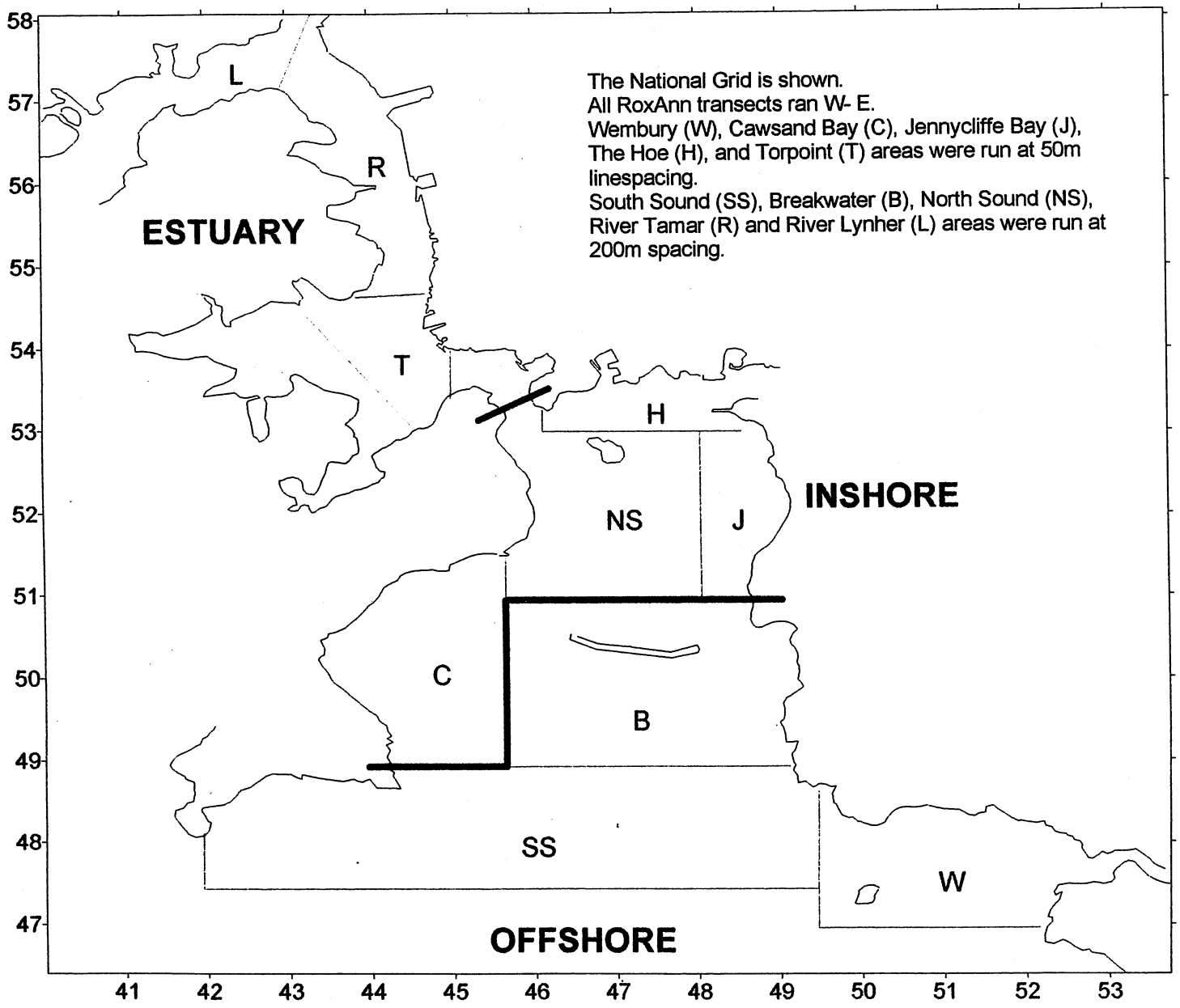
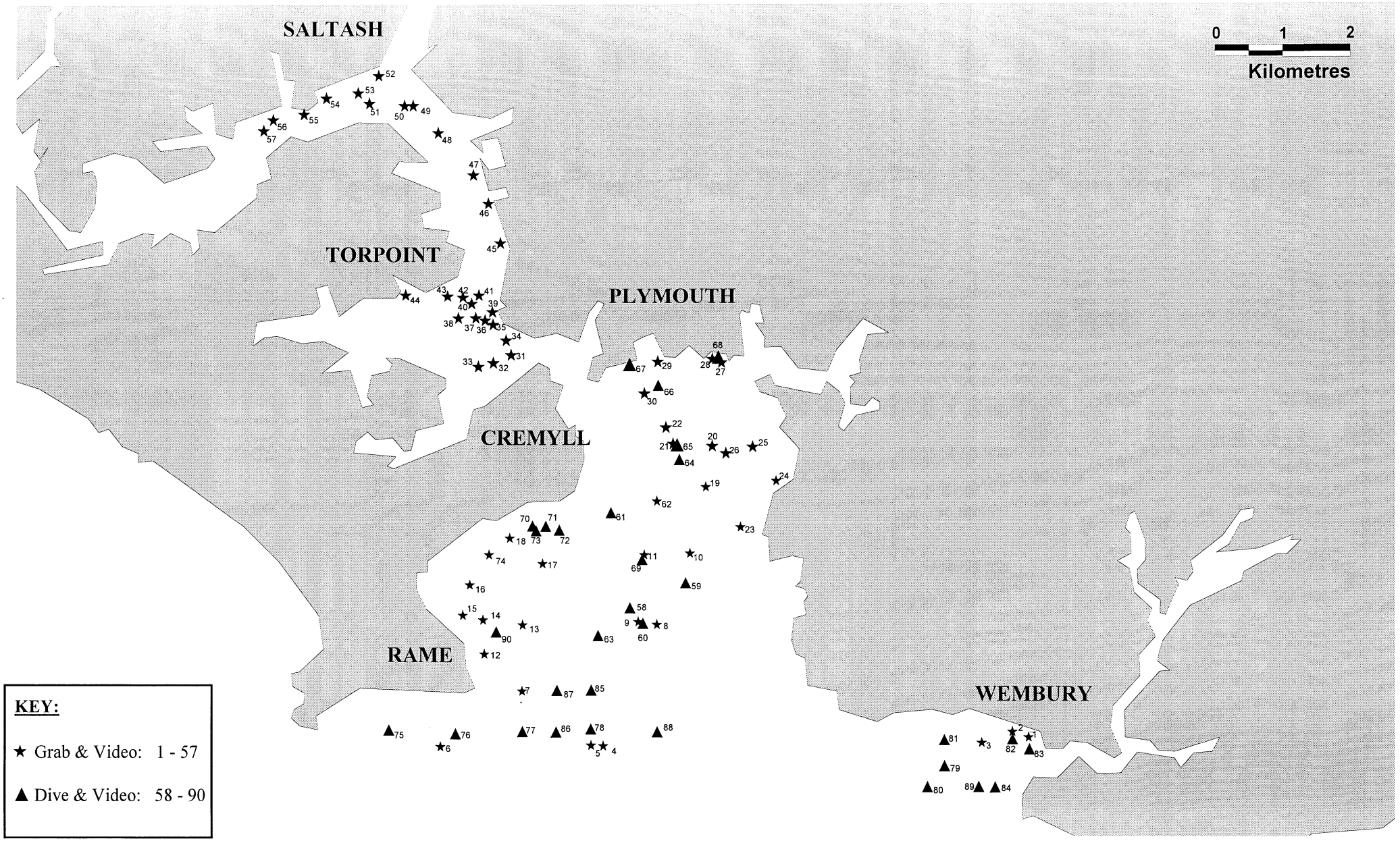


Figure 3.2.1 Location of Main Regions of Substrate/Habitat types



ENGLISH NATURE	PLYMOUTH SAMPLE SITES	POSFORD DUVIVIER	Date: January 1997	Drawn By: J.L.H	Checked By: C.S.A
			Figure Number: 3.2.2	Map 1 of 1	

KEY:

Areas of upper infralittoral bedrock or stable boulder, supporting kelp forest.

Areas of lower infralittoral and circalittoral bedrock where red algal or epifaunal species dominate.

Areas of upper infralittoral mixed substrate, including: sand with slates, cobbles or boulders, often with ephemeral foliose algae; sand plains with occasional bedrock outcrops which may support foliose red algae, *Chorda* and / or kelp; areas of gravel waves / megaripples.

Areas of lower infralittoral and circalittoral mixed substrate. *

Upper estuarine muddy gravels and cobbles.

Sand. **

Mud.

Upper estuarine areas of boulder, cobble, (mussel) shell debris or live mussels.

Live mussel beds.

Number 1 - 38 Target notes (refer to text)

Sandbanks deeper than 20m bcd.

* In part, equivalent to 'Subtidal Sandbank' classification as defined for the Habitats Directive

** Equivalent to 'Subtidal Sandbank' classification as defined for the Habitats Directive

KEY TO INTERTIDAL BIOTOPES

(shown approximatly between HWM and LWM)

LRK.BP

LRK.BP
LRK.LPYG

LRK FSE.RED

LRK.FVES.BP
LRK.FSP
LRK.FSE.RED
LRK.RED.LAU
LRK.RED.MAS
LRK.RED.COR

LRK.LDIG.T
LRK.LDIG.LDIG
LRK.LDIG.SPOL

L.MXD EPH
LRK.EPH

LRK.RED.LAU
LRK.RED.MAS
LRK.RED.COR

LMXD.BAR
LSND.BAR

LRK.VER.B

1 - 9 Target Notes (see text for description)

KEY TO BIOTOPES

UPPER MARSH

Spartina Swards
(Saltmarsh Community 15.12)

LRK.FSE.RED

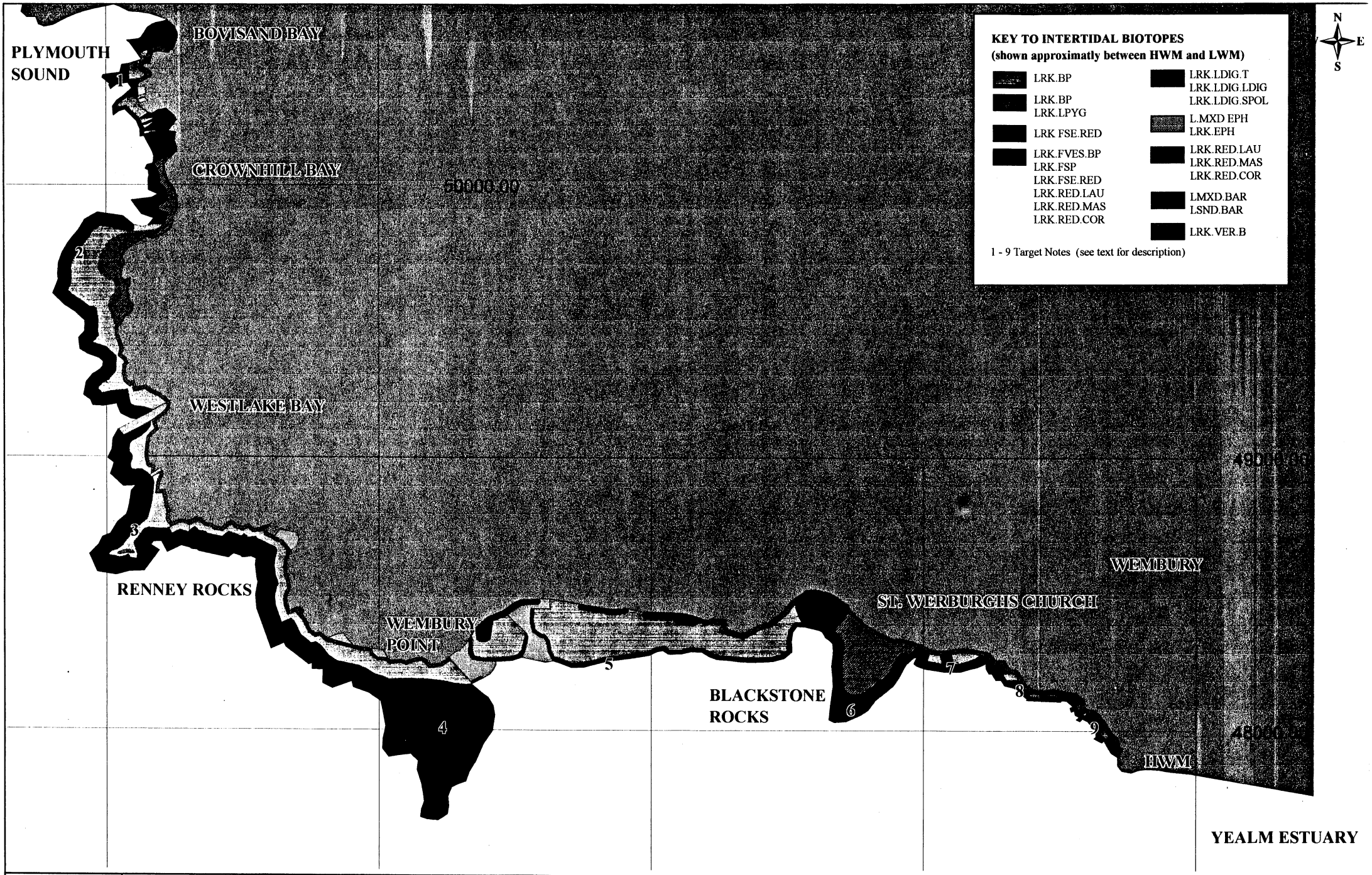
LMUD.HM.NEP
LMXD.MYT

L MUD.HM.NEP

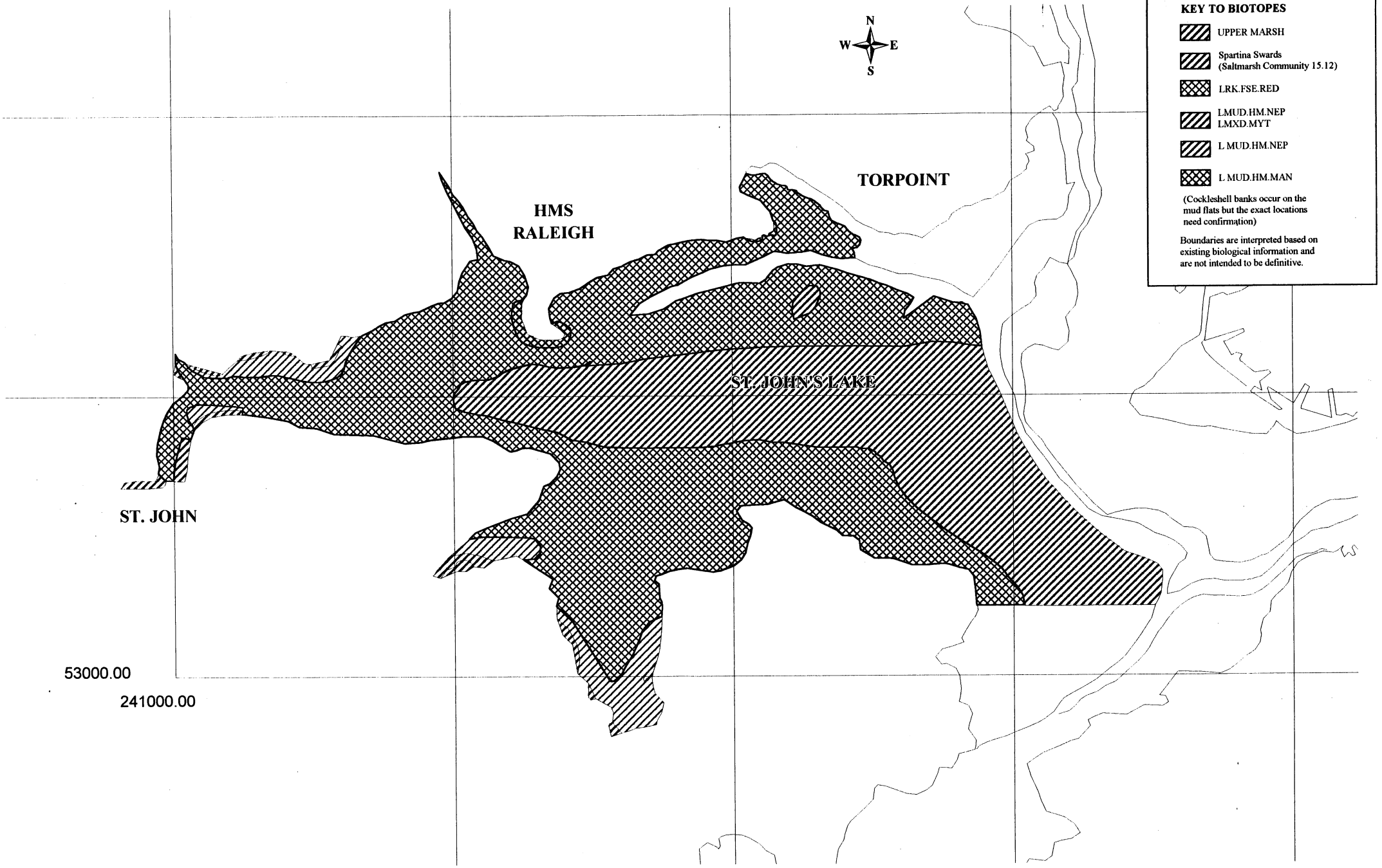
L MUD.HM.MAN

(Cockleshell banks occur on the mud flats but the exact locations need confirmation)

Boundaries are interpreted based on existing biological information and are not intended to be definitive.



ENGLISH NATURE	BROAD SCALE BIOLOGICAL MAPPING OF PLYMOUTH SOUND AND ESTUARIES INTERTIDAL MAPPING - WEMBURY TO BOVISAND	POSFORD DUVIVIER	Date: January 1997	Drawn By: J.L.H	Checked By: C.S.A
			Figure Number: 4.1(a)	Map 1 of 1	Scale : 1:12,500

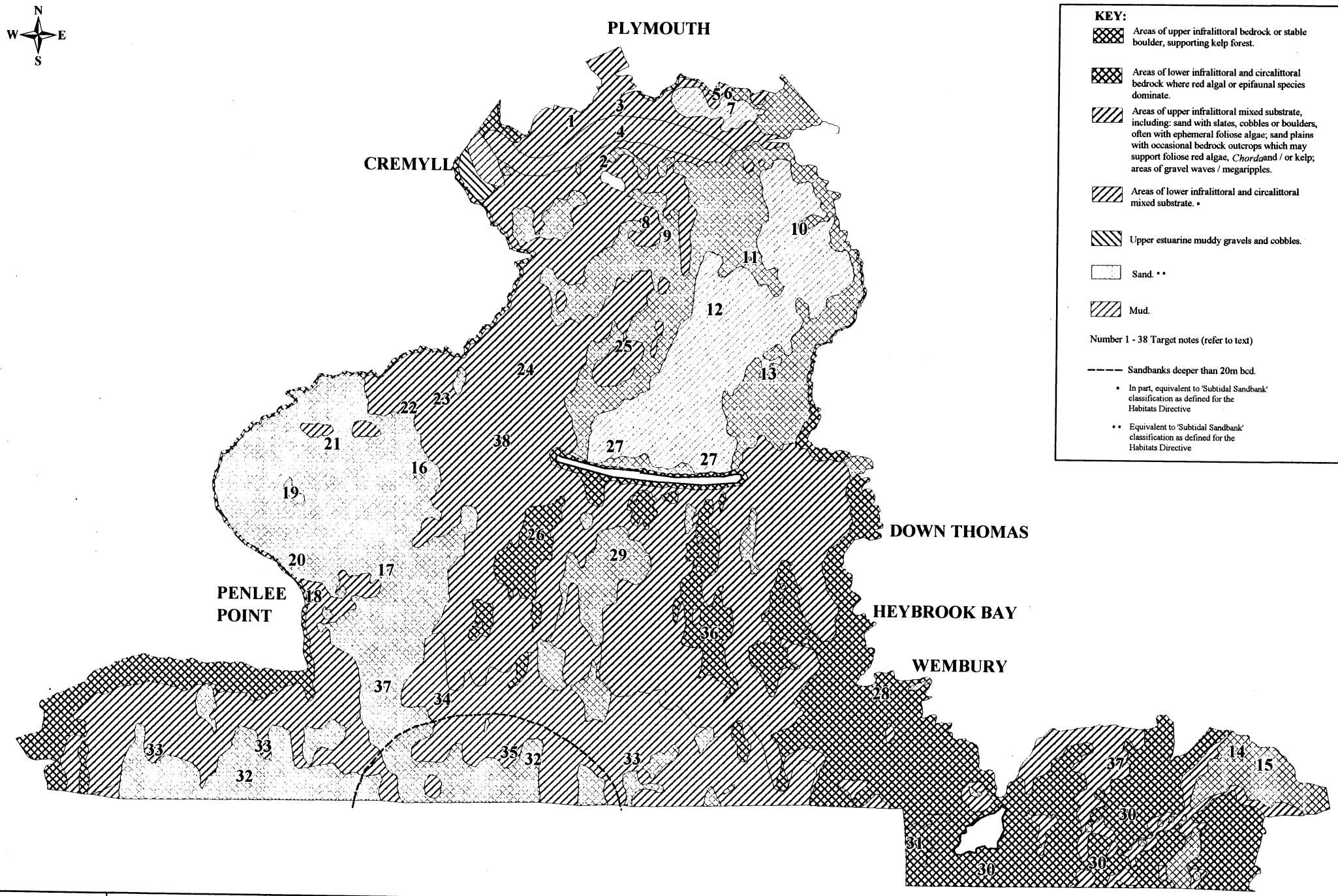


ENGLISH NATURE

BROAD SCALE BIOLOGICAL MAPPING OF PLYMOUTH SOUND AND ESTUARIES
INTERTIDAL MAPPING - ST JOHNS LAKE

POSFORD DUVIVIER

Date: January 1997	Drawn By: J.L.H	Checked By: C.S.A
Figure Number: 4.1(b)	Map 1 of 1	Scale : 1:12,500

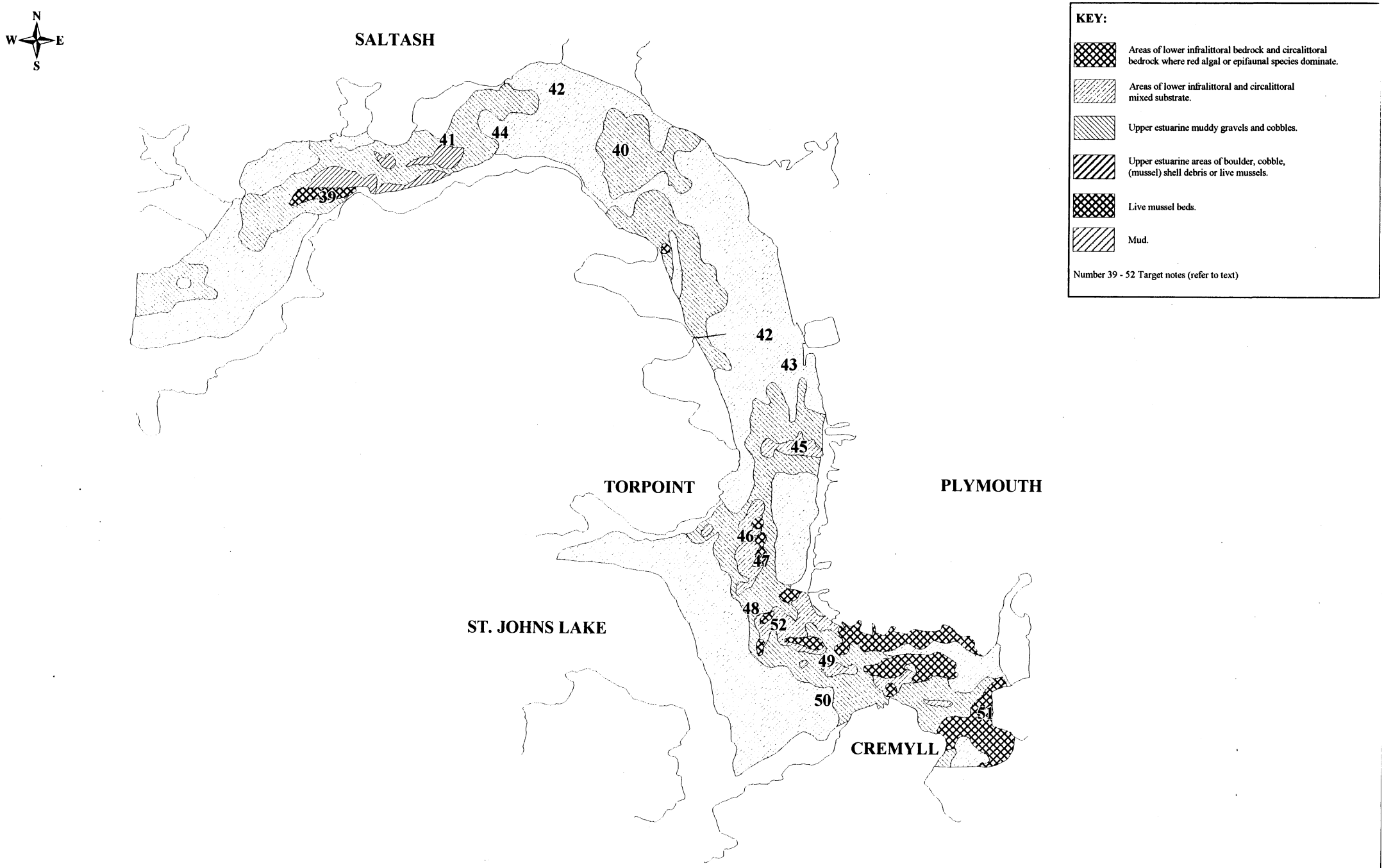


ENGLISH NATURE

BROAD SCALE BIOLOGICAL MAPPING OF
PLYMOUTH SOUND AND ESTUARIES
SUBTIDAL MAPPING - PLYMOUTH SOUND

POSFORD DUVIVIER

Date: January 1997	Drawn By: J.L.H	Checked By: C.S.A
Figure Number: 4.2.2a	Map 1 of 1	Scale : 1:30,000



ENGLISH NATURE

BROAD SCALE BIOLOGICAL MAPPING OF
PLYMOUTH SOUND AND ESTUARIES
SUBTIDAL MAPPING - TAMAR ESTUARY

POSFORD DUVIVIER

Date: January 1997	Drawn By: J.L.H	Checked By: C.S.A
Figure Number: 4.2.2b	Map 1 of 1	Scale : 1:25000

Number	Target Note (Connor *et al.*, 1995)[1]
1	LRK.CHL(G); LRK.COR(Cor); LRK.RSP(S.R)
2	LRK.COR; LRK.SAR.[2]; LRK.FK(FK)
3	LRK.COR; LRK.SAR.[2]; LRK.FK; LRK.BSP(Fser.Bo); LRK.BAS(S.ByAs);
4	LRK.FK; LRK.BAS; LRK.BSP; LRK.COR
5	LRK.CHL; LRK.FK.SP(Fk.Snd); LRK.COR; LRK.SAR[2]
6	LRK.CHL; LRK.ENT(Eph.Ent); LRK.COR; LRK.FK; LRK.FK.BEP(Fk)
7-9	LRK.BAS; LRK.RSP; LRK.COR

1 Updated equivalent biotope code (Connor *et al.*, 1996) given in brackets, where first occurs in table

2 For the purposes of this report this rockpool type has been classified as LRK.SAR.

Number	Target Note
25	Featureless sand, shells with some ephemeral algae
26	'Panther Shoal' and 'Knapp Shoal': Slate bedrock ridges topped with kelp; steep sided gullies. Gully sides are animal and red algae dominated, bases filled with sand and slates
27	Soft mud with burrows; *Turritella, Melinna* sp., few *Virgularia mirabilis*
28	Steep sided, limestone bedrock topped with *Corda filum*; deeper rock with kelp forest
29	Fine sand with burrows, *Amphiura* sp. and *Dosinia* sp.; some ephemeral filamentous algae
30	Infralittoral slate bedrock ridges and gullies topped with kelp. Gully walls with foliose red and brown algae and echinoderms (*Echinus, Marthasterias, Holothuria, Pawsonia*)
31	Circalittoral slate bedrock ridges with *Alcyonium digitatum, Eunicella, Pentapora, Holothuria*
32	Fine, silty sand with burrows and *Amphiura* sp.
33	Bedrock outcrops with foliose red algae and sand patches
34	Broken bedrock: red algae, *Nemertesia* sp., *Pentapora*, few *Eunicella*
35	Gravel waves with few stones and scallops in troughs
36	'Tinker Shoal': as 26
37	Sand with slates, foliose red algae on slates. Few small bedrock outcrops with kelp
38	'Queen's Ground': sand and occasional bedrock outcrops with kelp

Target Notes Associated with Figure 4.2.2(a) and 4.2.2(b)

Number	Target Note
1	Steep limestone bedrock with sponges and tunicates; gravel, cobbles and boulders at base
2	Mixed sediments, silty sand with stones; rock outcrops with kelp
3	Coarse shell, sand/shell gravel; stones heavily encrusted with *Pomatoceros*, bryozoans and hydroids
4	Silty sand with *Zostera* sp.; tubicolous worms (*Myxicola, Lanice, Megalomma vesiculosum*) and *Cerianthus*
5	Stiff mud with burrows. Abundant *Melinna* sp., holothurian *Leptopentacta elongata* occasional
6	Soft mud with burrows
7	Mud with terrigenous material. *Melinna* sp. superabundant, numerous *Dosinia* sp.
8	Shell gravel, impoverished infauna, ephemeral algae
9	Coarse sand with shell fragments and small stones. Some attached algae
10	Soft mud with burrows, abundant *Melinna* sp.
11	Stiff mud with dense *Melinna* sp.
12	Mud with burrows, few *Melinna* sp.
13	Coarse sand and shell gravel; *Laminaria saccharina, Chorda*, filamentous algae
14	Shallow, slightly silty fine sand with drift algae. *Echinocardium* sp. and *Spisula* sp.
15	Fine sand with *Zostera* sp. and *Lanice*
16	Fine sand with burrows; some stones with attached foliose algae
17	Megarippled medium/fine sand and shell gravel; impoverished fauna
18	Medium/coarse sand, impoverished; bedrock outcrops with kelp
19	Slightly silty fine sand; shell fragments; ampharetid worms; stones with algae
20	Medium/fine sand; *Dosinia* sp., *Lanice* sp.; shells with ephemeral algae
21	Muddy fine sand with burrows; some stones with filamentous algae
22	Gravel waves; isolated rock outcrops with kelp
23	Gravel waves; isolated rock outcrops with kelp
24	Rippled sand, slate gravel, few slate bedrock outcrops with faunal turf including *Nemertesia* sp., *Alcyonidium diaphanum, Bugula turbinata*

Number	Target Note
39	Live mussel bed with attached foliose red algae and hydroids and encrusting bryozoans
40	Mud, gravel and mussel shells, surface iron crust. Stones heavily encrusted with *Pomatoceros,* bryozoans, hydroids (*Halecium halecinum*) and *Perophora listeri.* Terebellid worms amongst stones
41	Mud with heavily encrusted shells and stones, shell gravel, coal slag and terrigenous material. Hydroids (including *Halecium* sp.), encrusting bryozoa, few *Corella*, few errant polychaetes
42	Soft mud overlying stiff, anaerobic mud. Few Ampharetid worm tubes only
43	Soft mud with fine sand, few pebbles, abundant worm tubes. *Parvocardium* sp., hydroids, encrusting bryozoa, tunicates (*Diplosoma listeriamum, Aplidium, Corella*)
44	Iron-encrusted shell gravel and small stones amongst stiff mud *Pomatoceros, Balanus crenatus*, encrusting bryozoans on stones and shells. Few *Crepidula*
45	Shell gravel and isolated boulders. Few *Melinna* sp., few errant polychaetes, *Halecium halecinum* common
46	Stiff mud with fine sand, encrusted stones, shell fragments, numerous artifacts. Abundant Ampharetid worms, few *Ophiura* sp.
47	Bedrock ridge covered in sponges (*Hymeniacidon/Halichondria*?) and abundant *Nemertesia* sp.
48	Mud and fine sand. Superabundant *Mellina* sp.
49	Cobble-sized slate and limestone plates, few boulders. *Asterias*, cobbles heavily encrusted with *Balanus crenatus, Pomatoceros, Anomia, Corella,* sponges
50	Mud and fine sand. Superabundant *Melinna* sp., *Lanice, Amphiura* sp., *Acanthocardia* sp., few errant polychaetes
51	Steep, tideswept limestone bedrock. Dense covering of sponges, hydroids and tunicates (esp. *Halichondria bowerbankia, Dendrodoa*)
52	Steep bedrock with dense sponge, *Nemertesia* sp. and tunicate covering

APPENDIX 1.1

CANDIDATE SAC CITATION FOR PLYMOUTH SOUND AND ESTUARIES

Reasons for recommendation as a possible Special Area of Conservation

Area Name: Plymouth Sound and Estuaries

County/District: Cornwall
Devon

Component SSSI: Lynher Estuary
St John's Lake
Tamar - Tavy Estuary
Wembury Point

This area is being considered as a possible Special Area of Conservation (SAC) because it contains habitat types and/or species which are rare or threatened within a European context. The SSSI citation describes the special interests for which the site was notified in the British context. [NB Not for marine interests below mean low water mark]. The interests for which the site was selected as SSSI may differ from the interests selected in a European context.

The habitats and/or species for which this area has been proposed as a possible SAC are listed below. The reasons for their selection are listed, together with a brief description of the habitats and species as they typically occur across the UK. This area contains the interests described although it may not contain all the typical features. (Please see the accompanying Natura 2000 booklet for further information on the approach to site selection.)

The area is considered to have a high diversity of habitats/species of European importance.

European interest(s):

1. Subtidal sandbanks.†

- for which this is considered to be one of the best areas in the United Kingdom.

†Sandbanks which are slightly covered by sea water all the time: Sandbanks permanently covered by sea water to depths of up to 20 metres below low water. These include muddy sands, clean sands and maerl beds (carpets of small, unattached, calcareous seaweed).

2. Estuaries.†

- for which this is considered to be one of the best areas in the United Kingdom.

†Estuaries: These are semi-enclosed bodies of water which have a free connection with the open sea and within which the seawater is measurably diluted by freshwater from the surrounding land. They are large features which often contain a complex range of habitats that reflect the variations in tidal influence and substrate type.

3. Shallow inlets and bays.†

- for which this is considered to be one of the best areas in the United Kingdom.

†Large shallow inlets and bays: These are bays and inlets such as rias and voes (drowned river valleys in south-western parts of the UK and Shetland respectively), and fjards (shallow inlets in western Scotland and Northern Ireland). They are often large physiographic features which may contain a range of marine habitats.

4. Shore dock.†

- for which this is considered to be one of the best areas in the United Kingdom;
- which is known from 15 or fewer 10 km squares in the United Kingdom;
- for which the area contains more than 10% of the United Kingdom resource.

†*Rumex rupestris*: Shore dock grows on rocky and sandy beaches, at the foot of cliffs and infrequently in dune slacks where there is a supply of freshwater. It is thought to be the world's rarest dock and is one of the rarest plants in Europe. In the UK it is found only on a small number of sites in south-west England, Wales and the Channel Isles.

Site name	**Plymouth Sound and Estuaries**
Country	England (Devon and Cornwall)
Boundary	See map The boundary for the majority of the site is high water mark since the site is selected for marine features only except for a small area (around Rame Head) included for a coastal feature (shore dock). Note that the enclosed area of the Barbican is excluded together with other dock/harbour areas indicated on the Admiralty Chart based map. Intertidal areas that are not SSSI which may be considered further include the Yealm and the coast around Bovisand and Jennycliff bays. The upstream boundary in estuaries follows that of relevant SSSIs - Tamar-Tavy Estuary, Lynher Estuary and St John's Lake. These are shown in more detail on the accompanying OS map(s).

Reasons for recommendation of site

The site contributes to the essential range and variation of large shallow inlets and bays in the UK as the best example of a southern drained river valley. Estuaries and estuarine habitats, and subtidal sandbanks contribute significantly to the overall diversity of the site.

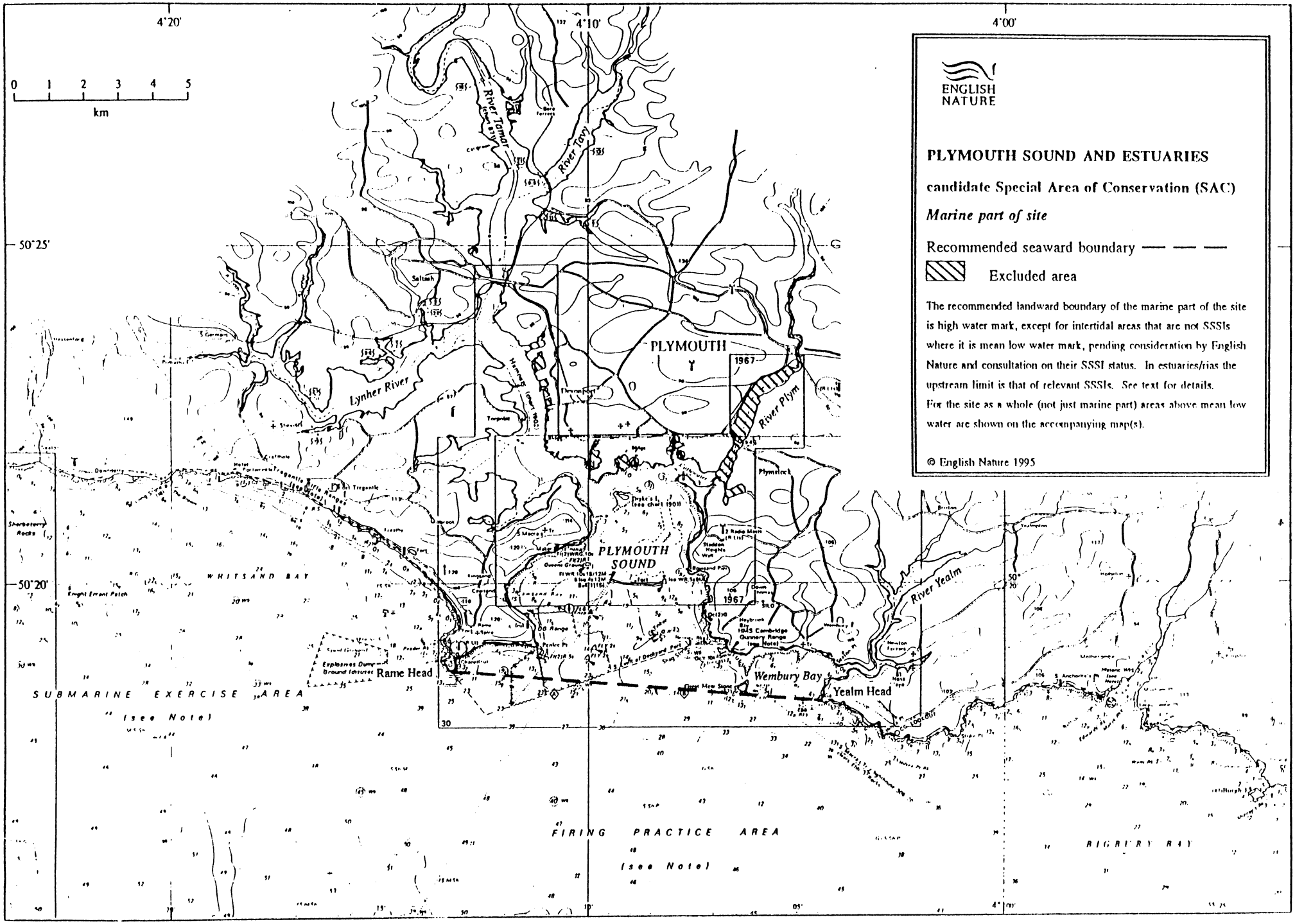
Marine habitats for which selected	Extent
Large shallow inlets and bays	Five ria systems comprise nearly 50% of the area - Lynher, St John's Lake, Tamar, Tavy and Yealm. Large bays (Plymouth Sound and Wembury Bay) make up much of the remainder.
Estuaries	Much of St John's Lake and the upper reaches of several parts of the system.
Sandbanks which are slightly covered by seawater all the time	Extensive areas within inlets and on the open coast

Site description

This complex site is one of the finest, extensive ria (drowned river valley) systems in Britain. It is comprised of four ria systems entering Plymouth Sound (St John's Lake and parts of the Tavy, Tamar and Lynher), the large bay of the Sound itself (with an artificial breakwater sheltering large areas), Wembury Bay, and the ria of the River Yealm. Good examples of inlets with both estuarine conditions and a low freshwater input are present. A high diversity of habitats with an extremely rich marine flora and fauna is recorded here, including abundant southern Mediterranean-Atlantic species rarely found in Britain.

The upper part of the Tamar and Lynher estuaries includes a very well developed estuarine gradient which has not been modified by the construction of locks or weirs. As a consequence, they exhibit one of the finest examples of changing estuarine communities (both on rock and in sediment) with changing salinity regime. Rocky reefs in low salinity estuarine conditions far inland on the Tamar are very unusual and support rarities such as the hydroid *Cordylophora lacustris*. St John's Lake supports notably diverse sediment communities. The Yealm, which is a ria, is also almost entirely natural, but with a wide diversity of habitats, communities and species characteristic of low freshwater input. These range from mudflats at the head of the system to fine sediments at the entrance with beds of the eel grass *Zostera marina* extending up from the subtidal.

Plymouth Sound is of international marine conservation importance for its wide range of habitats and species richness, with many rarely encountered algae and animals (including the only known location in Britain for Steven's goby). Particularly important habitats include: littoral and sublittoral limestone reefs extensively bored by bivalves and harbouring a rich fauna, eg steep rocky subtidal slopes from the Hamoaze to east of Drake's Island which support some of the most notable marine communities in the area; sublittoral tide-swept reefs offshore such as broken shale reefs at the entrance to the Sound; tide scoured limestone channels with animal communities rarely encountered in other marine inlets; and subtidal sediments with rich and often diverse invertebrate communities including muddy/fine sediments in Jennycliff Bay, Cawsand Bay, north of the Breakwater and in the middle of the Sound.


4°20'
4°10'
4°00'
0 1 2 3 4 5
km
50°25'
50°20'
ENGLISH NATURE
PLYMOUTH SOUND AND ESTUARIES
candidate Special Area of Conservation (SAC)
Marine part of site
Recommended seaward boundary
Excluded area
The recommended landward boundary of the marine part of the site is high water mark, except for intertidal areas that are not SSSIs where it is mean low water mark, pending consideration by English Nature and consultation on their SSSI status. In estuaries/rias the upstream limit is that of relevant SSSIs. See text for details.
For the site as a whole (not just marine part) areas above mean low water are shown on the accompanying map(s).
© English Nature 1995
River Tamar
River Tavy
Lynher River
River Plym
River Yealm
PLYMOUTH
PLYMOUTH SOUND
WHITSAND BAY
Rame Head
Wembury Bay
Yealm Head
SUBMARINE EXERCISE AREA
(see Note)
FIRING PRACTICE AREA
(see Note)
BIGBURY BAY

APPENDIX 3.2.2

ROXANN CONTOUR MAPS IDENTIFYING AREAS OF HARDNESS AND ROUGHNESS
(see Section 4.2.1 for explanation)

Note from the Nominated Project Officer

For convenience the 3 large colour maps from Appendix 3.2.2
have been ommitted. Originals can be loaned for copying on request.

APPENDIX 4.1(a)

LIST OF PHOTOGRAPHS TAKEN IN THE INTERTIDAL ZONE

INTERTIDAL BIOTOPE SLIDE LIST

1. St. Johns Lake looking South
2. St. Johns Lake looking South
3. (15) Intertidal rockpool Wembury Bay (LRK.COR)
4. (17) West of Wembury Beach
5. (16) West of Wembury Bay (LRK.BP and LRK.LPYG)
6. (30) Wembury beach
7. (28) Rockpool to the west of Wembury Beach (LRK.ENT)
8. (22) Rockpool to the west of Wembury Beach (LRK.FK, LRK.SAR)

APPENDIX 4.1(b)

INTERTIDAL BIOTOPE CODES

(Taken from Connor *et al.*, 1995)

Intertidal biotopes used in this report as defined in the MNCR classification (Connor, *et al.*, 1995)

LRK.VER.B	Exposed littoral fringe bedrock with *Verrucaria maura* and sparse barnacles
LRK.LPYG	Steep exposed lower littoral fringe bedrock with *Lichina pygmaea*
LRK.ENT	Freshwater-influenced or unstable littoral fringe hard substrata with *Enteromorpha* spp.
LRK.CHL	Supralittoral and littoral fringe rockpools with *Enteromorpha* spp. and *Cladophora* spp.
LRK.BP	Exposed, or sheltered vertical, eulittoral rock with barnacles and *Patella vulgata*
LRK.FSP	Sheltered upper eutlittoral rock with *Fucus spiralis*
LRK.FVES	Moderately exposed to sheltered mid eulittoral rock with *Fucus vesiculosus*
LRK.EPH	Sand-scoured eulittoral rock with *Porphyra purpurea* or *Enteromorpha* spp.
LRK.RED.LAU	Moderately exposed mid to lower eulittoral rock with *Laurencia pinnatifida* and *Gelidium pusillum*
LRK.RED.MAS	Moderately exposed lower eulittoral rock with *Mastocarpus stellatus* and *Chondrus crispus*
LRK.FSE	Moderately exposed to very sheltered lower eulittoral rock with *Fucus serratus*
LRK.FSE.RED	Moderately exposed lower eulittoral rock with *Fucus serratus* and red algal mosaics
LRK.COR	Shallow eulittoral rockpools with coralline crusts and *Corallina officinalis*
LRK.FK	Deep eulittoral rockpools with fucoids and kelps
LRK.FK.BEP	Deep eulittoral bedrock pools with *Fucus serratus* and *Laminaria digitata*
LRK.FK.SP	Sediment-floored eulittoral rockpools with *Fucus serratus*, *Laminaria digitata* and sand-tolerant algae
LRK.RSP	Overhanging lower eulittoral rock with shade-tolerant red algae and sponges
LRK.BAS	Overhanging lower shore bedrock with bryozoans, ascidians and sponges
LRK.BSP	Eulittoral under-boulders with encrusting bryozoans, serpulid worms and *Porcellana platycheles*
LRK.LDIG.LDIG	Moderately exposed sublittoral fringe rock with *Laminaria digitata*
LRK.LDIG.T	Tide-swept sublittoral fringe rock with *Laminaria digitata*, ascidians and bryozoans

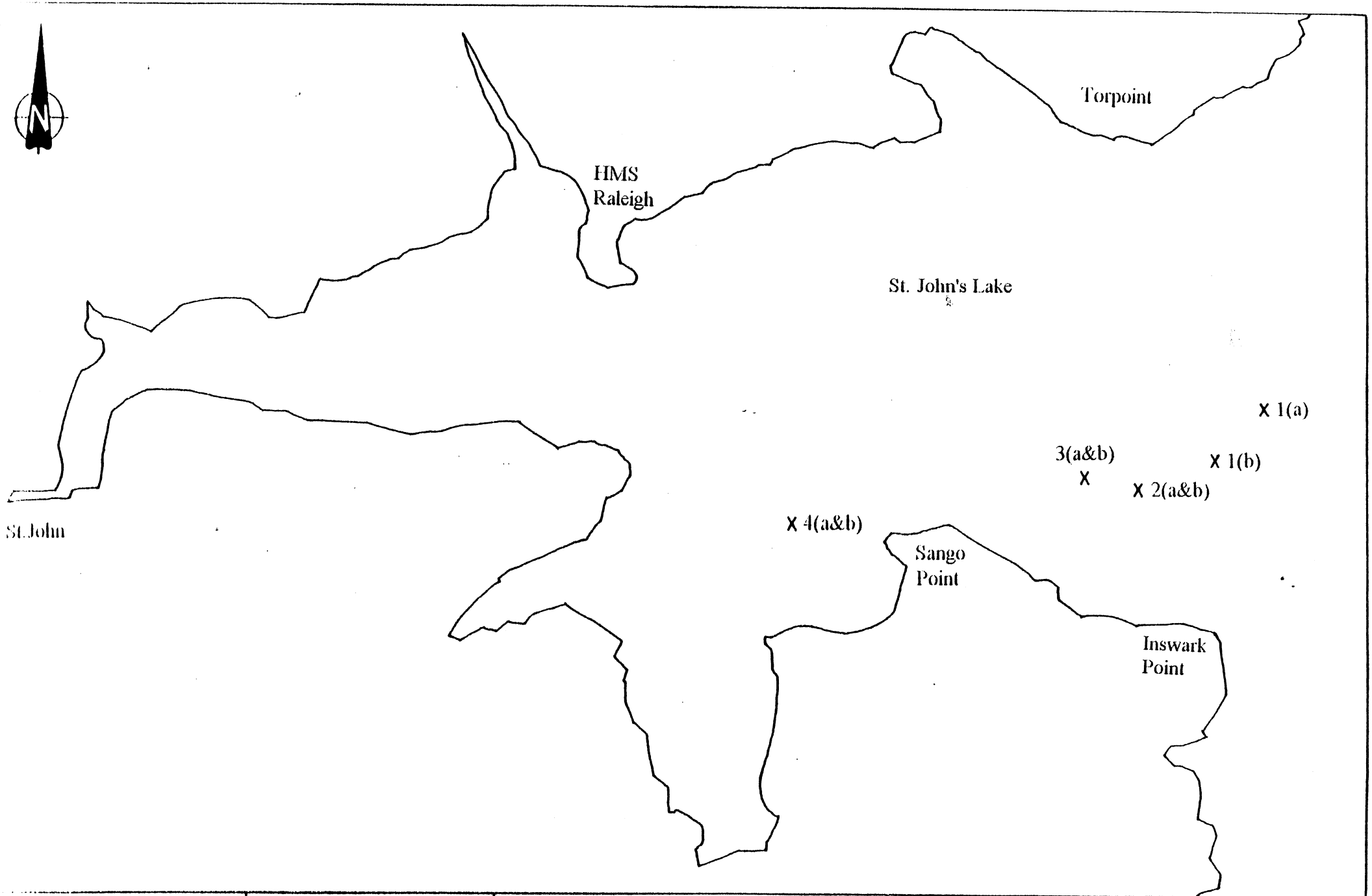
LRK.SPOL	Disturbed sublittoral fringe rock with *Saccorhiza polyschides*
LMXD.EPH	Variable salinity or disturbed eulittoral mixed substrata with ephemeral green and red algae
LMXD.MYT	Eulittora mixed substrata with *Mytilus edulis* beds
LMXD.BAR	Shingle or gravel shores with no apparent macrofauna
LSND.BAR	Very exposed coarse sand shores with no apparent macrofauna
LMUD.HM.MAN	Reduced salinity mid shore sandy mud with *Hediste diversicolor, Macoma balthica* and *Manayunkia aestuarina*
LMUD.HM.NEP	Reduced salinity lower shore sandy mud with *Hediste diversicolor, Macoma balthica* and *Nephtys hombergii*

APPENDIX 4.1.2

RESULTS OF SURVEY WORK IN ST. JOHN'S LAKE AND MAP OF SAMPLING LOCATIONS

Results of Survey work in St. John's Lake

	Site Number							
TaxonName	**1A**	**1B**	**2A**	**2B**	**3A**	**3B**	**4A**	**4B**
NEMERTEA	-	-	1	-	-	-	-	-
Hediste diversicolor	-	-	-	-	-	-	-	1
Nephtys hombergii	1	-	2	1	-	2	-	-
Pygospio elegans	-	-	3	9	-	-	-	-
Spio decorata	-	3	-	-	-	-	-	-
Streblospio shrubsolii	-	-	-	-	5	1	2	1
Caulleriella killariensis	3	16	11	32	2	-	-	1
Chaetozone gibber	20	39	-	1	-	-	-	-
Aphelochaeta marioni	-	-	24	23	-	-	-	-
Cossura longocirrata	4	13	-	-	-	-	-	-
Notomastus sp.	-	-	-	2	-	-	-	-
Melinna palmata	6	5	3	2	2	-	-	-
Ampharete acutifrons	-	-	8	17	6	7	9	4
Tubificoides benedii	-	-	8	11	39	3	3	1
Tubificoides pseudogaster (agg)	-	-	-	-	7	-	-	-
Tubificoides galiciensis	5	7	-	-	-	-	-	-
Elminius modestus	-	-	-	2	-	-	-	-
Melita palmata	-	1	-	1	-	1	-	-
Cerastoderma edule	-	-	-	1	-	1	-	-
Scrobicularia plana	-	-	-	-	2	-	-	-
Phoronis sp.	-	1	-	-	-	-	-	-



ENGLISH NATURE

BROAD SCALE BIOLOGICAL MAPPING OF PLYMOUTH SOUND AND ESTUARIES

Title: INTERTIDAL MAPPING - ST JOHNS LAKE SAMPLING LOCATIONS

Consulting Engineers
POSFORD DUVIVIER
Head Office PETERBOROUGH

Date FEB 97	Scale 1:1,250
Drawn MJM	Chkd CSA
Drg No.	

APPENDIX 4.2

LIST OF PHOTOGRAPHS TAKEN IN THE SUBTIDAL ZONE

PLYMOUTH BIOTOPES: SLIDE LIST

Slide No.	Station No.	Description	Photographer
302	-	Robert Irving recording biotopes	Chris Adnitt
303	66	*Zostera marina*, near Drake's Island	Chris Adnitt
305		Robert Irving photographing biotopes	Chris Adnitt
308	66	*Zostera marina*, near Drake's Island	Chris Adnitt
309	66	Dense *Zostera marina*, near Drake's Island	Chris Adnitt
311	69	Soft mud with burrows just North of Plymouth Breakwater	Chris Adnitt
313	69	Soft mud with burrows, *Turritella* and one *Asterias*; just North of Plymouth Breakwater	Chris Adnitt
315	59	Bedrock outcrop just South of Plymouth Breakwater: dense red algal cover, *Nemertesia antennina, Alcyonium digitatum* and encrusting bryozoa	Chris Adnitt
317	59	Cobbles and boulders amongst sand, just South of Plymouth Breakwater: dense red and green algal cover, few *Nemertesia* and *Pentapora* colony	Chris Adnitt
320	59	Rock outcrop with slates, just South of Plymouth Breakwater: dense red algal cover (*including Phycodris rubens/Delesseria sanguinea* with heavy bryozoan encrustation), *Nemertesia* and other hydroids	Chris Adnitt
321	59	Rock outcrop just South of Plymouth Breakwater: dense red and green algal cover, *Alcyonium digitatum* and *Henricia* starfish	Chris Adnitt
323	70	Northern end Cawsand Bay: sand, gravel and slates with attached foliose algae (esp. *Desmarestia aculeata* and *Halarachnion ligulatum*)	Mike Camplin
325	70	Northern end Cawsand Bay: sand waves with coal slag in trough, some attached algae on coal slag	Mike Camplin

Slide No.	Station No.	Description	Photographer
327	67	Eastern King Point. Steep, tideswept, silty limestone bedrock with rich sponge and tunicate epifauna, edge of steep drop into main channel. Visible in photograph: *Suberites fiscus, Hymeniacidon perleve, Raspailia/Stelligera* indet.; *Clavelina lepadiformis, Styela clava, Dendrodoa, Diplosoma listerianum, Morchellium argus, Nemertesia antennina*	Colin Munro
329	67	Eastern King Point, shelving slope in shallows away from main channel. Dense mat of amphipod tubes in silt covered limestone	Colin Munro
331	67	Eastern King Point. Steep, tideswept, silty, bedrock and boulder slope, 20-30m. *Esperiopsis fucorum* colonies, amphipod tubes and *Polydora* sp. Also *Suberites fiscus, Diplosoma lisoclunum, Clavelina* and *Tubularia indivisa* colonies visible	Colin Munro
333	67	Eastern King Point, shelving slope in shallows away from main channel. Dense mat of amphipod tubes in silt covered limestone. Note also *Suberites fiscus* and *Clavelina* colonies and turbellarian worm *Prostheceraeus vittatus*	Colin Munro
336	58	South of Breakwater, East of Panther Shaol. Sand, cobbles and slates with *Desmarestia aculeata* and *Brogniartella byssoides* attached	Colin Munro
337	58	South of Breakwater, East of Panther Shaol. *Desmarestia aculeata* on sand covered slates	Colin Munro
339	60	South of Breakwater, East of Panther Shoal. Fine sand	Colin Munro
341	79	Bedrock ridges, Wembury Bay. Vertical gully wall with dense red algae, *Aslia/Pawsonia* holothurians and *Dercitus bucklandi* in crevices	Colin Munro
344	79	Dense kelp canopy on tops of bedrock ridges, Wembury Bay	Colin Munro
345	79	Grazed bedrock ridges under kelp canopy, Wembury Bay. *Echinus esculentus, Marthasterias glacialis* and *Galathea strigosa* visible amongst encrusting and foliose algae	

Slide No.	Station No.	Description	Photographer
347	79	Wembury Bay. *Saccorhiza polyschides* and corkwing wrasse on ridge tops	Colin Munro
349	79	Ballan wrasse, Wembury Bay	Colin Munro
351	79	Foliose red algae with low hydroid and bryozoan turf, vertical bedrock. Note small *Parethropodium coralloides* (?) colonies on overhang	Colin Munro

APPENDIX 4.2.1(a)

ROXANN CALIBRATION GRAPHS

(see Section 4.2.1 for explanation)

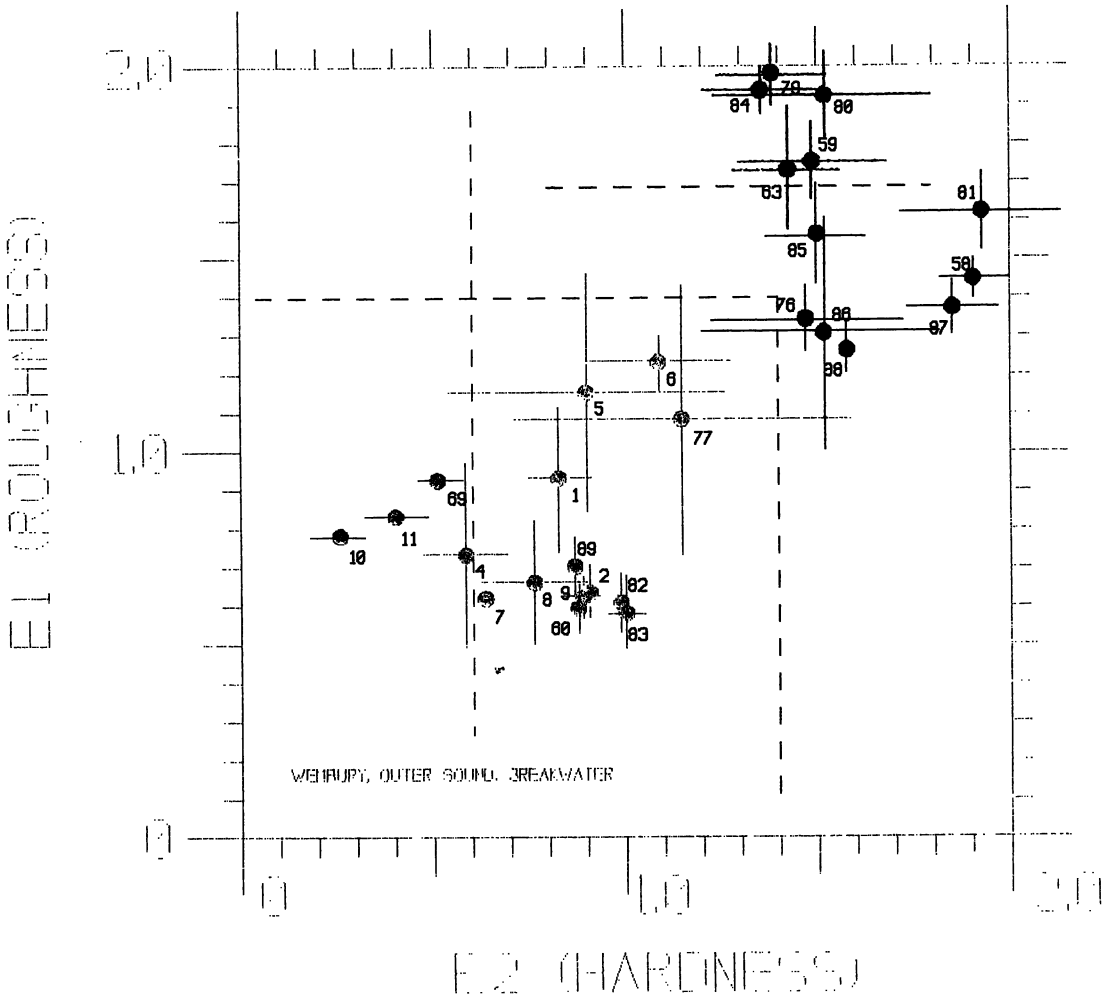


Figure 1 RoxAnn Calibration - Offshore (see text, Section 4.2.1, for further explanation)

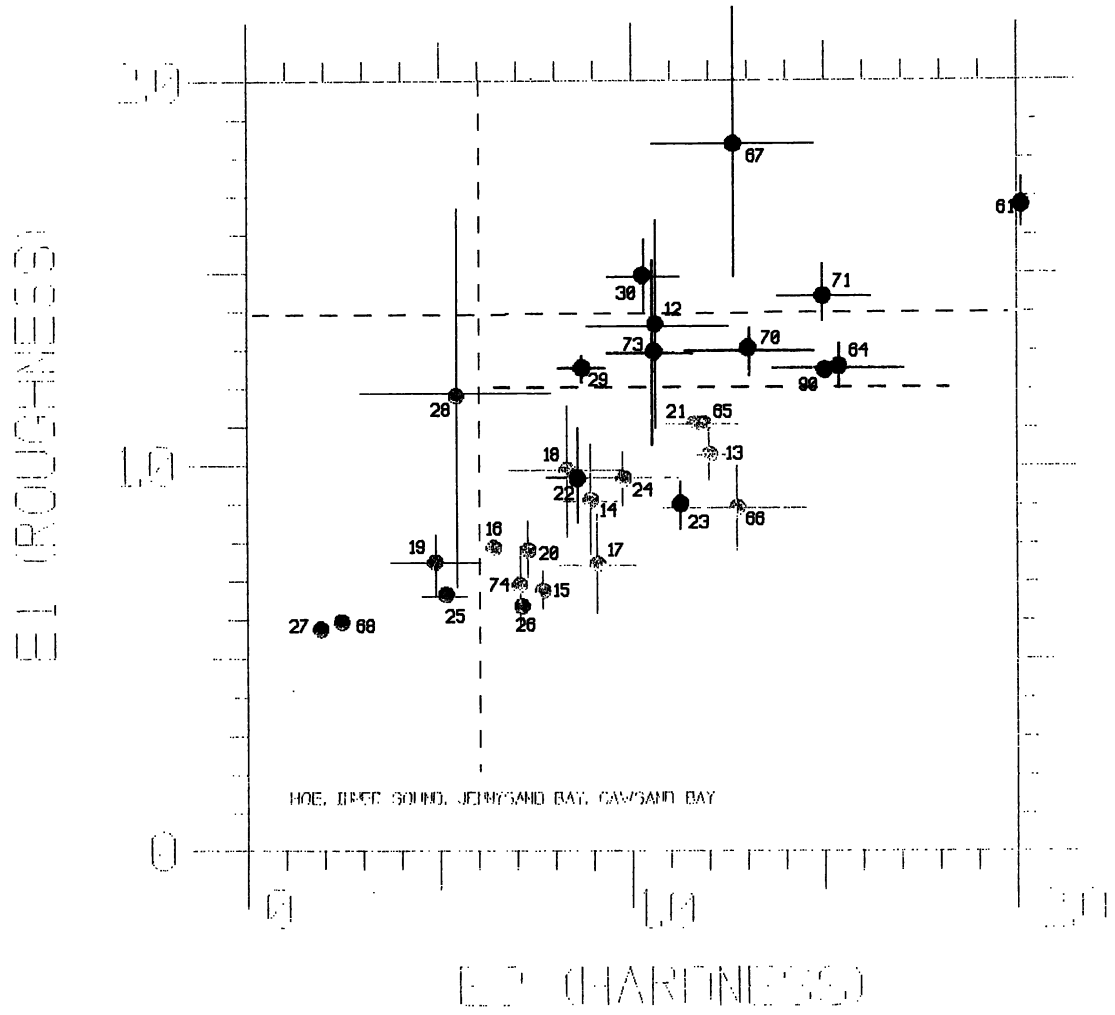


Figure 2 RoxAnn Calibration - Inshore (see text, Section 4.2.1, for further explanation)

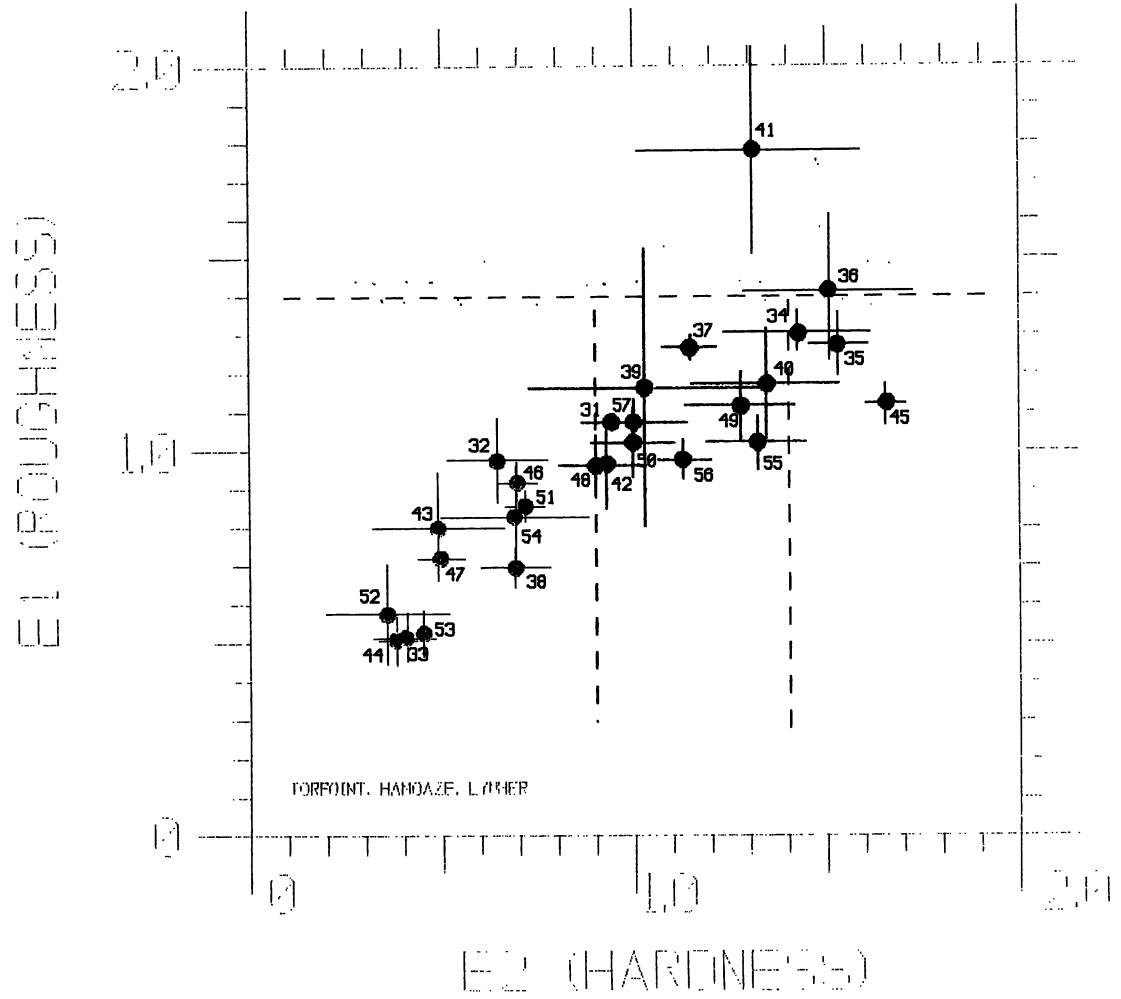


Figure 3 RoxAnn Calibration - Estuary (see text, Section 4.2.1, for further explanation)

APPENDIX 4.2.2(a)

SUMMARY TABLE OF SURVEY RESULTS

Grab & Video

Stn No	AREA	E1		E2		Depth (m)		Comment	Particle size		Sand		Grab	Seabed
		Mean	Sd	Mean	Sd	Mean	Sd		%gravel	%mud	mean	sort	volum	description
1	1	0.94	0.19	0.83	0.08	6.01	0.20		0	2	125	1	1	fine sand; Zostera; wave-ripples
2	1	0.64	0.04	0.91	0.08	8.20	0.13		0	5	110	2	1	slightly silty fine sand; burrowed
3	1							Offtrack	1	5	550	2	1	coarse sand in amongst rock; kelp
4	2	0.73	0.24	0.59	0.12	29.12	1.18		0	17	90	2	1	silty fine sand; burrowed
5	2	1.15	0.31	0.91	0.36	29.78	0.19		0	12	125	2	2	silty fine sand; burrowed
6	2	1.23	0.08	1.10	0.19	21.77	1.20	60m NE of site	0	2	110	2	2	irregular (burrowed) fine sand
7	2	0.61	0.02	0.64	0.02	18.80	0.13		0	1	125	1	3	fine sand; wave rippled
8	4	0.66	0.16	0.78	0.14	14.32	0.35		0	4	110	2	2	fine sand; burrows; rock patches
9	4	0.63	0.06	0.90	0.05	14.86	0.21		0	2	110	1	2	fine sand; sparse filamentous weed
10	4	0.78	0.03	0.26	0.07	10.53	0.82		0	67	63	1	4	soft mud; burrowed
11	4	0.84	0.02	0.41	0.09	12.82	0.14		0	60	70	1	4	soft mud; burrowed
12	3	1.35	0.28	1.04	0.18	8.17	2.29	40m NE of site	1	1	400	1	2	medium/coarse sand in amongst rock
13	3	0.99	0.07	1.17	0.04	12.99	0.73		0	2	150	1	1	medium/fine sand; megarippled
14	3	0.88	0.14	0.85	0.07	10.44	0.64		2	6	110	1	2	slightly silty fine sand with shell fragments
15	3	0.63	0.03	0.72	0.05	5.67	0.62		1	5	150	2	2	slightly silty medium/fine sand
16	3	0.75	0.02	0.59	0.03	11.17	0.37		0	25	90	2	2	muddy fine sand; burrowed
17	3	0.71	0.13	0.88	0.10	14.30	0.30		1	1	125	2	2	fine sand with scattered stones; burrowed
18	3	0.97	0.17	0.80	0.15	12.34	0.53		1	7	90	2	2	fine sand amongst rippled gravelier sand
19	5	0.71	0.08	0.43	0.12	14.13	1.15		1	68	63	0	3	mud; burrowed
20	5	0.74	0.02	0.68	0.08	13.22	0.11		0	42	110	0	4	mud and fine sand; tube worm colonies
21	5	1.08	0.03	1.14	0.07	12.00	0.28		8	8	150	0	1	slightly silty medium/fine sand with shell gravel
22	5	0.95	0.12	0.81	0.09	7.56	0.44		32	2	1500	2	2	gravel of broken shell; plane bed
23	6	0.87	0.03	1.10	0.06	8.32	0.28		7	2	600	1	3	coarse sand with fine shell gravel; mudballs
24	6	0.93	0.07	0.94	0.14	7.72	0.55		2	22	180	1	1	silty medium/fine sand with some small stones/shell
25	6	0.63	0.02	0.47	0.05	11.00	0.12		1	49	80	1	4	mud and fine sand; tube worms; burrowed
26	6	0.60	0.02	0.67	0.06	12.05	0.34		0	62	63	1	4	stiff mud; tube worms; plane
27	7	0.54	0.02	0.13	0.02	10.72	0.54		7	68	63	0	4	soft mud with shells; plane
28	7	1.17	0.50	0.49	0.25	13.01	0.60		4	68	63	0	4	mud with scattered shells; dense tube worm colony
29	7	1.22	0.03	0.83	0.06	28.65	0.64		27	11	1500	0	3	gravel of stones with coarse shell debris; plane
30	7	1.48	0.09	1.00	0.09	3.93	0.49		4	4	250	1	1	patches of slightly silty medium sand with stones amongst kelp
31	8	1.07	0.07	0.94	0.05	18.63	1.24		11	21	180	0	1	muddy medium/fine sand patches amongst gravels & cobbles
32	8	0.98	0.11	0.66	0.13	3.56	1.04		0	38	90	1	4	mud and fine sand; tube worm colony
33	8	0.51	0.06	0.40	0.08	2.07	0.06		2	45	90	2	3	stiff mud and fine sand; tube worm colony; plane
34	8	1.30	0.05	1.43	0.19	23.61	1.74							very encrusted gravels and cobbles with occasional boulder
35	8	1.28	0.08	1.54	0.08	11.25	0.14							very encrusted gravels and cobbles with occasional boulder
36	8	1.42	0.19	1.52	0.22	18.14	5.73							rock outcrop; cliffed
37	8	1.26	0.03	1.15	0.07	33.30	1.58		66	21	1500	0	2	muddy gravel; encrusted stones and shell; plane
38	8	0.70	0.05	0.70	0.09	15.07	0.90		3	54	90	1	4	mud and fine sand; tube worm colonies; plane
39	8	1.17	0.37	1.04	0.30	15.50	4.45							shale outcrops; encrusted tabular boulders and cobbles
40	8	1.18	0.14	1.36	0.19	14.83	1.96		3	75	63	0	2	stiff mud with fine sand; surface of encrusted stones; artifacts

41	8	1.78	0.27	1.32	0.29	21.93	1.53							rock outcrop
42	8	0.97	0.12	0.93	0.10	9.43	0.35		6	52	90	0	3	mud with fine sand and surface layer of encrusted gravel
43	8	0.81	0.14	0.49	0.17	3.46	1.58		1	58	80	1	3	soft mud and fine sand; filamentous algae; plane bed
44	8	0.52	0.06	0.38	0.05	2.08	0.18		0	50	63	2	4	soft mud and fine sand; surface algal film
45	9	1.12	0.09	1.67	0.16	8.12	1.45		49	3	1500	0	1	coarse encrusted gravel with isolated boulders
46	9	0.93	0.05	0.70	0.05	10.79	0.13		4	77	80	0	3	soft mud with fine sand; tube worm colonies
47	9	0.72	0.03	0.51	0.06	13.65	0.83		0	89	63	0	3	stiff anaerobic mud; plane; soft surface veneer
48	9	0.97	0.09	0.92	0.10	17.36	1.35		7	60	90	0	2	stiff anaerobic mud with scattered shells; soft surface veneer
49	9	1.12	0.09	1.29	0.14	11.24	1.02		10	57	1500	0	2	mud with encrusted gravel; surface iron crust
50	9	1.05	0.09	1.00	0.11	14.33	1.10		20	43	1500	0	2	mud and fine gravel; shells and artifacts
51	10	0.85	0.04	0.72	0.05	3.11	0.11		3	74	63	0	4	stiff mud and fine sand; shell debris
52	10	0.58	0.13	0.36	0.16	7.77	3.49		0	77	63	1	4	soft mud overlying anaerobic stiff mud
53	10	0.54	0.06	0.45	0.00	15.29	0.47		22	37	1000	0	3	gravel of rotten iron-coated shells with stiff mud
54	10	0.83	0.14	0.70	0.19	9.89	0.86		11	52	1500	0	4	mud with fine broken shell; isolated stones
55	10	1.03	0.07	1.32	0.13	8.23	0.56		35	27	1500	0	3	soft mud with gravel of stones and shell
56	10	0.98	0.05	1.14	0.07	5.61	0.64		40	29	1500	0	2	culch layer with underlying stiff mud
57	10	1.07	0.05	1.01	0.14	4.48	0.29		22	49	1500	0	4	mussel bed; culch and mud

NOTES

Sand mean: estimated mean diameter of sand grain population; microns
Sand sorting: Index, 0 = very poor, 2 = very good
Grab volume: 1 = poor sample, 4 = grab full; useful index of seabed hardness
% sand equals 100 - (% gravel and % mud)

DIVE & VIDEO SITES

Station No.	Field Site No.	Area	E1		E2		Depth (m)		Seabed Description
			Mean	Sd	Mean	Sd	Mean	Sd	
1	58	4	1.45	0.06	1.91	0.09	13.87	0.32	Cobbles with sand veneer/patches; sparse red and brown algal cover
2	59	4	1.76	0.10	1.48	0.19	8.25	0.53	Slate outcrop with kelp forest
3	60	4	0.60	0.04	0.88	0.06	14.83	0.24	Fine sand with burrows and degraded wave-ripples
4	61	5	1.66	0.06	2.02	0.00	13.72	0.39	Slate outcrop, slate gravels with sand patches
5	62	5					13.31	0.20	Sand
6	63	4	1.72	0.16	1.41	0.14	10.77	0.68	Ridges of bedrock; kelp forest
7	64	5	1.24	0.05	1.51	0.18	12.39	0.28	Bed or loose slate with thin sand veneers
8	65	5	1.08	0.03	1.15	0.09	11.97	0.28	Hard sand
9	66	7	0.87	0.11	1.23	0.19	7.48	1.02	Silty sand with Zostera
10	67	7	1.85	0.35	1.22	0.21	17.72	5.78	Cliffed limestone outcrop with boulders and cobbles in hollows
11	68	7	0.55	0.03	0.19	0.02	10.90	0.74	Burrowed soft mud
12	69	4	0.91	0.03	0.51	0.06	12.65	0.15	Burrowed mud
13	70	3	1.29	0.06	1.28	0.16	12.28	0.09	Encrusted cobbles and gravels; sand patches
14	71	3	1.42	0.07	1.49	0.12	11.80	0.09	Rock outcrop with some kelp; sand with degraded wave-formed megaripples
15	72	4	1.45	0.02	1.63	0.06	12.23	0.23	Sandy gravels with degraded wave-formed megaripples

Station No.	Field Site No.	Area	E1		E2		Depth (m)		Seabed Description
			Mean	Sd	Mean	Sd	Mean	Sd	
16	73	3	1.29	0.25	1.01	0.12	12.19	0.53	Wave-formed megaripples in gravel; bedrock ridge with some kelp and red algae
17	74	3	0.64	0.04	0.66	0.10	11.97	0.17	Silty fine sand; burrowed, degraded wave-ripples
18	75	2	1.47	0.12	1.19	0.14	17.04	0.50	Rock outcrop with dense turf of red algae; some sand patches
19	76	2	1.33	0.09	1.46	0.25	18.97	0.42	Rock outcrop with dense turf of red algae; some sand patches
20	77	2	1.10	0.35	1.15	0.45	27.28	0.39	Shelly sand with degraded wave-ripples
21	78	2					28.28	0.73	Wave-formed megaripples in sandy gravel; stones and scallops in troughs
22	79	1	1.98	0.09	1.38	0.14	10.31	1.11	Bedrock ridges with kelp forest
23	80	1	1.92	0.11	1.52	0.29	13.13	1.74	Bedrock ridges with kelp forest
24	81	1	1.62	0.11	1.93	0.21	10.02	0.52	Slate outcrops and shell gravel; red and brown algae
25	82	1	0.60	0.02	0.99	0.08	8.64	0.24	Shelly sand with degraded wave-ripples
26	83	1	0.59	0.05	1.00	0.09	6.57	0.23	Shelly sand
27	84	1	1.93	0.07	1.35	0.15	9.50	0.27	Slate ridges with kelp
28	85	2	1.54	0.13	1.50	0.13	16.25	0.69	Bedrock and boulders with red algae
29	86	2	1.30	0.30	1.51	0.31	27.23	0.17	Rock outcrops with slate gravel and sand areas
30	87	2	1.37	0.07	1.85	0.12	17.01	0.35	Bedrock with red algae
31	88	2	1.27	0.02	1.58	0.07	19.11	0.21	Bedrock with red algae

Station No.	Field Site No.	Area	E1		E2		Depth (m)		Seabed Description
			Mean	Sd	Mean	Sd	Mean	Sd	
32	89	1	0.72	0.03	0.86	0.08	14.84	0.22	Stable sand with algal film; pocked/burrowed
33	90	3	1.21	0.05	1.48	0.16	12.84	0.15	Shells and gravels with sand

APPENDIX 4.2.2(b)

DRAFT DEFINITION OF SANDBANKS, AS DEFINED FOR THE HABITATS DIRECTIVE

SUBTIDAL SANDBANKS

DRAFT DEFINITION (Interpretation Manual of EU Habitats Final Version EUR April 1996)

11.25 Sandbanks which are slightly covered by sea water all the time

NATURA 2000 code: **1110** PAL.CLASS: 11.125, 11.22, 11.31

1. **Sandbanks which are slightly covered by sea water all the time**

2. Sublittoral sandbanks, permanently submerged. Water depth is seldom more than 20m below Chart Datum. Non-vegetated sandbanks or sandbanks with vegetation belonging to the *Zosteretum marinae* and *Cymodoceion nodosae*.

3. Plants: *Zostera marina*, free living species of the *Corallinaceae* family. In Baltic Sea also *Potamogeton pectinatus, Ruppia cirrhosa* and *Tolypella nidifica*

   Animals: Important wintering habitat for many bird species, in particular *Melanitta nigra* but also *Gavia stellata* and *Gavia arctica*. Resting places for seals. Invertebrate communities of sandy sublittoral (eg. polychaetes).

4. Geographical distribution:

   Belgium (along the Belgian coast between the coast line to 10km in sea (Ramsar site "Vlaamse Banken" eg.), Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands (Voordelta), Portugal, Spain (included the *Halophila decipiens* communities of Tenerife), Sweden, United Kingdom.

   Corresponding category of the German Biotoptypen: "040202a Sandbank der Ostsee (standing wasserbedeckt)", "030202a Sandbank der Nordsee (standing wasserbedeckt).

   Corresponding category of Nordic vegetation types: "4411 *Zostera marina*-typ", "4412 *Ruppia maritima*-typ".

5. These sandbanks can be found in association with mudflats and sandflats (14).

6. ERICSON, L & WALLENTINUS, H.-G (1979). Sea-shore vegetation around the Gulf of Bothnia. Guide for the International Society for Vegetation Science, July-August 1977. Wahlenbergia 5:1 - 142.

   LAPPALAINEN, A., HALLFORS, G & KANGAS, P. (1977). Littoral benthos of the northern Baltic Sea. IV. Pattern and dynamics of macrobenthos in a sandy bottom *Zostera marina* community in Tvarminne.

For the purposes of mapping based on British Geological Survey Charts, the following BGS sediment classes are included in the Annex 1 habitat "subtidal sandbanks" (Hiscock, personal communication)

- Muddy sand mS
- Sand S
- Slightly gravelly muddy sand (g)mS
- Slightly gravelly sand (g)S
- Gravelly muddy sand gmS
- Gravelly sand gS
- Muddy sandy gravel msG
- Sandy gravel sG

Where:

Mud	=	Fine particles of silt and/or clay, <0.0625 mm diameter
Sand	=	Particles 0.0625 to 2mm diameter
Gravel	=	Particles 2 to 256mm in diameter
Granules	=	Particles 2 to 4mm in diameter

Since *gravel* can include particles from 2mm to 256mm all areas of gravel cannot generally be included in the definition of sandbanks. However, for sandy gravels, muddy gravels and various other mixtures of fine sediments with gravel, the gravel is most likely to be of granule size. For this reason, gravel/sand mixtures have been included in the definition.

APPENDIX 4.2.2(c)

SUBTIDAL BIOTOPE CODES

(Taken from Connor *et al.*, 1996)

Subtidal Biotope Codes used in this report (taken from Connor, *et al.*, 1996)

EIR.LhypFa	*Laminaria hyperborea* with a faunal cushion (sponges and polyclinids) and foliose red seaweeds on exposed infralittoral rock
EIR.LhypFa.Ft	*Laminaria hyperborea* forest with a faunal cushion (sponges and polyclinids) and foliose red seaweeds on exposed upper infralittoral rock
EIR.LsacSpol	*Laminaria saccharina* and/or *Saccorhiza polyschides* on exposed infralittoral rock
MIR.Ldig	*Laminaria digitata* on moderately exposed or tide-swept sublittoral fringe rock
MIR.Lhyp	*Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock
MIR.Lhyp.Pk	*Laminaria hyperborea* park and foliose red seaweeds on moderately exposed lower infralittoral rock
MIR.EphR	Ephemeral red seaweeds and kelps on tide-swept mobile infralittoral cobbles
MIR.LsacChoR	*Laminaria saccharina, Chorda filum* and dense red seaweeds on shallow unstable infralittoral boulders and cobbles
SIR.MytT	*Mytilus edulis* beds on reduced salinity tide-swept infralittoral rock
ECR.Axi	Axinellid cup and branching sponges on deep very exposed circalittoral rock
ECR.AlcMaS	*Alcyonium digitatum*, large *Cliona celata* and *Pachymatisma johnstonia* and *Nemertesia antennina* on moderately tide-swept exposed circalittoral rock
ECR.CuSH	Cushion sponges, hydroids and ascidians on very tide-swept sheltered circalittoral rock
MCR.ErS	Erect sponges on slightly tide-swept moderately exposed circalittoral rock
MCR.ErS.Eun	Erect sponges, *Eunicella verrucosa* and *Pentapora foliacea* on slightly tide-swept moderately exposed circalittoral rock
MCR.ErSPenPol	Erect sponges, *Pentapora foliacea, Polymastia* spp., and *Nemertesia* spp. on moderately exposed cobbles and boulders
IGS.Mob	Sparse epifauna on clean mobile infralittoral sand
IGS.Sell	*Spisula elliptica* and other bivalves in infralittoral clean sand and shell gravel
IGS.Zmar	*Zostera marina/angustifolia* beds in lower shore to infralittoral clean or muddy sand
CGS.AfilEcor	*Amphiura filiformis* and *Echinocardium cordatum* in circalittoral clean medium to fine sand