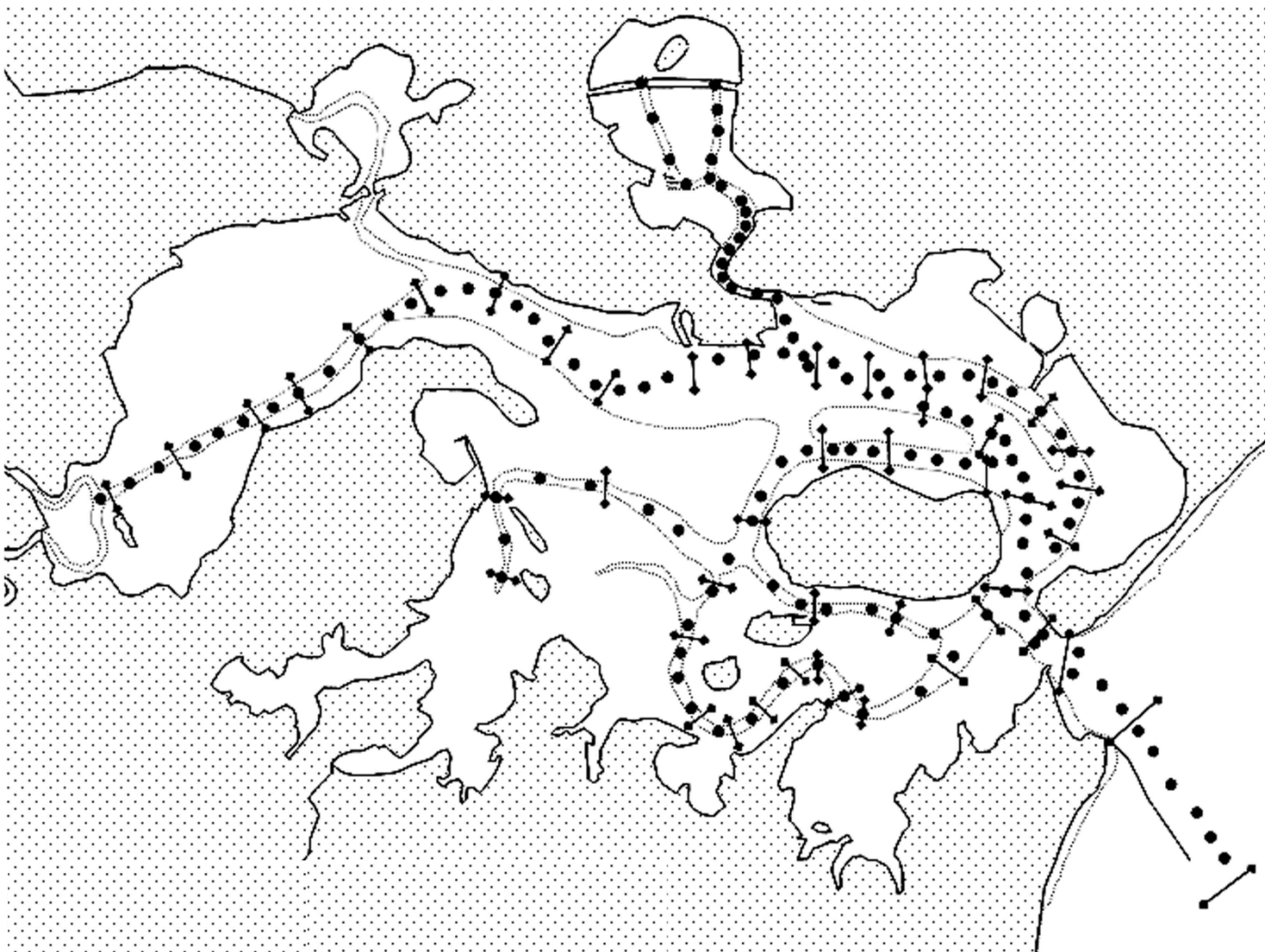


Poole Harbour Subtidal Survey

IV. Baseline Assessment(1987)

Report to Nature Conservancy Council



Dr PETER DYRYNDA

University College of Swansea

MAIN INDEX

Section 1	SUMMARY, INTRODUCTION, ACKNOWLEDGEMENTS
Section 2	QUICK REFERENCE GUIDE
Section 3	GENERAL ASSESSMENT
Section 4	SCIENTIFIC ASSESSMENT
Appendix I	FIGURES AND DIAGRAMS (for Sections 3 & 4)
Appendix II	FULL SPECIES LIST & GLOSSARY OF COMMON NAMES
Appendix III	DIVE TRANSECT RESULTS - EXAMPLES
Appendix IV	REFERENCES

POOLE HARBOUR SUBTIDAL SURVEY - RELATED DOCUMENTS:

1. DYRYNDA, P.E.J. 1983 Investigation of the subtidal ecology of Holes Bay, Poole Harbour. Report to the Nature Conservancy Council.
2. DYRYNDA, P.E.J. 1985 Poole Harbour Subtidal Survey - Southern Sector - 1984. Report to the Nature Conservancy Council
3. DYRYNDA, P.E.J. 1987a Poole Harbour Subtidal Survey - III. Dive Transect Survey - Northern Sector, 1985. Report to the Nature Conservancy Council
4. This Report.

COMPLEMENTARY REPORT:

- Doody, P. & Dennis, E. 1984 Poole Harbour - Dorset. An appraisal of ecological research. Nature Conservancy Council

The content of this report must not be reproduced in published form without prior approval from the Nature Conservancy Council.

Address of Author: Dr Peter Dyrinda,
Marine Research Group,
University College of Swansea,
Singleton Park,
Swansea SA2 8PP.

Tel. (0792) 205678.

Section 1

Index

SUMMARY..... 1 - 1

INTRODUCTION..... 1 - 2

ACKNOWLEDGEMENTS..... 1 - 5

Summary

This assessment provides a general synthesis of the results of three surveys, which together have covered all areas of the subtidal Harbour bed. It is also designed to serve as a baseline, according to which any changes concerning species or areas of particular interest can be identified by resurveying. The surveys were commissioned by the Nature Conservancy Council, with additional funding and practical support from various authorities, industries and individuals concerned with the Harbour.

The primary objective of this work is to provide an independent source of factual information of practical value in the context of Environmental Management within the Harbour. To this end, the report has been prepared for users concerned with various aspects of the Harbour and representing a wide range of scientific experience. Separate sections, written in non-scientific and scientific language respectively, contain descriptions of the hydrography, and the substrates and biological communities of the Harbour bed. These have also been considered with respect to their environmental significance, and whether they have been affected by human activities, particularly navigation, reclamation, fisheries, pollution, or the introduction of alien species.

The interdependences between natural and human aspects of the subtidal system are considered in the context of Environmental Management, and particularly the prospects for maintaining or improving natural environmental quality.

General Introduction

THE CONCEPT OF ENVIRONMENTAL MANAGEMENT

The growing need for management policies aimed at the preservation and regulation of the environment has become more apparent in recent times, as has the irrevocable fact of the total dependence of man on the natural environment. The view that the power of nature is invincible and something to challenge is being replaced by the realization that many facets of the natural world can be very vulnerable to some of man's activities. Human health and welfare are totally linked with those of the living world because so many resources, e.g. air, food, water, and places to live are shared.

Major changes to the environment, the atmosphere, land or water, brought about by the transformation of natural habitats or by pollution can have unfavourable long term effects which may be difficult or impossible to reverse. However, it is not only the major activities which are important in this context. The cumulative effects of small scale, local activities can also be significant.

The problem lies with equating the needs of the natural environment with the more direct needs of society in such a way as not to impede the clear requirements for human progress, and the improvement of the quality of life. The phenomenon of Environmental Management, in which all parties having an effect on the environment work together, is geared to identifying the optimal stance of compromise. However, this process requires hard factual information in order to be successful.

The adverse effects of human activities on the natural environment can be considered from opposing viewpoints, e.g. that the environment can ultimately recover from the effects of any human activity, or that by definition any human activity always has a major adverse effect and therefore must be opposed. These polarised and unrealistic views are widely held in the general absence of hard, factual information on the actual or likely effects of human activities on the natural environment, and of the consequences of these effects to man. This absence is partly the result of a lack of adequate provision for appropriate scientific research, the information provided by underfunded projects can be so lacking in detail as to be of little use. However, the overfunding of projects can also be counterproductive by producing excessive data and by absorbing resources needed elsewhere. Irrespective of funding, established programmes often can be waylaid along avenues of pure academic interest such as to be of little value for management.

POOLE HARBOUR

Clearly, the areas where Environmental Management is most needed are those where human activities are concentrated. Within the marine environment, this applies to inshore coastal systems, and in particular estuaries and other coastal basins since these are generally the most developed and stressed systems of all. Their sheltered waters and shores often provide favourable sites for a diversity of activities, particularly the development of berths for commercial or leisure vessels, and for the siting of installations discharging effluents (sewage, chemicals, heat, etc.). Coastal basins are often also highly biologically productive, supporting rich and diverse communities of species including commercially harvested varieties. Urbanization of shorelands coincides with industrial or commercial developments or occurs simply because coastal basins are often aesthetically pleasing places for habitation (permanent or touristic). Whereas some coastal basins within the British Isles remain virtually undeveloped, others are the focus for a great deal of human activity and heavy development, the resulting multiple stresses sometimes combining to cause substantial unfavourable changes to the natural environment.

Poole Harbour provides a very good example of the intermediate condition. It is an increasingly stressed coastal basin which also, at present, retains outstanding natural characteristics. Much of the fringing terrain is protected by what is one of the largest concentrations of Nature Reserves within the British Isles. The Harbour itself has been designated a Site of Special Scientific Interest by the Nature Conservancy Council, yet also supports significant levels of all of the above specified human activities, and more. The recent discovery of the largest known 'onshore' oilfield in north west Europe beneath the southern sector of the Harbour provides an additional dimension to the human equation. At present the various activities and interests within the Harbour all continue to prosper, even those which might be expected to be mutually exclusive. This coexistence is assisted by spatial segregation where conflicts of interest are most clearly evident. The greatest segregation is the north-south divide: the Nature Reserves are all concentrated along the shores of the southern sector where human activities are less, although much of the oyster farming industry, some leisure boating and beach tourism, and now the oilfield developments are concentrated within that area. Commercial and other heavier shipping, marinas for leisure boats, heavy urbanization, and also industrialization are virtually confined to the northern sector.

POOLE HARBOUR SUBTIDAL SURVEY

During the 1970's Poole Harbour was noted as being one of the least studied and least understood of the British estuarine systems (Natural Environmental Research Council, 1972). Most of what was known of the Harbour concerned the saltmarsh communities and bird fauna of the intertidal zone as investigated by members of the Institute of Terrestrial Ecology at Furzebrook (papers by Bird, Ranwell, Gray, Goss-Custard, see Doody and Dennis, 1984). Little was known of other intertidal communities or those of the subtidal zone.

In recognising the need for factual information in the context of environmental management, during 1982 the Nature Conservancy Council convened a Poole Harbour Ecological Working Group representing the various organizations actively undertaking research within the Harbour. The principal outcome was the initiation of coordinated surveys covering Holes Bay, regarded as the most stressed area (Doody and Dennis, 1984). In addition to the saltmarsh, intertidal sediments and bird fauna, this provided the opportunity to obtain the first detailed

baseline data on habitats and biological communities of the subtidal channel zone of the Harbour (Dyrynda, 1983). Since that time, an overall assessment of intertidal habitats within the Harbour has been undertaken by Gray (1985). Resources were also subsequently sought to extend the subtidal work to other areas. In 1984, the Southern Sector was surveyed (Dyrynda, 1985) and during 1985 the remaining, largest section of the Harbour, the Northern Sector, was covered. Subtidal surveying is, by comparison with terrestrial and intertidal work of an equivalent nature, both cost and labour intensive. All stages of this work have been undertaken as a collaborative exercise supported financially and practically by most authorities, industries and other organizations concerned with the Harbour (see acknowledgements). This collaboration has very greatly improved the scope, the cost effectiveness, and factual content of this subtidal programme.

USE OF THIS REPORT AS A MANUAL FOR ENVIRONMENTAL MANAGEMENT

For each survey, different techniques have been combined to provide detailed information on the subtidal environment within the Harbour. Survey stations have been established throughout the Harbour. The survey methods employed, which include a new diving procedure developed specifically for the project, have been designed to allow reassessment, i.e. the data from the total number of sampling stations provides not only a baseline of information, but also the foundation for monitoring programmes by which future changes can be identified (by resurveying the same stations using the same methods).

This report attempts to compile and synthesize the data from the three preceding subtidal surveys in order to gain a first, overall baseline impression of the subtidal environment within the Harbour. A central theme is to provide broad and unbiased basic information suitable for evaluating environmental management priorities and policies. For this to be effective, the information must be presented such as to be assimilable and of value to readers representing a range of scientific experience. There is no single format satisfying this requirement, so the report has been divided into several levels or sections. There is a **QUICK REFERENCE GUIDE** which provides abbreviated data of importance for Environmental Management, separately covering each survey zone within the Harbour (see Section 2). There is a **GENERAL REPORT** which provides a broad account of the subtidal environment of the Harbour, highlighting points of interest, assuming no prior scientific knowledge, and avoiding as much scientific language as possible (see Section 3). A fuller and more detailed technical appraisal is provided in the **SCIENTIFIC REPORT** (see Section 4). Figures referred to in both Sections 3 and 4 are provided in Appendix I. A full species list for the subtidal areas of the Harbour is given in Appendix II. Although the main list uses Latin names in accordance with scientific convention, a glossary of common names is also included within this section. Appendix III provides examples of technical dive transect data. The full dive transect results for the Southern Sector (surveyed in 1984) are provided in Dyrynda (1985), and for the Northern Sector (surveyed in 1985) in Dyrynda (1987a).

The **QUICK REFERENCE GUIDE**, **GENERAL** and **SCIENTIFIC REPORTS** are subdivided according to standardized headings in order to facilitate cross referencing.

N.B. Although every effort has been made to maximize the comprehensiveness of this report, it is very much an experimental document, and feedback from users would be gratefully appreciated by the author.

Acknowledgements

The author is very grateful to the individuals, authorities and industries that have provided cooperation, collaboration and other support to the surveys, as outlined below, and particularly wishes to thank Miss Eve Dennis (N.C.C.) for her support and advice throughout the work, and also Miss Elisabeth Freeman for her assistance in the preparation of this report.

The author apologises for any omissions from the table below, which would be entirely unintentional.

a) Holes Bay (1982-83), b) Southern Sector (1984-85), c) Northern Sector (1985-86).

	Funding / major practical support	General	Diving Survey	Dredge Survey	Grab Survey	Sample Analysis	Data Analysis
Nature Conservancy Council, (Contractor)	abc						
Miss Eve Dennis		abc					
Miss Sarah Fowler		bc	b				
Mr Chris Lumb			b				
Dr Roger Mitchell		abc					
Poole Harbour Commissioners	abc	abc	abc	a c	abc		
Capt W. Allison		ab					
Capt Barton		c					
Lt G. Warham		abc					
Mr K. Birkmar		abc					abc
Mr C. Fowler		abc					
Mr S. Vince			abc	a c	abc		
The crew of Rough Ryder		abc	a c	abc			
British Petroleum (Development)	bc						
Miss J. Firbrache		b					
Mr M. Mason		c					
Mr P. Stephenson		c					
Miss V. Wilson		c					
Dorset County Council	ac						
Poole Borough Council	a						
Mr J. Winder		a					
Mr R Parish		a					

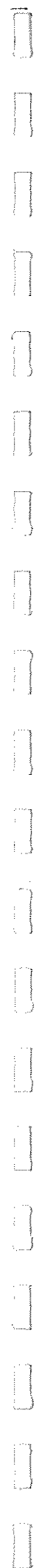
	Funding / major practical support	General	Diving Survey	Dredge Survey	Grab Survey	Sample Analysis	Data Analysis
Poole Fishermens Association Mr B, Mullins		bc		c			
Royal Marines (Poole) Maj, Barrett Lt, Webster	b	b b	b				
Sea Harvest (Poole) Mr D, Davis Mr I, Davis Mr C, Brewer		bc bc bc	bc	bc bc		*	
Southern Sea District Fisheries Committee Maj A, Parker		abc					
Wessex Water Authority Mr B, Huggins Mr R, Bracchi Miss F, Bowles	abc	abc abc abc ab	a a		abc		
Swansea University Prof J, Ryland Miss E, Freeman Mr A, Osborn Mr J, Partington Mr P, Pugh Mr A, Scott Miss A, Smith Miss E, Richards Mr J, Walker Miss S, Wheeler Miss N, Yonow		abc c c c c c c c c c c	c c c c	c c		c c c c c	c c c c
Others Mr S, Alderson Miss E, Rickett Mr M, Potts Mr J, Taylor			c b c b		c		

Section 2

QUICK REFERENCE GUIDE

INDEX

GUIDE KEY.....	2 - 1
SWASH CHANNEL.....	2 - 4
HAVEN CHANNEL.....	2 - 6
LOWER MAIN CHANNEL.....	2 - 8
UPPER MAIN CHANNEL.....	2 - 10
DIVER CHANNEL.....	2 - 12
LOWER WAREHAM CHANNEL.....	2 - 14
MIDDLE WAREHAM CHANNEL.....	2 - 16
UPPER WAREHAM CHANNEL.....	2 - 18
LOWER SOUTH DEEP.....	2 - 20
UPPER SOUTH DEEP.....	2 - 22
BLOOD ALLEY.....	2 - 24
LOWER WYTCH CHANNEL.....	2 - 26
UPPER WYTCH CHANNEL.....	2 - 28
LOWER HOLES BAY CHANNEL.....	2 - 30
UPPER HOLES BAY CHANNEL.....	2 - 33
LYTCHETT BAY CHANNEL.....	2 - 35



Section 2

QUICK REFERENCE GUIDE

This quick reference guide aims to summarize information useful from the viewpoint of environmental management. Separate information is provided for each of the survey zones covering the subtidal channel network within the Harbour. The data is compiled according to the results of the grab, dredge and dive survey stations within each channel zone, supplemented with information from other sources. The information is presented under headings which correspond to those of both the General and Scientific Reports (sections 3,4,) in order to facilitate cross-referencing.

EXPLANATION OF CRITERIA OF ASSESSMENT

The data for each survey zone is presented according to the following scheme:

SURVEY DETAILS

NAME: Established channel names have been adapted and coded for survey purposes.
** Major channel lineage. * Subsidiary channel lineage.

LENGTH: of the survey zone (metres)

DIVE TRANSECTS: Locations shown on map

DREDGE / GRAB STATIONS: As above

WHEN SURVEYED: Holes Bay (surveyed 1982) (refer to Dyrinda, 1983)
Southern Sector (surveyed 1984) (refer to Dyrinda, 1985)
Northern Sector (incl. some resurveying in Holes Bay), surveyed 1985, refer to appendix 3 in this report).

HYDROGRAPHY

SALINITY: values expressed according to the following categories: Marine (30-40%.); polyhaline (18-30 %.); mesohaline (5-18%.); oligohaline (1-5%.); fresh water (<1%).
Based on pooling of tidal and seasonal readings available for stations throughout the Harbour. Although a full tidal / seasonal salinity survey covering stations throughout the Harbour is only now underway, existing data is sufficient to establish broad trends.
Self explanatory (significant ones only)

DIRECT FRESHWATER INPUTS:

DEPTH RANGE: The range of maximum channel depths, in 5m increments below chart datum (according to data prepared by the Hydrographic Unit of Poole Harbour Commissioners).

TIDAL CURRENTS: Velocities expressed in knots are presented where known, i.e., according to current meter data provided by the Poole Harbour Commissioners, (P.H.C.). Otherwise, estimates (bracketed) or no data is given.

WAVE EXPOSURE: This is expressed on a relative scale (for the Harbour) as high, moderate, or low, & the direction is specified.

TURBIDITY: According to Secchi Disc data & the max. depth of algal growth, on a relative scale: high, medium, low

HARBOUR BED

SUBSTRATES

UNCONSOLIDATED: SM = soft mud; HM = hard mud (semi-consolidated); FS = fine sand; MS = medium sand; CS = coarse sand; GR = gravel; ST = stones

CONSOLIDATED: BL = boulders; CL = clay; PT = peat; LI = lignite; SA = sandstone (poorly cons); SS = 'hard' sandstone; SC = sandstone conglomerate; SX = steel; CX = concrete; WX = wood; FX = fibreglass.

BIOLOGICAL COMMUNITIES

Presence of benthic communities as recognised by this survey, minor ones are not included (refer to results for individual transect stations).

INFLUENCES OF MAN

NAVIGATION

DREDGING: Major dredging - programmes involving removal of large volumes of material and / or areas of channel, resulting in a long term change in channel bed structure. Usually undertaken by contract dredgers using suction, bucket or grab machinery.

Maintenance dredging - routine and minor dredging is undertaken by a grab dredger operated by Poole Harbour Commissioners.

BERTHAGE: Temporary - < 1 day at a time, e.g. jetties and slips where vessels load / unload but do not lie.

Longer term - where vessels lie when out of service.

VESSEL MOVEMENTS: Vessels categorised according to size:

Small - < 10m, predominantly leisure: windsurfers, canoes, dinghies, small yachts & cruisers; small fishing vessels, chiefly Poole canoes, Royal Marines small craft.

Intermediate - 10-50m, Survey and maintenance vessels, tugs, dredger of Poole Harbour Commissioners, Police, Sea District Fisheries, trawlers, larger Royal Marines craft, large cruisers and yachts, tourist viewing boats.

Large - > 50m. Coasters, cross channel ferries (the largest vessels to regularly use the Harbour).

+ - Heaviest traffic.

NAVIGATIONAL MARKERS:

Poole Harbour Commissioners maintain a system of markers designating the channel peripheries (about or below the C.D. line as appropriate). Major shipping channels are marked by buoys, and minor ones by metal or wooden stakes.

RECLAMATION

IMPOUNDMENT:

Developments by which areas of the Harbour are semi- or completely enclosed / annexed by bunds, breakwaters or seawalls, but remain tidal (i.e., lagoonization).

INFILLING:

Infilling of intertidal or subtidal areas to above the high water mark so creating land for development.

FISHERIES

- OYSTER FISHING:** Subdivided into natural and farmed. Natural comprises fishing for natural stocks and takes place both in leased and non-leased (public) grounds, farmed comprises fishing for laid / introduced stocks and only occurs on leased grounds.
- OTHER FISHING:** Self explanatory but very difficult to detail, many small professional and non-professional operators involved, their activities are not always notified to the authorities.

ALIEN SPECIES

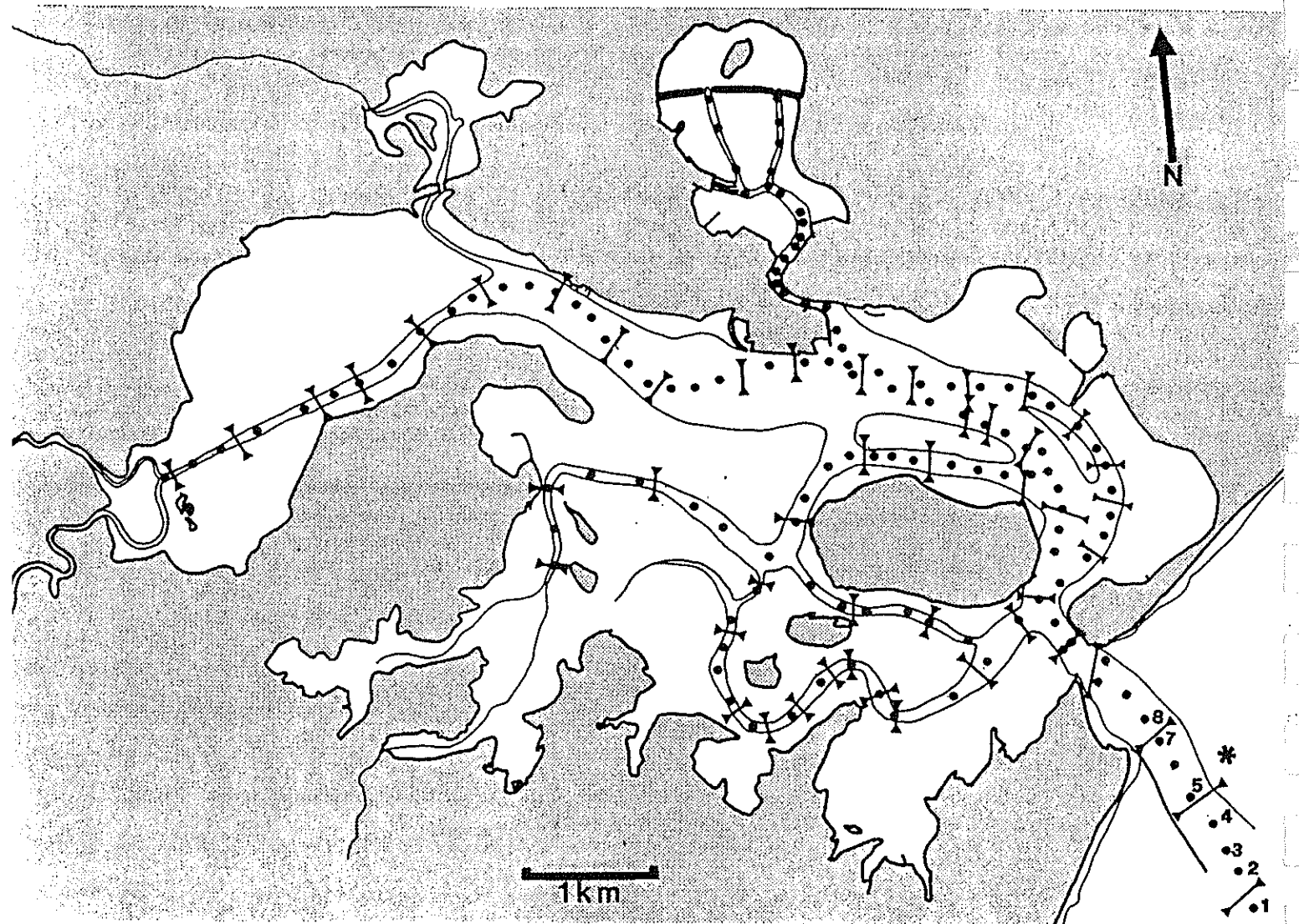
Indication of the presence of substantial quantities of the specified alien species within the survey zone.

POLLUTION

In view of very poor tidal flushing characteristics of the Harbour and the presence of major potential polluting activities, pollution is a very important aspect of the ecology of the Harbour. Pollution monitoring did not constitute part of this survey work. The information provided in the following sections is based on predictive analysis and on published information (see **Scientific Report**).

- EUTROPHICATION:** Areas where excessive artificial input of nutrients and organic substances boosts plant & animal growth (production)
- FLUID DISCHARGES:** Points where fluid effluents discharge into the Harbour.
- HYDROCARBONS:** Presence of fuel / lubricant, or crude hydrocarbons
- SOLID WASTES:** Unnatural presence of biological or non-biological solid wastes.
- TRACE METALS:** Presence of unnaturally high levels of trace metal contaminants.

Important: See from the above that omissions and negative answers are not always absolute. ? means presence possible but uncertain.

SWASH CHANNEL** - SWC

The most downstream section of the principal subtidal channel lineage, forming the Harbour approaches within Poole Bay, and extending from Poole Bar, an area of sand shallows, to the Haven Channel**. Flanked to the north by open water and the shores of Sandbanks beyond (bathing beach) and to the south by the Training Bank and further upstream by Studland Point and Shell Bay (bathing beach). The Training Bank is a 1000m long boulder bund constructed to concentrate tidal flow and so to increase navigational depths within the Swash Channel. All of the flanking shores are of sand.

SWC cont...SURVEY DETAILS

LENGTH: 1917m
 DIVE TRANSECTS: 3
 DREDGE / GRAB STATIONS: 8
 WHEN SURVEYED: 1985

HYDROGRAPHY

SALINITY: Polyhaline / marine
 DIRECT FRESHWATER INPUTS: None
 DEPTH RANGE: 0 - 5m
 TIDAL CURRENTS: No records (>2 knots)
 WAVE EXPOSURE: Sheltered (except to E & NE)
 TURBIDITY: Low

HARBOUR BEDSUBSTRATES

UNCONSOLIDATED: MS, CS, GR, ST
 CONSOLIDATED: CL

BIOLOGICAL COMMUNITIES

Cobble / shell / gravel -
Crepidula
 Coarse sand (principal)
 Medium sand - Lanice

INFLUENCES OF MANNAVIGATION

DREDGING: Regular sand extraction by suction dredger from Poole Bar
 BERTHAGE: None
 VESSEL MOVEMENTS: Small, Medium+, Large+
 NAVIGATIONAL MARKERS: Buoys, stakes on Training Bank

RECLAMATION

IMPOUNDMENT: Training Bank
 INFILLING: None

FISHERIES

OYSTER FISHING: No
 OTHER FISHING: Commercial rod fishing (bass), trawling

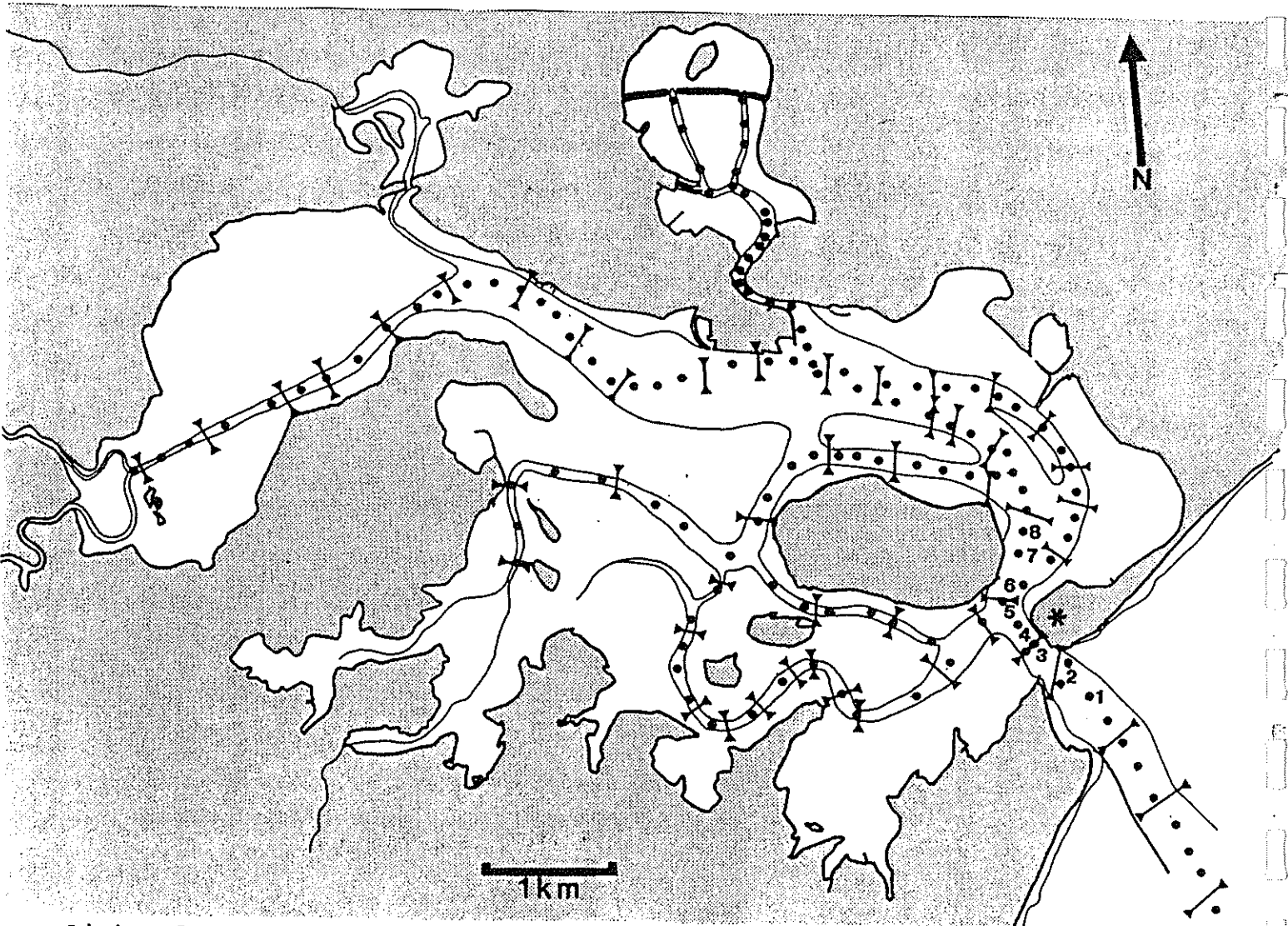
ALIEN SPECIES

Sargassum, Crepidula

POLLUTION

EUTROPHICATION: No
 FLUID DISCHARGES: No
 HYDROCARBONS: No
 SOLID WASTES: No
 TRACE METALS: No

N.B. Please check guide key for interpretations

HAVEN CHANNEL** - HAC

Links downstream with the Swash Channel**, extending from Studland Point (Nature Reserve, bathing beach), through the Harbour entrance between South and North Haven Points (Nature Reserve / holiday beach; residential / holiday beach respectively), branches either side of Brownsea Island (Nature Reserve), southwards into the South Deep*, and northwards to where it divides into the Lower Main** and Diver** Channels, and the Lower Wych Channel*. The Haven experiences the strongest tidal velocities, exhibits the greatest depths and the highest energy channel bed forms of Poole Harbour and Poole Bay. The flanking shores are mainly of sand, but locally of gravel.

HAC cont...SURVEY DETAILS:

LENGTH: 1786m
 DIVE TRANSECTS: 3
 DREDGE / GRAB STATIONS: 8
 WHEN SURVEYED: 1985

HYDROGRAPHY

SALINITY: Polyhaline / marine
 DIRECT FRESHWATER INPUTS: None
 DEPTH RANGE: 5-20m (deepest point of Harbour)
 TIDAL CURRENTS: 4.5 knots (strongest in Harbour)
 WAVE EXPOSURE: Weak except from E
 TURBIDITY: Low

HARBOUR BEDSUBSTRATES

UNCONSOLIDATED: MS, CS, GR, ST
 CONSOLIDATED: CL, BL, SS

BIOLOGICAL COMMUNITIES

Cobble, shell, gravel -
Sabella, Sargassum (principal)
 Coarse sand - Crepidula
 Medium sand - Lanice
 Fine sand - Sargassum /
 scrub algal copse

INFLUENCES OF MANNAVIGATION

DREDGING: Only Chapmans' Peak
 BERTHAGE: Medium (temp), Small - moorings
 VESSEL MOVEMENTS: Small+, Medium+, Large+
 NAVIGATIONAL MARKERS: Buoys

RECLAMATION

IMPOUNDMENT: Brownsea Lagoon
 INFILLING: See above
 Shorelines of North Haven Point
 (Only intertidal)

FISHERIES

OYSTER FISHING: Public fishing grounds
 OTHER FISHING: Rod fishing for bass

ALIEN SPECIES

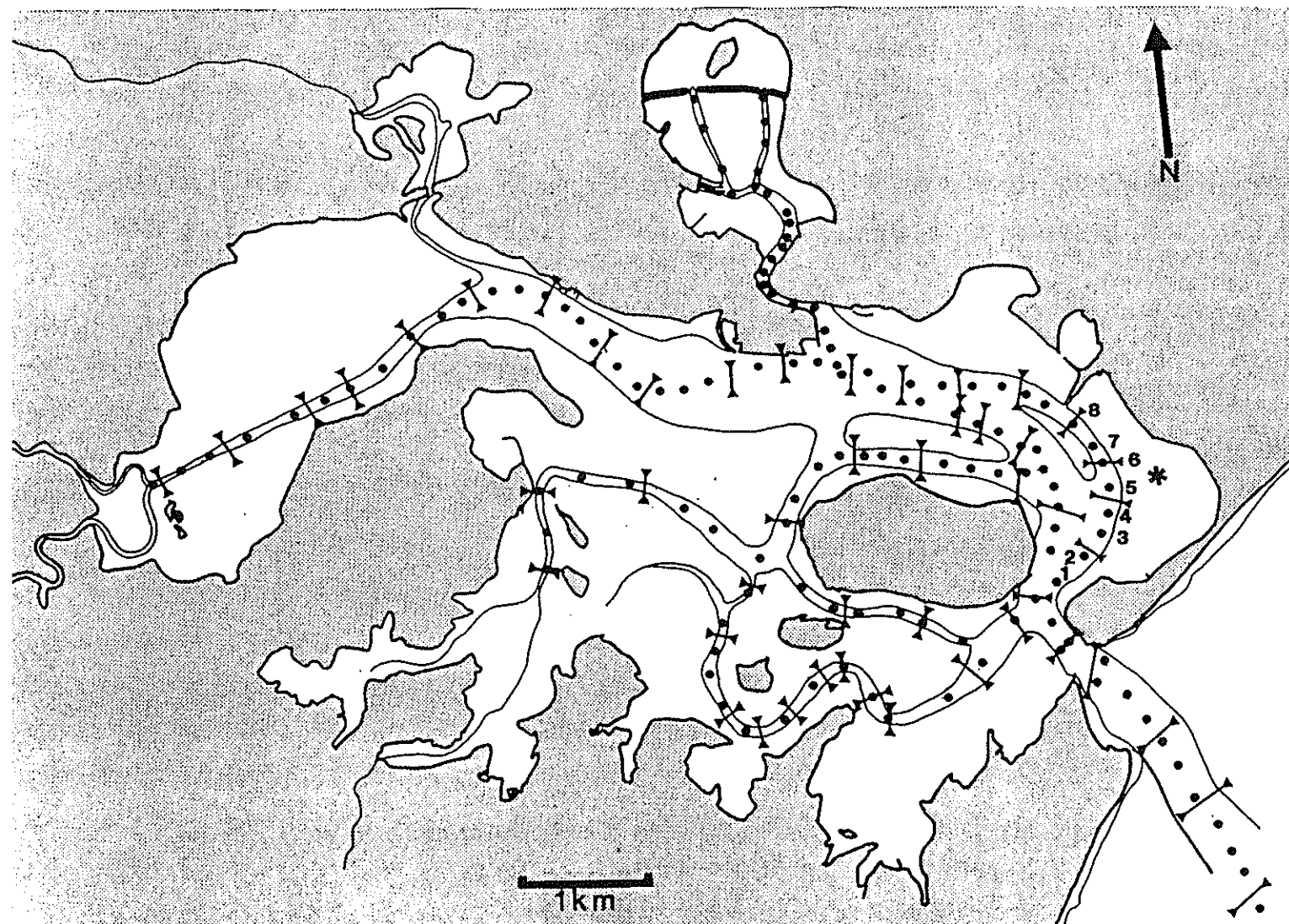
Sargassum, Crepidula

POLLUTION

EUTROPHICATION: No
 FLUID DISCHARGES: No
 HYDROCARBONS: No
 SOLID WASTES: No
 TRACE METALS: No

N.B. Please check guide key for interpretations

LOWER MAIN CHANNEL** - MCL
(Main Channel in part)



Extends from the Haven Channel east of North Haven Point and arcs around the north eastern sector of the Harbour as far as Poole Harbour Yacht Club Marina and continuing upstream as the Upper Main Channel. The channel is the most confined section of the principal lineage and at the time of the survey was the major navigational link to the Port for large vessels, coasters and ferries, although intermediate and small vessels were able to use the more direct, but shallower Diver Channel (now the major channel - see NAVIGATION - DREDGING). This is now changed with the dredging of the Diver Channel to 5m (see section on Diver Channel). Although depths are being maintained within the Main Channel for the time being, large vessel traffic will virtually cease (Lt. Wareham, P.H.C., pers. com.). The Main Channel, Upper and Lower, has been extensively dredged to maintain navigable depths. Evidence of this process was identified at the more upstream stations in the Lower Main Channel. The generally very poor biological communities of the Main Channel were probably naturally poor but this has been exaggerated by disturbances associated with dredging and perhaps the movement of large vessels (see NAVIGATION - VESSEL MOVEMENTS). MCL is flanked mainly by natural sand and mud flats, with only limited saltmarsh development.

MCL cont...**SURVEY DETAILS**

LENGTH: 1567m
 DIVE TRANSECTS: 4
 DREDGE / GRAB STATIONS: 8
 WHEN SURVEYED: 1985

HYDROGRAPHY

SALINITY: Polyhaline
 DIRECT FRESHWATER INPUTS: None large.
 DEPTH RANGE: 5-10m
 TIDAL CURRENTS: ?
 WAVE EXPOSURE: Moderate, from SW & W
 TURBIDITY: Moderate

HARBOUR BED**SUBSTRATES**

UNCONSOLIDATED: SM, FS, MS, CS, GR
 CONSOLIDATED: CL, PT, SA, SC, FB, CX

BIOLOGICAL COMMUNITIES

Soft consol. (dredged,
 principal)
 Coarse sand (some dredged)
 Medium sand
 Fine sand / mud - Sabella
 (very local, dredged in part)

INFLUENCES OF MAN**NAVIGATION**

DREDGING: Yes, partic. upper section
 BERTHAGE: Small - marina's and moorings
 VESSEL MOVEMENTS: Small+, Medium+, Large+
 NAVIGATIONAL MARKERS: Buoys

RECLAMATION

IMPOUNDMENT: Blue Lagoon
 INFILLING: P.H.Y.C. Marina & flats

FISHERIES

OYSTER FISHING: No
 OTHER FISHING: No

ALIEN SPECIES

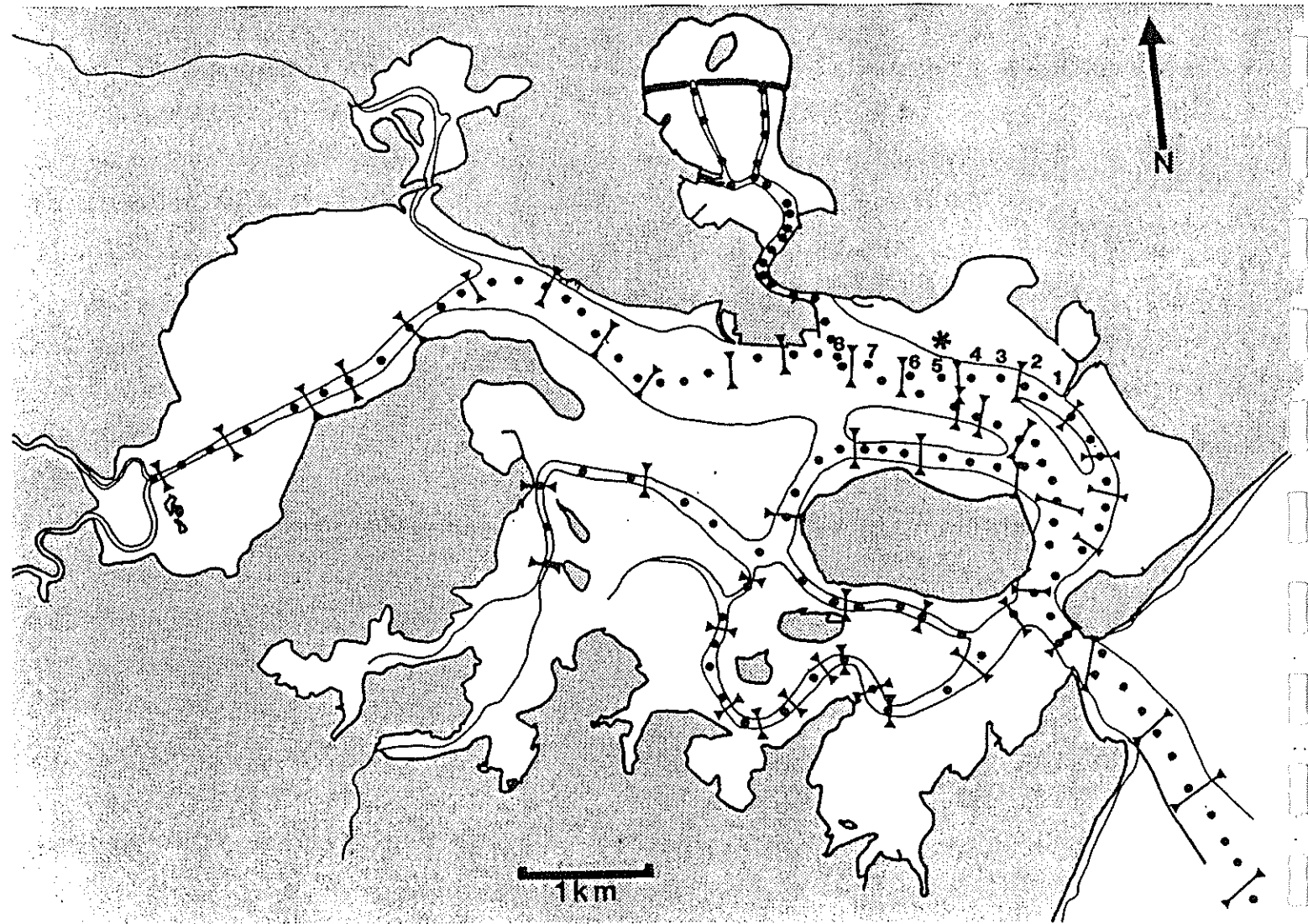
No

POLLUTION

EUTROPHICATION: No
 FLUID DISCHARGES: No
 HYDROCARBONS: No
 SOLID WASTES: No
 TRACE METALS: No

N.B. Please check guide key for interpretations

UPPER MAIN CHANNEL - MCU**
 (Main Channel in part)



Upstream half of the Main Channel, from Poole Harbour Yacht Club Marina to the New Quay area of the Port of Poole, merging with the Diver Channel** halfway, the Lower Wareham Channel (major lineage)** and the Lower Holes Bay Channel (subsidiary lineage) upstream. This is the most upstream section of the major navigational channel leading to the Port of Poole. It is used by all large vessels, in the upstream section supplemented by the heavier medium and small vessels from the Diver Channel (after early 1986, the Diver Channel was made the major channel - see below). There is extensive evidence of disturbances from dredging and perhaps the passage of large vessels, particularly within the more confined downstream section which is, in places, maintained largely devoid of benthos, and unnatural substrate sequences are exposed. The upstream section of the channel has been affected by the major programme of dredging of the Diver Channel during 1986. At that time, dredging was undertaken along most of the Diver Channel, and extended into the Upper Main Channel as far as Stakes Buoy, so creating a continuous channel at least 5m in depth, right along the principal lineage (with the exception of Poole Bar in the Swash Channel). Significant areas of the flanking intertidal zone have been lost, i.e., P.H.Y.C. Marina and within Parkstone Bay. Otherwise, the shores are mainly of open sand (often stony), and locally of mud.

MCU cont...SURVEY DETAILS

LENGTH: 1786m
 DIVE TRANSECTS: 4
 DREDGE / GRAB STATIONS: 8
 WHEN SURVEYED: 1985

HYDROGRAPHY

SALINITY: Polyhaline
 DIRECT FRESHWATER INPUTS: None
 DEPTH RANGE: 0-5m
 TIDAL CURRENTS: 1.5 knots
 WAVE EXPOSURE: Moderate, only from SW
 TURBIDITY: Moderate to high

HARBOUR BEDSUBSTRATES

UNCONSOLIDATED: SM, HM, FS, MS, CS, GR
 CONSOLIDATED: CL, SS, SC, FB

BIOLOGICAL COMMUNITIES

Soft consolidated - Crepidula
 Coarse sand
 Fine sand / mud - Sabella
 (all of the above dredged
 in part)

INFLUENCES OF MANNAVIGATION

DREDGING: Major structural dredging
 in 1986, part of DVC
 programme. Otherwise
 frequent maintenance
 dredging.
 BERTHAGE: Small - Moorings
 VESSEL MOVEMENTS: Small+, Medium+, Large+
 NAVIGATIONAL MARKERS: Buoys & stakes
 Medium - None
 Large - None

RECLAMATION

IMPOUNDMENT: No
 INFILLING: No
 (Parkstone Bay extensively
 reclaimed). Large marina
 with enclosing bund
 planned for Parkstone Bay

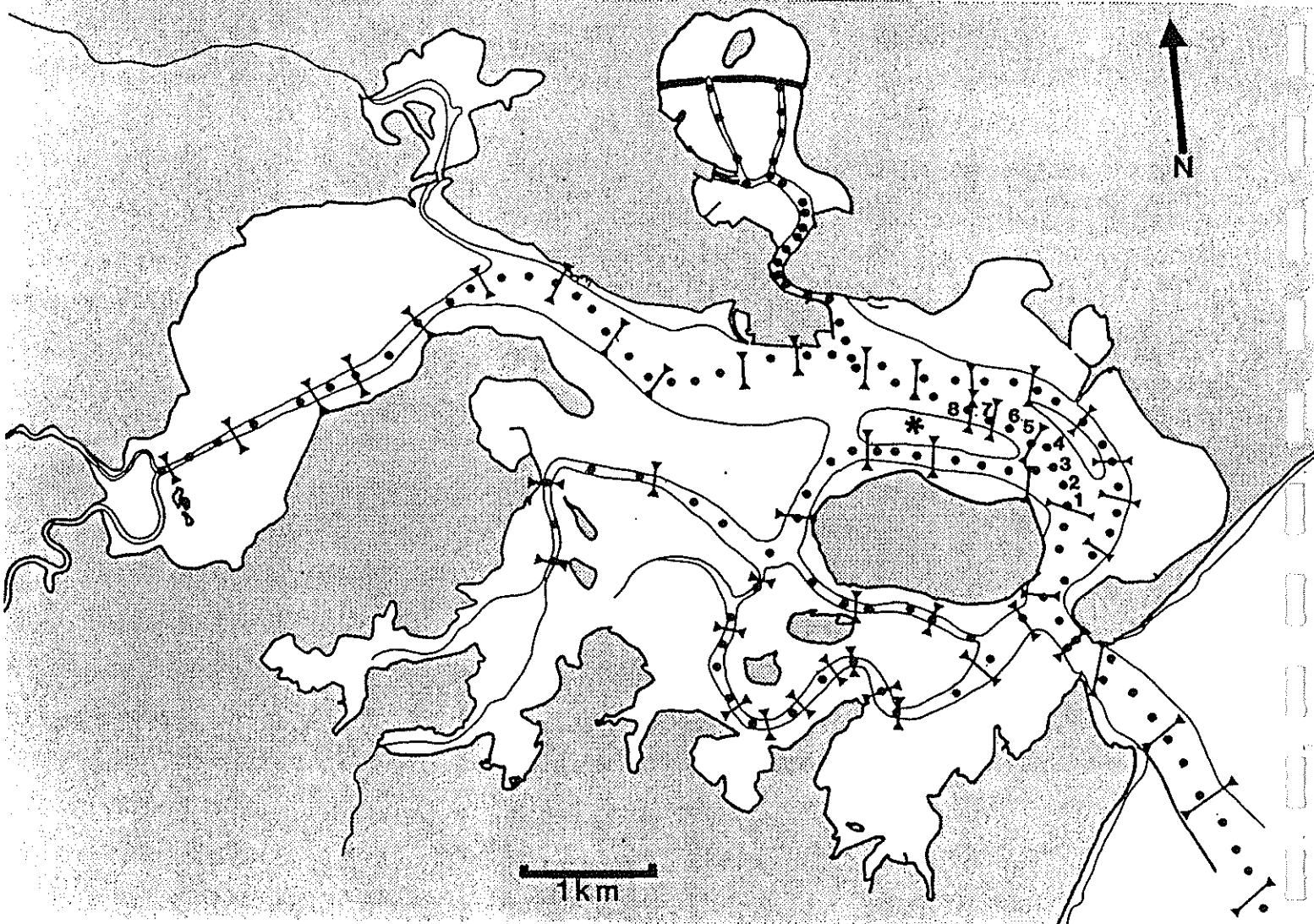
FISHERIES

OYSTER FISHING: No
 OTHER FISHING: No

POLLUTION

EUTROPHICATION: ?
 FLUID DISCHARGES: No
 HYDROCARBONS: ?
 SOLID WASTES: No
 TRACE METALS: ?

N.B. Please check guide key for interpretations.

DIVER CHANNEL** - DVC

Arises from Haven** and merges with Upper Middle Channel** to link with the Lower Wareham Channel**. Naturally shallower than the Main Channel, hence really a subsidiary channel lineage. However, attempts have been made to convert this to the major channel lineage so providing a shorter and more direct link between the Haven Channel and the Port. It was first dredged during the 1930's (P.H.C., 1982), but by net accretion has since reverted to its former state. A new attempt has just been made. During the period February to April 1986, the entire channel and the Upper Main Channel beyond was dredged to at least 5.0m below chart datum, entailing the removal of Harbour bed material in excess of 250,000 cu.m., i.e. since the 1985 survey. Prior to 1986, this was the major route for small and intermediate vessels using the Harbour. Now it is also the major route for large shipping. As to whether this remains the case will depend on accretion rates and subsequent dredging policies. The only intertidal areas flanking this channel are sand banks.

Unless specified, data applies to the channel prior to 1986.

DVC cont...SURVEY DETAILS

LENGTH: 2143m
 DIVE TRANSECTS: 4
 DREDGE / GRAB STATIONS: 8
 WHEN SURVEYED: 1985

HYDROGRAPHY

SALINITY: Polyhaline
 DIRECT FRESHWATER INPUTS: None
 DEPTH RANGE: 0-5m
 TIDAL CURRENTS: 1.9 knots
 WAVE EXPOSURE: Moderate (from W & SW)
 TURBIDITY: Moderate

THE HARBOUR BEDSUBSTRATES

UNCONSOLIDATED: FS, MS, CS, GR
 CONSOLIDATED: CL

BIOLOGICAL COMMUNITIES

Coarse sand (principal)
 Fine sand / mud - Sabella &
Sargassum
 (dredged after early 1986)

INFLUENCES OF MANNAVIGATION

DREDGING: Major dredging during 1930's
 Maintenance dredging
 Major dredging 1986 (see above)
 BERTHAGE: Small - Peripheral moorings
 Medium - temp. - P.H.C. vessels
 VESSEL MOVEMENTS: Small+, Medium+, Large+ 1986 on
 NAVIGATIONAL MARKERS: Buoys

RECLAMATION

IMPOUNDMENT: None
 INFILLING: None

FISHERIES

OYSTER FISHING: Public oyster fishery
 OTHER FISHING: Trawling

ALIEN SPECIES

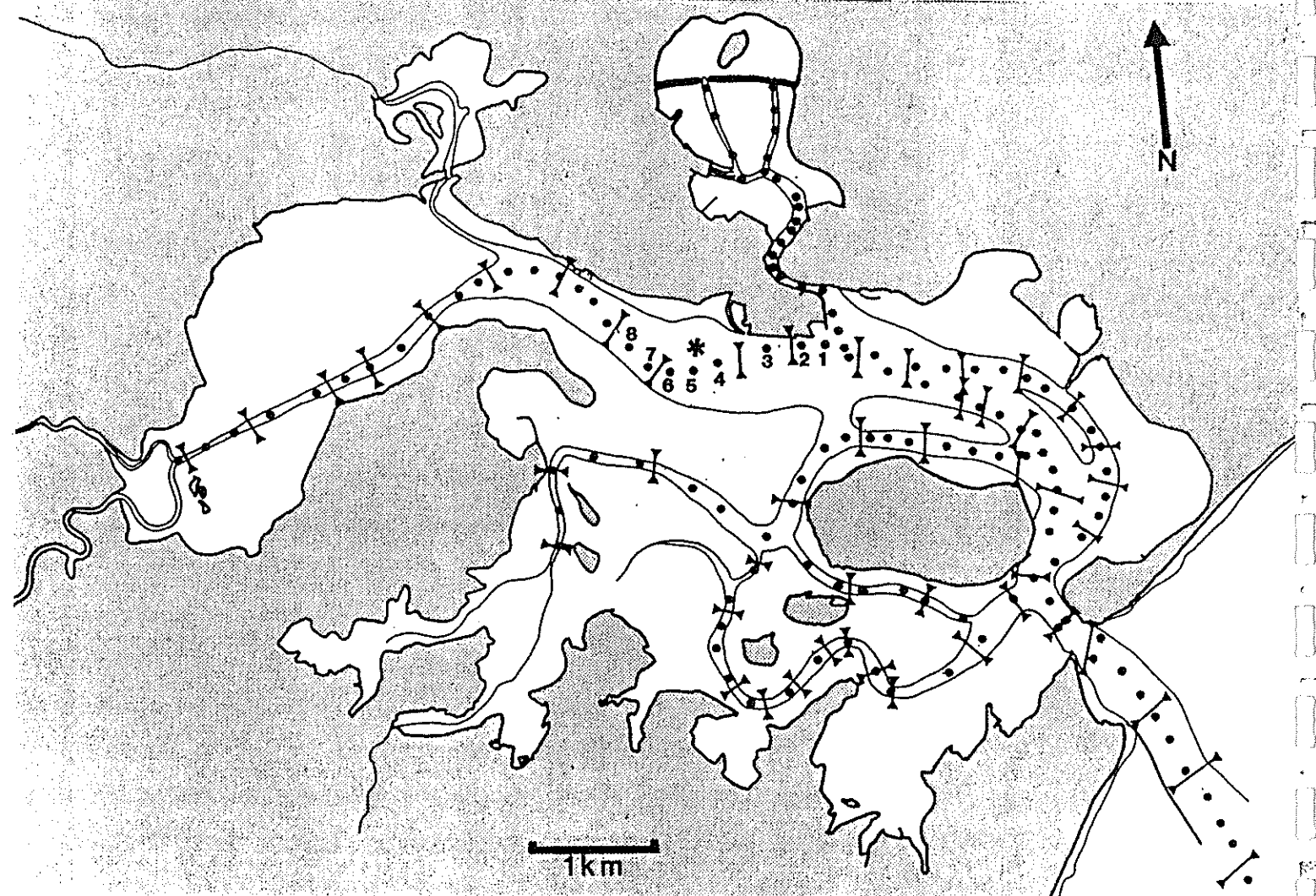
Sargassum

POLLUTION

EUTROPHICATION: ?
 FLUID DISCHARGES: No
 HYDROCARBONS: ?
 SOLID WASTES: No
 TRACE METALS: ?

N.B. Please check guide key for interpretations.

LOWER WAREHAM CHANNEL** - WCL



The lowest third of the Wareham Channel extending from the Upper Main Channel** to the Central Wareham Channel**. The downstream section has been greatly changed by reclamation and by major dredging. The original subtidal channel passed approx. 0.5km offshore to the Hamworthy foreshore with maximum depths of 2 to 4m below C.D. In a substantial programme, much of the intertidal area north of this channel together with the upper northern flank of the subtidal channel has been reclaimed. The project was undertaken to generate land for a Port Expansion programme providing the establishment of a ferry service for vehicles to Cherbourg (France). The first, easternmost section was reclaimed in 1972. This included an artificial embayment containing a ferry berth and gantry, and was flanked to the west by a breakwater of boat wrecks and a jetty for coasters carrying hydrocarbon cargoes. In 1982, the reclaimed area was extended substantially westwards. This more recent, larger section incorporates a second berth for cross channel ferries, a large slip and pontoon for cargo and passenger ferries to B.P.'s installations on Furzey Island, and at the west end, what is in effect, an artificial lagoon, i.e. a marina (with adjacent clubhouse) for Poole Yacht Club. These installations aside, the reclaimed area is fringed by a bund of large limestone boulders which now constitutes the top of the northern flank of the subtidal channel. The entire subtidal channel off the reclaimed area has been dredged to depths in excess of 5m., although in reality this tapers, at present from a depth of approximately 5m off the upstream west end to more than 10m off the east end where ferries manoeuvre or berth. Upstream of this development, the natural channel bed is dredged for oysters.

The dredged channel off the reclaimed area experiences locally increased currents, probably in excess of 2 knots, which may have been elevated by the constricting effect of the reclaimed area.

Besides the reclaimed areas, the only adjacent intertidal areas are of open sands and muds.

SURVEY DETAILS

LENGTH: 1667m
DIVE TRANSECTS: 3
DREDGE / GRAB STATIONS: 8
WHEN SURVEYED: 1985

HYDROGRAPHY

SALINITY: Polyhaline
DIRECT FRESHWATER INPUTS: None
DEPTH RANGE: 0-15m (deepest area inside Harbour.
TIDAL CURRENTS: > 2 knots
WAVE EXPOSURE: Moderate (only from SW)
TURBIDITY: High

HARBOUR BED

SUBSTRATES

UNCONSOLIDATED: SM, HM, FS, MS, CS, GR, ST.
CONSOLIDATED: CL, BL, WX, SX, CX

BIOLOGICAL COMMUNITIES:

Hard consolidated substrate - (artificial)
Turbid water, epibenthic, mud - (dredged)
Turbid water, infaunal

INFLUENCES OF MAN

NAVIGATION

DREDGING: Major dredging 1972 / 1982-83
Maintenance dredging.
BERTHAGE: Small - marina P.Y.C.
Medium - Pontoon / slip for B.P. Furzey I. ferries.
Large - Ferry berths, P.H.C.
VESSEL MOVEMENTS: Small+, Medium+, Large+
NAVIGATIONAL MARKERS: Buoys

RECLAMATION

IMPOUNDMENT: Poole Yacht Club Marina.
INFILLING: Extensive, Port Expansion Area.

FISHERIES

OYSTER FISHING: Leased areas, natural / farmed stocks
OTHER FISHING: Eel trapping

ALIEN SPECIES

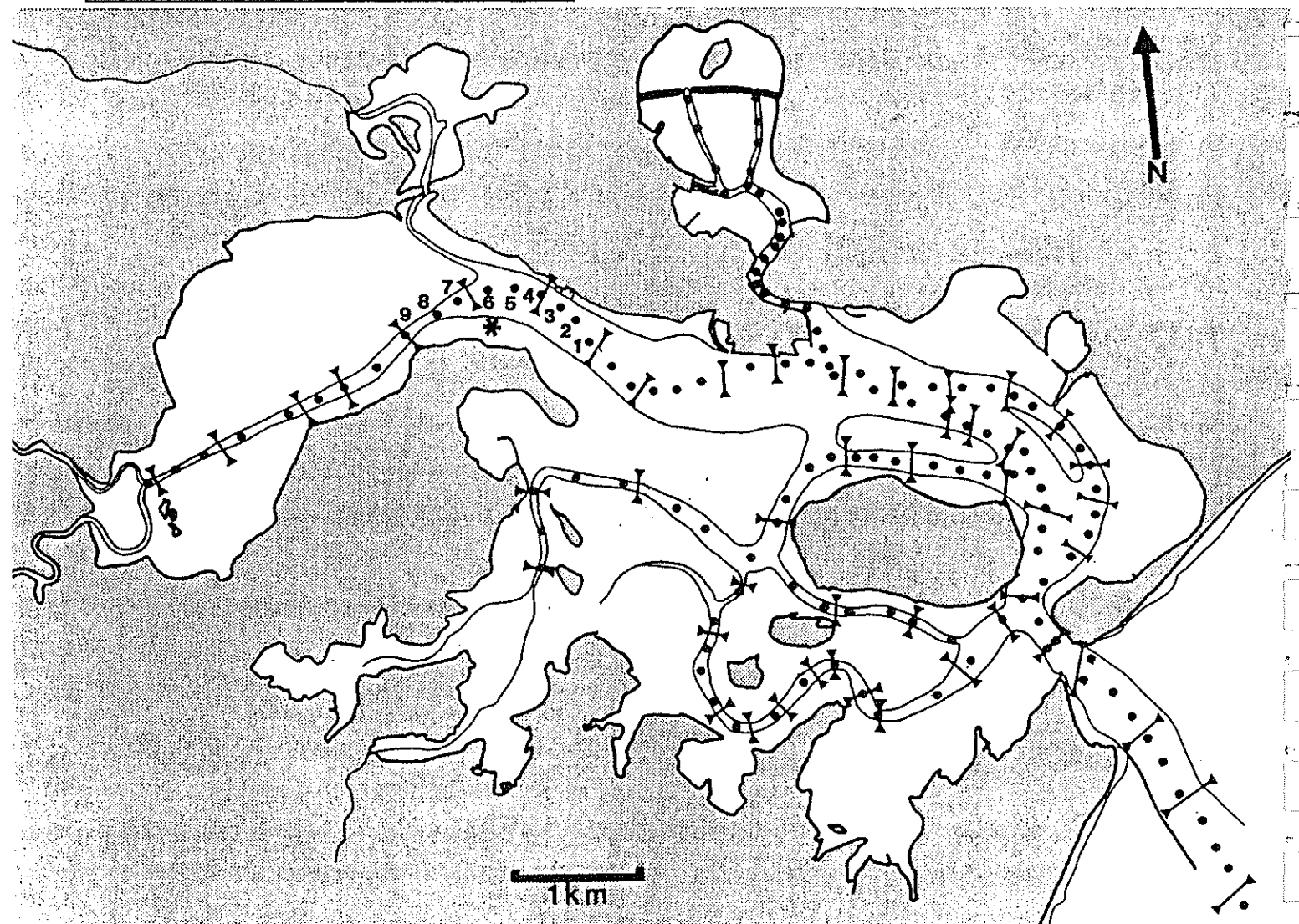
Styela, Venus mercenaria

POLLUTION

EUTROPHICATION: ?
FLUID DISCHARGES: Wastes from moored vessels
HYDROCARBONS: Fuel / oil from moored vessels
SOLID WASTES: No
TRACE METALS: ?

N.B. Please check guide key for interpretations.

MIDDLE WAREHAM CHANNEL** - WCM



The central third of the Wareham Channel links the Lower Wareham Channel** to the Upper Wareham Channel**, and gives rise to the Lytchett Bay Channel. WCM passes between the Arne Peninsula (Nature Reserves) and the Hamworthy foreshore (urbanized, boatyards, Royal Marines Base) as far as Rockley Peninsula (Holiday Camp and bathing beach) before veering south towards Wareham. It is fringed by shallow areas with moorings and also contains heavier moorings for larger vessels (Royal Marines) in its upper reaches. The downstream section of the Middle Wareham Channel includes some leased oyster grounds. Evidence of oyster dredging activity was observed at one station. Sections of the immediately adjacent foreshores have been developed as berthage for military and for leisure craft. The natural sections that do exist are mainly of open sand or mud.

WCM cont...SURVEY DETAILS

LENGTH: 1905m
 DIVE TRANSECTS: 4
 DREDGE / GRAB STATIONS: 9
 WHEN SURVEYED: 1985

HYDROGRAPHY

SALINITY: Mesohaline
 DIRECT FRESHWATER INPUTS: None
 DEPTH RANGE: 0-5m
 TIDAL CURRENTS: ?
 WAVE EXPOSURE: Low
 TURBIDITY: High

HARBOUR BEDSUBSTRATES

UNCONSOLIDATED: SM, HM, FS, MS
 CONSOLIDATED: CL, FB

BIOLOGICAL COMMUNITIES

Turbid, sand, Crepidula
 Turbid, mud, epibenthic
 (principal)
 Turbid, mud, inbenthic

INFLUENCES OF MANNAVIGATION

DREDGING: Only in vicinity of berths
 BERTHAGE: Small - Boatyards
 Medium - Royal Marines base
 & moorings
 VESSEL MOVEMENTS: Small+, Medium
 NAVIGATIONAL MARKERS: Buoys

RECLAMATION

IMPOUNDMENT: None
 INFILLING: None significant

FISHERIES

OYSTER FISHING: Leased grounds, natural and
 farmed stocks
 OTHER FISHING: Eel trapping, mullet netting

ALIEN SPECIES

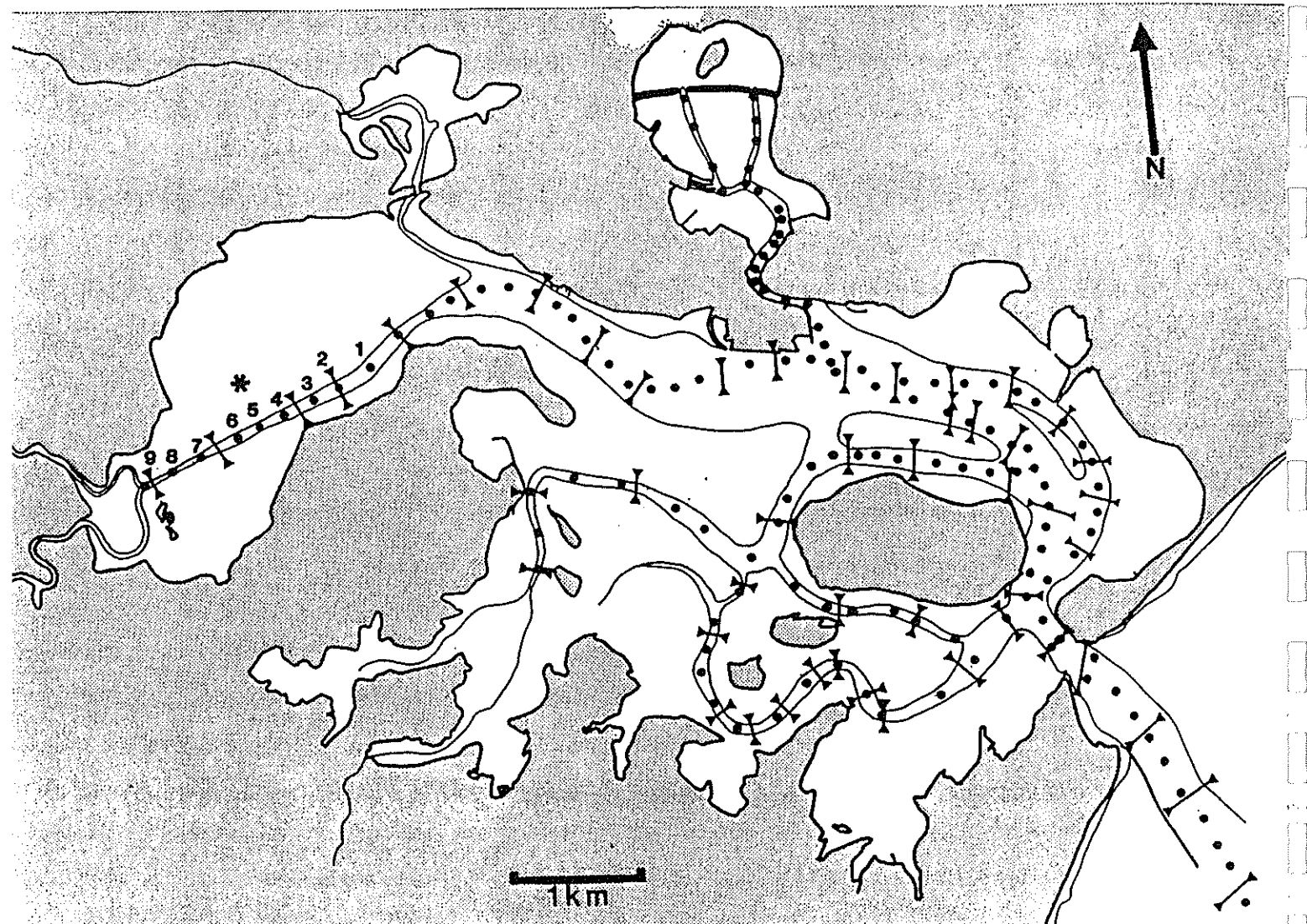
No

POLLUTION

EUTROPHICATION: ?
 FLUID DISCHARGES: From moored vessels
 HYDROCARBONS: ?
 SOLID WASTES: From moored vessels
 TRACE METALS: ?

N.B. Please check guide key for interpretations. Omissions and negative answers are not always absolute. ? means presence possible but uncertain.

UPPER WAREHAM CHANNEL - WCU



The top of the principal channel lineage, extends from the Central Wareham Channel** to the mouths of the rivers Frome and Trent. Passes due south, skirting the western side of the Arne Peninsula (Nature Reserves) and further west, the shores at Sandford (agricultural / undeveloped). Generally very shallow with little disturbance, boat traffic limited to vessels bound for / from the Ridge Quay Marina or Wareham Quay in the lowest section of the Frome. The watershed of the Frome and Trent covers most of Dorset to the west of the Harbour. The immediately adjacent intertidal flats of the Arne Peninsula are mainly of open sand downstream, with a transition to mudflats supporting Phragmites upstream. The western shores are mainly of extensive mudflats with saltmarsh, also grading to Phragmites to the south.

SURVEY ZONE DETAILS

LENGTH: 2095m
DIVE TRANSECTS: 4
DREDGE / GRAB STATIONS: 9
WHEN SURVEYED: 1985

HYDROGRAPHY

SALINITY: Mesohaline - oligohaline
DIRECT FRESHWATER INPUTS: Appreciable, from Frome & Trent
DEPTH RANGE: 0-5m
TIDAL CURRENTS: ?
WAVE EXPOSURE: Low
TURBIDITY: High

HARBOUR BED

SUBSTRATES
UNCONSOLIDATED: SM, HM, FS, MS
CONSOLIDATED: CL

BIOLOGICAL COMMUNITIES

Turbid, sand, Crepidula
Turbid, mud, epibenthic
(principal)
Turbid, mud, inbenthic

INFLUENCES OF MAN

NAVIGATION

DREDGING: No
BERTHAGE: No
VESSEL MOVEMENTS: Small
NAVIGATIONAL MARKERS: Buoys & stakes

RECLAMATION

IMPOUNDMENT: No
INFILLING: No

FISHERIES

OYSTER FISHING: No
OTHER FISHING: No

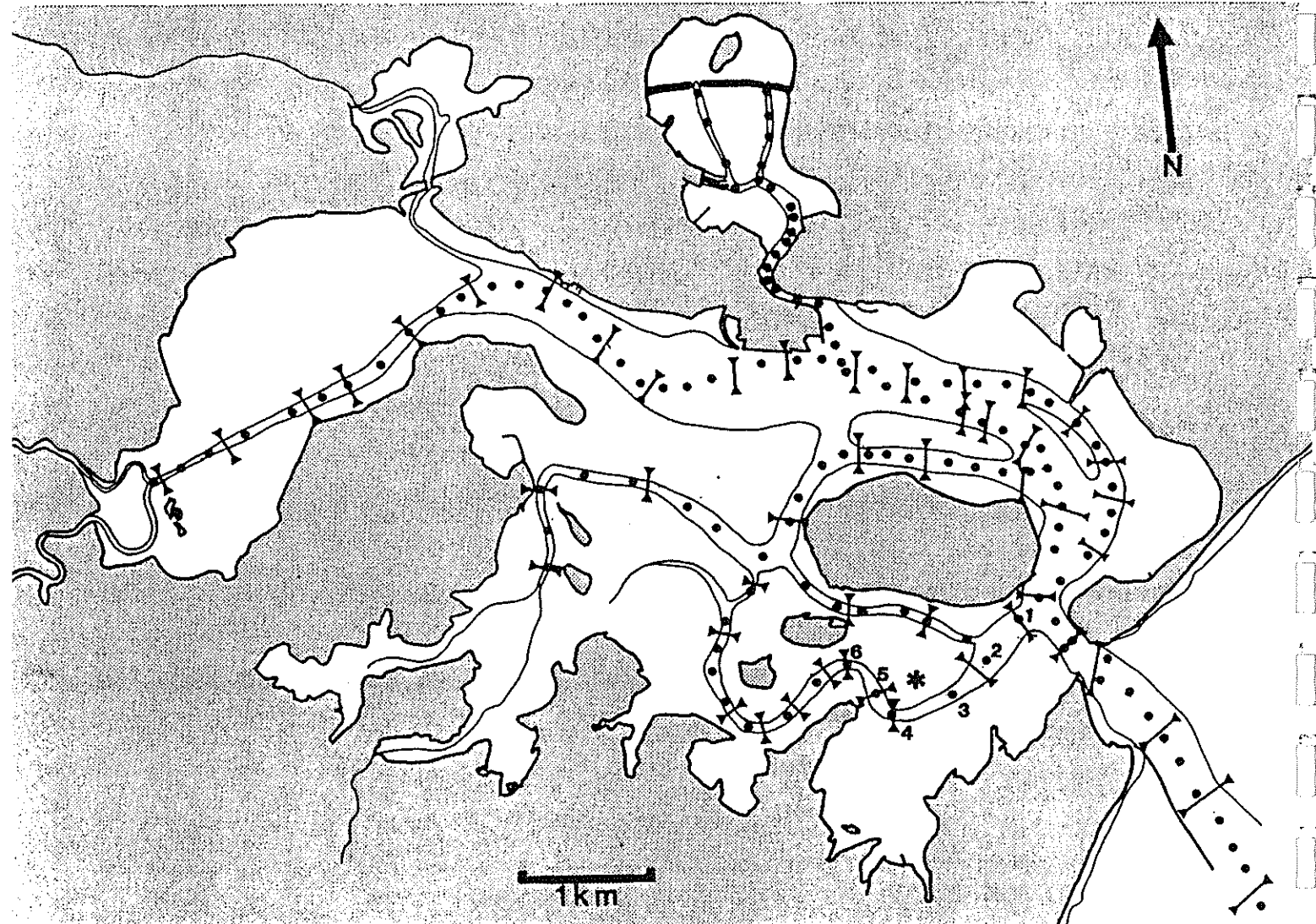
ALIEN SPECIES

No

POLLUTION

EUTROPHICATION: ?
FLUID DISCHARGES: No
HYDROCARBONS: No
SOLID WASTES: No
TRACE METALS: ?

N.B. Please check guide key for interpretations.

LOWER SOUTH DEEP* - SDL

The most downstream subsidiary lineage. This links the Haven Channel** with the Upper South Deep*, passing the shores of Studland (Nature Reserve) and Goathorn Points. The upstream section of this includes leased oyster grounds which are, in part, farmed. Until recently, the only shipping consisted of small sized leisure and medium tourist tripper and oyster boats. The development of exploratory wellheads on Furzey Island has changed the status of the lower South Deep, which is now the route used by ferries carrying material payloads from Poole to the island. (Personnel travel via Blood Alley*). After the Haven Channel, the Lower South Deep is perhaps the most marine of the channels within the Harbour, but is less exposed to water currents than the Haven Channel. Because of these characteristics, the South Deep supports the most extensive, also the most species rich and highest biomass biological communities encountered within the Harbour. The entrance to the South Deep is flanked to the east by 'Stone Island', a high energy gravel bank faced with cobbles, and otherwise, the most downstream intertidal areas are of sand. Moving upstream, these are progressively replaced by muds, increasingly colonised by saltmarsh. The shores are almost entirely natural.

SDL cont...SURVEY DETAILS

LENGTH: 2024m
 DIVE TRANSECTS: 5
 DREDGE / GRAB STATIONS: 6
 WHEN SURVEYED: 1984

HYDROGRAPHY

SALINITY: Polyhaline / marine
 DIRECT FRESHWATER INPUTS: None
 DEPTH RANGE: 0-5m (v.locally to 10m)
 TIDAL CURRENTS: ?
 WAVE EXPOSURE: Low
 TURBIDITY: Low - moderate

HARBOUR BEDSUBSTRATES

UNCONSOLIDATED SM, FS, MS, CS, GR, ST
 CONSOLIDATED: CL

BIOLOGICAL COMMUNITIES:

Cobble, shell, gravel,
 incl. Crepidula
 Coarse sand
 Medium sand - Lanice
 Fine sand, mud - Sargassum -
 (largest most extensive copses)
Sabella (most extensive,
 species - rich), Crepidula

INFLUENCES OF MANNAVIGATION

DREDGING: Local, vicinity of Furzey slip
 (1985)
 BERTHAGE: Small - temporary moorings.
 Medium - Furzey I., B.P. slip.
 (temporary)
 VESSEL MOVEMENTS: Small, medium (since 1985 -
 (B.P. vessels)
 NAVIGATIONAL MARKERS: Stakes

RECLAMATION

IMPOUNDMENT: No
 INFILLING: Local - B.P. slip.

FISHERIES

OYSTER FISHING: Farming of leased ground
 OTHER FISHING: Eel trapping

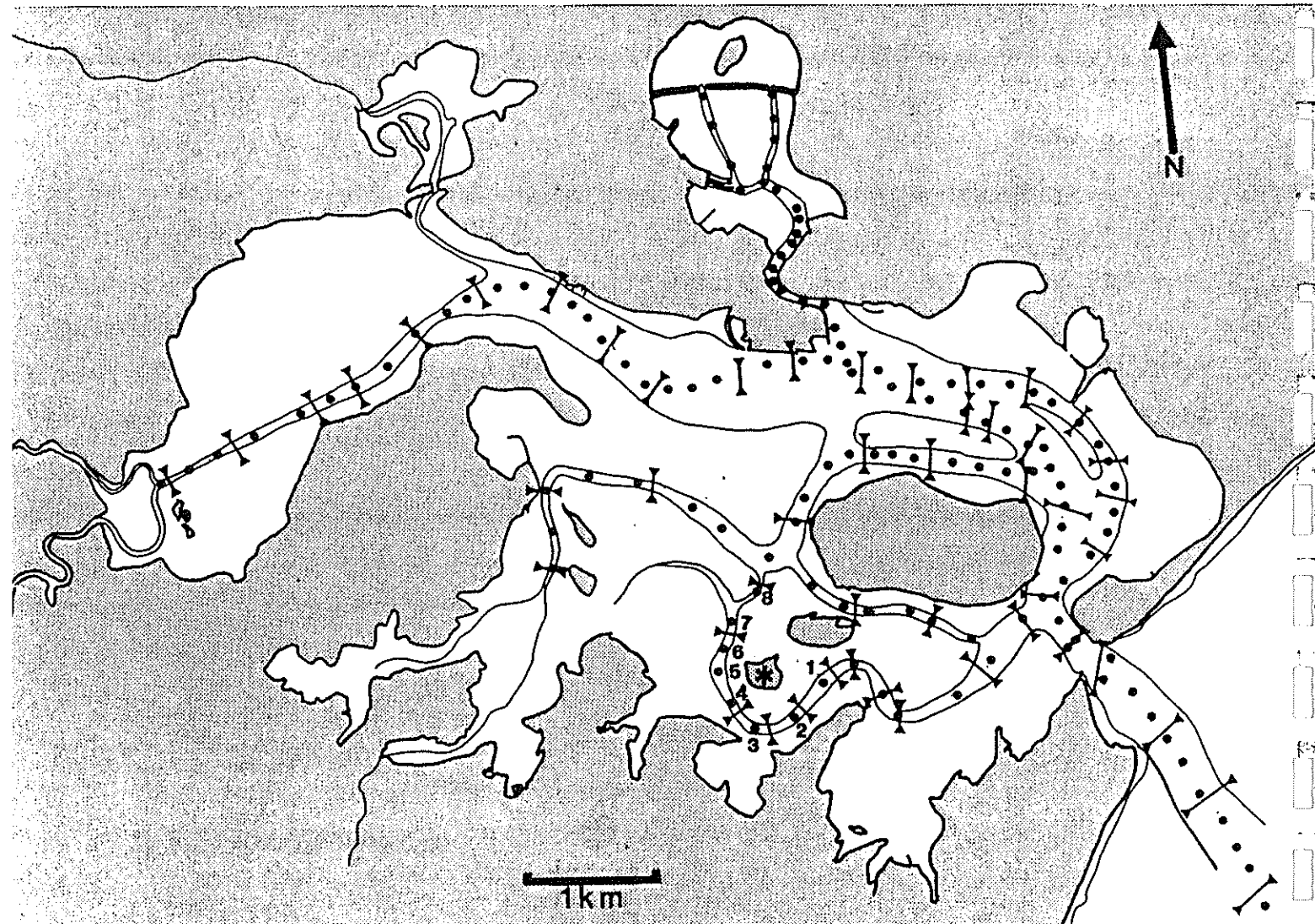
ALIEN SPECIES

Sargassum, Crepidula,
Crassostrea

POLLUTION

EUTROPHICATION: ?
 FLUID DISCHARGES: No
 HYDROCARBONS: ?
 SOLID WASTES: No
 TRACE METALS: ?

N.B. Please check guide key for interpretations



SDU, the top section of the South Deep, links with the Lower South Deep Channel* between Furzey Island and Goathorn Point. It then passes west and then north between Green Island and Cleavel Point before veering west again and phasing out. A very shallow passage, due north west of Furzey Island, links the uppermost section with both the Upper Wych Channel* and Blood Alley*. The flanking intertidal areas, almost entirely natural, are mainly of soft organic mud, extensively colonized by saltmarsh.

SURVEY DETAILS

LENGTH: 2048m
 DIVE TRANSECTS: 5
 DREDGE / GRAB STATIONS: 6
 WHEN SURVEYED: 1984

HYDROGRAPHY

SALINITY: Polyhaline / marine
 DIRECT FRESHWATER INPUTS: None
 DEPTH RANGE: 0-10m
 TIDAL CURRENTS: ?
 WAVE EXPOSURE: Low
 TURBIDITY: High

HARBOUR BED**SUBSTRATES**

UNCONSOLIDATED: SM, FS, MS, CS, GR, ST
 CONSOLIDATED: CL

BIOLOGICAL COMMUNITIES:

Fine sands, muds, Sabella,
Crepidula
 Turbid, mud, epibenthic
 Turbid, mud, inbenthic

INFLUENCES OF MAN**NAVIGATION**

DREDGING: No
 BERTHAGE: None
 VESSEL MOVEMENTS: Small, medium (touristic)
 NAVIGATIONAL MARKERS: Stakes

RECLAMATION

IMPOUNDMENT: None
 INFILLING: None

FISHERIES

OYSTER FISHING: Farming of leased ground
 (several species)
 OTHER FISHING: Eel trapping

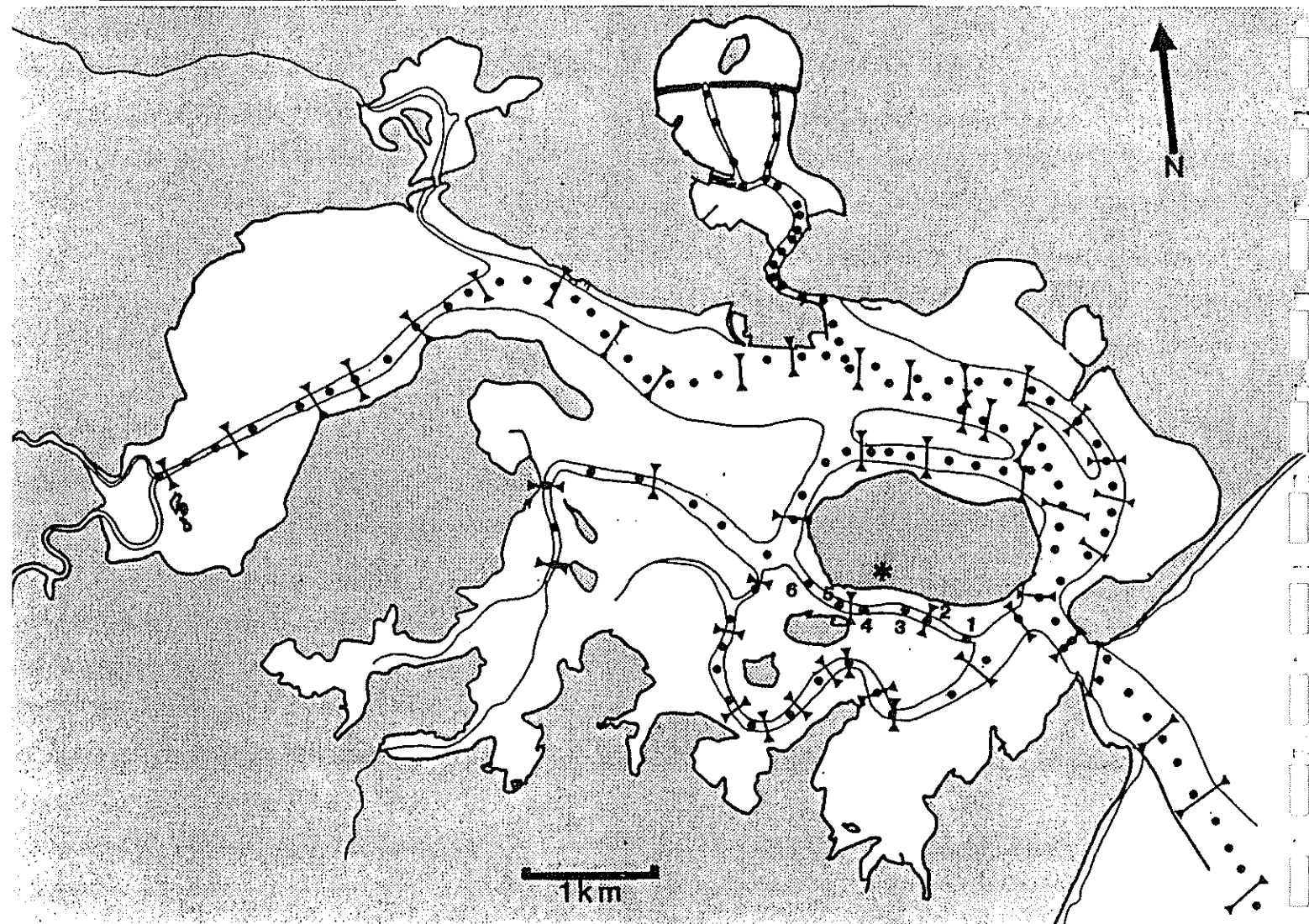
ALIEN SPECIES

Crepidula, Crassostrea

POLLUTION

EUTROPHICATION: ?
 FLUID DISCHARGES: No, but there is a seawater
 intake for the oilfield
 HYDROCARBONS: ?
 SOLID WASTES: No
 TRACE METALS: ?

N.B. Please check guide key for interpretations.

BLOOD ALLEY* - BAC

Links the Lower South Deep* with the Upper Wych Channel*, spanning the entire southern flank of Brownsea Island (Nature Reserve), and passing between this and the north shore of Furzey Island (Oilfield Development). Boating previously limited to light small leisure vessels, now with frequent passage of the B.P. passenger ferry to Furzey Island (several times daily). Poole Harbour Commissioners oppose dredging within this channel because of a prospect of the principal channel lineage within the Harbour breaking through (Poole Harbour Commissioners, 1982). The intertidal zone to north of the channel, i.e., the shore of Brownsea Island is mainly of sand, but with an appreciable content of fragmented pottery to westwards. To the south, an intertidal sand bank extends as far as Furzey Island, where the lower intertidal zone is of firm clay. The shores are nearly all natural.

BAC cont...

2-25

SURVEY DETAILS

LENGTH: 1619m
DIVE TRANSECTS: 3
DREDGE / GRAB STATIONS: 6
WHEN SURVEYED: 1984

HYDROGRAPHY

SALINITY: Polyhaline
DIRECT FRESHWATER INPUTS: None
DEPTH RANGE: 0-5m
TIDAL CURRENTS: 1.1 knots
WAVE EXPOSURE: Low
TURBIDITY: Moderate

HARBOUR BED

SUBSTRATES

UNCONSOLIDATED: SM, FS, MS, CS
CONSOLIDATED: CL

BIOLOGICAL COMMUNITIES

Medium sand
Fine sand, mud - Sargassum
Sabella

INFLUENCES OF MAN

NAVIGATION

DREDGING: No
BERTHAGE: Small - temporary moorings
Medium - Furzey Island B.P.
passenger jetty
VESSEL MOVEMENTS: Small, medium (BP ferry from 1985)
NAVIGATIONAL MARKERS: Stakes

RECLAMATION

IMPOUNDMENT: None
INFILLING: None

FISHERIES

OYSTER FISHING: None
OTHER FISHING: None

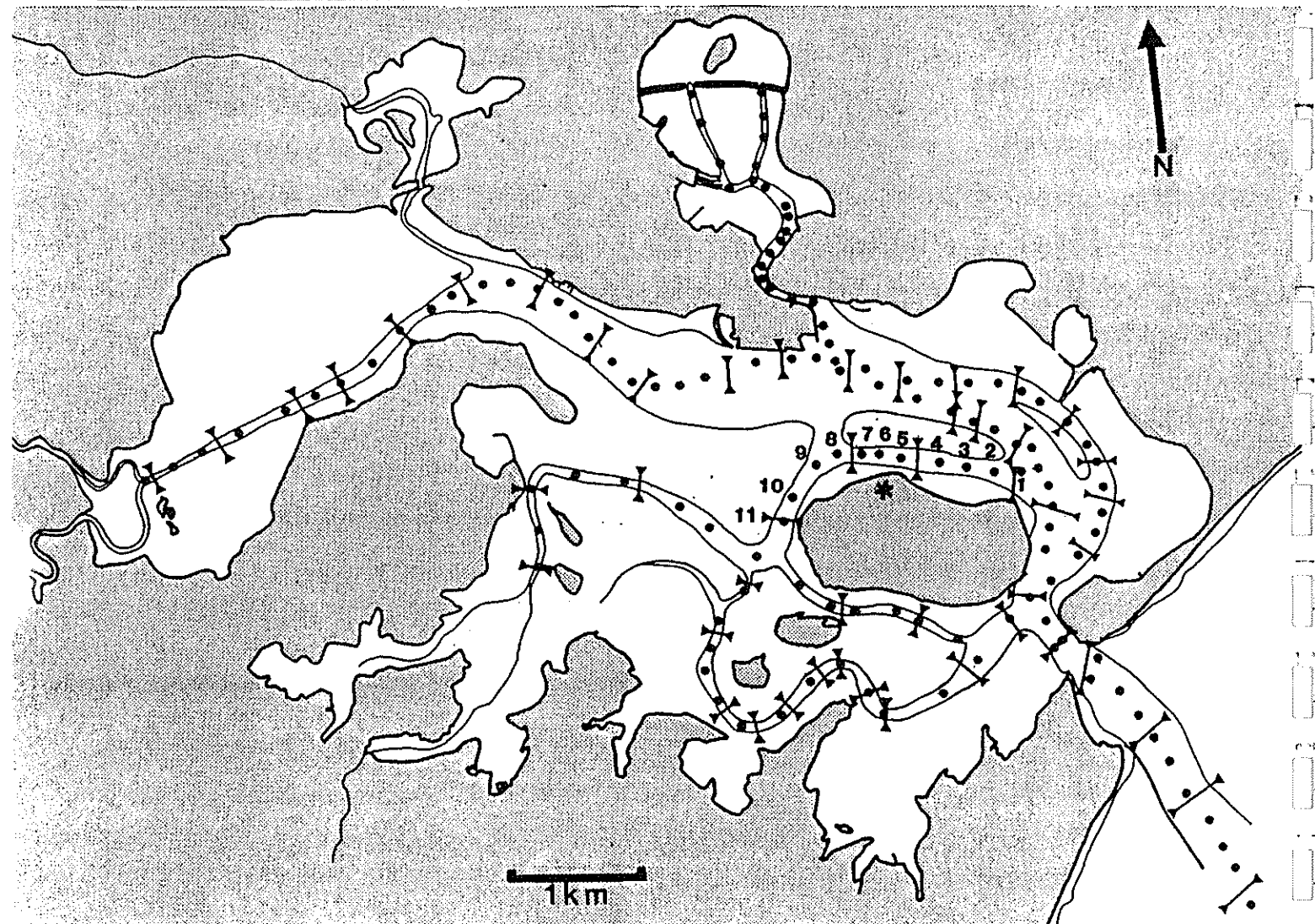
ALIEN SPECIES

Sargassum

POLLUTION

EUTROPHICATION: ?
FLUID DISCHARGES: No
HYDROCARBONS: ?
SOLID WASTES: No
TRACE METALS: ?

N.B. Please check guide key for interpretations

LOWER WYCH CHANNEL* - WYL

Links the Haven Channel** to the Upper Wych Channel*. Skirts entire northern flank of Brownsea Island (Nature Reserve) and is separated from the Diver Channel further north by an intertidal bank. Upstream section is leased as oyster grounds. Boating limited to light leisure and fishing vessels. On yacht racing circuit. The shores of Brownsea Island are mainly of sand, but grades to mud at the western extremity of the Island. The same is true of the bank flanking the north of the channel. All shores are natural.

WYL cont...**SURVEY DETAILS**

LENGTH: 1667m
 DIVE TRANSECTS: 3
 DREDGE / GRAB STATIONS: 9
 WHEN SURVEYED: 1985

HYDROGRAPHY

SALINITY: Polyhaline
 DIRECT FRESHWATER INPUTS: None
 DEPTH RANGE: 0-5m
 TIDAL CURRENTS: 1.4 knots
 WAVE EXPOSURE: Low
 TURBIDITY: Moderate - high

HARBOUR BED**SUBSTRATES**

UNCONSOLIDATED: SM, HM, FS, MS, CS, GR
 CONSOLIDATED: CL

BIOLOGICAL COMMUNITIES

Coarse sand
 Medium sand - Lanice
 Fine sand, mud - Sabella,
Crepidula
Turbid, inbenthic

INFLUENCES OF MAN**NAVIGATION**

DREDGING: No
 BERTHAGE: Small - temporary moorings
 VESSEL MOVEMENTS: Small
 NAVIGATIONAL MARKERS: Stakes

RECLAMATION

IMPOUNDMENT: None
 INFILLING: None

FISHERIES

OYSTER FISHING: Leased grounds
 OTHER FISHING: ?

ALIEN SPECIES

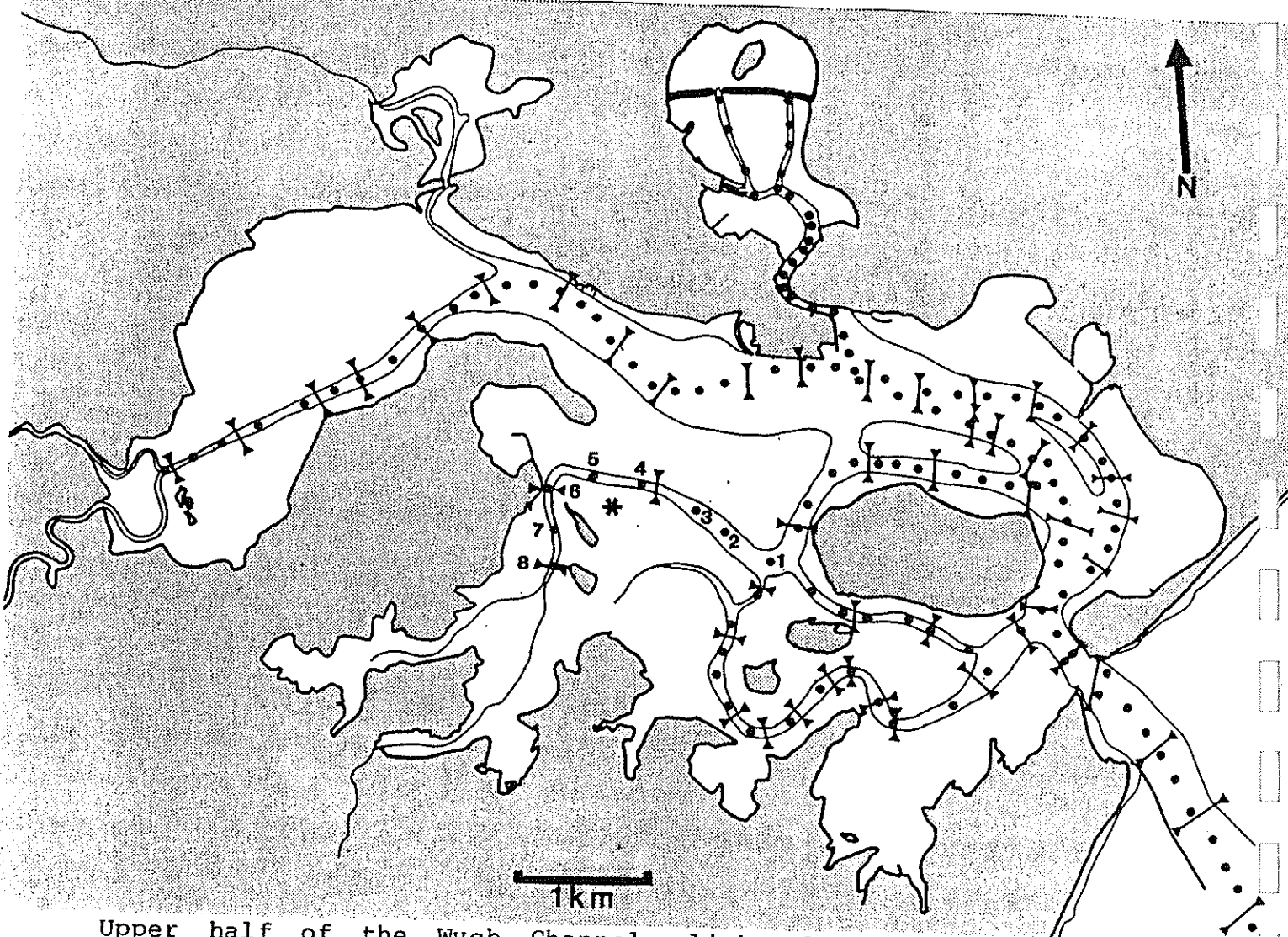
Crepidula

POLLUTION

EUTROPHICATION: ?
 FLUID DISCHARGES: No
 HYDROCARBONS: ?
 SOLID WASTES: No
 TRACE METALS: ?

N.B. Please check guide key for interpretations

UPPER WYCH CHANNEL* - WYU



Upper half of the Wych Channel, links downstream with Lower Wych Channel* and upstream extends to its extinction point at the mouth of the Corfe River. The channel extends from just west of Brownsea Island (Nature Reserve), before passing north west of Furzey Island (Oilfield Development) where it links to Blood Alley* and the South Deep*, before passing due west across to Arne (Nature Reserves) and then South Round Island (private, residential). Vessel traffic is confined to small leisure and fishing boats and a launch serving Round Island. Although the channel bed is not fished for oysters, an intertidal area (approx. chart datum) due west of the junction with the South Deep* is leased as an oyster bed, farmed for the native *Ostrea edulis* and other species. The eastern section of the channel is flanked by intertidal banks of increasingly fine mud, to the south colonized by saltmarsh. The shores of Arne and Long Island are stony with sand, and sandy respectively where the channel veers south, but further upstream, mud flats colonized by saltmarsh again become prevalent. With the exception of the oyster ground, intertidal areas are virtually undeveloped.

SURVEY ZONE DETAILS

LENGTH: 2095m
DIVE TRANSECTS: 3
DREDGE / GRAB STATIONS: 8
WHEN SURVEYED: 1984

HYDROGRAPHY

SALINITY: Polyhaline & mesohaline
DIRECT FRESHWATER INPUTS: Corfe River (at head)
DEPTH RANGE: 0-5m
TIDAL CURRENTS: ?
WAVE EXPOSURE: Low
TURBIDITY: High

HARBOUR BED

SUBSTRATES

UNCONSOLIDATED: SM, HM, FS
CONSOLIDATED: No

BIOLOGICAL COMMUNITIES:

Turbid, epibenthic
Turbid, inbenthic (principal)

INFLUENCES OF MAN

NAVIGATION

DREDGING: None
BERTHAGE: Small - temporary moorings
Small - Round Island Jetty
VESSEL MOVEMENTS: Small (leisure / fishing)
NAVIGATIONAL MARKERS: Stakes

RECLAMATION

IMPOUNDMENT: None
INFILLING: None

FISHERIES

OYSTER FISHING: Intertidal leased area
south of the downstream section
OTHER FISHING: Eel trapping, netting for mullet

ALIEN SPECIES

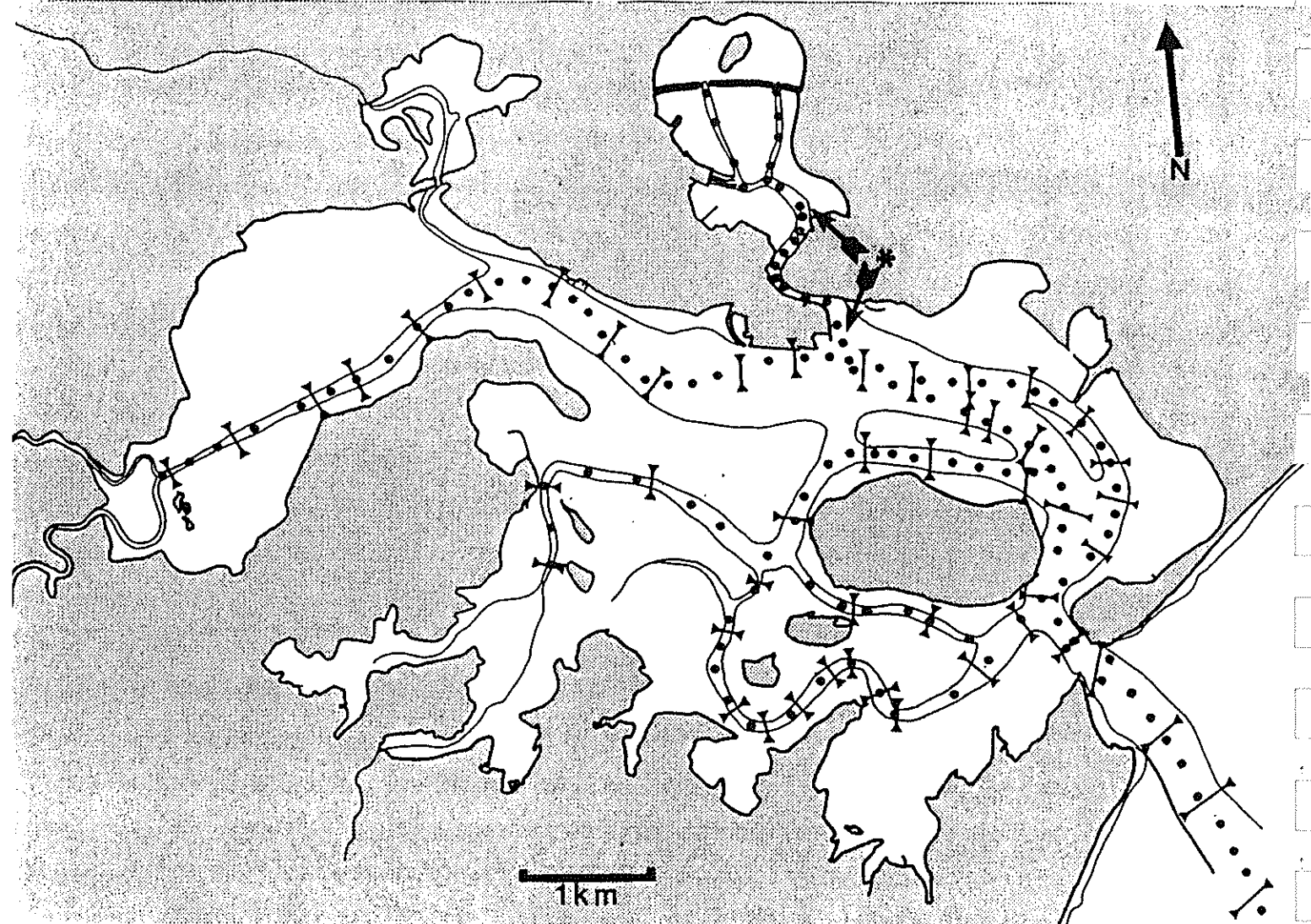
No

POLLUTION

EUTROPHICATION: ?
FLUID DISCHARGES: No
HYDROCARBONS: ?
SOLID WASTES: No
TRACE METALS: ?

N.B. Please check guide key for interpretations

LOWER HOLES BAY CHANNEL* - HBL



Arising from the head of the Upper Main Channel, this lineage passes through the Port of Poole and into Holes Bay to link with the Upper Holes Bay Channel. This is the most heavily developed waterway within the Harbour not only from the viewpoint of the subtidal zone, but also its intertidal and fringing terrain. The channel first passes north, skirting New Quay to its west and subtidal banks to the east. It then veers west to pass as a narrow sound (down to approx. 35m in width) between the Town Quay and New Quay (shipping wharves), giving an offshoot along the eastern Town Quay up to the Fishermen's Dock. Beyond Poole Bridge, the channel widens before veering north between an industrialised and commercialised waterfront on the east side (light industry, a small marina, B.D.H. chemical works and the R.N.L.I. boatyard) and a timber wharf and Poole Power Station (now closed) to the west. Beyond, the channel links with the Upper Holes Bay Channel. Throughout this area, intertidal flats have been extensively reclaimed to extend wharfage up to or into the subtidal. Large commercial vessels (non-ferry traffic) moor along all wharfs downstream of Poole Bridge, and along the western waterfront upstream. Intermediate commercial and non commercial vessels, and those of the Harbour and other Authorities, moor along the wharfs at points throughout the area. The Fishing Dock, a small dredged area enclosed by a bund at the east of the Port, and the aforementioned 'marina' (a series of pontoons fringing the eastern wharf upstream of the lifting bridge), provide berthage for small vessels. Pollution surveys reveal this to be one of, if not the most, polluted section of Poole Harbour. It is downstream of the main treated sewage outfall for Poole (in Upper Holes Bay Channel) and receives direct discharges from municipal and industrial drains. This problem is exacerbated by the extremely poor tidal flushing which characterises Poole Harbour in general and Holes Bay in particular (Falconer, 1983). As described above, virtually all intertidal areas flanking this channel have been lost by reclamation.

HBL cont...SURVEY DETAILS

LENGTH: 1619m
 DIVE TRANSECTS: None (water turbid, polluted,
 too many obstructions)
 10 peripheral stations,
 DREDGE / GRAB STATIONS: 11 (1982 survey)
 5 (1985 survey)
 WHEN SURVEYED: 1982, 1985

HYDROGRAPHY

SALINITY: Polyhaline
 DIRECT FRESHWATER INPUTS: Only municipal drains
 DEPTH RANGE: 0-10m
 TIDAL CURRENTS: to approx. 2.5 knots
 WAVE EXPOSURE: Low
 TURBIDITY: High

HARBOUR BEDSUBSTRATES

UNCONSOLIDATED: SM, HM, FS, MS, GR
 CONSOLIDATED: CL, PT, BL, WX, CX, SX, FX

BIOLOGICAL COMMUNITIES

Hard consol. (artificial,
 co-principal)
 Coarse sand
 Turbid, fine sand / mud -
Crepidula
 Turbid, mud, epibenthic (co-
 principal)
 Turbid, mud, inbenthic

INFLUENCES OF MAN**NAVIGATION**

DREDGING:
BERTHAGE:

Local maintenance
Small - marina, boatyards,
fishing dock, moorings
Medium - boatyards, fishing
dock, moorings,
P.H.C. & other
authority vessels
Large - Extensive wharfage
for coasters

VESSEL MOVEMENTS:
NAVIGATIONAL MARKERS:

Small+, medium+, large+
Stakes, wharfage

RECLAMATION

IMPOUNDMENT:
INFILLING:

Fishing dock breakwater
Very extensive
wharfage throughout
Poole Power Station (closed)

FISHERIES

OYSTER FISHING:

None. Holes Bay Channel
designated Reserve for
Scientific Study)

OTHER FISHING:

?

ALIEN SPECIES

Crepidula

POLLUTION

EUTROPHICATION:
FLUID DISCHARGES:
HYDROCARBONS:

Yes
Municipal & industrial drains
Yes, fuel & lubricants used by
vessels

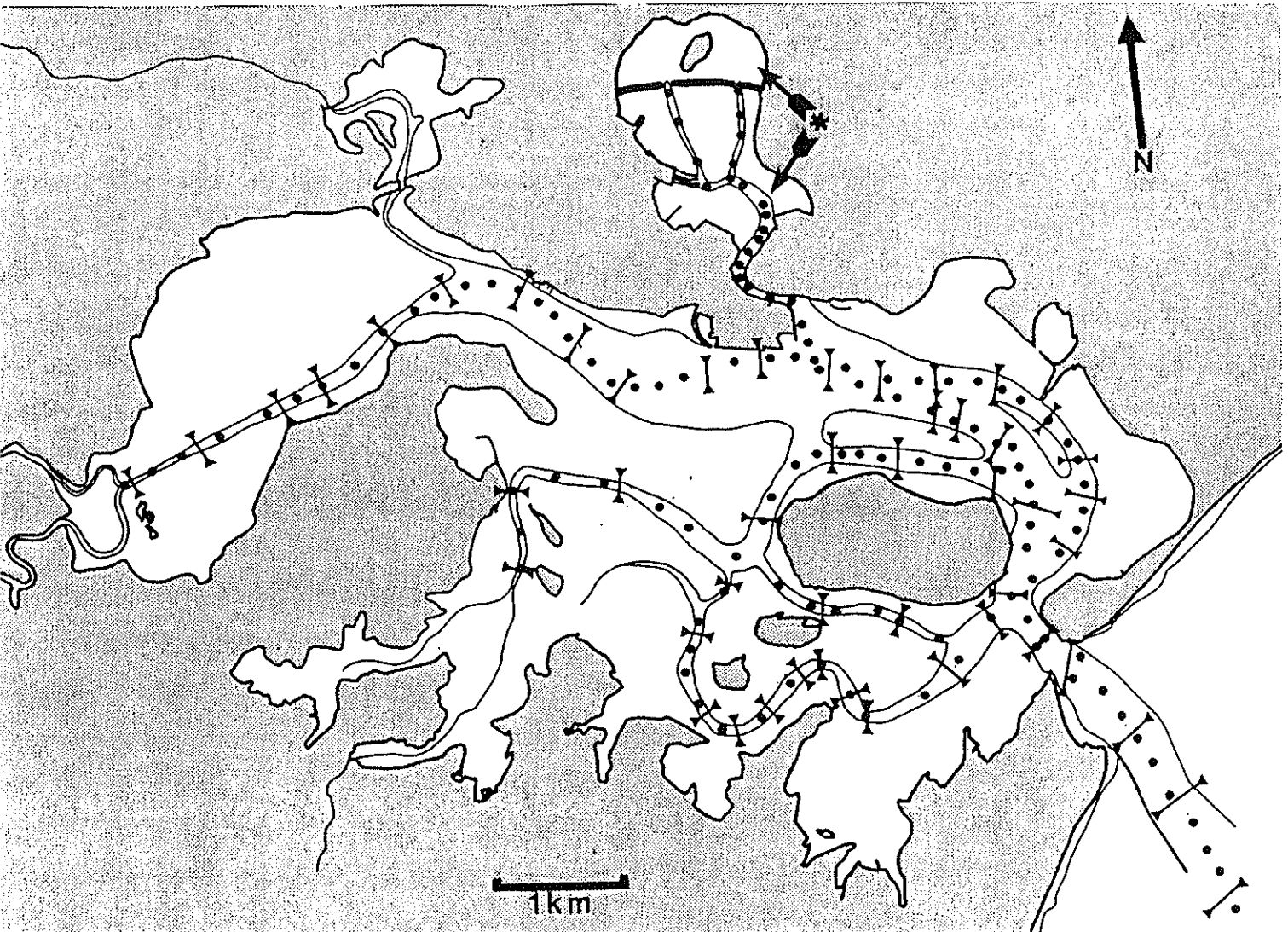
SOLID WASTES:
TRACE METALS:

Assorted refuse (unofficial)
Yes

N.B. Please check guide key for interpretations



UPPER HOLES BAY CHANNEL* - HBU



The subtidal channels of the main basin of Holes Bay have a Y configuration. Leading from the Lower Holes Bay Channel, a reach, flanked by extensive intertidal flats, passes due north west before dividing in the centre of the Bay into eastern and western arms which together drain the inner, northern section of the Bay. The northern section of Holes Bay was annexed during the late nineteenth century by a railway embankment with two small passages accommodating the two subtidal channels (without affecting their trajectories). The eastern channel leads from the outfall of the main Sewage Treatment works for Poole (discharging into the northern, inner basin). The intertidal flats to its west have recently been extensively reclaimed to carry a new relief road for Poole. The enclosing boulder bund almost reaches the subtidal channel. The longer (but more shallow) western branch leads from the northern, inner basin, Upton Lake, which is flanked by the only undeveloped shoreline within the Bay (Upton Country Park) and receives limited freshwater input via a small stream. The western channel runs south to Cobbs Quay Marina before veering east up to the point of union between the three branches. Boat movements within Holes Bay are virtually confined to small leisure vessels. Remaining natural intertidal flats within Holes Bay are mainly of fine organic muds, towards the upper intertidal, extensively colonized by *Spartina* saltmarsh. Elsewhere, shorelines have changed considerably with losses in area and conversions to artificial hard substrate shores resulting from reclamation and shoreline protection developments.

HBU cont...SURVEY DETAILS

LENGTH: 2071m
 DIVE TRANSECTS: None (water too turbid
 & polluted)
 DREDGE / GRAB STATIONS: 11 (1982 survey)
 WHEN SURVEYED: 1982

HYDROGRAPHY

SALINITY: Polyhaline & mesohaline
 DIRECT FRESHWATER INPUTS: Poole Sewage Treatment Works,
 Upton Brook, municipal drains
 DEPTH RANGE: Generally 0-5m, but 10-15m
 at point of union of branches
 TIDAL CURRENTS: 1.0 knots
 WAVE EXPOSURE: Low
 TURBIDITY: High

HARBOUR BEDSUBSTRATES

UNCONSOLIDATED: SM, HM, GR, ST
 CONSOLIDATED: CL, PT, BL, WX, CX, FX

BIOLOGICAL COMMUNITIES:

Turbid, gravel (local)
 Turbid, inbenthic (principal)

INFLUENCES OF MANNAVIGATION

DREDGING: Local maintenance (Cobbs Quay)
 BERTHAGE: Small - Marina, moorings
 VESSEL MOVEMENTS: Small+, to Cobbs Quay Marina
 NAVIGATIONAL MARKERS: Stakes

RECLAMATION

IMPOUNDMENT: Railway embankment
 INFILLING: Extensive: Route 9 development
 (further related reclamation
 planned for Holes Bay Bridge)
 Cobbs Quay

FISHERIES

OYSTER FISHING: None. Holes Bay Channel (upper
 & lower, designated Reserve
 for Scientific Studies)
 OTHER FISHING: Netting mullet

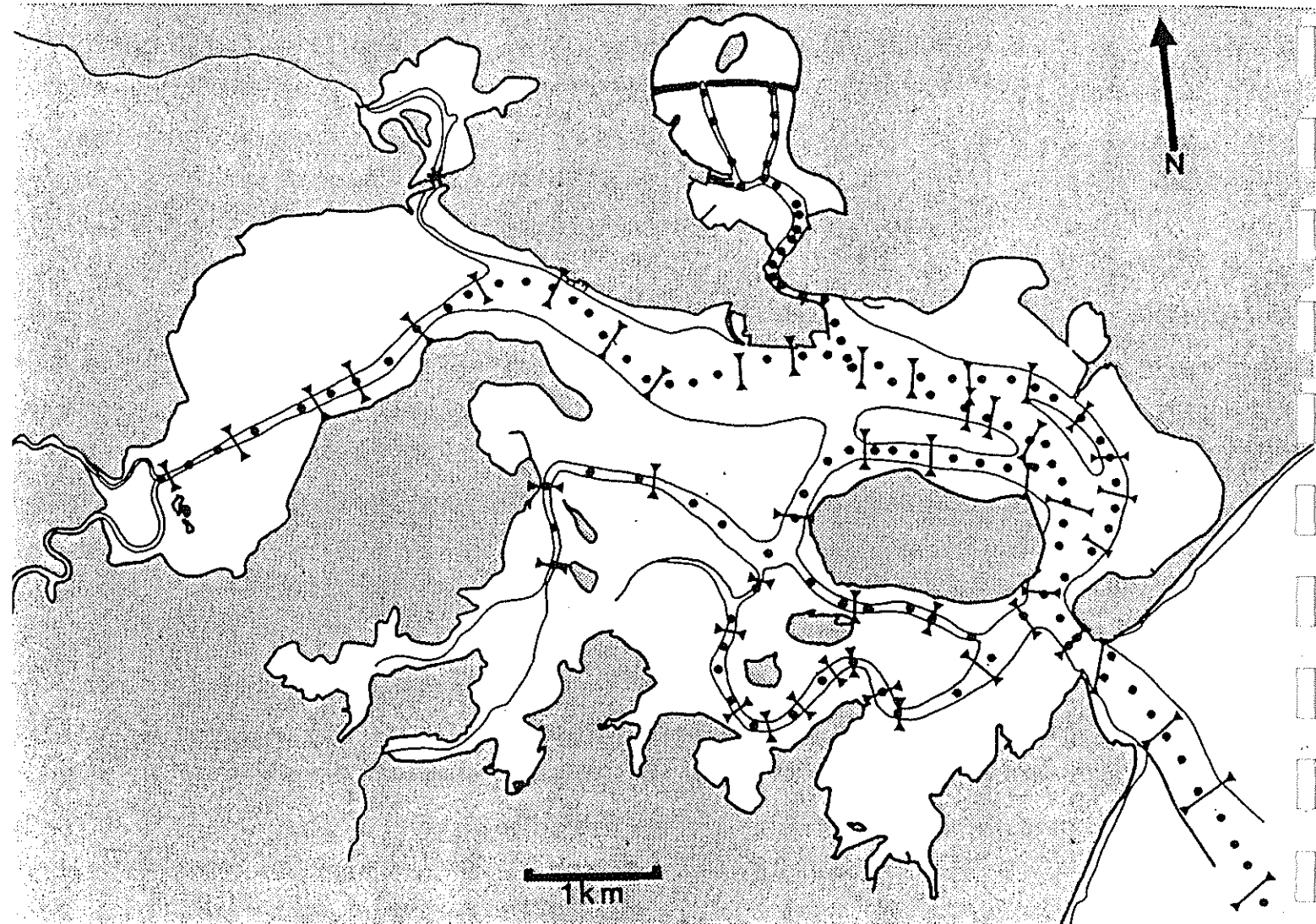
ALIEN SPECIES

No

POLLUTION

EUTROPHICATION: Yes
 FLUID DISCHARGES: Poole Sewage Treatment Works
 Municipal / domestic drainage
 Fuels & lubricants used by
 vessels, other?
 HYDROCARBONS: Refuse (unofficial)
 SOLID WASTES: Yes
 TRACE METALS: Yes

N.B. Please check guide key for interpretations.

LYTCHETT BAY CHANNEL

The Lytchett Bay Channel is the most upstream offshoot of the principal channel lineage. Arising from the Middle Wareham Channel, this veers west and then north into Lytchett Bay itself, as far as the mouth of the Sherford River. Lytchett Bay has been almost isolated from the primary basin of Poole Harbour since the late nineteenth century by the construction of a railway embankment across its mouth. The embankment incorporates only a single, small link-channel for tidal exchange. An area downstream of this embankment has been reclaimed for development as a small marina (Rockley Point). Outside Lytchett Bay, the channel is mainly flanked by intertidal sandflats, but fine organic muds predominate within, most extensively colonized by Phragmites beds. The concrete and steel flanks of the railway embankment provide a significant hard substrate resource which is mainly intertidal, but extends into the subtidal within the link-channel.

SURVEY DETAILS

LENGTH: 2238m
DIVE TRANSECTS: 0
DREDGE / GRAB STATIONS: 0
Shore accessed station within link-channel, intertidal / subtidal, monitored since 1981 onwards
WHEN SURVEYED: 1981 onwards

HYDROGRAPHY

SALINITY: Mesohaline
DIRECT FRESHWATER INPUTS: Sherford River
DEPTH RANGE: 0-5m
TIDAL CURRENTS: High within link-channel
WAVE EXPOSURE: Low
TURBIDITY: High

HARBOUR BED

SUBSTRATES
UNCONSOLIDATED: SM, HM, GR, ST
CONSOLIDATED: BX, CX, SX

BIOLOGICAL COMMUNITIES

Hard consol.
Turbid, mud, gravel, epibenthic (principal)

INFLUENCES OF MAN

NAVIGATION

DREDGING: No
BERTHAGE: Small - Marina, moorings
VESSEL MOVEMENTS: Small, leisure boats to marina
NAVIGATIONAL MARKERS: Stakes

RECLAMATION

IMPOUNDMENT: Railway embankment
INFILLING: Local, downstream to embankment

FISHERIES

OYSTER FISHING: No
OTHER FISHING: Netting for mullet

ALIEN SPECIES

No

POLLUTION

EUTROPHICATION: ?
FLUID DISCHARGES: ?
HYDROCARBONS: ?
SOLID WASTES: No
TRACE METALS: ?

N.B. Please check guide key for interpretations

Section 3

GENERAL ASSESSMENT

Index

<u>INTRODUCTION</u>	3 - 1
<u>SURVEY DETAILS</u>	3 - 2
<u>HYDROGRAPHY</u>	3 - 4
TIDAL CURRENTS AND WAVE EXPOSURE.....	3 - 4
SALINITIES.....	3 - 5
OTHER FACTORS.....	3 - 6
<u>THE HARBOUR BED - SUBSTRATES</u>	3 - 7

CONTINUED OVERLEAF

INDEX - CONTINUED...

<u>THE HARBOUR BED - BIOLOGICAL COMMUNITIES</u>	3 - 10
GENERAL FEATURES OF THE BIOLOGICAL COMMUNITIES.....	3 - 10
DETAILED DESCRIPTIONS OF BIOLOGICAL COMMUNITIES AND THEIR SUBSTRATES.....	3 - 12
<u>Communities of natural and artificial consolidated materials</u>	3 - 12
<u>Communities of cobble, stone and gravel beds</u>	3 - 12
<u>Communities of coarse sands</u>	3 - 13
<u>Communities of medium sands</u>	3 - 13
<u>Communities of fine sands - General</u>	3 - 13
<u>Peacock Worm Communities</u>	3 - 14
<u>Slipper Limpet Communities</u>	3 - 15
<u>Japanese Seaweed Communities</u>	3 - 15
<u>Communities of soft muds</u>	3 - 16
<u>THE INFLUENCES OF MAN</u>	3 - 18
NAVIGATION.....	3 - 18
RECLAMATION.....	3 - 20
FISHERIES.....	3 - 21
ALIEN SPECIES.....	3 - 23
POLLUTION.....	3 - 24
<u>DISCUSSION AND CONCLUSIONS</u>	3 - 27

Introduction

The objective of the **GENERAL ASSESSMENT** is to provide a review and synthesis of the combined results of the subtidal survey in a manner which should be understood by readers not having a scientific background. All but essential scientific terminology and detail are avoided, and unavoidable terms and concepts are explained (definitions for many of these are also provided in the key at the beginning of the **QUICK REFERENCE GUIDE**). **Common names are used for groups and species of plants and animals.** The scientific equivalents are provided in the glossary in Appendix II (table 2).

Survey Details

The aim of this survey has been to broadly assess the seabed and all of its plants and animal species by using evenly-spaced sampling stations covering all areas of the Harbour (fig. 2). By avoiding biases for particular areas or species, a full and balanced baseline image has been compiled which should be of use, not only in the context of areas or species of current interest, but of any which may become important in the future. This is one aspect for which the close spacing of sampling stations is a prerequisite. Another relates to the main purpose of the report as a manual providing factual information for Environmental Management, i.e. because many developments and activities are localized to particular areas within the Harbour. It is hoped that the work will also have other applications, e.g. in the context of the national assessment of coastal environments currently being undertaken by the Nature Conservancy Council.

The survey has proceeded in three phases, scaled and timed according to the availability of funding. The Holes Bay Subtidal Survey of 1982 (Dyrynda, 1983) was undertaken as one of a coordinated programme of assessments carried out independently by separate contractors and covering, in addition to the subtidal zone, the intertidal flats, the saltmarsh and the bird fauna (Doody and Dennis, 1984). In 1984 funding became available to survey the Southern Sector of the Harbour (fig. 2)(Dyrynda, 1985). A standardized survey methodology was then developed, which was also applied in 1985, at which time resources became available to survey the remaining and largest area of the Harbour, i.e. the Northern Sector (fig. 2)(Dyrynda, 1987a and this report). All of the surveys have been commissioned by the Nature Conservancy Council and supported and funded by a number of other authorities and industries concerned with the Harbour (including the N.C.C.) (see Acknowledgements, Section 1).

The detail and comprehensiveness of the survey exceeds that which would have been feasible according to the funding alone because of additional practical and other support, often with high cost values, provided free of charge by organisations and individuals concerned with the Harbour, e.g. survey vessels and shore facilities provided by the Poole Harbour Commissioners for all three surveys, and by the Royal Marines at Poole for one, and shore facilities provided by 'Sea Harvest' (Poole) for two of the surveys. Beyond practical support, the effectiveness of the investigation was very much dependent on advice, consultations and the cooperativeness of many persons concerned with the Harbour (see Acknowledgements, Section 1).

Conventional methods for taking seabed samples for analysis are to deploy grabs and dredges from a surface vessel. Although effective for areas where the seabed and its marine life varies little over substantial distances, their value is less in small systems in which the seabed can change substantially over very limited distances. Preliminary results revealed Poole to be a case in hand. In several areas, important changes on the channel bed were found to occur over distances of less than 10m, not only along-channel, but particularly across-channel. The use of grabs and dredges alone in such circumstances can give information which is precise but erroneous.

In view of this, a new dive transect method was developed specifically for use in Poole. Divers swimming along lines laid cross-channel were able to record, metre by metre, the precise depth, the nature of the seabed and of visible species. Dive transects stations were established at 49 points, covering all sections of the Harbour (fig. 2). More than 5 km of the seabed was covered, metre by metre, in this way. The method proved effective in providing accurate three dimensional impressions of the Harbour bed, not only of detailed changes within particular areas but also of broad trends across the Harbour, and has therefore been adopted as the mainstay procedure for the survey. One important feature of the method is that it allows for resurveying in the context of the future monitoring of changes. Since the exact location of each transect is known, resurveying at subsequent times will provide detailed information on any changes in depth, channel bed and of the species.

Samples were also taken at 120 stations across the Harbour using the conventional dredge and grab sampling methods (fig. 2), the information attained being used to supplement the dive data.

By combining results obtained from the three procedures, accurate and balanced impressions of the subtidal environment within the Harbour were obtained, providing not only a baseline picture but also a framework for future monitoring.

The only subtidal areas of the Harbour bed for which the biological communities had been investigated previous to the current survey are leased oyster beds off the Hamworthy foreshore and within the South Deep. These have been monitored in the context of developments within adjacent areas (Collins, 1980, 1983).

Hydrography

Hydrography concerns the natural movement and properties of marine, fresh, or brackish (mixed) waters.

TIDAL CURRENTS AND WAVE EXPOSURE

The two major kinds of water movement affecting the seabed environment are tidal currents and wave action.

The tidal cycle, as governed by the lunar cycle, consists of two high and two low tides each 24 hours, i.e. alternating every six hours. The tidal range, the vertical distance between low and high water, alternates approximately every seven days between large **spring** tides and small **neaps**. The range also varies considerably around the country from area to area. Poole Harbour lies within a section of the English Channel with a very small range, less than 2 metres during spring tides and as little as 1m during neaps (fig. 5). The tidal cycle in the Harbour is also unusual in that there is a double high tide (two highs for every low)(fig. 5). The consequences of this are, 1) the tide stays in for longer than would be the case under a normal tidal cycle, and 2) at the time of neap tides, during the period around and between each pair of high tides, conditions within the Harbour approach those of a marine lake or lagoon.

Tidal currents occur whilst the tide is running, i.e. rising (flood tides) or falling (ebb tides). Despite the small tidal range, the currents are strong within some parts of Poole Harbour, are generally moderate, and weak in some areas (fig. 4). The strength of the tidal currents influences the intertidal and subtidal areas of the Harbour bed (the former of which is fully uncovered during the times of low water spring tides). Where currents are weak, soft muds or fine sands accumulate to form extensive intertidal flats, and floor shallow and narrow subtidal channels (fig. 8). These sediments are inhabited by species specially adapted to fine, soft sediments. Where currents are strong, the scouring effect of the water movement produces steeply sloping and hence narrower intertidal areas fringing wider and deeper subtidal channels. The Harbour bed within areas scoured by currents are either of coarser sediments, e.g. gravels or stones, or even of exposures of the underlying geological strata, i.e. rocks. The biological communities inhabiting such beds include species adapted to living under the mainly favourable conditions of strong water movement

which ensures a good supply of food and oxygen.

Wave induced water movements influence the nature of the bed of both intertidal and subtidal areas in a different way to tidal currents. Breaking waves on the shore and the associated surge motion within nearby subtidal areas is a turbulent, destructive kind of water motion. As with currents, greater wave exposure leads to coarser sediments or greater exposures of geological strata, but the effect on the biological communities is different. Biological communities exposed to strong wave action contain fewer species than those exposed to strong currents. Most of the species concerned tend to be of robust construction in order to tolerate the turbulent conditions.

Wave exposure is secondary to current exposure as an environmental factor within Poole Harbour. The land-locking terrain reduces the strength of winds which, anyhow, only have a small expanse of water (i.e. fetch) across which to generate wave motion. The most wave exposed section of the Harbour is the north west sector which is at the end of a significantly long fetch to the prevailing south westerly winds (figs 1, 4). Even this area can only be rated as low to moderate in terms of wave exposure.

In conclusion, many areas of the Harbour experience moderate to strong tidal currents combined with weak wave exposure, a combination which favours the development of substantial biological communities, both in the case of intertidal and subtidal areas of the Harbour bed, i.e. substantial in terms of the number of constituent species and also their productivity (see **BIOLOGICAL COMMUNITIES** below).

SALINITIES

One property of coastal water which is very important in influencing the kinds of species inhabiting the seabed is the salt content. This is referred to as the **salinity**, marine waters of the open sea being regarded as **fully saline**, and fresh waters of rivers and lakes as **non-saline** (or **fresh**). The intermediate condition, i.e. **partly saline**, or **brackish**, is encountered where fresh and marine waters mix, e.g. within estuaries where rivers meet the sea. Poole Harbour is entirely brackish but is not strictly an estuary. It is a small enclosed sea, receiving a tidal influx of marine water from the English Channel via a single narrow entrance, but also receiving freshwater inputs from several rivers, the most substantial of these being the Frome and Piddle (figs. 1, 6). Because of the mixing of fresh and marine waters, all parts of the Harbour are brackish, but not uniformly so (fig. 6). The downstream, eastern half of the Harbour towards the entrance is nearly fully marine with salinities changing little, not only over the tidal cycle but also seasonally. The upstream, western part of the Harbour, i.e. in the combined approaches to the mouths of the Frome and Piddle also experiences more typically estuarine conditions, i.e. much lower salinities which vary substantially as the tide rises and falls, and also according to rainfall levels (the same is the case in the vicinities of small river and effluent discharges).

Many species of **plants** and **animals** that are common in the fully marine conditions of the open coast cannot tolerate brackish water conditions at all. This is why many of the marine species encountered within the open coastal areas of Dorset and beyond are precluded from Poole Harbour. Other more tolerant marine species do extend into the Harbour, mainly into the downstream sections where salinities are higher and more stable. Yet other species, specially adapted to living

within brackish water conditions, are common within the Harbour but are not found on the open Dorset coast at all. Many species are confined to particular sections of the Harbour experiencing particular salinity ranges. Most brackish water species are of marine origin. Very few freshwater species are represented within the brackish environment.

In conclusion, the biological communities colonizing the brackish waters of Poole Harbour are quite different from those of the open coast beyond.

OTHER HYDROGRAPHIC FACTORS

Enclosed seas, particularly when shallow and with extensive intertidal flats, tend to show more extreme water temperatures than more open waters within the same geographical region, Poole Harbour being a case in hand. Summer maxima and winter minima are more extreme than in adjacent coastal waters. In view of the Harbour's southern location, within an area often attaining the lowest cloud cover levels of the country, temperatures are among the most extreme for any marine system within the British Isles. This has biological consequences, 1. warm summer temperatures boost rates of growth of many species, and 2. enable the survival of warmer water species characteristically confined to more southern latitudes. In winter, the prospect of exceptionally low temperatures sometimes accompanied by sea ice can produce mass mortalities of less resistant species.

Poole Harbour Commissioners maintain a permanent Hydrographic Team who continually monitor the tidal cycle and the depths of the navigational channels within the Harbour, and who also investigate currents and their effects on silting and scouring patterns. The work is essential in order to maintain minimum navigational depths within the Harbour - certain sections of the major navigational channels are not naturally deep enough to accommodate the size of vessels using the Port and have to be dredged (the minimum acceptable working depth being approximately 5 metres). The present survey has depended heavily on, and benefited from information provided by the Hydrographic Unit concerning bathymetry, the tidal cycle and tidal currents within the Harbour, this being invaluable in view of the objectives to examine the inter-relationships between hydrography, the channel bed materials and the biological communities within the Harbour.

The Harbour Bed -

Substrates

The kinds of living species inhabiting particular intertidal or subtidal areas of seabed is most strongly influenced by the nature of the non-living materials of the seabed, i.e. the substrate. The role of water currents and waves in fashioning the Harbour bed substrates has already been mentioned (see **HYDROGRAPHY**). The nature of the substrates also depends on the nature of the underlying geology and on materials introduced by rivers and from adjacent sea areas. Finally, man made materials can contribute to the range of substrates encountered. All of these factors have a bearing on the wide range of substrates which occur as a mosaic on the bed of Poole Harbour (fig. 8).

In geological terms, most of the bed and shorelands of the Harbour are underlain by the Bagshot beds, strata deposited 60 million years ago whilst the area formed part of the bed of the 'Solent River'. These geologically 'recent' strata are soft and poorly consolidated, a combination of quartz sands containing numerous cobbles, mixed with layers of hard clay. These elements have been re-exposed in many places within the Harbour by the eroding force of water motion. Intertidally, both the sands and clays feature in cliff faces cut by wave action. Subtidally, natural exposures of the Bagshot Clay occur within several sections of channel where tidal currents and scour are sufficiently strong to prevent the settling of more recent sediments, i.e. particularly within the deeper sections of the Haven Channel (fig. 8, also Appendix III). Bagshot Sands, on the other hand, are too readily erodable to naturally feature intact. However, along certain stretches of the Main and Lower Wareham Channels, i.e. where navigational dredging has taken place recently, intact Bagshot clays, and in places sandstones and sandstone conglomerates feature as artificial exposures.

Hard natural bedrock is virtually absent within the Harbour with one exception, i.e. one area of the Haven Channel where outcrops of sandstone have been exposed (from beneath the Bagshot Beds) by the strong currents.

Across most of the Harbour bed the geological strata are overlain by sediments within which a wide variety of constituent materials and particle sizes are represented. The erosion of the Bagshot Beds has released large quantities of quartz particles. Fine and medium quartzitic sands feature on shores fronting eroding cliffs at various points within the Harbour. These accumulate as still more extensive flats and banks within the current-scoured, downstream areas of the

Harbour, particularly the more wave exposed north-eastern sector.

The same pattern is repeated within the subtidal channels (fig. 8). Extensive areas of the more downstream channels are floored by quartz sands. The fine and medium sand beds are typically stable, level and rippled, whereas the coarse sands are thrown by the currents into waves and undulations which are constantly being reworked by the tides. Within the most current scoured areas, i.e. the Haven Channel, the sands give way to firm gravels, usually faced by a veneer of small stones. Within the deepest, most current-scoured section of all (between the Haven Points), beds of cobbles occur, even incorporating occasional quartz boulders.

Calcareous hard remains of marine life, particularly molluscs, also feature within the Harbour bed sediments. The shells of dead **mud snails** and **cockles** originate within intertidal mud and sand flats, whereas **slipper limpets** and **oysters** originate within the subtidal zone. Once released from the living mollusc beds, the shells are transported, widely distributed and sorted by the tidal currents. Scattered shells occur throughout the Harbour in association with most substrates, but are most significant when concentrated and accumulated by the currents into beds. These are characteristic of current scoured areas throughout the Harbour with the exception of the Haven, the most current scoured area of all where heavier quartz materials are more predominant, and with respect to shells, only those of **oysters** occur. With specific reference to **oysters**, artificial accumulations of these occur on former dumping grounds of the oyster industry, e.g. off the Town Quay within the Port.

Upstream areas of the Harbour sheltered from strong currents and wave action are floored by fine sediments, i.e. muds. These marine soils contain materials originating from a variety of sources: 1) particularly the rivers, 2) the Bagshot Beds, 3) organic biological remains, particularly of **saltmarsh** and **seaweed plants** but also of **animals**, and 4) solids from effluents. The **bacterial** decomposition of the organic substances contained within the muds leads to their becoming blackened and having an odour of hydrogen sulphide (rotten eggs). Although this effect occurs naturally, it can be increased by the incorporation of organic pollutants into the muds, e.g. as occur within farm silage or domestic sewage effluents.

Within the sheltered areas of the Harbour the muds have risen apace with rising sea levels (over the past 5000 years), and in places, the total depth of the mud column now exceeds ten metres. However, this is not ten metres of fluid mud, the deeper, older mud levels have become compressed and compacted to form consolidated marine clays - only the most recent, very top of the sediment column is soft. In some places the mud is so fine and has such a high organic content as to be gelatinous, and where this occurs subtidally, the muds can run with the tide, e.g. as happens in parts of Holes Bay.

Within many sections of the Harbour the channels are shifting their position, rather like the meandering of rivers. The advancing, outer erosion faces of bends often cut through the accumulated mud banks to expose faces of consolidated marine clay. Such exposures occur within a number of sections of channel, one of the best examples being within the Lower South Deep.

Finally, there are the artificial, man-made substrates (and these can also be colonized by marine organisms). They are most widespread within the more developed Northern Sector of the Harbour. Infilled

areas are not considered here since they are essentially lost to the marine environment. However, the surfaces of fringing bunds, sea walls, wharfs, jetties, piers and breakwaters that are permanently submerged within the subtidal zone, or regularly so within the intertidal zone, can be colonized by a variety of species of **seaweeds** and **invertebrates**. Whether composed of wood, steel, concrete or even natural stone, these surfaces provide a much more extensive resource of hard substrates within the Harbour than occurs naturally. Such surfaces are most widespread within the intertidal zone. Within the subtidal zone, the wharfs throughout the Port and the boulder bund of the recently constructed Port Expansion Area constitute the most substantial resources of artificial hard substrates. The fibreglass and steel surfaces of pontoons and moored vessels also provide substrates, which can be colonized by marine species.

Artificial hard substrates are much rarer within the Southern Sector, but do occur locally, e.g. the 'Monks Causeway' within the Upper South Deep. This boulder and wood construction originally linked the mainland at Cleavel Point with Green Island, and is now well colonized by marine species. Another example is the recently constructed B.P. ferry slip on Furzey Island.

Most artificial structures within the Harbour have hard surfaces which can be colonized by 'fouling' species. Artificial equivalents to natural sediments are rare, the railway chippings or hard core occurring within the vicinity of the railway embankments in Holes and Lytchett Bays being exceptions.

The dive transect programme has shown that within the subtidal zone, natural and artificial substrates can occur together in complicated sequences which change, both along and across the channels (fig. 8, also Appendix III). This pattern of substrates is much more complicated within the subtidal zone than in the intertidal. It is also very important from the viewpoint of the biological communities of the Harbour bed because there is a strong link between the two, really an interdependence rather than a one way relationship. In several areas of the Harbour, the nature of the substrate is governed by the colonizing species as opposed to the more normal converse, e.g. extensive intertidal banks of mud have been accumulated and stabilized by **saltmarsh** beds, whereas in the subtidal zone, the same effect is produced by beds of the **peacock tubeworm** (see below).

The Harbour Bed -

Biological Communities

GENERAL FEATURES OF THE BIOLOGICAL COMMUNITIES

A group of living species which together inhabit a particular area of seabed are referred to as a **biological community**, and the area in question as its **habitat**. Most communities contain a broad diversity of species representing a very large size range, from **microbes**, through **small plants** and **invertebrate animals** (without backbones), to **large plants** and **vertebrate animals** (with backbones).

Within the marine environment, **microbes** such as **bacteria** occur naturally and perform vital decomposing roles. **Plants**, growing where there is sufficient light, harness sunlight energy by photosynthesis to produce plant tissues which in turn form the basis of the marine food chains, i.e. **plant-eating animals** are in turn fed upon by **carnivores**, and so on. Most marine **plant** species are **seaweeds**, ranging from the submicroscopic **plankton** floating within the water column, to larger more familiar forms, some of which exceed several metres in height. More advanced **plant** species are much less numerous but include some that are very important, e.g. **saltmarsh** and **seagrass plants**.

Many **invertebrate animals** are also submicroscopic, living as drifting **plankton**, or upon or within the seabed. Larger forms, visible to the naked eye, include non-moving species, free-standing on the seabed or attached to hard surfaces, e.g. **sponges**, **sea anemones**, **sea firs**, **barnacles**, **sea mats** and **sea squirts** (see Appendix II). Then there are the slow movers, e.g. **crabs**, **lobsters**, **sea slugs** and **molluscan shellfish**, **starfish** and **sea urchins**, and finally, the more agile **invertebrates**, e.g. **prawns**, **squids** and **octopus**. As for the **vertebrates**, most fish species are fast moving, e.g. including the soft-boned **rays** and **sharks** and the hard-boned **eels**, **flatfish** such as **flounder**, and **roundfish** such as **bass**. **Birds** found within the marine environment include **seagulls**, **waders** such as **Oyster Catchers** (which graze on intertidal **invertebrates** at low tide), and a few diving species such as **shags**. The largest marine animals are the **mammals**, ranging in size from **dolphins**, **porpoises** and **seals** to the enormous **whales**.

Many seabed areas contain hundreds of species. The areas containing the greatest numbers of all are the shallow seas around the continents, and particularly, inshore waters where there is sufficient light penetration for plant growth. Above average numbers of species often occur within areas swept by tidal currents but sheltered from wave action, e.g. close to headlands or within sounds. Estuaries contain

fewer numbers of species than on the open coast, but can also include a number which are not found elsewhere (see **HYDROGRAPHY**).

The numbers of species encountered intertidally, whether on the open coast or in estuaries, is usually very much less than the number occurring within associated subtidal areas.

It is not only the number of species which is important, but also their productivity, i.e. how well they grow and breed. Shallow inshore continental seas such as those around Britain are the most productive areas of the oceans. Many estuaries support particularly high levels of biological productivity - the nutrient-laden waters discharged from the rivers boosts plant productivity which is then passed to animals through the food chain.

Poole Harbour is an unusual example of an estuarine environment, in that it combines very high levels of biological production, i.e. typical for an estuary, with a total number of species which may be regarded as exceptionally large in estuarine terms (figs. 22, 23).

The Harbour is, no doubt, more productive than adjacent open coastal waters and includes some species not found on the open Dorset coast. However, others are present in far greater quantities (per unit area of seabed) than on the open coast. The biological productivity is increased by water borne nutrients and organic materials from both natural and human sources, introduced via the rivers, outfalls and land run-off. The Harbour supports a diversity of plant and animal life representing nearly all the groups listed above with the exception of marine mammals (although dolphins, the symbol of Poole, occasionally venture into the Harbour). As would be expected, the numbers of species found within subtidal areas, more than 250 of which were recorded during the current survey, are much greater than occur within the intertidal areas of the Harbour bed (figs. 22, 23, Appendix II). This large number includes elements typical for estuaries, i.e. marine species that are resistant to the changing salinities, but also species specially adapted and confined to the brackish conditions. However, in contrast to many typical estuaries, part of the outer section of the Harbour experiences atypically stable and nearly fully saline conditions. This allows the presence of numerous marine species which can tolerate slightly brackish conditions, such as would not occur within typical estuaries. The area in question extends from the Swash and Haven Channels and into the South Deep (figs. 22, 23)(see **HYDROGRAPHY**).

So, the numbers and kinds of species vary through the Harbour according to salinities, with the total declining in an upstream direction (figs. 22, 23). However, it is not only salinities which cause this declining trend. There is an upstream decline in water clarity related to the increase in suspended solids. Within the Harbour entrance where the water is clearest, seaweeds can grow at depths of in excess of 5 metres (fig. 7). By contrast, within upstream areas, algal growth is confined to the intertidal areas. This upstream phasing out of seaweeds contributes to the reduction in the numbers of species. Still greater variations in the composition and nature of inhabiting species are related to the changing nature of the seabed which, as outlined in the previous sub-section, can vary dramatically on a local basis, not only along-channel but also across-channel. In fact it is possible to classify the biological communities of the Harbour according to the non-living Harbour bed materials, i.e. the substrates (see previous section).

Since in contrast to many intertidal areas, most of the subtidal zone of the Harbour is composed of natural substrates, the associated species would also be expected to be natural. However, this is not the case. Most areas of the Harbour bed include, or can even be dominated by so called alien species, i.e. those introduced artificially (by man) from other areas of the world (see below) and to that extent, cannot be regarded as natural. Other areas are even less natural in that their species are more directly influenced by man's activities, e.g. by reclamation, navigational dredging, oyster dredging or pollution, and these changed communities are considered in separate sections below.

DETAILED DESCRIPTIONS OF BIOLOGICAL COMMUNITIES AND THEIR SUBSTRATES

Communities of natural and artificial consolidated materials

The few outcrops of hard bedrock that feature locally on the bed of the Haven are colonized by a diversity of current-preferring attached **invertebrates** and particularly by a species of sea mat known as the **hornwrack** (which is also very common in the fully saline waters of the open coast).

The natural exposures of Bagshot and marine clays tend to be nearly biologically barren, the crumbling material is only regularly colonized by a burrowing **bivalve mollusc** *Petricola pholadiformis*, an alien from North America. The same applies to natural exposures of peat and lignite. Recently dredged exposures of the above specified soft materials and also of Bagshot sandstones tend to be biologically barren. However, if sufficiently level, even dredged exposures can support a biological cover based on mobile species, **hermit crabs** in particular, together with non-mobile forms attached to stones or shells and transported by tidal currents, e.g. **seaweeds** such as the **Japanese seaweed** and **sea lettuce**, or attached **invertebrates**, particularly **sea squirts**.

Artificially constructed hard substrates, i.e. surfaces of stone, concrete, steel, fibreglass or wood, are colonized by the same kinds of species that colonize natural rock. The greatest numbers of species occur where tidal currents are moderate to strong. Of particular note is the brackish water **sponge - sea squirt** community of the Port area. The dominant species there, the **sponge** *Suberites massa*, is present in exceptional quantities. This is a warmer water species, known from the Mediterranean, but in Britain only known from three brackish water locations on the central southern coast of England, the Solent and Fleet and Poole, but the Poole population is by far the most substantial.

Crevice habitats provide important refuges for the carnivorous predators of rocky seabeds. Even the very local natural crevices formed beneath sandstone ledges within the Harbour Entrance were found to be inhabited by young **crabs** and by **lobsters**. The boulder bund of the Port Expansion Area, now four years old, forms a major crevice habitat known to be colonized by small numbers of **edible crabs**, but also large numbers of **common eels** (which are commercially trapped).

Communities of cobble, stone and gravel beds

Although the consolidated substrates occupy a significant proportion of the Harbour bed, the sediments are far more widespread, but not to

the extent that they are intertidally.

Natural beds of cobbles and gravels are only common within the part of the Harbour where the tidal scour is greatest (fig. 8). These constantly shifting, dynamic beds constitute a hostile environment, mainly colonized by abrasion and crush resistant **seaweeds** and **invertebrates** growing attached to the surfaces of the cobbles, and accompanied by mobile **invertebrates** inhabiting temporary crevices between the cobbles. Comparable biological communities occur more widely within the Harbour within beds of **mollusc** shells such **oysters** or **slipper limpets**. As well as resisting natural disturbances, these robust communities are well adapted to coping with human disturbances, e.g. caused by the passage of **oyster** dredges and other towed fishing gear.

Communities of coarse sand

The biological communities of sands vary considerably according to the grain size. Only a very small number of species are able to inhabit the dynamic, constantly changing waves and undulations which characterize beds of coarse sand (extensive within many downstream channels of the Harbour)(fig. 8). **Sand eels** are able to, since they can quickly reburrow as the sands change. **Hermit crabs** and occasional **seaweeds** and **invertebrates** attached to small stones or shells, are rolled or dragged by currents as they occupy the sand wave troughs. More mobile species such as **swimming crabs** and **flatfish** can also be common. This species-poor community is naturally robust, and would reform quickly following not only **oyster** dredging (such areas are not good **oyster** ground) and trawling (coarse sands are occasionally trawled), but even small-scale navigational dredging.

Communities of medium sands

Medium sands, which are more stable than coarse sands, are widespread within the downstream channels (fig. 8). These are often colonized by beds of a tube building **worm** known as the **sand mason** (**Lanice concheliga**). When occurring at density, these can stabilize and raise the level of sand by 10-20cm above normal, so forming hummocks, these being most extensive upon one flank of the Swash Channel (fig. 12). Elsewhere, the sands are virtually clear of surface dwellers and only contain a few burrowing species such as relatives of the **ragworm**. Yet elsewhere, level tracts of medium sand support **slipper limpet** beds. These **molluscs** grow attached to each other as free-standing stacks, each typically containing around 5 individuals, and being 10cm across. The stacks are free to roll with the tide and are mainly colonized by abrasion-resistant attached species. Although low in species numbers, these areas probably provide important feeding grounds for **flatfish** and other commercially harvested **fish** species. Medium sand beds are fairly resistant to minor physical disturbances, e.g. trawling, occasional **oyster** dredging.

Communities of fine sands - General

Beds of fine sand are most widespread within the midstream channels of the Harbour, and particularly the South Deep (fig. 8). Some of the most biologically productive communities found within the Harbour, containing the largest numbers of species occur within their proximity (figs. 13, 14). Moderate tidal flow is weak enough to allow the

establishment of a diversity of often delicate surface dwelling or rooted **invertebrates**, but is still strong enough to prevent these from being smothered by silting. The moderate currents promote the growth of many species by importing good supplies of food materials.

Organisms thriving under such conditions include the key species that provide the foundations for species-rich communities within the Harbour.

Peacock Worm Communities

The **peacock worm** (*Sabella pavonina*) is the most notable of these. It builds and inhabits flexible tubes up to one metre in height of which half is rooted within the sediment. Pioneer clumps of **worm** tubes form on fine sands, and as the tubes increase their density to form a forest, they form a natural sediment trap - muds can accumulate within forests of **peacock worms** to thicknesses in excess of a metre, therefore substantially raising the level of the Harbour bed. The most extensive **peacock worm** beds (with associated mud banks) were found to occur within the Upper and Lower South Deep, followed in a approximate declining order by the Lower Wych Channel and Blood Alley (fig. 9). Evidence suggests that fairly extensive beds may have once occurred within the Upper Main Channel. At the time of the survey, fragmented patches, perhaps remnants of former beds together with newly established pioneer clumps, were found to be widespread within this area which is subjected to navigational dredging. Another, more localized **Peacock Worm** bed, clearly disrupted by dredging, was located at the top of the Lower Main Channel (fig. 2).

The **peacock worm** beds provide a refuge for very large numbers of species of **seaweeds**, **invertebrate animals** and **fish**. A diversity of **seaweeds**, **sponges** and **sea squirts** colonize the outer surfaces of the **worm** tubes. Other species occur free-standing between the tubes, e.g. more **sponges**, and also **slipper limpets** and **brittle starfish**. Numerous small **invertebrates** colonize the larger species, or burrow into the mud bank beneath. These can be preyed upon by **crabs**, particularly the **shore crab**, and by small **fish**, particularly **gobies** and **pipefish**. It is possible to draw comparisons between the **peacock worm** communities as reservoirs of species richness, and the hedgerows or woodlands of terrestrial environments.

The species associated with the **peacock worm** beds change moving across the Harbour. The greatest numbers occur within the Lower South Deep where the salinity range is the highest and least variable (see **HYDROGRAPHY**), and the lowest numbers within the Upper Main Channel (figs. 22, 23). Although the **peacock worm** is common on most British Coasts, evidence suggests that the beds within Poole Harbour are exceptionally extensive and exceptionally rich in numbers of associated species.

The **peacock worm** beds are probably the most sensitive of all communities within the Harbour to physical disturbances. Beds can be affected, not only by navigational dredging, but also dredging for **oysters**, as well as the passage of other fishing gear. Once the **worms** are uprooted, the banks of sediment which they have harnessed will be remobilized by the tidal currents, producing a significant increase in channel depth and redistribution of the released muds. The role of the **peacock worm** in influencing the bathymetric regime of the Harbour is significant. Probably because of dredging within the Upper Main and perhaps also the Lower Wareham Channels, dense beds of **worms** have been

removed from the major navigational routes (since they significantly reduce water depth, their presence there is undesirable from the navigational viewpoint). However, their persistence within the smaller, non-navigational channels may serve, not only to shallow these, but also perhaps to rechannel additional tidal flow through the navigational channels, and by increasing the scour, may also increase their depth.

Slipper Limpet Communities

The two other major community forming species found on fine sands are both aliens (introduced species), i.e. the **slipper limpet** (*Crepidula fornicata*) and the **Japanese Seaweed** (*Sargassum*). The **slipper limpet**, accidentally introduced to British waters from North America a century ago, is now the most widespread and abundant subtidal species within the Harbour, the free standing clusters of shells accumulating as dense beds on fine sands, and sometimes also on the mud banks associated with the **peacock worm** beds. These **slipper limpet** beds are far denser than those occurring on medium sands (see above), and, in that the constituent clusters are not rolled about by the currents, they are stable enough to support fairly rich communities of associated species, **seaweeds**, **invertebrates** and small fish. However, these are by no means as rich as the communities formed in association with the **peacock worm** beds. The most extensive **slipper limpet** beds of this kind were found to occur within the Upper Main Channel, but other more local ones occur within all channels of the Harbour (figs. 10, 15).

The arrival of the **slipper limpet** has undoubtedly considerably changed the ecology of the Harbour. Since it prefers conditions very similar to those of the native **oyster** but is a superior space competitor, many of the natural **oyster** beds which previously characterized much of the Harbour floor have been overrun. However, the presence of the **slipper limpets** also increases the total species richness within the Harbour, i.e. not only in terms of the species associated with the living **limpet** beds, but also because of the release of dead **limpet** shells which constitute a major resource of hard surfaces providing attachment for a multitude of **seaweeds** and non-mobile **invertebrates** through most of the Harbour.

Slipper limpet clusters are quite robust in the context of mechanical disturbances. Rolling and abrasion caused by **oyster** dredging or other fishing methods will not harm the **limpets** themselves, but may affect their associates, but to nowhere near the degree that **peacock worm** beds can be affected. Even areas dredged for navigation can be recolonized fairly quickly, by **limpet** clusters rolled by tidal currents from adjacent areas.

Japanese Seaweed Communities

The **Japanese seaweed** (*Sargassum muticum*) is a more recently introduced alien within the Harbour. This was first recorded at the entrance in 1978, 6 years after its arrival on the Isle of Wight. The presence of this prolifically growing and reproducing **seaweed** was quickly noticed because of its tendency to form copses within channel areas not previously noted for **seaweeds**, including shallow navigational channels where the fronds, up to 3m or more in length, can accumulate to densities sufficient to cause nuisance to small vessels.

Its rapid spread and ability to form copses in unusual places is the

consequence of its preference for colonizing small shells or stones. As the growing plants, which bear rows of small floats, increase their size, they can be transported by tidal currents by a combination of buoyancy and drag, often trailing their anchors along the seabed. This process of transport is probably how the first pioneer plants arrived within the Harbour, to be stranded on the banks of the Haven. It also accounts for the occurrence of dense copses flanking parts of the Haven, Lower South Deep and Middle Channels, and occurring more generally across the bed of the much shallower Blood Alley Channel.

Although the **Japanese seaweed** has very appreciably increased in abundance within the Harbour since 1978, the dense copses are confined to the downstream channels (figs. 11, 17). Only isolated plants are swept to many parts of the middle and upstream channels by tidal transport. However, these do not and cannot become established there. 1) The turbid water precludes sufficient illumination for plant growth (fig. 7). 2) the **Japanese seaweed** cannot tolerate the lower salinities found within the inner recesses of Poole Harbour (see **HYDROGRAPHY**)(fig. 6). Very dense copses of **Japanese seaweed** were found to have a local effect on the Harbour bed by serving as sediment traps and so accumulating small banks of sediment within their vicinities. However, since the plants shed their fronds every autumn, the mud accumulations are remobilized over winter, but may reform as plants regenerate their fronds during the following year. The scale of sediment accumulation is very much less than for **peacock worm** beds and is not considered to be sufficient to have an effect in the navigational context.

The spread of **Japanese seaweed** along the south coast of England has been dramatic, as have been the changes brought to the areas colonized. In seven years the **Japanese seaweed** has proliferated within Poole Harbour from total absence to its present status as one of the major dominant subtidal species. However, what is certain is that it is here to stay. Eradication is not feasible. Harvesting can only be used to clear local areas of seabed where, e.g. the weed is interfering with small boat movements, and this process must be repeated each summer. The weeds can be lifted by hand or by the use of **oyster** dredges. If possible, the anchoring stone or shell should also be lifted since the encrusting holdfast of the weed can survive and regenerate if only the fronds are gathered.

Communities of soft muds

Moving further upstream within the channels, fine sands give way to more open mud beds. The occasional scatterings of stones and shells which can occur within such areas are colonized by silt-resistant non-mobile **invertebrate animals**, e.g. certain **sponges**, **sea squirts** and by the **edible mussel**. Such communities are most common within the Mid and Upper Wareham, Upper South Deep and Lower Holes Bay Channels (fig. 21). The number of species involved is very much less than with the **peacock worm** or **slipper limpet** beds of more downstream areas.

Elsewhere, the soft mud is mainly free of attached, surface dwellers, but can support **shore crabs**, **flounder** and **mullet** and the juveniles of a diversity of other **fish** species (both commercial and non-commercial). These feed on the small **invertebrates** burrowing beneath the surface of the mud, but during high tide periods many move onto the intertidal mudflats where greater quantities of food are to be found. So these more open mud beds are particularly important as nursery grounds for commercial **fish** species which may, as adults, move

offshore. Such areas occur within the Upper Wych, Upper Wareham, and perhaps the Upper Holes Bay Channels. One interesting feature of mud beds within the midstream areas of the Harbour are the burrows of eels (Anguilla anguilla) which occur in local patches, the most extensive of these having been located within the Lower South Deep.

The Influences of Man

NAVIGATION

A fundamental aspect of man's relationship with the Harbour has concerned its use as a Port by boats of many kinds. Wareham and Holes Bay were used by vessels during Roman times, and during the last three centuries, the Port of Poole has developed. Initially, vessels anchored within the entrance to Holes Bay which is naturally scoured to navigable depths by tidal currents. This is now flanked by the Town and New Quays providing berths for coasters using the modern Port. Most recently, two major berths for a continental ferry service have been established on reclaimed land extending into the main Harbour basin from the original Hamworthy foreshore (fig. 24). Although near land-locking provides a naturally safe berthage for small vessels, the Harbour is not naturally deep enough to allow the small commercial coasters and ferries which use the Port to pass from the Harbour entrance to their berths. Naturally shallow sections of the access channels have to be dredged regularly to maintain navigable depths (fig. 25).

The Harbour is also used by a variety of 'medium' sized vessels (see **QUICK REFERENCE GUIDE**) including those of the authorities, the Harbour Commissioners, Police, Fisheries Committee, Water Authority, Royal Marines and Lifeboats (the R.N.L.I. boatyard is in Poole), together with the fishing fleet, tourist sight seeing vessels and large yachts and cruisers, and most recently, the B.P. ferries operating between Poole and Furzey Island. Finally, there are very large numbers of 'small' vessels (see **QUICK REFERENCE GUIDE**), fishing boats, leisure cruisers and yachts, dinghies, speed boats, and smallest of all, the wind surfers. Many of the thousands of vessels which use the Harbour each year are maintained at permanent berths or moorings. The authority vessels have berths within the Port or the Royal Marines Base, and the fishing vessels moor within the Fishermens Dock. B.P. operates its ferries from a slip constructed within the Hamworthy section of the Port. Many of the leisure vessels have berths within one of the several marinas located around the Harbour, whereas others are maintained on permanent moorings. Virtually all berths and moorings are located within the Northern Sector of the Harbour (with the exception of the mouth of the River Frome) (fig. 24).

All of the navigable channels within the Harbour have been marked out by the Poole Harbour Commissioners, the deeper ones by buoys, and the others by stakes.

The movement and berthing of vessels within the Harbour can exert various effects on the natural environment, some aspects of which are covered below, and others separately within the sections on **RECLAMATION** and **POLLUTION**.

The navigational dredging undertaken within the Harbour can be subdivided into **structural** and **maintenance** work. The first concerns the excavation and deepening of channels to depths well in excess of natural values, whereas the second is to counteract shallowing caused by natural sedimentation.

Until last year (1975) the Main Channel was the one used by large commercial vessels, this having been structurally widened and deepened on several occasions (fig. 25). Early last year, the Diver Channel was deepened and widened in a major structural operation providing a more direct approach to the Port (fig. 25), and in particular, to the recently constructed berths of the ferry terminal at Hamworthy. The area of channel adjacent to the terminal has also been structurally dredged during the past 15 years, in places to depths in excess of 10 metres.

These operations have ensured a navigable depth of at least 5 metres between the Harbour entrance and the Port. However, the factor which most limits the size of vessels using Poole is not to be found within the Harbour, but within its approaches. An area of shallows known as Poole Bar lies off Studland Point and peaks at less than 5m from the water surface. The construction of a Training Bank from Studland Point has served to artificially deepen some of the Bar, but not the outermost section. Since the Bar is a dynamic structure composed mainly of coarse and mobile sands, navigational dredging may cause little improvement because the bank would quickly recover.

Strong tidal currents within the Harbour entrance generally scour-out the Haven Channel to depths well in excess of navigational requirements. The exception is 'Chapman's Peak', a high energy structure of gravel and stones thrown up by the strong tides, which naturally peaks within 3m of the surface, and so is subjected to periodic maintenance dredging (from which it soon 'recovers').

Both structural and maintenance dredging have an effect on the seabed biological communities of a kind which can be likened to underwater quarrying. The large bucket, grab or suction dredgers that are used can remove thousands of cubic metres of seabed material within single programmes. Since the living community represents a thin veneer upon the seabed, it is essentially eradicated by the dredging process (although the degree varies from dredging method to method). If the bed is allowed to 'recover', redeposited sediments may be colonized in time, but this is cancelled out if maintenance dredging is subsequently undertaken ('recovery' is clearly undesirable from the navigational viewpoint). The subtidal survey covered a number of stations where navigational dredging has taken place, and these confirm the above conclusions, with recently cut craters and trenches bearing little marine life (the Main and Lower Wareham Channels being most affected at the time of the survey in 1985)(see fig. 25 and Appendix III). However, what is less obvious are any potential 'at range' effects. The Harbour bed substrates and biological communities are distributed along an upstream hydrographic gradient of change which is represented within all of the Harbour channels such that each section of channel is interdependent on all the others. Should the hydrographic regime within a particular dredged section of channel be substantially altered to a

sufficient extent, this may result in hydrographic changes further afield (upstream or downstream) which might produce up- or downstream shifts in the distribution of particular substrates or biological communities. Shifts are more likely than are total losses.

The passage of vessels through the channels can have a significant effect on the seabed communities within sections of channel where the clearance is small. This may have happened within the shallower sections of the Main Channel which is negotiated by coasters and ferries. Because of the limited clearance there, large vessels are known to throw up a bow surge which may disturb the seabed without making direct contact, and additional disturbances may be produced by water turbulence induced by the screws of the vessel. More direct and obvious disturbances would be produced by propeller and keel gouging. However, since this can cause more damage to the vessel than the seabed, it is generally avoided, and clear evidence of gouging was only observed on a very local scale.

RECLAMATION

Reclamation has been undertaken within the Harbour fundamentally for the development of berthage of various kinds, but also for the improvement of road and rail communications and for urban, commercial and industrial constructions.

Reclamation can be categorized into **impoundment** and **infilling**. Impoundment entails the construction of barriers, in effect annexing the system in question, e.g. embankments, breakwaters and jetties, or may be the precursor to infilling to create dry land. Both categories are widespread within the developed, Northern Sector of the Harbour, but are rare in the south. Approaching 10% of the total intertidal and subtidal area of the Harbour has been affected to date (fig. 25). Although substantial areas have been reclaimed recently, changes on a comparable scale also occurred during the last century during the construction of the railways.

Reclamation started around the town of Poole, originally located on a near isolated peninsula. The town expanded to the north-east and west, into what are now Holes and Parkstone Bays. Wharfage has been progressively extended into the mouth of Holes Bay from both the Poole and Hamworthy shores, contributing to the isolation of this from the main basin of the Harbour. Railway embankments have isolated the deeper recesses of Parkstone Bay from the main basin (now Poole Park Boating Lake), and have near isolated the northern half of Holes Bay, and of Lytchett Bay in general, leaving only small link-channels for communication. Further areas of Parkstone Bay and Holes Bay and a large area off the Hamworthy foreshore have been lost since. Further small areas of the Hamworthy shore, Holes Bay, and the shore at Parkstone have been annexed for development as marinas.

The effects of these programmes on the environment can be subdivided into direct and indirect, the former concerning the actual developed area, the latter, range effects on other areas.

The direct effects of impoundment are usually to change the nature of the seabed and the biological communities within the impounded area, the degree of change reflecting the degree of isolation. It is possible to describe this process as 'lagoonization', the creation of artificial lagoons, and this has happened to various degrees within several areas

of the Harbour. Increased shelter against wave action, together with reduced tidal currents has lead to the accumulation of finer, more organic sediments within the enclosed basins, accompanied by the appropriate shift towards mud dwelling marine organisms.

Both natural and artificial lagoons can support specialized and distinct biological communities containing some rare lagoonal species, and when this occurs, 'lagoonization' can be regarded favourably. However, in being virtually 'marine lakes' lagoons have very poor flushing characteristics and are consequently very susceptible to pollution (see POLLUTION). Materials discharged into lagoons tend to be retained, such that those lying within developed areas often lose their specialized natural assets. The entrances to artificial lagoons are often exempt from the aforementioned risks - the constricting effect of the narrow entrance leads to the generation of strong tides, in turn producing a coarsened, well flushed bed which is colonized by current-preferring species.

The direct effects of infilling are the loss of the reclaimed area to the marine environment, and its replacement with dry land. Most infilling within Poole Harbour has been confined to intertidal areas. The only significant incursion into the subtidal zone has occurred within the Port area in terms of the subtidal extensions of berths, seawalls and bunds, i.e. in the entrance to Holes Bay and fringing the Port Expansion Area off the Hamworthy foreshore. (see sub-section on **Communities of consolidated substrates**).

FISHERIES

Requirements for the vital resources of clean food, water and air are common to man and the remainder of the living world, and lead to the close affinities and shared interests between the conservation of human health and that of the natural environment.

Methods of exploiting marine species for food are very basic in comparison with modern agricultural methods on land in that they mainly depend on the harvesting of natural stocks, e.g. around the British Isles **crustaceans** such as **crabs, lobsters** and **crayfish**; **molluscs** including **oysters, scallops, whelks** and **winkles**; and **fish** including **eels, plaice, bass**, etc...

Mariculture, the marine equivalent of intensive agriculture on land, is a minority activity but is undertaken with **oysters, mussels, turbot** and **salmon**. Mariculture entails the manipulation of the species or its habitat to improve production levels. Even so, the levels of sophistication are far removed from those of intensive land agriculture.

Natural stocks of **oysters**, once very abundant, have long been harvested within the Harbour (at least since Roman times), the same probably being the case for some **fish** species such as **eels, bass** and **mullet**. These and a number of other species are currently caught by a large number of full and part time professionals, and by non-professional fishermen, the total value of the catch being considerable.

Commercially exploited species are of interest in the context of this Baseline Assessment because 1) in themselves they constitute a considerable component of the natural environment, in their own right

and by virtue of their interdependence with non-commercial species, and 2) some methods for harvesting and mariculture can have a significant effect on environment.

With respect to the impact of fishing operations, these vary according to the methods employed, with respect to the following criteria:

1) **Catch efficiency.** The more efficient the method is, the more likely it is to deplete the stocks to commercially inviable levels (if catches are not carefully regulated).

2) **Incidental catches.** These can include a) the juveniles and breeding females of the target species, the capture of which can unfavourably affect stock levels of that species, and b) non-target species, the capture of which can have wider effects on the environment in question.

3) **Seabed disturbances.** Methods which disturb, change or destroy the seabed can adversely affect the habitats, not only of the target species and their dependents, but also of others inhabiting the same grounds.

Rod and line fishing is used by many non-professional operators within the Harbour, and is used by professionals for catching bass (particularly from boats within the Haven Channel). Adverse impacts of this method according to the above criteria may be minimal.

Seine netting is used to catch bass and mullet. When used within the confines of small channels (as is often the case), this may be sufficiently effective to adversely affect stock levels. However incidental catches may be small and the effects on the seabed, negligible.

Traps are used commercially within the Harbour for the taking of eels. The effects of this method on stocks and the seabed may be minimal, however the incidental catch may be more significant.

Trawling for flatfish is undertaken within certain channels of the Harbour, generally within the more downstream channels that are floored by medium and coarse sands. Since this is only occasional, adverse effects may be small. Intensive trawling within narrow channels could be harmful by depleting stocks, taking substantial incidental catches, but may not significantly affect the seabed.

Shellfish dredging is regularly undertaken within various areas of the Harbour, i.e. particularly on the public and leased oyster grounds (fig. 29). Although natural stocks of oysters were once very considerable and provided the basis for a very large industry, these crashed in the early part of this century and at present the levels are much smaller than was previously the case. Reasons for the decline are thought to have included disease and overfishing. The arrival of the slipper limpet to British waters, accidentally introduced with consignments of live oysters from North America, has also had a major effect in many British estuaries including Poole. The preferred conditions of this superior competitor overlap with those of the oyster, and very extensive slipper limpet beds now correspond with areas where oysters were probably once naturally common, relegating the latter to a subsidiary status. Another factor which has the increasing potential to affect the prospect of recovery of natural oyster and other shellfish stocks is pollution.

Since the favourable conditions for the growth of oysters still persist within the Harbour, as natural stocks have declined, they have been replaced by farmed stocks. Juvenile oysters imported from other U.K. locations are laid on grounds cleared of Slipper Limpets and other natural species, so giving the oysters the competitive advantage. The laid oysters are harvested once the required commercial size has been attained.

Of all the major fishing methods used within the Harbour, shellfish dredging has the potential to cause the greatest impact on the seabed and its biological communities. Stock depletion of oysters and other shellfish can be caused by intensive dredging of particular areas of seabed. Dredging invariably retains a substantial incidental catch (except for fish and other agile species), and can significantly affect the structure of the seabed substrates and natural biological communities by a ploughing effect comparable to the ploughing of fields on land. The most vulnerable communities in this context within Poole Harbour are the peacock worm communities. The current survey has demonstrated that significant changes to the seabed have occurred on farmed oyster beds within some leased areas of the Harbour. However, such areas tend to be confined for practical reasons to very local patches of seabed (effectively small submarine fields). Areas adjacent to those that are farmed, even within the same leased ground, remain intact and little affected.

Some of the most obvious potential (and in cases actual) effects of different fishing methods are described above. However, the importance of any adverse effects can only be considered realistically in the context of natural processes within the Harbour, e.g. whether the loss by fishing of a few hundred fish within a particular area of the Harbour per week is significant when compared with losses of the species from natural processes, e.g. aging, disease, predation, etc... Whereas in some cases, this has been the case (e.g. when species have decreased because of overfishing), in other cases the loss may be relatively insignificant.

ALIEN SPECIES

The global travelling behaviour of man has, to an extent broken down geographical barriers which previously separated and localized different species to different areas of the earth. Our countryside has been transformed by the purposeful or accidental introduction of exotic species of plants and animals from other areas of the world, and the same thing is happening within the marine environment. Many alien marine species have been introduced to British waters on the hulls of ships. Others have been purposefully introduced as experiments, e.g. the transfer of oysters and other shellfish between countries. However, as on land, these purposeful introductions have often backfired, not only have the introduced species become established in undesirable ways, but unwelcome associates, including diseases, have been introduced at the same time. One of the most spectacular accidental introductions within the marine environment has been the slipper limpet, introduced from North America within consignments of oysters, and now abundant within estuaries throughout southern Britain including Poole Harbour.

In fact, a whole host of alien species occur in Poole Harbour, some of which dominate the ecology to an exceptional degree. In addition to the slipper limpet (North America) and the Japanese seaweed, other

accidental introductions that are very common include an acorn barnacle (Elminius modestus, New Zealand), the Korean sea squirt (Styela clava), and a bivalve mollusc (Petricola pholadiformis). Species introduced by the shellfishing industry include the Portuguese oyster (Crassostrea gigas) and the North American clam (Venus mercenaria) which has not taken the hold in Poole that it has in the Solent area. Although accidental introductions cannot be prevented, voluntary ones by the fishing industry are now being more tightly regulated. Caution is clearly preferable since the control of unwanted species within the marine environment after arrival is even more difficult than it is on land, in fact near impossible.

POLLUTION

Pollution concerns the artificial introduction of agents into the environment with the potential to produce unfavourable effects. It is of fundamental interest to man because of the consequences for human health and quality of life, rather than in the context of the natural environment. However, human welfare is largely dependent on the underlying health of the living, natural environment.

The occurrence of pollutants is symptomatic of an advanced human society and few would deny, and still far fewer would sacrifice the enormous benefits to man of activities and processes for which pollutants are by-products. However, the introduction of polluting agents into the environment can cause substantial problems. Whether intentional or accidental, this can be by means of catastrophic pollution, i.e. the usually accidental release of very substantial quantities of an agent into the environment, or can be chronic, i.e. either the accidental or intentional release of small quantities, regularly or on a piecemeal basis. The cumulative effects of chronic releases can be as, or even more significant than the effects of catastrophic pollution.

The range of pollutants arising from domestic, commercial, industrial, agricultural and other sources is vast. Pollutants can be released in isolation, or, as is usually the case, in a multitude of combinations. Biologically produced organic substances dominate the sewage from animals and plants, and can also occur within wastes from farming, fishing, or from the food industry. Living microbes, viruses and bacteria, and parasites can be released with human or animal sewage. Chemical pollutants include detergents and the multiplicity of other man made substances used in the domestic environment, together with agricultural fertilisers and pesticides, and the very many substances produced or handled by industry. Hydrocarbon pollutants include crude oil and refined fuels and lubricants. The former is of particular current interest in view of the present expansion of the Poole Harbour Oilfield. Solid wastes can range from small particulate materials suspended in fluid effluents through to refuse and wreckage.

Examining the effects of pollutants on human health, and also the health of plants and animals occupies a great deal of scientific effort in Britain and elsewhere. Many pollutants are known to be harmful, and much debate centres on the level to which a particular factor or agent may assert itself before becoming unsafe. In this context it is important to know that the methods for measuring the levels of many chemical pollutants in plants and animals are very refined and highly sensitive. These can measure concentrations of some polluting substances, which may well be above normal natural levels and therefore

do constitute pollution, but are not necessarily sufficient to adversely affect either natural plants or animals or human health. However, this is by no means always the case. An exception to this principle may be the organotins, highly toxic substances which may have an effect, at least on the health of natural species, when present at very low concentrations. This report considers pollution in the context of the natural environment only, and not in the context of human health.

Investigations evaluating the effects of pollutants have usually considered the effects of individual substances in isolation. A small number have studied the effects of pollutants in combination, in several cases coming to the disconcerting conclusion that agents operating in combination can behave quite differently to isolated agents, in some cases less unfavourably but in others, much more unfavourably.

In terms of marine systems, Poole Harbour can be regarded as being particularly at high risk from pollution by virtue of its near isolation and very poor tidal flushing characteristics. Polluting agents released into the Harbour could potentially be contained and circulated, rather than being more widely dispersed beyond the Harbour. This containment could lead to elevated concentrations of pollutants which could either be taken up by plants and animals, or incorporated into the sediment column. Therefore, the amounts of pollutants necessary to have an unfavourable effect in Poole Harbour would be less than the amounts necessary to have a comparable effect within systems with better flushing. This problem has been exacerbated within the areas of the Harbour which have been affected by impoundment programmes which, by a process of annexation, produce what are in effect artificial lagoons with poor flushing characteristics. Holes Bay, and in particular the inner basin (into which treated sewage effluent is discharged) may provide a case example of 'lagoonization' (see **RECLAMATION**). Falconer (1981) used a mathematical model to examine tidal circulation within Holes Bay, and came to the conclusion that the flushing characteristics were exceptionally poor. On a smaller scale, other examples of 'lagoonization' within the Harbour may include constructed marina basins.

A wide variety of agents find their way into the Harbour environment via one of several lines of entry, 1. via the Frome, Piddle and other rivers, 2. direct input (via outfalls, run off, etc...), 3. from the more open sea via the entrance, and 4. from the atmosphere. The monitoring of levels of pollution is beyond the scope of this particular survey. However, monitoring is undertaken by the Wessex Water Authority, Ministry of Agriculture, Fisheries and Food, the Marine Biological Association of the United Kingdom, and others. Data from such sources have shown that certain pollutants occur at above normal levels within the Harbour. Evidence suggests that Holes Bay (see above) may be particularly affected by pollution. It has been suggested that levels of organic pollution are above normal, along with microbes such as bacteria, trace metals including organotins, and fuel hydrocarbons. Marina basins may be at risk from pollution by domestic type wastes, fuels and lubricants, and any factors leaching from antifouling paints applied to moored vessels.

As for the effects of pollution on the natural communities within the Harbour, in the context of this Baseline Assessment all that can be stated at this stage is that living marine species were found to occur within all areas of the Harbour, including sections of Holes Bay regarded as being polluted, and that the distributions of the major

species are consistent with general expectations according to the natural characteristics of the Harbour. However, these facts alone by no means confirm that pollution is not having an effect on the Harbour environment, only that if there are any effects, they are subtle rather than gross, e.g. they may affect the health, growth and reproduction of particular species, or the distribution of subsidiary species. The identification of such effects would require the more detailed investigation of species of particular interest.

In conclusion it is possible to regard the natural characteristics of poor flushing and related risks of pollution which characterize Poole Harbour as a scaled down version of those of other landlocked seas, e.g. the Baltic and Mediterranean. A still more specific parallel may be drawn between the problems of the Venice Lagoon as a sub-system within the Mediterranean, and Holes Bay as a sub-system within Poole Harbour (not in terms of the degree of pollution, but the basic problem of poor flushing).

Discussion and Conclusions

These subtidal surveys have been undertaken to provide independent, factual information on Poole Harbour as a natural environment and to describe any changes which have taken place under the influence of man. The report can only be considered as an opening baseline statement rather than a definitive conclusion because this is only the first overall assessment of the subtidal environment to have taken place. It has been undertaken at a time (1984-85) when man's relationship and influences on the Harbour are changing. This prospect is accommodated for within the survey design which allows for future monitoring by resurveying those particular species or areas of interest, and to identify changes by drawing comparisons with the initial baseline.

This all embracing appraisal, out of necessity in view of the objective to be impartial and well balanced, considers many aspects of the Harbour environment in what may appear to be superficial terms. More detailed appraisals of particular species, groups of species, or areas of the Harbour could be undertaken by further processing particular aspects of the data as required.

The survey results give an impression of the complexity of Poole Harbour as a natural system, in excess of 250 species inhabiting more than 30km of subtidal channel, and affected by a multiplicity of natural and human influences. The survey has also highlighted the interdependences between all parts of the natural system. It is not possible to consider single species or areas within the Harbour independently of the others, e.g. 1) the fortunes of any particular economic species are invariably totally dependent on other, often obscure non-economic ones, 2) structural developments within one section of a channel may affect the natural characteristics within another area of the Harbour, and 3) the combined effects of mixed polluting agents can be quite different to the effects of individual agents acting in isolation.

Close interdependences are also evident, not only between man and the environment, but also between the various human activities within the environment, e.g. 1) the need to manage pollution has direct bearing on the food, tourism, and on those industries using seawater, as well as on the natural biological communities. 2) Several key species have been shown to be capable of changing the seabed considerably including water depths, this being of particular interest within the context of the Port since in places navigational depths are

critically fine. 3) From the converse viewpoint, both navigational and shellfish dredging can have significant effects on the seabed species within the areas affected.

The desirability of conserving particular species or areas within the Harbour can be considered from various viewpoints. It is possible to refer to the total conservation of a natural area, or of particular species or groups of species, perhaps because they are rare, appealing, or of commercial value (as food stocks, as resources of natural pharmacological agents, etc...). Channels can be conserved for navigation or recreation, or for their scenic attributes, water quality, or fisheries potential. Whereas some of these justifications are entirely compatible, others may not be, e.g. although certain groups of animals such as anemones, corals, molluscs, birds or mammals are conserved because they are attractive or collectable, these are not necessarily the most biologically important species in the context of the environment as a whole. Often plain, 'unappealing' species, ranging from bacteria, through crabs, to eels, can be very significant in regulating the environment, as key species whose fortunes influence many others. Such species are often overlooked, and therefore neglected by default.

The successful survival of man is largely dependent on the ability to control the natural environment. Poole Harbour is an area which supports activities central to the welfare of many, and in this context, it is already a substantially changed environment. Rather than safeguarding a natural wilderness, Environmental Management in the case of the subtidal areas of the Harbour can only be a difficult compromise.

Comparable changes have taken place within the majority of tidal basins within southern Britain, and can be compared with the changes brought about by agriculture and urbanization on land. However, the degree of change is not uniform across the Harbour. The majority of human activities and related changes are concentrated within the northern half of the Harbour, e.g. reclamation, navigational dredging, vessel movements, oyster farming, and pollution. The southern half has been regarded as being at least semi-natural in that the aforementioned activities have taken place there to a far lesser degree. However, some areas there are designated as leased oyster grounds which, if used to their full potential could have a significant effect on the Harbour bed. The recent commencement of the development of oil production well heads on Furzey Island represents another potential influence.

From the viewpoint of pollution, it is difficult to subdivide the Harbour. Water born pollutants released within one section may become widely circulated by tidal currents within the Harbour because the channels are interlinked into a network, and also because the Harbour is contained as a land-locked unit. So polluting agents released into the developed northern half may be circulated into the undeveloped southern half, or vice versa.

Another reason for regarding the biological communities within the Harbour as being generally only semi-natural is the very widespread presence of alien species, intentionally or unintentionally introduced by man from other areas of the world. Several of the most common species of all are aliens, e.g. the slipper limpet and Japanese seaweed, both of which provide the foundations for biological communities in their own right. Other aliens feature within most parts of the Harbour as subsidiary species.

It does not follow that every development or activity which has taken place or is underway within the Harbour has produced or is producing significant adverse effects. The adverse effects produced by 'low profile' activities can be greater than those of 'high profile' very visual activities. Adverse effects which are most significant in the context of Environmental Management are those that are long term or permanent. Reclamation has the potential to cause adverse effects because, in the case of impoundment, the enclosed area is affected on a long term basis, and in the case of infilling, the affected area is permanently lost. Although the effects of individual reclamation programmes may not have been particularly significant on a Harbour-wide scale, the cumulative, combined effects of all of the reclamation programmes which have been undertaken within the Harbour over the past centuries is more significant. Navigational dredging has a far smaller long term impact than reclamation since recovery commences as soon as dredging ceases. The effects of dredging for **shellfish** are still smaller. Whether pollution is 'catastrophic' (large quantities of an agent released over a short period) or 'chronic' (small amounts released over a long period) the long term effects can be significant if the agent involved is toxic and non-degradable and if it is released in sufficient quantities. As such, it may feature within **plants, animals,** and sediments for a long period of time.

In the case of less significant, shorter term adverse effects, the powers of recovery of the natural environment determine how quickly some form of normality is restored. The powers of recovery of estuarine communities can be very considerable. Many estuarine systems, including Poole Harbour, are naturally very dynamic and vigorous. This is paralleled by a natural robustness in the constituent species, which is advantageous from the viewpoint of withstanding human influences.

In terms of the natural importance of individual species, a number found within Poole Harbour fall into the category of being estuarine specialists that are not generally common, i.e. they do not occur on the open coast, and some species only occur within a small number of British estuaries. However, whereas many of these are most abundant within the more natural areas of the Harbour, others are particularly common within developed areas, i.e. species colonizing the hard surfaces of jetties, bunds and other constructions. Other species inhabiting Poole Harbour are more generally common, also widely occurring in other estuaries and on the open coast, but are significant within Poole Harbour by being present in exceptional quantities. Yet other species are generally abundant, both in estuaries and on the open coast, and are therefore of no importance in terms of rarity, but as key species may substantially contribute to the general health and biological productivity of the Harbour (see above).

The general importance of estuaries in terms of their biological productivity and as a refuge for many species, including rare ones and as a nursery for commercially utilized species, has been highlighted throughout this report. Poole Harbour has all of these attributes, combined with an exceptionally high content of species (for an estuarine environment), the product of its unusual hydrographic characteristics. This hydrographic regime (including salinities) differs considerably from those of other major coastal basins within the same region, i.e. the Fleet, Portland, Weymouth, Christchurch, Southampton water, Portsmouth, and Chichester Harbours, and therefore, the biological communities must also differ.

Poole Harbour can be regarded as a case example of the kind of marine system where Environmental Management would be an advantage, not

to safeguard a natural, subtidal wilderness (Poole Harbour is far removed from that condition) but to strike a compromise between the needs of man and his environment. The results of the survey show that whereas some human activities are having an effect within some areas of the Harbour, other activities may be having little effect, and yet other areas of the subtidal system can be regarded as nearly natural. The results highlight those biological communities which, in terms of numbers of species and productivity, may be of significance in terms of the natural health of the Harbour. The many areas where these are still intact have been indicated. One way of ensuring the survival of these natural communities within what is in effect a working environment would be to establish 'reserve zones' within appropriate sections of the subtidal channel system which would serve as reservoirs of natural species.

Section 4

SCIENTIFIC ASSESSMENT

Index

<u>INTRODUCTION</u>	4 - 1
<u>SURVEY DETAILS</u>	4 - 2
<u>HOLES BAY SURVEY</u>	4 - 2
<u>SOUTHERN AND NORTHERN SECTOR SURVEYS</u>	4 - 2
DIVE TRANSECT PROCEDURE.....	4 - 3
DREDGE AND GRAB SAMPLING PROCEDURES.....	4 - 4
<u>HYDROGRAPHY</u>	4 - 4
<u>TIDAL CYCLE</u>	4 - 4
<u>TIDAL CURRENTS</u>	4 - 5
<u>WAVE EXPOSURE</u>	4 - 5
<u>TURBIDITY</u>	4 - 5
<u>SALINITY</u>	4 - 6
<u>TEMPERATURE</u>	4 - 7

CONTINUED OVERLEAF...

INDEX - CONTINUED....

<u>THE HARBOUR BED - SUBSTRATES (general).....</u>	4 - 8
<u>THE HARBOUR BED - BIOLOGICAL COMMUNITIES (general)..</u>	4 - 12
<u>BIOLOGICAL COMMUNITIES, AND SUBSTRATES:</u>	
<u>DETAILED DESCRIPTIONS.....</u>	4 - 17
<u>COMMUNITIES OF HARD CONSOLIDATED SUBSTRATES.....</u>	4 - 17
<u>Natural bedrock.....</u>	4 - 17
<u>COMMUNITIES OF SOFT CONSOLIDATED SUBSTRATES.....</u>	4 - 18
<u>Clays, Bagshot and marine.....</u>	4 - 18
<u>Peat.....</u>	4 - 18
<u>Lignite.....</u>	4 - 19
<u>Cobble, stone and gravel substrates.....</u>	4 - 19
<u>Coarse sand.....</u>	4 - 19
<u>Medium sands - Lanice beds.....</u>	4 - 20
<u>Fine sands and muds - General.....</u>	4 - 21
<u>Sabella pavonina (Peacock Worm) communities.....</u>	4 - 21
<u>Crepidula fornicata (Slipper limpet) communities...</u>	4 - 23
<u>Sargassum muticum (Japanese Seaweed) communities....</u>	4 - 25
<u>Epibenthos of muds within very turbid areas.....</u>	4 - 27
<u>Inbenthos of muds within very turbid areas.....</u>	4 - 29

CONTINUED OVERLEAF...

INDEX - CONTINUED...

<u>THE INFLUENCES OF MAN</u>	4 - 30
<u>NAVIGATION</u>	4 - 30
NAVIGATIONAL FACILITIES.....	4 - 30
<u>The Port of Poole</u>	4 - 30
<u>Berthage for other 'working' vessels</u>	4 - 31
<u>Berthage for leisure vessels</u>	4 - 31
NAVIGATIONAL DREDGING.....	4 - 32
<u>Poole Bar, the Swash and Haven Channels</u>	4 - 32
<u>Main and Middle Channels</u>	4 - 32
<u>The Port Area: Lower Wareham Channel</u>	4 - 33
<u>The Port Area: Lower Holes Bay Channel</u>	4 - 34
THE ENVIRONMENTAL EFFECTS OF SHIPPING.....	4 - 34
<u>The effects of dredging</u>	4 - 34
<u>The movement of vessels</u>	4 - 38

CONTINUED OVERLEAF...

INDEX - CONTINUED...

<u>RECLAMATION</u>	4 - 39
IMPOUNDMENT.....	4 - 39
INFILLING.....	4 - 40
<u>The developments</u>	4 - 40
<u>The effects</u>	4 - 41
<u>FISHERIES</u>	4 - 43
ANNELIDS (MARINE WORMS).....	4 - 43
CRUSTACEA - PRAWNS.....	4 - 43
CRUSTACEA - CRABS & LOBSTERS.....	4 - 44
MOLLUSCA - WINKLES & WHELKS.....	4 - 44
BIVALVE MOLLUSCS.....	4 - 45
FISH SPECIES.....	4 - 47
SUMMARY OF SOME POTENTIAL EFFECTS OF FISHING TECHNIQUES ON THE ENVIRONMENT.....	4 - 48
<u>ALIEN SPECIES</u>	4 - 50
ACCIDENTALLY INTRODUCED ALIENS.....	4 - 50
<u>Sargassum muticum</u> - Japanese Seaweed.....	4 - 50
<u>Crepidula fornicata</u> - American slipper limpet.....	4 - 51
<u>Other species</u>	4 - 52
COMMERCIALY INTRODUCED ALIENS.....	4 - 52
<u>POLLUTION</u>	4 - 53
FLUID DISCHARGES.....	4 - 54
SOLID WASTES.....	4 - 55
EUTROPHICATION.....	4 - 55
MICROBIAL POLLUTION.....	4 - 56
HYDROCARBONS.....	4 - 56
TRACE METALS.....	4 - 57

Introduction

The **SCIENTIFIC ASSESSMENT** provides a detailed and technical appraisal of the subtidal environment within the Harbour. Although scientific terminology and latin names for species are used, those not familiar with this style should be able to understand sections of particular interest provided that the appropriate section within the **GENERAL REPORT** is read first. To facilitate cross-referencing, the **SCIENTIFIC ASSESSMENT** is organised in the same way as, and uses headings comparable to those of both the **GENERAL ASSESSMENT** and the **QUICK REFERENCE GUIDE**. Common names for species (which have them) are provided within the **FULL SPECIES LIST**.



Survey Details

All three surveys have relied on a combination of three methods to provide as complete and detailed an impression of the subtidal environment as is possible, i.e. dredge and grab sampling from a survey vessel, together with diving at stations covering all sections of the Harbour. For this, the subtidal channel network within the Harbour was subdivided into survey zones of the same order of length, each of these containing a series of sampling stations. The survey layout is shown in fig. 2. The survey strategem was to provide a first baseline impression of the subtidal zone of the Harbour, this being a foundation for subsequent monitoring, to be undertaken when and where required, in order to identify any future changes which may occur.

HOLES BAY SURVEY

In the case of Holes Bay which is a relatively small subsystem within the Harbour, dredge and grab samples were taken at 22 stations at channel centre. Because of poor underwater visibility, pollution and seabed debris, diving was confined to the sampling of subtidal wharf surfaces at 9 peripheral stations within the most downstream section of the survey area (Channel HBL). All sampling was undertaken during summer months. Holes Bay stations were accessed by craft provided by the Poole Harbour Commissioners. A full account of methods and results is provided by Dyrynda (1983).

SOUTHERN AND NORTHERN SECTOR SURVEYS

DIVE TRANSECT PROCEDURE

A new dive transect procedure, developed initially for the Southern Sector Survey, was subsequently also employed during the Northern Sector Survey. This method enabled both long and cross channel variations in the relationship between bathymetry, channel bed substrates and benthic communities to be assessed in great detail, not on a one off basis, but as a baseline against which the results of future reassessments can be compared, in order to test for any future changes. Southern Sector diving stations were accessed using assault craft provided and manned by the Royal Marines. Northern Sector stations (many of which coincided with busy shipping channels) were accessed from 'Rough Ryder', the 40' workboat of the Poole Harbour Commissioners. The technique entailed the recording of channel bed data at one metre intervals marked on a (up to) 250m weighted transect line laid cross channel. Data was recorded using an underwater tape

recorder. Depths were measured using a calibrated depth gauge sensitive to 0.1m changes. Substrates and epibenthos were assessed visually and photographically. Compilation of the data allowed the construction of detailed and accurate cross channel profiles even for localities where the visibility was very poor (as is often the case in Poole Harbour). 16 transect stations were covered by the Southern Sector Survey. A further 33 stations were covered during the Northern Sector Survey bringing the total to 49, and representing observations at more than 5000 seabed points and a total transect distance of more than 5km (fig. 2).

DREDGE AND GRAB SAMPLING PROCEDURES

In the case of dredge and grab sampling within the main Harbour, the same procedures were employed as for the Holes Bay Survey except for a substantially larger sampling interval (137 dredge / grab stations in all). For the Holes Bay and Southern Sector Survey, an 0.1m Hunter Grab provided by the Wessex Water Authority was deployed from 'Rough Ryder' (Poole Harbour Commissioners). For the Northern Sector Survey, a spring loaded Smith McIntyre Grab, also provided by the W.W.A., also was deployed from the P.H.C. vessel. Replicate samples were taken at all channel-centre stations within the system. Sediment samples were removed for particle fraction and organic content analyses (standard procedures), the remainder being sieved (1mm) for the retention and quantitative assessment of inbenthos (including the infauna) and the epibenthos as sampled.

For the dredge survey, a small commercial dredge (mesh size 2.5") was used for the Holes Bay and Southern Sector Survey, in the former case deployed from 'Rough Ryder' and in the latter, hand operated from an open oyster boat (provided by 'Sea Harvest' of Poole). Dredge runs centred upon the grab sampling stations. For the Northern Sector Survey, a full size oyster dredge, but of comparable design and mesh size to that used previously was deployed from 'Rough Ryder' (dredge provided by B. Mullens. All samples underwent preliminary analyses before being bulk-preserved for detailed examination including the identification and semi-quantitative assessment of component species.

Hydrography

Poole Harbour Commissioners (P.H.C.) maintain a permanent Hydrographic Team (under the direction of Mr Keith Birkmar), concerned principally with the management of the navigational channels, monitoring and planning for the maintenance of adequate navigational depths, but who also undertake a diversity of other hydrographic work. The current survey benefited greatly from the comprehensive hydrographic information generously made available by the Hydrographic Unit. In addition to the cross-channel bathymetric profiles, the only hydrographic fieldwork undertaken during the survey was the recording of salinities for which other data is not available.

TIDAL CYCLE

Poole Harbour is located close to an area of the English Channel experiencing a small tidal range, such that the mean spring range is less than 2m. Because of local effects, there is a departure from the normal semidiurnal rhythm throughout the Harbour, a double high tide, such that submergence times on the lower two thirds of the shore are longer than is normal. This is reflected in an elevation of zonations, not only of intertidal organisms to unusual heights up the shore, but also of normally subtidal organisms up on to the lower shore. Greater immersion also raises the maximum depth of penetration of the infralittoral (photic) zone to a level higher than it would otherwise be (fig. 7).

During spring tides, the first high is substantially higher than the second, whereas during neaps it is the second high that is higher although less substantially so (fig. 5). Neap tides in particular are affected by climatic and even local wind variations (K. Birkmar, pers. comm.). The tidal wave takes approximately 1.5h to progress from Poole Bar, along the Harbour, to the mouth of the River Frome.

The double high tide phenomenon also has consequences for the flushing characteristics of the Harbour. The period between highs in effect constitutes a prolonged tidal stand, particularly during neap tides. This further exacerbates the very poor flushing characteristics of the Harbour which are fundamentally the product of the high degree of land-locking. These poor flushing characteristics of the Harbour, and Holes Bay in particular, have been highlighted by the mathematical modelling studies of Falconer (1981) (pollution consequences are

discussed in a separate sub-section below).

The Hydrographic Unit of P.H.C. maintain a permanent tide guage on Poole Quay. Data from this were used to determine the chart datum levels for the dive transect bathymetric profiles.

TIDAL CURRENTS

Channel depth and width, the nature of benthic sediments and of biological communities are all strongly influenced by water movements, in the Harbour, principally by tidal currents. The P.H.C. Hydrographic Unit have taken current meter records at stations covering most channels of the Harbour (fig. 4). Bathymetries and substrates also give a good impression as to the prevailing current strengths.

There is a general downstream gradient of increasing tidal velocities superimposed upon which are local variations. Velocities are locally increased 1. on bends, 2. where channels are constricted (laterally or by depth), and 3. where channels merge. All of these phenomena coincide within the Haven Channel (HAC) between North and South Haven Points, where the maximum velocities for the Harbour of 4.5 knots have been recorded (see dive transect data for the Haven - Appendix III). Velocities within the Harbour generally range from 1-2 knots, but are locally greater (fig. 4).

WAVE EXPOSURE

The near total landlocking of the Harbour minimizes fetch and hence potential wave exposure from all directions. However, significant wave exposure can be generated during windy periods, particularly within the north east sector of the primary basin which has a fetch of the order of 4km from the south west, the prevailing wind direction, and this is reflected in a strong south-west - north east coarsening of the substrate regime (fig. 8) which cuts across the long-channel gradients produced by increasing exposure to currents. The most sheltered section of the Harbour is the area extending from east of Arne to the south of Brownsea. This shelter partly accounts for the particularly extensive occurrence of fine sands and muds supporting heavy epibenthic cover within the South Deep (SDL, SDU), and to a lesser extent, within Blood Alley (BAC)(fig. 8).

The combination of shelter from wave exposure and moderate to strong tidal currents greatly favours the development of high occupancy, species-rich epibenthic communities within the Harbour.

TURBIDITY

Levels of turbidity are generally high within the Harbour, but also show strong upstream gradients (reflecting the estuarine turbidity zone), with variations over the tidal cycle and according to wind conditions (fig. 7). Suspended materials include 1. both planktonic and dead organic matter, 2. biogenic carbonates including the products of shell degradation, 3. non-biogenic siliceous materials. High levels of planktonic productivity are particularly prevalent during the summer blooms of Phaeocystis and other algae. The enriched conditions also favour high production rates of intertidal saltmarsh (particularly Spartina), reed beds (Phragmites) and benthic macroalgae, all of which contribute to the high levels of suspended particulate organic matter during summer. On a shorter term basis, turbidities are substantially

greater during spring tides than during neaps. Within each tidal cycle, turbidities are greatest during runs, particularly ebbs, with a significant proportion of suspended material quickly settling out during tidal stands.

The steep upstream increase in turbidity is evident from Secchi Disc measurements undertaken throughout the Harbour, but perhaps a more reliable indicator of long term trends is provided by variations in the maximum penetration of the infralittoral zone, the depth to which light levels are sufficient to support the growth of benthic macroalgae (fig. 7). Results from various components of the survey reveal the water to be clearest within the Swash and Haven Channels (infralittoral to between 5 & 10m below chart datum), the deepest infralittoral level rising steeply within the Lower South Deep, Blood Alley, the Lower Wych, Diver and Lower and Upper Main Channels (0-5m). Further upstream, turbidity levels are sufficient to confine the infralittoral up to, and in extreme cases, to well above chart datum.

SALINITY

Poole Harbour can perhaps best be described as an estuarine complex since it receives input from several rivers (fig. 1). Although these are small in relation to the size of the Harbour, because of the high degree of land-locking and consequently poor flushing and mixing, salinities are reduced generally such that all parts of the Harbour are brackish.

Salinity records have been taken at various stages of the survey. However, only recently has a Harbour wide recording programme commenced (covering all channels, stations accessed by fast boat on a rising / falling tide). Compilation of the salinity records taken to date provide sufficient information to draw conclusions on broad trends (fig. 6).

Gradients of declining salinity are generally gradual within much of the primary basin (the eastern, downstream section), salinity values there being polyhaline and fairly stable both tidally and seasonally. Gradients become steeper, and mesohaline or lower salinity regimes develop within the vicinities of the freshwater inputs. The combined input from the Frome and Trent has the greatest effect by rendering the eastern third of the primary basin mesohaline (west and north of Arne)(WCU, WCM), this being supplemented by input from the Sherford River via Lytchett Bay (LBC). Freshwater input from Poole Sewage Treatment Works (Fleetsbridge) reduces the immediate section of the Upper Holes Bay Channel (HBU) to mesohaline conditions. The top half of the Upper Wych Channel (WYU) is also rendered mesohaline by input from the Corfe River. Vertical stratification is most evident within the innermore mesohaline areas closest to the points of freshwater discharge, particularly within the Upper Wareham Channel (WCU).

Although no part of the Harbour is fully marine, the highest and most stable salinities occur within the South Deep which receives no substantial direct freshwater input and is furthest from the channels that do (figs. 1,6).

Salinity values strongly influence the species composition of benthic communities. Species richness broadly declines along with salinity, those species tolerant of or even specialised to low and variable salinities becoming increasingly prevalent as others phase out. This partly accounts for the general upstream decline in species richness moving up through the Harbour, and also for the peaks in

richness evident within the South Deep and to a lesser extent, the Haven Channel (figs. 22, 23).

TEMPERATURE

The inshore waters off central southern England usually develop the highest summer water temperatures of the British Isles, and within this area, maximum values develop within landlocked shallow water systems such as Poole Harbour. Records compiled by the Hydrographic Unit of Poole Harbour Commissioners reveal summer and winter temperatures more extreme than those within adjacent more open water localities such as Poole Bay. High summer temperatures, as well as boosting productivity generally, may favour the growth of species exhibiting more southern distributions. Exceptionally low winter temperatures do result in mass mortalities. Poole Harbour was one of the areas noted for this during the exceptionally cold winter of 1963. More enclosed, quieter embayments within the Harbour are most likely to develop the most extreme temperatures, e.g. sea ice can form during exceptionally cold spells, particularly within Holes Bay and the Upper section of the South Deep (as happened during February 1986).

The Harbour Bed - Substrates

The subtidal channels of Poole Harbour occupy approximately 25% of the Harbour bed area and consist of one major and several subsidiary lineages. These are interlinked at points to form a network rather than the more straightforward branching hierarchies typical of most coastal basins (figs. 1-3).

The major channel lineage extends from Poole Bar out in Poole Bay, through the Haven, the Harbour entrance, and across the Harbour to the (now truncated) entrances of the Frome and Trent. It is constituted by the Swash (SWC), Haven (HAC), Lower and Upper Main (MCL, MCU), and Lower, Middle, and Upper Wareham Channels (WCL, WCM, WCU) (for the survey, the channel network has been subdivided into logical sub-units of approximately equal length, see fig. 2 & **Quick Reference Guide - Section 2**). Subsidiary channel lineages include the Lower and Upper South Deep (SDL, SDU), Blood Alley (BAC), the Lower and Upper Wych Channels (WYL, WYU), the Lower and Upper Holes Bay Channels (HBL, HBU), and the Lytchett Bay Channel (LBC). Whereas the major channel lineage constitutes a distance of 12km, the total length of the network of channels, as surveyed, covers more than 30km in distance (figs. 1-3).

Poole Harbour lies in the path of the former Solent River which flowed across the area 60 million years ago. In consequence, both intertidal and subtidal areas of the Harbour bed, and also the fringing shorelands are underlain by fluvial (river) deposits, the Bagshot Beds, a soft and erodable combination of quartzitic sands with bands of kaolinitic pipe clay. After the last ice age (approximately 10,000 years ago) a smaller river system flowed across what is now the Harbour bed, the major lineage probably being an extension of the present Frome / Trent system, receiving tributaries such as the present Sherford and Corfe Rivers. The Harbour has formed since that time (during the Flandrian transgression) by marine submergence, the consequence of rising sea levels and a sinking of the land mass. Freshwater peat extracted from a depth of 12m below C.D. at a borehole off Hamworthy and overlain by marine clays, was radiochemically dated as being 6000 years old, indicating this to have been the time inundation commenced (Bird and Ranwell, 1964). Since then, the sedimentation of fine particulate materials, whether released from eroding strata, introduced from rivers or the sea, or biologically produced, has kept pace with the rising water level to form the deep sediment column which now floors much of the Harbour. The Harbour has grown laterally as well as longitudinally, progressively inundating valleys and lowland areas to form the broad expanse, almost a marine lake, which constitutes the Harbour today (only interrupted by the islands, i.e. the former highlands). The increase in Harbour area has been particularly quick

because of the softness and erodability of the underlying and surrounding Bagshot strata. These weakly consolidated sands and clays are evident within the cliffs which characterise much of the mainland and island shorelines, always cut back by wave action to the high water mark. This relatively rapid process of shoreline loss has released large quantities of particulate quartzitic material representing all points on the particle size range from silt to boulders, but the sands, gravels and cobbles which characterise many shores are the most evident features.

Originally, the Harbour probably communicated with Poole Bay and the eastern basin of the English Channel beyond across a broad front, but this has become constricted by the deposition of sand bars from the north and south (North and South Haven Points) such that at present, communication is confined to a 350m wide entrance at the eastern end of the Harbour, i.e. the Haven, further increasing the lake or lagoon-like isolation of the Harbour. This process of bar formation is relatively recent, the southern bar, the Studland Peninsula, having substantially increased in area during the past 200 years.

The deepest accumulations of sediment correspond to the intertidal and shallow subtidal banks within the oldest sections of the Harbour. The subtidal channels represent the lineages of river drainage and tidal exchange, their trajectories being heavily influenced by the configuration of river inputs and Harbour shorelines. Within all areas of the Harbour, the tidal currents within the subtidal channels are stronger than in the corresponding intertidal areas.

The substrate regime within any section of the subtidal channel network within Poole Harbour is primarily determined by the amount of scour and secondarily, but still substantially, by the degree of exposure to wave action.

The structure of all subtidal channels within Poole Harbour are variations on the same theme, as is born out by the dive transect results.

Within each lineage, there is 1. a general upstream gradient of declining tidal energy, decreasing currents and scour, 2. the increasing incidence of net accretion as opposed to erosion on the channel bed, 3. the increasing incidence of unconsolidated as opposed to consolidated substrates, and 4. a declining particle size range within the unconsolidated substrates. However, there is usually considerable local variability in these trends. There is always cross channel variation. On linear (straight) reaches of channel, there is usually an increase both in sediment coarseness and in the incidence of consolidated substrates from the channel periphery (the chart datum line) down the channel flank (the sloping section) to the centre of the channel floor (the less sloping, central section). This is related to a concomitant gradient of increasing tidal velocity and scour. On channel bends, the greatest scour is on the outer flank, and it is there that the coarsest sediments or greatest incidence of unconsolidated substrates occurs. Because of net erosion on the outer flank, bends are typically migrating outwards and hence the inner, depositional flank is (and can only be) composed entirely of sediments. On linear reaches, the channel is typically symmetrical and with shallow inclined flanks. On bends, the profile is typically skewed, the channel slopes are steeper and the overall channel is deeper than on adjacent reaches, the deepest point being located towards the outside of the bend. This pattern is repeated for bathymetric profiles throughout the system (see dive transect data within Appendix III and also Dyrzynda, 1985, 1987a). The largest-scale examples of the pattern typical of bends were

encountered within the Haven (HAC2, HAC5), but also within the three 90' bends of the South Deep (SDL, SDU), and the near continuous arc of the Main Channel (MCL, MCU). The outward migration of the Main Channel has been accelerated by dredging. Evidence on several Main Channel transects revealed dredge sculpturing of the consolidated clays of the outer channel facet (fig. 25).

Although the above-mentioned gradients of change are the same throughout the system, the range of substrates exposed on the channel bed varies between channels as does the scale of the profile (fig. 8). Within the Haven, the most current-scoured section of Poole Harbour, the channel is more than 15m deep and substrates range from medium and coarse sand at the channel peripheries to stones, boulders and consolidated clay at channel centre (HAC2) (see Appendix III). At the other extreme, typical upstream profiles may hardly bottom out below the chart datum level and the profile may be entirely of soft mud, or where currents are a little stronger, of firm mud, i.e. representing the exposure of semi-consolidated muds close to the top of the sediment column. Other areas of the Harbour represent intermediates between these two conditions.

Other sources of local variation where tidal velocities are locally increased (in addition to bends) are where 1. the channel is constricted, and 2. channels merge. The Haven provides all of these factors in combination in being 1. one of the most downstream sections of the channel system of the Harbour, 2. a point where several channels merge, and 3. it contains a series of channel bends including two that occur where the subtidal gully / trench veers from side to side as it passes between the North and South Haven Points. Other natural complications to the theme occur within more upstream sections, where channels skirt close to shores bearing cliffs of Bagshot strata. At these locations, quartzitic sands released from the cliffs (which may be as little as 1m in height) accumulate intertidally as sandy beaches but grade into mud at, or close to the chart datum line (e.g. WCU). Artificial developments that complicate intertidal and subtidal hydrographic and substrate regimes, abound. Reclamation and impoundment processes not only directly affect local regimes but also can have consequences further afield within the Harbour. Dredging of navigational channels can also have substantial effects, and even the dredging processes used for oyster fishing can be significant (see relevant sections).

The consequence of the above-mentioned natural gradients is that cross channel sequences of substrates can be very complex, as was revealed by many of the dive transects (see appendix III). It is certainly not possible to draw conclusions as to the nature of subtidal substrates from, e.g. grab samples taken at channel centre (the main value of grab sampling was the provision of samples of inbenthic species), and the question that begs is as to how many other estuaries exhibit comparable characteristics that have been masked by the sampling methods used.

The template for individual channels is repeated throughout the Harbour, whether the channel concerned receives freshwater input or not, e.g. the South Deep (which does not) exhibits the same sequences as do all other channels. However differences between channels do exist, and the major ones that do can be correlated to the southwest - north east gradient of increasing sediment coarseness reflecting a trend of increasing wave exposure corresponding to the increased fetch to prevailing winds (fig. 8).

Another major complication to the theme is the influence of

epibenthic species. Within the turbid waters of the Harbour, several of the principal epibenthic community types substantially alter the substrate and bathymetric regimes by acting as sediment traps, accelerating / promoting the accretion of a finer and deeper sediment column than would occur under open bed conditions. Several areas of the Harbour are affected in this way.

The above provides an introduction to the substrate regimes within the Harbour. More detailed information concerning the natural substrates is given in the sub-section after this one (**BIOLOGICAL COMMUNITIES**), and on substrates influenced by man, in the one after that (**INFLUENCES OF MAN**).

The Harbour Bed - Biological Communities

High levels of dissolved and particulate nutrients and organic substances, combined with at least moderate water currents and shelter from strong wave action, all of which characterise Poole Harbour, favour the flourishing of most categories of marine biota. Within both the intertidal and subtidal zones natural community structure varies most strongly according to the substrate (reflecting exposure to water movement), and secondarily, according to the salinity regime.

The upper sections of most muddy shores are epibenthically dominated, i.e. by Spartina saltmarshes, whereas the lower sections of these and also of sandy shores are mainly characterised by inbenthic communities, particularly including annelids (e.g. rag and lug worms) and shellfish (e.g. cockles), often predated by birds during low tide and by crabs and fish during high tide periods. Natural consolidated substrates (Bagshot strata) are virtually absent from intertidal areas, only bands of clay can occur and their crumbling surface provide very poor anchorages both for marine algae and sessile invertebrates and so are usually barren of benthos. Intertidal areas within the Northern Sector have been extensively physically affected by human activities. Intertidal habitats within Poole Harbour have recently been extensively and comprehensively surveyed and mapped by Gray (1986).

Both macroalgae and suspension feeding invertebrates (including sponges, many coelenterates, barnacles, shellfish, and ascidians) dominate the biological communities colonizing the subtidal channel beds within the Harbour. Broad trends in the extent of occurrence of these are evident from the dredge survey data, confirmed by the grab and diving survey results. Variation in the quantity of epibenthos is evident from these results, even though they refer specifically to biota occurring at channel-centre. From the results it is clear that epibenthic biomass (e.g. expressed as wet weight epibenthos per dredge haul) is lower in the downstream sections of the Harbour, and peaks in the midstream section, before declining again within upstream areas. These trends are evident within all channel lineages, although the position and extent of each of the zones within the Harbour differs from channel to channel and trends are, in places, reversed by local factors (figs. 13, 14). It is believed that these differences most fundamentally correlate to the nature of the seabed substrates as governed by tidal currents and, to a lesser extent, by wave exposure.

The peaks in biomass within midstream zones can be related to the peaking of certain 'foundation' community dominants around which biomass and species richness are boosted. Salinity gradients, it is believed, are secondary in that they influence the species content but not the gross nature of the constituent communities.

This strong dependence (and in cases, interdependence) between the nature of the benthos and of the physical substrates leads to variations across the Harbour which follow logical patterns and sequences (fig. 8). Because of the greater influence of tidal currents within the subtidal zone than in the intertidal, both coarser sediments and consolidated substrates are more frequent there than in the intertidal.

The numbers of species and also the biomass of the benthic standing stock are both very much greater within the subtidal than in the intertidal zone. This is largely the product of the proliferation of epibenthic macroalgae and suspension feeding groups within certain areas of the Harbour, flourishing within the very favourable conditions, good supply of dissolved and particulate nutrients and organic food materials, at least moderate tidal currents, but shelter from the disruptive effects of wave action. Epibenthic biomass (of macrobiota) greatly outweighs that of infaunal biomass within subtidal areas of the Harbour (figs. 13, 14). This prevalence of species is, perhaps surprisingly, very much associated with sedimentary rather than consolidated bed substrates. The epibenthos colonizing sedimentary channel bed substrates can be anchored in several ways, 1. within the sediment by rooting (or attached to rooted species), 2. colonizing small hard substrates on the bed surface, i.e. stones or shells, or 3. free standing on the bed surface.

The long and cross channel gradients of change in the substrate regime described in the preceding sub-section, related to changes in the scouring effects of tidal currents, and to a lesser extent, wave exposure are highly significant from the viewpoint of the epibenthic standing stock. The greatest values for the standing stock correspond with areas of the Harbour where fine sands and muds coincide, as they do most extensively within the Lower and Upper South Deep (SDL, SDU), but also within parts of all lineages, e.g. sections of the Upper Main Channel (MCU) and Lower Wych Channel (WCL). It is in these areas that ideal hydrographic conditions favouring the growth of epibenthos prevail. Turbidities may be moderate or high (relative to other sections of the Harbour) but currents are strong enough to prevent levels of sediment accretion that would smother epibenthic biota (further upstream, high accretion rates prevent the formation of heavy epibenthic cover). Yet currents are not sufficiently strong to mobilise larger, higher drag epibenthic forms, whether rooted, colonizing small hard substrates, or free standing (this being the factor limiting the standing stock in the downstream direction). The upstream areas where epibenthos is limited include the top of the Upper South Deep (SDU), the tops of Blood Alley (BAC) and the Lower Wych (WYL), and the Upper Wych (WCU) in its entirety, sections of the Middle and Upper Wareham Channel (WCM, WCU), the Upper Holes Bay (HBU) and Lytchett Bay Channels (LBC). The downstream areas where epibenthos is limited include the entrance to the Lower South Deep (SDL), the downstream most third of the Lower Wych Channel (WCL), the Diver (DVC) and Lower Main Channels (MCL) in their entirety and the downstream half of the Upper Main Channel (MCU).

Cross channel gradients of change of tidal velocities and substrates are paralleled by changes in the benthos, e.g. towards the upstream end of the 'midstream' epibenthos dominated zones, peaks in benthic cover

occur towards channel centre on reaches, and towards the outer flank on channel bends. By contrast, at the downstream ends of such zones, epibenthic communities with the greatest biomass are often confined to the channel peripheries where scour is less, and can be totally absent from channel bends.

According to the combined results of the subtidal survey, several key natural benthic communities have been identified and these correspond to particular substrates. They reflect the full spectrum as encountered within the Harbour, although there is substantial intergrading and other local variation. The basic communities are considered in detail below. In several areas of the Harbour, particularly in the north, the biological communities have been either lost, or considerably altered, together with their supporting substrates. Various case examples are considered within the next sub-section (INFLUENCES OF MAN).

Another broad trend which is evident concerns the emphasis towards either primary or secondary production, i.e. the occurrence of algae as opposed to suspension feeding invertebrates. These occur side by side through much of the Harbour. At any one site, the abundance of algae declines with increasing water depth (and hence declining light levels) until the bottom of the infralittoral zone. Shore surveys and the dive transects show how the depth of the infralittoral zone rises, moving upstream through the subtidal channel network (fig. 7). Whereas in the Swash (SWC) and much of the Haven Channel (HAC), the infralittoral zone extends to in excess of 5m below chart datum, within much of the eastern primary basin, the Lower and Upper Main MCL, MCU), the Diver (DVC), Lower Wych (WYL), Lower South Deep (SDL) and Blood Alley (BAC) Channels the limit is between chart datum and 5m; within the upstream areas, the Middle and Upper Wareham Channels (WCM, WCU), the Holes Bay and Lytchett Channels (HBL, HBU, LBC), the upper Wytch and Upper South Deep (WYU, SDU), the infralittoral zone phases out around or even some distance above the chart datum level. Lytchett and Holes Bay provide extreme examples of turbidity and poor light penetration where the transition can be in excess of 0.75m above chart datum (fig. 7). These trends are evident from the comparison of Harbour wide trends in algal and invertebrate biomass as shown by the dredge surveys (figs. 13, 14). Superimposed upon the trend governed by light penetration are peaks corresponding with the zone of intermediate tidal energy where conditions are most favourable for the development of both algal and invertebrate epibenthic growth.

Another major complication to the Harbour wide scheme concerns the tidal mobilisation and transport of epibenthos. This survey has shown that algae and invertebrates in general and certain species in particular are shifted around the Harbour in large quantities, particularly during spring tidal runs. This process was observed during dives, and was also evident from the very considerable quantities of material, particularly algae, which were snagged by the dive survey lines when laid in certain areas. This material consists of the colonizers of stones and shells which have 'outgrown' these and because of the increased drag, have been mobilized and transported around the Harbour by currents. The same is the case for the colonizers of larger heavier substrates which have become detached by currents, again perhaps because of their high drag factors. The most common drifting species are, in order of frequency, Sargassum muticum, Ulva lactuca, Laminaria saccharina, Asciidiella aspersa and Styela clava (figs. 11, 16, 17, 18, 20). Many of these forms continue to grow and are even colonised by other subsidiary forms whilst being transported around the Harbour, although if swept into and retained within areas where unfavourable conditions occur, they will eventually die (but may

feature for some time before this happens). Problems arising from this drifting process include the delineation of the infralittoral and cirralittoral zones. For this survey dive transect data has been used to establish the maximum extent of the infralittoral zone, i.e. by identifying the maximum depth of occurrence of attached algae, or any major decline in the abundance of free standing algae. Occasional or even appreciable quantities of algae that are clearly out of their depth can be very misleading, e.g. isolated Sargassum plants can occur well upstream or at depths well below the main distribution, but only temporarily. Detached Ulva plants drift and apparently flourish within the turbid waters of the Holes Bay Channels (as well as others), although exposure to adequate light levels is only be intermittent, i.e. as the weeds are swept to the surface of the water.

Further details on drifting species are given in specific sections below.

In terms of biomass, epibenthic communities within the Harbour were found to be dominated by a small number of **principal cover species**, identified as those constituting more than 1% of the total sample biomass (wet weight values, according to the Dredge Survey):

THE FIFTEEN MOST COMMON EPIBENTHIC SPECIES

Results pooled for the whole Harbour

<u>SPECIES</u>	% BIOMASS
<u>Crepidula fornicata</u>	31.8
<u>Ascidella aspersa</u>	22.4
<u>Sargassum muticum</u>	16.1
<u>Ulva lactuca</u>	6.2
<u>Styela clava</u>	6.1
<u>Halichondria bowerbanki</u>	4.2
<u>Ostrea edulis</u>	3.0
<u>Sabella pavonina</u>	2.8
<u>Mytilus edulis</u>	2.4
<u>Laminaria saccharina</u>	1.4
<u>Haliclona oculata</u>	1.3
<u>Hymeniacion perleve</u>	1.3
<u>Halichondria panicea</u>	0.5
<u>Cliona celata</u>	0.4
<u>Suberites ficus</u>	0.3

Combined survey data reveal Crepidula fornicata, Sargassum muticum and Sabella pavonina to have central roles in the formation of biological communities within the Harbour. This status is reflected in their position towards the top of the above table, although the relatively small biomass value for Sabella belies its ecological importance.

Frequency distribution maps are also provided showing spatial variations in the occurrence of various key biota according to incidence along dive transects (figs. 9 - 12) and biomass according to the dredge survey (figs. 13 - 21). These show definitive trends which are considered in more detail in appropriate sections elsewhere within

this section. It is important to bear in mind that the results for the dredge survey are based on **channel-centre** hauls. Dive transects have shown that at any particular point within the channel network, communities may be confined to one or both of the flanks or peripheries, they may not feature at all at channel centre and hence not in the dredge results. Transect results reveal instances of this for all community types identified within the Harbour. In this context, it is useful to compare the abundance / frequency plots based on the dive transects and dredge survey, e.g. for Crepidula (figs. 10, 15) and also Sargassum (figs. 11, 17). Such local differences aside, the broad trends identified according to both methods are realistic.

Harbour wide trends in species richness, i.e. the numbers of species present, have been examined using both the dredged survey data (fig. 22) and the overall survey data (fig. 23, Appendix II). The trends revealed by the two methods is comparable and the following categories were identified:

- High species richness:** *Haven, *Lower & Upper South Deep,
(* Highest of all) Lower Wytch, Blood Alley, Upper Main,
 Lower Holes Bay.
- Intermediate species richness:** Swash, Diver, Lower and Mid Wareham,
 Upper Holes Bay.
- Low species richness:** Lower Main, Upper Wych, Upper Wareham.

Peaks in species richness correspond with areas known to have the most appreciable epibenthic cover. Minimal values within the Lower Main Channel (MCL) may be influenced by disturbances from major navigational dredging and the passage of large vessels. Similar trends within the dredged area of the Lower Wareham Channel (WCL) are masked - whereas species richness on the dredged channel bed is minimal, values are boosted by records for sessile species colonizing the flanking subtidal extension of the boulder bund. The same may be the case for the Lower Holes Bay Channel (HBL). Low values within the Upper Wareham (WCU) and Upper Wych Channels (WYU) can be equated to a combination of reduced (mesohaline) salinities and high accretion rates of fine suspended particulate materials.

A strong pattern of the peaking of species richness within the midstream sections of the channels (figs. 22, 23) reflects the high biomass epibenthic communities occurring there, the midstream Sabella, Crepidula and Sargassum communities which provide substrates and shelter for a host of subsidiary species (see below). Among these midstream communities, the greatest species richness occurs in the Lower South Deep (SDL). The Sabella fields there are exposed to the highest and most stable salinities, the lowest turbidities and perhaps the lowest levels of pollution and physical disturbances within the Harbour. However, this is only a matter of degree, Sabella beds within the midstream sections of other channels are also rich in species.

Biological Communities and Substrates

Detailed Descriptions

According to the combined results of the subtidal survey, several key natural benthic communities have been identified and these correspond to particular substrates. They reflect the full spectrum as encountered within the Harbour, although there is substantial intergrading and other local variation. In several areas of the Harbour, particularly to the north, the biological communities, along with their supporting substrates, have been either lost, or considerably altered. Various case examples of these are considered within the next sub-section (INFLUENCES OF MAN).

COMMUNITIES OF HARD CONSOLIDATED SUBSTRATES

Natural bedrock

This is rare within the Harbour. However, outcrops of hard bedrock in the form of horizontal slabs were identified at a depth of approximately 9m at one point within the Haven Channel, on the eastern subtidal slope of Brownsea Island (HAC5) (fig. 8). Since the Haven Channel includes the deepest sections of the subtidal channel network, it is the area in which rock outcrops would be most likely to occur. Rock outcrops were not recorded at the other two Haven transect stations (both deeper than HAC5), i.e. HAC2 and HAC3. Under the favourably strong tidal currents, the exposures at HAC5 support a species-rich circalittoral cover of sessile epibenthos dominated by the bryozoan Flustra foliacea and the sponge Suberites ficus, the former being characteristic of current-exposed stable hard substrates in fully or near fully marine conditions. Large stable boulders, located at HAC2 were colonized by near monospecific covers of Flustra foliacea, but at HAC3, apparently the most current scoured section of channel within the Harbour, boulders were found to support only abrasion resistant biota, Balanus improvisus and Pomatoceros lamarki (the passage of sand, gravel and stones probably abrades the armouring of stones, cobbles and boulders at this site).

COMMUNITIES OF SOFT CONSOLIDATED SUBSTRATES

Clays - Bagshot and marine

The substrate most indicative of increased tidal scour within Poole Harbour is consolidated clay, two kinds of which are evident - marine clays formed since the origin of the Harbour and the clays of the earlier Bagshot Beds (fig. 8).

Marine clays have formed progressively within accumulating columns of finer sediments. Vertical gradients of increasing consolidation are evident within the sediment column, soft mud at the surface, then 'hard mud' and then the clay beneath. Hard muds and marine clays feature along current scoured sections of the shallower channels, 'hard mud' where scour is less pronounced, and clay where currents are sufficiently strong to cut deeper into the sediment column. Extensive cliffs of marine clays feature naturally on the outer erosional facets of channel bends, e.g. within the Haven at transect HAC5 and within the Lower South Deep at transect SDL4.

Bagshot clays are only exposed where the currents are particularly strong such as to cut completely through the marine strata and into the Bagshot strata beneath. The only substantial Bagshot outcrop to be identified was found within the bottom of the channel between North and South Haven Points (HAC2 & HA3).

Both marine and Bagshot clays provide very poor biological substrates and support what are virtually the poorest biological communities within the Harbour. Few species can colonize the clay surface, the only infaunal biota consistently featuring being the (introduced) boring bivalve Petricola pholadiformis, which occurs in clays throughout the Harbour.

Bagshot sand, gravel and stone conglomerates

These very poorly consolidated substrates which are very rapidly eroded by water movement do not feature naturally within the subtidal zone. However, they have been artificially exposed at least at one point within the Harbour, i.e. within the Upper Main Channel where major dredging has cut through the marine series to reveal exposures, firstly of peat and then sandstone conglomerates below (MCU2).

These short-lived materials provide only very poor substrates for colonization and do not support significant benthic communities.

Peat

Peat represents the top of the freshwater series deposited prior to marine inundation. This appears to be fairly resistant to erosion (more so than sandstone, less than clay) and is exposed at localities within the Harbour where currents are strong, e.g. at the bottom of the 'Hole' at the centre of the Upper Holes Bay Channel and within the Lower Holes Bay Channel (HBL) just upstream from Poole Bridge. Peat also features within sequences exposed by dredging within the Upper Main Channel (MCL8, MCU2).

Peat represents a very poor substrate for colonization. However, in common with consolidated clays, the introduced boring bivalve Petricola

pholadiformis does feature.

Lignite

Exposures of lignite occur within the top of the Haven Channel (HAC), in a current scoured area off the north-eastern corner of Brownsea Island. In common with all of the above specified substrates, lignite provides a poor surface for colonization by epibenthos, yet is colonized by the inbenthic Petricola pholadiformis.

Cobble, stone and gravel substrates

Cobbles, stones and gravel often occur together in substrate complexes. Cobbles and stones, where present in quantity, form a monolayered (only under the strongest currents, multilayered) armouring on the channel bed, overlying and stabilizing either gravel or very coarse sand (fig. 8). The dense and typically well rounded siliceous Bagshot materials are most prevalent within the Haven Channel (HAC), but also occur within the narrowest section of the Lower Holes Bay Channel (HBL). Armourings of cobbles on gravel occur on transects HAC2 and SWL1 within the Haven area, and stones set in coarse sand characterise Chapman's Peak on transect HAC3 and also the crest of Stone 'Island' to the south of the Haven (SWC1), exposed only during spring tides. Biogenic materials within the cobble - pebble grain size range include living and dead molluscs. At the top end are Crepidula clusters, live or dead Ostrea (both at least locally common within all channels except the Upper Holes Bay and Lytchett Bay Channels (HBU, LBC)), and shells of Mya (abundant within the Upper Wareham Channel (WCU), present within the Middle Wareham Channel (WCM), not occurring elsewhere). Towards the bottom of this size range are the shells of Cerastoderme and Mytilus (the former at least locally common in all except the Swash and Haven Channels (SWC, HAC), the latter sporadically present throughout the Harbour but only common within the Upper South Deep, the Middle and Upper Wareham Channels and the Lower Holes Bay Channel (SDU, WCM, WCU, HBL). Shell fragments of any of the above species or the intact shells of Hydrobia, can form gravel beds, examples of the former are to be found in all channels, and of the latter, within the Upper Holes Bay Channel (HBU). Substantial differences in density between the non-biogenic and biogenic particles are paralleled by substantial differences in their water current mobilization thresholds, reflected in spatial segregation between e.g. cobbles and oyster shells of the same size. Taking the Haven Channel (HAC) as an example, even large oyster shells are absent from the most current scoured section (HAC3), but these do occur at the next most exposed station (HAC2). Crepidula clusters and shells are not found in quantity closer than HA5.

With declining tidal velocities, the cover of stones or shells ceases to form an armouring, and fragments into a patchy scattering overlying sands or even muds (see subsequent sections).

Coarse sand

Where coarse sand occurs on channel flanks, it is typically steeply sloping, often rippled, and usually devoid of benthos. Where it occurs on the channel floor, it forms near horizontal beds, often thrown into (rippled) waves or other undulatory formations up to 1m in amplitude. Both the coarseness of the sand, its gravel content and the amplitude of waves / undulations increase along with tidal velocity moving from

channel peripheries towards the more central, deepest section. Coarse sand is widespread within the Swash Channel (SWC) (particularly on Poole Bar), along the length of the Diver Channel (DVC), within certain parts of the Lower and Upper Main Channel (MCL, MCU), within the downstream half of the Lower Wych Channel (WYL) and within the entrance to the South Deep (SDL) (fig. 8). The most symmetrical waves form within the more confined sections of channel where currents are rectilinear (flowing along one axis). Where the channel experiences more multidirectional tidal currents, undulations form rather than waves (lowest section of the Diver Channel).

Coarse sand, particularly when containing a high gravel content, is a mobile dynamic substrate continuously reworked by the tidal currents. In Poole, it is dominated by heavy siliceous grains of the Bagshot Strata and supports one of the most species poor, lowest biomass communities within the Harbour. The infauna is minimal except for the sand eel Ammodytes tobianus, sufficiently common to feature regularly within grab samples in these areas. Individuals of this agile species are able to maintain their orientation within the changing sediment column. No rooted species could survive under such conditions and epibenthic small hard substrates are generally sparse. In places, shells and stones do collect within wave troughs and other depressions and these are sometimes colonized by specialized sessile species characteristic of such environments, i.e. by the Alga Gracilaria verrucosa, the hydroid Hydrallmania falcata and the bryozoan Valkeria uva. Mobile epibenthic species found to be common include hermit crabs colonizing shells of Littorina and Buccinum and the swimming crab Macropopus depurator.

In places, Crepidula beds also occur in association with beds of coarse sand. These are covered in a separate section below.

Medium sands - Lanice beds

Medium sands occur at least locally in all sections of the subtidal channel network of the Harbour except for the Upper Holes Bay and Lytchett Bay Channels (HBU, LBC) (fig. 8). This is because, even if fine particulates dominate the subtidal profile, the shores down to at least the chart datum line in the vicinity of Bagshot cliffs are dominated by medium sands. Usually anoxic within a small distance of the sediment surface (<5cm), subtidal medium sands can be clear of epibenthos, only exhibiting surface rippling (particularly when sloping steeply, e.g. on the inner faces of some bends). Elsewhere, they can support a significant, but rarely very high occupancy epibenthic cover. Usually well separated local stands of Sabella, Crepidula beds or particularly Sargassum may feature (see appropriate sections below), and small substrate colonizers such as Gracilaria can occur where stones or shells gravitate. Perhaps the species most typically associated with medium sand is the tubeworm Lanice conchelig. At higher densities, Lanice stabilises accretion to form medium sands where these would not otherwise occur (usually where smaller grained coarse sands would otherwise be found). The Lanice stands are typically 1-2m across, occurring on raised mounds separated by depressions of coarser material. This occurrence is comparable to that of beds of Sabella on fine sands and muds. These Lanice beds are widespread within the more downstream sections of the channel network (Lower and Upper South Deep, Lower Wych Channel, Diver and Lower Main Channel - SDL, SDU, WCL, DVC, MCL), but were found to be most extensive at one station within the Swash Channel (SWC5) (fig. 12).

Fine sands and muds - General

Fine sands are most common within a broad band orientated north to south across the centre of the Harbour, increasing in breadth to southwards. The sands, which typically are anoxic immediately below the surface, are of particular interest because of the species rich, high biomass epibenthic communities which they often support. As the epibenthic cover increases, the effect is to entrap increasingly fine sediments to form mud beds which would be inviable under open bed conditions. The epibenthic communities in question are described in the following sections.

Sabella pavonina (Peacock Worm) communities

Sabella pavonina is a tube dwelling annelid which colonizes marine sediments. Its parchment like tubes, approximately 0.5cm in diameter and up to 1m in length, grow anchored within the sediment column, with up to 30cm or so protruding. It is a suspension feeder, its expanded crown of tentacles spreading to form a cone up to 10cm across. This withdraws entirely into the tube whilst the worm is not feeding or is disturbed.

In Poole Harbour, Sabella can occur at densities ranging from the occasional well separated individuals to high density stands (fig. 9). Sabella has had a major effect on the subtidal ecology of the Harbour on several counts:

- 1) It is a major epibenthic colonizer and is one of the most abundant and widespread species within the Harbour.
- 2) When occurring as high density stands, it can modify the substrate regime of the channel bed on a substantial scale.
- 3) Some of the high density stands provide the framework for the most species rich, highest biomass benthic communities within the Harbour.
- 4) The distribution of Sabella as revealed by dive transect and other data shows this to be common within the Harbour approaches and all downstream and midstream channels, but not the Middle or Upper Wareham, the Lytchett, Upper Wych or the Upper Holes Bay Channels (WCM, WCU, LBC, WYC, HBU).

It is believed that the upstream limit of Sabella is determined by salinity, this species being precluded from channels where salinities are low polyhaline or mesohaline (Upper Wych Channel, Middle and Upper Wareham Channels, most of Lower and all of Upper Holes Bay Channel - WYU, WCM, WCU, HBL, HBU).

Two categories of high density Sabella beds occur within the Harbour:

- 1) Moderately current-exposed beds, the main category of Sabella beds, are confined to channels experiencing intermediate exposure to tidal currents and moderate turbidities. These conditions are found along most of the South Deep, the upstream half of Blood Alley and the Lower Wych Channels (BAC, WYL) and also the upstream half of the Upper Main Channel (MCU). There is also a small Sabella bed of comparable nature at the junction between the Lower and Upper Main Channels (MCL, MCU).

- 2) One highly current exposed Sabella bed was located in the bottom of

the most current-scoured section of the channel network, i.e. within the central area of the Haven between North and South Haven Points (HA2). This high density bed occurs among a cover of large angular cobbles set in coarse gravel. The subsidiary benthos is limited to cobble fauna typical of mobile substrates (see appropriate section above). In contrast to the moderately current exposed Sabella beds, the tubes here were found to be devoid of subsidiary colonizers.

Juvenile Sabella individuals colonize a range of hard substrates including the tubes of established worms, shells, stones and large stable hard substrates, e.g. subtidal concrete surfaces within the Lower Holes Bay Channel (HBL). Pioneer clumps of older individuals colonize substrates ranging from soft muds to medium sands, but particularly fine sands. As these grow to form more continuous covers, the stand of tubes serve as a baffles, entrapping and therefore accelerating the accretion of increasingly fine sediments, finer than would settle under open bed conditions. The result is the formation of very high densities of tubes deeply embedded in soft organic, anoxic muds up to 1m in thickness. The establishment of colonisers on the worm tubes and of other biota on shells, stones or free standing between the tubes, further accelerates bed formation, so dense beds have the potential to bring about a significant reduction in channel depth.

Within any one of the channel lineages, turbidities and the accretion rates of fine particulate materials increases moving upstream and a point is reached beyond which high density covers of silt - trapping epibenthos become inviable, this being the factor limiting the upstream extent of dense Sabella beds in particular. These phase out over a comparatively short distance towards the top of the Upper South Deep, Blood Alley, and the Lower Wych Channels (SDU, BAC, WYL), giving way first to the silt tolerant epibenthic communities and then clear open mud. The downstream limit of Sabella stands is governed by the point beyond which strong currents, 1) generate sediments too coarse or mobile to allow pioneer stands of tubes to become established (coarse sand or above), and 2) prevent the accretion of stabilizing sediment banks (fig. 9).

These trends are well represented within the South Deep (SDL, SDU). At the upstream limit of their zone, Sabella beds are confined to the current-scoured outer facets of channel bends. More extensive colonizations across the channel profile occur in midstream sections, whereas at the downstream end of the Sabella zone, the beds are increasingly confined to channel peripheries. Although generally fine, the grain size of the sediments anchoring the Sabella beds decreases appreciably moving downstream, e.g. in the South Deep (SDU - SDL), the range is from very soft mud to fine / medium sand.

This pattern is repeated (with variations) within other channel lineages, i.e. Blood Alley, the Wych Channel and the principal channel lineage.

Evidence from transects suggests that high-density Sabella beds certainly take several years and perhaps even decades to form. This process may be naturally dynamic, with beds forming and receding according to natural fluctuations in the hydrographic regime. Changes could also be the result of human influences on the hydrographic regime.

The water current exposed Sabella bed within the central Haven (HAC2) has formed under different conditions (max. recorded tidal velocity - 4.5 knots). Within the local vicinity of the bed, there is evidence that the cobbles are relatively stable (which would be a

necessary prerequisite for bed formation). A few metres away, the cobble cover is evidently much more mobile and is entirely free of Sabella. At this locality, the Sabella tubes probably have no influence on the sedimentary regime.

The principal conservation significance of the Sabella beds within the Harbour lies in their provision of anchorage and / or shelter for a multitude of other species. In fact the greatest concentrations of species within the Harbour occur in association with Sabella beds. However, species richness varies considerably from bed to bed, differences relating principally to turbidity, salinity and perhaps pollution differences between channel lineages. The greatest species richness was found to occur in the outer South Deep, the area experiencing the clearest water, highest and most stable salinities and perhaps the lowest levels of pollution and other disturbances of all the channels within the Harbour.

Crepidula fornicata (Slipper Limpet) communities

Individuals of the gastropod mollusc Crepidula fornicata can grow up to 5cm across and are able to colonize a variety of hard substrates, but have their greatest ecological impact when colonizing each other as self supporting stacks or clusters. These can grow up to 25cm across and can accumulate to cover a range of unconsolidated and consolidated bed substrates to very high densities.

Crepidula is particularly characteristic of moderately to strongly current scoured channel beds, and more continuously spans the tidal velocity range than does Sabella pavonina (figs. 10, 15). Its confinement to more current swept areas is 1) a feeding requirement, and 2) necessary to avoid smothering by fine particulate materials. Unlike true limpets, but in common with oysters, mussels and cockles, it is a suspension feeder, filtering particulate food from the flowing water.

It is an alien (introduced) species of North American origin and was accidentally introduced into British waters along with consignments of live oysters during the late 1800's. Over the past century it has consolidated and greatly changed the ecology of many coastal basins within southern Britain including Poole Harbour. In Poole, it is particularly significant on several counts:

1) It constitutes the foundation of one of the four major epibenthic community types recognised within the Harbour. In terms of biomass (as gauged by the dredge survey) and in terms of the area colonized and range of penetration within the Harbour, it is the most common invertebrate.

2) Some of the more sheltered Crepidula beds provide the framework for colonization by numerous subsidiary species.

3) Crepidula shells liberated from clusters provide a major resource of hard substrates for colonization within the Harbour, not only within the Crepidula beds but also further afield, wherever the shells are transported to and remain exposed on the channel bed.

4) Crepidula overlaps strongly with the native oyster Ostrea edulis. The former, which is the superior space competitor of the two, is believed to have been and continues to be a major factor contributing to the decline in natural oyster stocks within the Harbour.

Crepidula has one of the highest ranges of tolerances to the estuarine gradient, e.g. to declining salinities and increasing turbidities. Live individuals can occur wherever hard substrates coincide with at least moderate tidal flow within the polyhaline and mesohaline (but not oligohaline) areas of the Harbour. Dense Crepidula beds occur in most channels of the Harbour with the exception of the Upper Holes Bay and Lytchett Bay Channels (HBU, LBC) (figs. 10, 15). However, it is relatively intolerant to desiccation and whereas isolated individuals can occur on the lower shore, clusters and beds only occur within the subtidal. Since these clusters are free to roll and be moved around by tidal currents, aggregations only accumulate on fairly level channel beds or within concavities.

The upstream extinction point for Crepidula beds is similar to that for Sabella and for the same reasons. Although the baffle effect of increasing the net accretion of fine particulate materials is not as great as with Sabella stands, it is still significant and fine particulate materials can accumulate between the clusters on the less current scoured beds. Upstream extinction points are evident within the Upper South Deep, the Lower Wych, the Lower Wareham and the Lower Holes Bay Channels (SDU, WYL, WCL, HBL). However, the process is complicated since unlike Sabella, which is less tolerant of reduced salinities, Crepidula beds can also occur further upstream, in areas where tidal velocities are locally elevated. Such isolated populations were identified within the Upper Wych, the Middle and Upper Wareham, and the Lower Holes Bay Channels (WYU, WCM, WCU, HBL).

Crepidula beds often coincide with those of Sabella within the same cross channel profiles. At certain localities the two intermix and alternate in predominance according to subtle changes in hydrography and the nature of the substrate, the Crepidula coinciding with more current scoured sections of the channel profile. This happens within parts of the Lower South Deep, the Lower Wych, and the Upper Main Channels (SDL, WYL, MCU).

The downstream limit of Crepidula is governed by tidal velocities. Beyond a certain threshold value, the Crepidula clusters are mobilized and expelled into quieter waters. Within the Haven Channel (HAC), Crepidula is totally precluded from the most current scoured areas but forms extensive beds to either end of this zone. Elsewhere, where current scouring is sufficient to preclude Sabella beds, Crepidula can be confined to less current scoured sections of the profile, e.g. at the union of the Upper Main and Diver Channels (MCU, DVC), the central section of the profile is of coarse mobile sand, clear of Crepidula clusters, however dense beds form at the channel periphery there. A little further upstream, where tidal scour is less, Crepidula beds occur at channel centre but not at the peripheries.

The size and nature of Crepidula clusters varies through the channel network. Rogers (1986) compared the size structure of Crepidula clusters from three locations within the Harbour, within the Lower Holes Bay, Upper Main, and the Haven Channels (HBL, MCU, HAC). The largest clusters with the largest number of juveniles occurs within the Upper Main Channel (MCU) populations (perhaps indicative of the most ideal conditions there). The Holes Bay Crepidula clusters contained few individuals, and most of these were large (old), very few juveniles being present. This may be indicative of a decline in this particular population. Holes Bay is regarded as the most polluted area of Poole Harbour in many respects and molluscs are known to concentrate some pollutants and to be very sensitive to others (see POLLUTION).

Crepidula can be regarded as a pest on several counts, not the least

as an unwelcome alien species which has displaced others including the native Ostrea edulis. However, Crepidula has been irrevocably part of the British fauna for 100 years. Accepting this, the Crepidula beds do have some positive aspects when considered in the context of the ecology of the Harbour as a whole, in providing the framework for reservoirs of species richness (see below).

Highly current exposed Crepidula beds usually occur on coarse sand or gravels and are composed of mobile clusters which may roll in the current. Such clusters are typically colonized by abrasion resistant species, by Pomatoceros and the barnacle Balanus improvisus. The inner facet of the dead end shell, protected from abrasion, is typically colonised by the thin encrusting sponge Microciona atrasanguinea. Very few subsidiary biota occur within such beds. These communities are common within the more downstream channels and occur within the Swash, the Haven, the bottom of the Lower South Deep, and also in the Upper Main Channels (SWC, HAC, SDL, MCU). In more upstream areas where salinities reduced, only the barnacles persist as epibionts.

The constituent clusters of moderately current exposed Crepidula beds tend to grow to a larger size (by supporting more individuals) and are less mobile. The clusters themselves, and interstices between, are colonized by a variety of subsidiary species, the content of which varies between beds according to changing salinities and other hydrographic factors. Within the less turbid, polyhaline areas of the Harbour, sessile species can include, in addition to small quantities of Pomatoceros and barnacles, larger, higher drag forms, algae such as Ceramium rubrum, the sponge Suberites ficus and the boring sponge Cliona celata (which can kill the limpets), together with ascidians such as Ascidiella aspersa and Styela clava. Interstices between clusters can be colonised by Crustacea such as the squat lobster Galathea strigosa or small fish such as Pholis gunellus. The most species rich bed of this type may be that occurring at the junction of the Upper Main and Diver Channels (MCU4 / DVC8) although others may occur within the Lower South Deep and Lower Wych Channels (SDL, WCL).

Within the more turbid, mesohaline areas of the Harbour, clusters are typically colonized by Metridium (plumose anemone) and Anguinella palmata (Bryozoa) both very characteristic of turbid waters. Species richness is much less than for less turbid, more saline waters. Such communities occur within upstream sections of the Harbour, within the Middle and Upper Wareham, the Lower Holes Bay and the Upper Wych Channels (WCM, WCU, HBL, WYU).

Sargassum muticum (Japanese Seaweed) communities

Sargassum muticum ('Japanese Seaweed') is a large brown seaweed with a very high colonization potential. Characteristics contributing to this include fast growth rates, a high reproductive potential and the ability for the plants, buoyed up by their floats, to be distributed long distances by water currents. Sargassum also tolerates brackish water, but not mesohaline conditions. It is capable of colonizing a broad spectrum of hard substrates ranging from small shells and stones to stable hard bedrock. Plants colonizing small substrates can be carried by water currents by a combination of buoyancy and drag forces for very considerable distances. Floating plants which have jettisoned their substrates can be transported even further.

This high colonization potential is reflected in the rapid spread of

this alien, first established in U.K. waters in 1972 on the Isle of Wight, to coastal basins right along the south coast of England and on to the northwest European mainland (Critchley *et al* 1983). Dense copses of Sargassum form where transported plants are dumped and / or where direct settlement of sporelings is heavy, typically within the confines of sheltered embayments and tidal basins such as Poole Harbour.

Sargassum is of particular interest at Poole on several counts.

1) First recorded in the Harbour in 1978, Sargassum is now one of the three major species within the Harbour (table 1 in this section, also figs. 11, 17).

2) Sargassum plants provide the foundation for one of the major communities within the Harbour. Although possessing strong antibiotic protection, the copses still support a moderately species-rich assemblage of biota, both of epibionts and also associated mobile species.

3) Sargassum is often considered a pest species, both from the conservation viewpoint and that of navigators.

As would be expected, colonization was first recorded at the Harbour entrance, simultaneously on the shores at North and South Haven Points (September 1978, personal observation). This population perhaps started with the tidal transport and stranding of drifted plants originating within the Solent. Since then, the population has consolidated in a stepwise fashion. Each year Sargassum starts to grow in late winter, the plants reaching their maximum length, of the order of 3m in Poole, by early September. A die back follows until new fronds are generated the following season, from newly settled sporelings and the holdfasts of previously established plants. Each year, the number of fronds produced by each plant increases.

The current survey has shown that major colonization within the Harbour has been confined to the downstream areas, the clearer and more saline waters around the Harbour entrance, although sporadic drifted plants can and were found to occur in all parts of the Harbour (figs. 11, 17). Plants which remain in the upper reaches will die, salinities are too low and turbidities too high to permit photosynthesis in the subtidal zone. The largest populations occur within the Haven, the Lower South Deep, and Blood Alley Channels (HAC, SDL, BAC), and lesser ones within the Upper South Deep, the Lower Wych, the Diver and the Lower Main Channels (SDU, WYL, DVC, MCL).

The largest copses occur within the Lower South Deep and Blood Alley (SDL, BAC), on the sandy peripheries of the former and across the breadth of the latter which is very much shallower. In the South Deep (SDL2), very dense copses 3m across were observed (see Appendix III). These were surrounded by a trough in the otherwise sandy seabed filled with very fine gelatinous mud entrapped by the baffle effect of the copse. Within Blood Alley, Sargassum does not form copses sufficiently large or dense to produce the same effect.

Copses within the Haven, Diver and Upper Main Channels (HAC, DVC, MCU) are also peripheral in location whereas those within the Lower Wych Channel (WCL) are more central.

Sargassum can also occur as a major subsidiary species within moderately current exposed beds of Sabella and Crepidula (see appropriate sections), in which case the underlying substrate is mud rather than the more usual fine to medium sand. Sargassum only occurs

on coarse sand, when in transit. Substantial quantities were recorded during a dive on Poole Bar (SWC1) in the Harbour approaches. These were mobile plants being transported out of the Harbour on an ebb tide (it is likely that the import on the flood is less appreciable). Although plants may be dumped during slack waters, transport recommences during the next tidal run.

Sargassum plants can support an appreciable subsidiary community of species, although this is less rich than in the case of the lower energy Sabella and Crepidula communities (see appropriate sections). Subsidiary biota include other algae and sessile invertebrates, e.g. Ascidiella is particularly common as an epiphyte. Other species, particularly scrub algae, can share the holdfast without coming in to direct contact with the plant. Mobile species such as wrasses may shelter among the fronds within the copse. Species richness is not as great as it could be because Sargassum produces a powerful antibiotic which deters many potential associates.

Sargassum is regarded as a pest on several counts, particularly causing navigational problems for small boats (see Section I) and also, from the conservation viewpoint, the displacing of native species. The only obvious benefit can be that it adds to the biological production, and to a limited extent, the species richness within the Harbour.

Epibenthos of muds within very turbid areas

Moving upstream from the areas where Sabella beds can form, epibenthic cover diminishes as the accretion of finer particle fractions increases. Muds predominate, but where currents are stronger, generally poorly mixed sands and gravels can occur. Although the nature of the benthos changes according to substrate, the common denominator is the predominance of certain silt tolerant epibenthic forms, many of which are sponge species (fig. 21):

The sponge Cliona celata, often a pest of oyster beds, typically occurs in its Alpha form, boring and weakening Ostrea and Crepidula shells, often killing the occupants, and in this form is common within downstream areas of the Harbour. Within increasing turbidity, Beta colonies become more prevalent, the sponge outgrowing its shell substrate to form a large mound, free standing and typically hemispherical. Specimens up to 0.3m across were recorded on mud, sand and gravel at stations within the Upper South Deep, the Mid and Upper Wareham Channel and the Lower Holes Bay Channel (SDU, WCM, WCU, HBL)(fig. 21).

The sponge Haliclona oculata (Porifera) is an erect branching form which can colonise shells, stones or stable hard substrates. It was found to be common within the Upper South Deep, Upper Middle Channel, Lower and Mid Wareham Channel and the Lower Holes Bay Channel (SDU, MCU, WCL, WCM, HBL)(fig. 21).

Haliclona cinerea, an encrusting form, was found to be locally common on shells and stones within the Lower Wareham and Lower Holes Bay Channels (WCL, HBL).

Silt impregnated mound colonies of the sponge Hymenacion perleve outgrow their substrate in the same way as does Cliona celata. These are common within the Upper South Deep, Lower and Mid Wareham Channel and Lower Holes Bay Channel (SDU, WCL, WCM, HBL).

Silt impregnated mound colonies of the sponge Suberites massa occur sporadically on shells and stones within the Upper South Deep, Blood Alley (upper), Diver, Upper Main, Middle and Lower Wareham, and Lower Holes Bay Channels (SDU, BAC, DVC, MCU, WCM, WCL, HBL), but are very much more abundant on subtidal wharfs and artificial hard substrates within the Lower Holes Bay Channel (HBL)(fig. 21)(see section on RECLAMATION).

The plumose anemone Metridium senile (Coelenterata) flourishes within the turbid conditions of Poole Harbour, being most common where the turbidities are greatest, therefore it occurs within the Upper South Deep, Blood Alley, the Lower and Mid Wareham Channel (SDU, BAC, WCL, WCM), but is particularly common within the Upper Wych Channel, the Upper Wareham Channel and the Lower Holes Bay Channel (WYU, WCU, HBL)(fig. 21).

The edible mussel Mytilus edulis is rare within less turbid areas of the Harbour, but becomes more common where turbidities are greater (figs 21, 28). Clusters are found colonizing stones and shells within the Upper South Deep, the Mid and Upper Wareham Channel and the Lower Holes Bay Channel (SDU, WCM, WCU, HBL). They are also common as imported stocks laid on leased grounds (Lower South Deep, Upper Wych Channel - SDL, WYU).

The erect tufted bryozoan Anguinella palmata incorporates silt particles into its exoskeleton, possibly to merge with its background. Turfs up to 10cm in height are common on stones and shells within the most turbid areas where hard substrates occur (where it can co-dominate with Metridium senile) - the Upper South Deep, the Upper (most) Wych Channel, Middle and Upper Wareham Channel and the Lytchett Bay Channel (SDU, WYU, WCM, WCU, LBC)(fig. 21). Of indistinct appearance, this species may be widespread within turbid brackish waters of Southern Britain but is clearly often overlooked, however, the sizes of both the colonies and the populations occurring in Poole Harbour are exceptional.

Although currents generally decline moving upstream, local effects can produce increases. In addition to consolidated substrates, hard mud and poorly mixed sands and gravels with a high mud content characterise such areas. Where currents are particularly strong, local Crepidula beds can occur, as in the Upper Wych, the Upper Wareham, and the Lower Holes Bay Channels (WCU, WCU, HBL) (fig. 15), the clusters being colonized by Metridium and Anguinella in the most silty areas. Elsewhere, the mobile shells of Crepidula or other species can occur and be colonized by characteristic species, typically Balanus improvisus. Tracts of the Upper Wareham Channel (WCU) support a heavy dead shell cover, particularly of species imported from the flanking mud banks. Mya shells are particularly characteristic of this channel, but are only sporadic within the Lower Wareham Channel (WCL) and virtually absent from other channels (reflecting the restriction of the live populations of this species to the more typically estuarine parts of the Harbour). Shells of another typically estuarine species Scrobicularia plana are common within the uppermost section of the Upper Wareham Channel (WCU). Crepidula is extinguished by declining salinities half way up this channel, and Ostrea, the shells of which are so abundant within the lower Harbour, are virtually absent from the Upper Wareham Channel (WCU). Quantities of dead shells of Ostrea were recorded at the very top of the Upper Wareham Channel which is oligohaline, these clearly having been dumped there by fishermen, possibly some time ago.

The epibenthic cover declines along with salinities. Many species

extinguish at the half way point of the Upper Wareham Channel. Only barnacles, particularly Balanus improvisus but also Elminius modestus, extend, albeit increasingly sparsely, to the very top of the channel where stones and shells alike are nearly devoid of epibenthos.

Further down the tidal velocity spectrum, stones and shells upon sand may support larger higher drag forms including many of the epibenthic colonizers referred to in the preceding sections. Such conditions are most widespread within the Upper and Middle Wareham and Lower Holes Bay Channels (WCU, WCM, HBL).

Even further down the spectrum, as sands give way to mud and the space occupancy of epibenthic species declines even further, the increasingly localized small hard substrates that are available can still support very high occupancy covers of silt tolerant species, particularly Cliona, Metridium and Anguinella, until these too phase out to give way to inbenthos dominated communities.

Inbenthos of muds within very turbid areas

Extensive tracts of soft organic, anoxic mud characterise the least current scoured sections of the subtidal channel network, within the Upper South Deep, the uppermost Lower Wych and the Upper Wych in entirety, parts of the Lower and Upper Wareham Channels and the Upper Holes Bay Channel where net accretion is most appreciable (SDU, WYL, WYU, HBU).

The subtidal inbenthos is generally (with a few exceptions) very poor in species content and biomass compared to those intertidal muds occurring within some areas of the Harbour. Within the eastern arm of the Upper Holes Bay Channel and parts of the uppermost Wareham Channel, the muds are virtually fluid, the sediment being insufficiently firm and stable to support inbenthos.

Stands of the tubicolous phoronid Phoronis psammophila characterise some of the firmer muddy areas.

A common vertebrate infaunal species was found to be the eel Anguilla anguilla, which burrows in the subtidal mud within various parts of the Harbour, all winter whilst in dormancy and intermittently during summer months. Burrows made by Anguilla, sometimes containing occupants, were identified in various sections of the Lower and Upper South Deep, the Upper Wych and the Lower and Mid Wareham Channels (SDL, SDU, WYU, WCL, WCM). Although eel burrowing is well known for freshwater systems where cryptic habitats are lacking, the phenomenon is less well known for marine systems.

The Influences of Man - Navigation

The central aspect of the human association with Poole Harbour has always concerned its use as a natural harbour. This relationship continues to develop as the numbers and diversity of vessels used by the authorities, and by the commercial and recreational sectors increases. The provision of berthage and navigational routes within the Harbour for this multitude of vessels has resulted in a significant departure from the natural state within several areas. Authority for the running of all navigational aspects of the Harbour lies with the Poole Harbour Commissioners (P.H.C.) (this role is fully documented in P.H.C., 1982).

NAVIGATIONAL FACILITIES

The Port of Poole - berthage for 'large' commercial vessels

The Port of Poole first evolved within the naturally scoured and deepened entrance to Holes Bay (figs. 24, 25). Wharfage was developed along the shores of the Lower Holes Bay Channel (HBL), leading to channel constriction, generating still stronger tidal currents and scour, and therefore, greater channel depths. Although this has allowed access to still larger vessels, even now only coasters and small ferries can reach the Port (small by commercial shipping standards but classed as 'large' for the purposes of this report, see **QUICK REFERENCE GUIDE**). During the early 1970's, the southern shores of the Hamworthy Peninsula, i.e. the Lower Wareham Channel (WCL), were extended by reclamation and developed as a roll-on, roll-off ferry terminal handling commercial vehicles (and linking with Cherbourg, France). The reclaimed area includes one ferry berth and a vehicle marshalling yard. The area offshore to the terminal was dredged to a depth in excess of 5.6m (in places, significantly deeper). During 1982 / 83, the reclaimed area was extended westwards to provide for a second ferry berth and additional marshalling and storage facilities (figs. 24, 25). Since this required the isolation of the Poole Yacht Club and the elimination of its moorings, a new marina and club house were incorporated into the west end of the reclaimed area. A central section of the area has since been developed as the shore base for the Furzey Island oilfield development. This required some re-excavation to provide a new slip for roll-on / roll-off ferry barges capable of carrying large loads, and a pontoon (incorporated in the slip channel) for a passenger ferry boat service to the Island. Most recently, a passenger and car ferry service to France has been commissioned, and the ferries providing the commercial vehicle service have been lengthened. Both of these

developments have been possible because of the recent dredging of the Diver Channel (DVC) as a second shipping channel (April 1986, see below), producing a shorter, deeper, and more direct route between the Harbour Entrance and the Port (fig. 25). At least in the short term, both shipping channels are to be maintained (K. Birkmar, P.H.C., pers. comm.).

Berthing facilities within the Harbour for other 'working' vessels

Small commercial and other working vessels of 'intermediate' size and draught (see **QUICK REFERENCE GUIDE**) have long been a feature of the Harbour, and perhaps may be regarded as the largest size which the Harbour is 'naturally' able to accommodate, i.e. without the need for dredging (fig. 24). Barges and other small vessels were previously concerned with the clay excavation and pottery industries on Brownsea Island and sites on the shores of the mainland. Wooden piers were constructed in connection with this at each end of Brownsea Island, and on the mainland at Studland (South Haven Pier, now dismantled), Goathorn Point (derelict), Hamworthy (Lake Pier, now alternative uses) and to the immediate west of Lytchett Bay (Rockley Pier, dismantled).

With the exception of these piers, the Southern Sector of the Harbour has few berthing facilities. Private jetties for very light motor vessels have been constructed on Round, Green and Furzey Islands. With the onset of the oilfield development on Furzey, the pier there has been adopted as the berth for the passenger ferry to the Island. On the southern shore of Furzey, a large slipway ramp has been constructed, forming the Island terminal for the ferry barges carrying heavy loads. This has required the dredging of a short access gully, extending from the nearby bend in the South Deep up to the slip itself.

Most berthage for commercial and authority vessels is concentrated within the Northern Sector. At Hamworthy, slips and pontoons of the Royal Marines Base (WCM). Also at Hamworthy, and along the Holes Bay link-channel (HBL) in Poole, there are several boatyards, including that of the R.N.L.I.. At the east end of the Port of Poole, there is the Fishermans Dock, a small area of moorings partly enclosed by a boulder bund (HBL).

Vessels of intermediate size can access most of the Harbour's subtidal channels with the exception of the Lytchett Bay Channel (LBC) in total, and the upstream extremities of the Upper Wych, Upper Wareham and Upper Holes Bay Channels (WYU, WCU, HBU), however even these can be accessed on high spring tides (fig. 24).

Berthage for leisure vessels (yachts and cruisers).

Very large numbers of small jetties, pontoons and other berths characterise most of the northern shores of the Harbour, from the Haven to Rockley Point (fig. 24). Marina's have been constructed at Rockley (Rockley Point Marina) (LBC), within the Port expansion development at Hamworthy (Poole Yacht Club) (WCL), in Holes Bay (Cobbs Quay, Quay West Marina) (HBU & HBL), and at Lilliput (Blue Lagoon, Poole Harbour Yacht Club) (MCL). These are purpose built marina's (of various sizes) in which vessels are berthed at high densities on pontoons or moorings, in the case of Poole Yacht Club, Poole Harbour Yacht Club, and the Blue Lagoon, in 'artificial lagoons' enclosed by bunds and with restricted entrances. Another such programme is being considered for Parkstone Bay (MCU).

In fact the entire Harbour is relatively sheltered and forms a giant natural marina. Moorings for long-term anchorage occur throughout the Northern Sector (fig. 24). Moorings for yachts and motorised pleasure vessels are extensive in shallow subtidal areas flanking the top of the Haven, the Main, and Diver Channels, the south side of the Lower Wareham Channel (WCL), within the Lower Wych, and the channels within Holes Bay (HAC, MCL, MCU, DVC, WYL, HBL & HBC). Permanent 'open water' moorings are rare within the Southern Sector, only featuring within the outer River Frome. However, temporary moorings for leisure vessels occur within the 'central' Wych west of Brownsea, the uppermost Wych around Long and Round Islands, within Blood Alley and within both the Lower and Upper South Deep (WYU, BAC, SDL, SDU).

The only other appreciable shoreline berthage developments within the Southern Sector are within the lowest section of the River Frome at Wareham. Ridge Quay Marina, a relatively small development, is located around creeks arising from the river, and there is a wharf at Wareham itself.

All but the largest cruisers and yachts can access all channels of the Harbour during favourable states of the tide, and on high springs, can venture over intertidal flats and banks.

NAVIGATIONAL DREDGING

Shallowness at certain key points within the channel system between the Harbour approaches and the Port remains the principal factor limiting the size of commercial vessels entering the Harbour, at present to a draught limit of the order of 4m. This minimum depth is maintained by dredging of the shallow areas (fig. 25). Dredging can be categorized as follows:

1. **Major (structural) dredging**, is used to increase navigable depths substantially in excess of natural values, either by exceeding dredging rates required to counteract net accretion of sediments, or by the excavation of underlying consolidated strata (peat, clay, sandstone, etc.). This constitutes a form of submarine quarrying.
2. **Maintenance dredging** is routinely undertaken, usually on a small scale, to counteract net accretion, both natural or within areas previously deepened by structural dredging.

Poole Bar, the Swash and Haven Channels.

The section of channel which most limits the size of vessel able to enter the Harbour is in its approaches on 'Poole Bar', i.e. at the downstream end of the Swash Channel (SWC), where the bed is of current swept coarse sand which can, at channel centre, be as little as 4m below the water surface. Being a very dynamic bed, any increase in depth effected by dredging may be very short lived, and the longer term net effect may even be unfavourable. The Training Bank, a 1000m long artificial bund of large boulders, was constructed out from Studland Point, thereafter flanking the outer Swash Channel as far as the Bar (the bank peaks intertidally along its entire length). By directing and concentrating tidal flow, this has served to increase scour and maintain an increased channel depth within the outer Swash Channel and to an extent, on the Bar. Within recent years some dredging has taken place on Poole Bar, undertaken by a commercial suction dredger (P.H.C.,

1982). The effects of this are being closely monitored (K. Birkmar, pers. comm.). Within the Swash and Haven Channels (SWC, HAC) depths are generally well in excess of those limiting the size of vessel able to enter Poole, and therefore with one exception, dredging is not necessary. In the immediate vicinity of the Harbour Entrance, between North and South Haven Points, the trajectory of the deepest part of the channel changes direction several times. Immediately downstream of the entrance, it heads north-west towards North Haven Point. Immediately downstream of the north ferry ramp (HAC2) it is redirected to the south east, and just upstream of the chain-ferry (HAC3), it is again redirected, this time due west towards Brownsea Island at which point it turns due north. These changes are not so acute and the channel so narrow as to require large vessels to change course in order to negotiate. However, negotiation is fairly tight, particularly since the deeper sections are steep-sided and are flanked by much shallower areas (HAC2, HAC3). Of these shallows, 'Chapman's Peak' is closest to the navigational path, and naturally rises to within 2-3m of C.D.. The crest of this is dredged periodically to a depth of the order of 4m below C.D. by the P.H.C. grab dredger (fig. 25) (K. Birkmar, P.H.C., pers. comm.).

Main and Middle Channels

The Main Channel (MCL & MCU) which arcs through the north-eastern sector of the primary basin between the Haven and the Port of Poole was, until very recently, the only access route for large commercial vessels (fig. 24). Whereas the downstream-most quarter of this Channel (most of MCL) is naturally scoured to depths in excess of 5m (fig. 4), the inner three quarters (all of MCU, some of MCL) are not, and periodically have to be dredged to maintain the set minimum navigational depth of 4-5m (fig. 25). According to requirements identified by the P.H.C. Hydrographic Section, sections of this channel have been dredged by P.H.C.'s grab dredger (see P.H.C., 1982). In 1982, major structural dredging was undertaken along this entire section of Channel using a chartered bucket dredger, approximately 65,000 cu m. of material being removed in all (the spoil was dumped at sea). This project entailed the widening as well as deepening of the channels in question. A shorter and more direct route between the Haven and the Port is provided by the Diver Channel, naturally much shallower than the Main Channel and until recently, only used by vessels of intermediate draught, e.g. pilots, police, P.H.C. vessels, trawlers, B.P. ferries to Furzey, and by small leisure boats. In terms of frequency of traffic, the Diver has long been much busier than the Main Channel. Between February and April of 1986, a bucket dredger was commissioned to dredge the length of the Diver Channel (up to the Port) to a new depth of 5m below chart datum, so removing in excess of 250,000 cu.m. of substrate (K. Birkmar, P.H.C., pers. comm.).

The Port Area: Lower Wareham Channel

The most downstream section of the Lower Wareham Channel (WCL) has been subjected to major structural dredging in connection with the two phases of development of the Port Expansion Area (Ferry Terminals) (figs. 24, 25). All of the area has been dredged in excess of 5.6m, and maximum depths of 8.8m and 6.5m below chart datum were recorded on transects WCL2 and WCL4 respectively (both of which span the dredged area - Appendix III). In spite of the overdeepening of the channel, tidal currents are still strong. Overdeepened harbour basins are often characterised by deep accumulations of fine soft muds. In this instance, silting subsequent to dredging has occurred to a some

degree at the western, upstream end of the dredged area, but much of the eastern, downstream end is still clear.

The Port Area: Lower Holes Bay Channel

The downstream half of the link-channel connecting Holes Bay with the primary basin of the Harbour is the original locus for the Port. At first, vessels anchored towards midstream, but subsequently, intertidal areas were reclaimed to extend wharfs to the subtidal, initially on the town side (Town Quay) and then also on the Hamworthy (New Quay) side (figs 24, 25). The outer section of the link-channel, open to the east and flanked to the west by New Quay is liable to silting and requires regular maintenance dredging, undertaken by the P.H.C. grab dredger.

Between New and Town Quays, the much narrower, constricted channel experiences strong currents and scour, sufficiently so for navigable depths to be maintained without dredging.

THE ENVIRONMENTAL EFFECTS OF SHIPPING

The large numbers of vessels using the Harbour and their frequency of passage (fig. 24) affects some areas in various ways. Within the remainder of this sub-section, the consequences of navigational dredging and of the passage of vessels are considered from two viewpoints: 1) The consequences to seabed structure, non-living and living, both within the directly affected areas and further afield. 2) The prospects for recovery following dredging. From the viewpoint of navigation, some aspects of recovery are counterproductive since they involve the re-shallowing of the dredged area. However, recovery commences as soon as the dredging ceases, and the progress of this is of importance, particularly from the viewpoint of the management of navigable depths.

The effects of berthage construction, and of pollution originating from vessels and associated on shore facilities are considered in subsequent sections (see **RECLAMATION** and **POLLUTION**).

The effects of dredging

The environmental effects of navigational dredging can be as substantial as produced by quarrying on land. The immediate effects and the prospects for recovery depend on many factors, 1) the dredging methods used, 2) the scale of the operation, 3) the frequency of dredging, and 4) the type of seabed being dredged.

Most benthos is confined to the top metre of the seabed substrate column, and often much less. Navigational dredging procedures remove the seabed surface to depths in excess of 0.5m such that in effect all of the marine life within the dredged area is eradicated. The degree of effectiveness varies considerably according to the dredging technique employed. All routine maintenance dredging within the Harbour is undertaken by the P.H.C. grab dredger. Major structural dredging and large scale maintenance work is undertaken by chartered vessels, i.e. bucket dredgers, which employ a continuously rotating belt of scoops, and suction dredgers which in effect vacuum up the seabed materials (P.H.C., 1982).

The dredging method having the least impact on the seabed and

therefore providing the greatest prospect for recovery is, by virtue of its relative inefficiency, the grab dredging technique. This creates craters on the seabed, leaving intervening areas intact, both in terms of the substrate and biological communities. Recovery of the cratered areas themselves can take place by the transport of sediments and biota from the adjacent intact areas, depending on the sea bed type. Grab dredge cratering was observed on several dive transects within the Upper Main Channel (MCU)(see Appendix III).

By contrast, the bucket and suction dredge methods are much more thorough, removing the seabed in blanket fashion such that the direct impact greater, and prospects for recovery are less.

Much of what has been said above applies only to soft consolidated substrates and to sediments. Hard consolidated substrates, i.e. rock, cannot be dredged. This is not a consideration in the case of Poole Harbour since hard rock is absent from the channels that are dredged.

Soft consolidated substrates are readily dredged, but cannot recover in that they cannot be reconstituted. However, providing that they are not inundated by sediments, newly exposed faces can be colonized by marine organisms. Alternatively, the enlarged cross-channel bathymetric profile and associated weakening of the tidal currents and scour, may lead to the deposition of overlaying sediments, which will in due course be colonized by the appropriate sedimentary biota.

Natural exposures of clay, peat, and lignite do occur within areas of the Harbour that are dredged, within the Lower and Upper Main, the Diver, and the Lower Wareham Channels (MCL, MCU, DVC, WCL). However, still greater exposures have been uncovered by the dredging process itself, within all of those channels. Dredged exposures, free of overlying sediments, were found to be extensive within the central section of the Main Channel (MCU-MCL), and in the Lower Wareham Channel (WCL) off the Port Expansion area. A complete exposed profile, from marine clays, through freshwater peat, to Bagshot clays and sandstone conglomerates was identified on transect MCU2, and was found to be virtually biologically barren (see Appendix III and Dyrinda 1987a). Prior to dredging, the natural channel bed within this area was probably medium sand. Within the Lower Wareham Channel, the seabed has been lowered by up to of the order of 5m in places. The downstream section of this dredged area, in places more than 8 metres deep, is floored by a platform of Bagshot Clay exhibiting extensive dredge sculpturing, free of sediment and almost biologically barren (WCL 2, Appendix III). It is probable that the intrusion of the adjacent reclaimed area into the channel has increased tidal currents and scour within that section, so contributing to the prevention of sedimentation. A little further upstream, the dredged bed is more complicated. Local tracts of exposed Bagshot clays and sandstone conglomerates (and their liberated products) are muddy, and are separated by tracts of more recently deposited soft mud (WCL 3/4, Appendix III). This may in part be 'run off' slurry from the naturally intact mud beds that exist a little further upstream, combined with net accretion (accretion levels are high within this naturally very turbid area of the Harbour).

The direct biological loss resulting from the dredging of natural exposures of soft consolidated materials is small. This is because natural exposures of these substrates support only very species-poor biological communities. Dredged exposures were found to be virtually biologically barren except for the occasional occurrence of mobile

forms imported by the tidal currents.

High energy, current scoured sediments, cobbles, shells, and gravel beds are constantly being reworked and reorganised by the strong currents as a natural process. This is reflected in the robustness of their colonizers, mainly sessile species attached to colonizing cobbles and shells, these usually being abrasion and crush resistant. In view of this, the direct effects of the dredging of these substrates are likely to be minimal, and the potential for recovery, good. The only such area to be regularly dredged is 'Chapman's Peak', between the Havens (HAC3). This very dynamic structure was found to consist of coarse gravel, faced with an armouring of smoothly polished stones, with a minimal biological content (probably the most biologically barren bed of the entire Harbour). Grab dredge craters there would be quickly infilled and restructured, perhaps even within the span of a few spring tidal cycles.

Coarse sands also fall into the category of being high energy beds, constantly reworked by the tides and thrown into waves and other undulations. Coarse sand beds feature extensively within the areas that are dredged for navigational purposes, e.g. on Poole Bar (SWC), and within the Lower Main (MCL) and Diver (DVC) Channels (particularly within the entrance to the Diver Channel). In view of the very high mobility of coarse sand beds, the impact of dredging is likely to be the smallest, and the recovery prospects, the greatest of all substrates occurring within the Harbour. The direct biological loss is likely to be very small because the community is naturally poor in species. Dredged craters are likely to be quickly infilled with materials transported from adjacent areas. Biological recovery is likely to be rapid, by an influx of species from adjacent areas, sand eels rapidly reburrowing, and the colonizers of small stones and shells being readily mobilized and imported by tidal currents.

Medium and fine sands, together with muds are the most likely to be directly affected by dredging operations. These substrates are widespread within the upstream most areas dredged for navigational purposes, i.e. the top of the Upper Main Channel (MCU) and the bottom of the Lower Wareham Channel (WCL). Dredge craters in medium and fine sands may be fairly quickly infilled from surrounding intact areas, but craters within muds (all but the softest) will be filled much more slowly, by net accretion rather than lateral invasion. Since medium sands are principally colonized only by stands of Lanice, the direct biological loss there would be small, and the recovery rate, fairly rapid.

The areas floored by a mixture of fine sands and muds are of particular biological interest in that they support the most species rich, highest biomass communities within the Harbour, i.e. the Sabella communities, and to a lesser extent, those of Crepidula and Sargassum. The direct impact of dredging is likely to be greatest within such areas, and the recovery rate of the substrates and the biological components, the slowest. The Sabella beds can accrue and stabilize a substantial column of mud, up to 1m in thickness, and it is believed that the development of this, commencing with the pioneer colonization of fine sands, may take several years, and the formation of the species rich community, several years beyond that. The top of the Upper Main Channel, and the outermost section of the Lower Wareham Channel (MCU, WCL) may well have supported extensive Sabella beds at some stage. This would have been consistent with the gross distribution of Sabella beds across the Harbour (fig. 9). Fragmented Sabella beds are still evident within the Upper Main Channel (MCU), within undredged deeper areas

around Stakes Buoy (MCU). Very occasional Sabella clumps are also evident within the dredged sections of the Lower Wareham Channel (WCL), perhaps the remnants of former beds within that area. An unexpected find was the presence of a local but dense Sabella bed within the top of the Lower Main Channel (MCL), heavily disrupted by dredging, but still in part intact. This occurrence does not fit in with the Harbour-wide distribution pattern for Sabella. If Sabella beds were common within this section of the Main Channel, it was because the Main Channel departs from the general scheme of tidal exchange exhibited within all of the other channels. This is feasible because it is known that the tidal cycle within the Main Channel is consistently out of phase with those of the other channels.

It is also true that the presence of Sabella beds within navigational channels is incompatible with navigational requirements since they very substantially raise the level of the sea bed. However, their presence within other channels can be beneficial from the navigational viewpoint, since any shallowing within those may serve to redirect more flow into the navigational channels, so improving the scour rates there. Extensive Sabella banks occur within most of the South Deep (SDL & SDU), parts of the Lower Wych Channel (WYL), and within a restricted section of the Blood Alley Channel (BAC).

The direct biological loss resulting from the dredging of species rich Crepidula beds would be less than for Sabella beds. The rate of recovery would also be greater, since rapid re-invasion can be achieved by the tidal transport of established Crepidula clusters from adjacent areas.

In the case of Sargassum copses, the loss would be still less, and the recovery still greater. The former because fewer subsidiary species are involved, and the latter because Sargassum plants are readily transported by tidal currents.

Another important consideration concerns the indirect effects of dredging, i.e. the effects to areas of Harbour bed beyond the directly dredged area. One such effect which is often often referred to is the mobilisation of sediments, caused during the actual dredging operation. This can produce a plume of suspended material, extending down current. Since Poole Harbour is naturally a very turbid water environment, with a large suspended sediment load, the impact of materials accreted from a dredge plume is likely to be insubstantial in relation to naturally accreted materials. Dredge plumes can also contain biological elements as well as sediments. At the time of the second major dredging programme undertaken for the Port Expansion (1982), above normal quantities of detached and drifting Sargassum were evident within the central northern area of the Harbour, together with substantial quantities of other epibenthos, particularly sponges being washed up on adjacent shores. This was a short term phenomenon which ended soon after the dredging. The dumping of dredge spoil can also have a major ecological effect when undertaken within confined areas, but is not a factor within the Harbour because all dredged spoil is dumped out at sea.

The consequences of dredging most likely to have a significant indirect effect are modifications to the hydrographic regime, to the direction and strength of tidal currents and associated scour. This is because the substrates and biological communities of the Harbour change along an upstream gradient of declining current and scour, which is evident within all channels within the Harbour (see beginning of this Section). Because of this interdependence, changes to the hydrographic

characteristics of one section of the channel system may result in changes to the hydrography of other areas, producing changes to their substrates and biological communities. Shifts in long- and cross-channel distributions, or in the extent of particular substrates and biological communities, are possible. This is much more likely to be the case, rather than the total loss of substrates or biological communities. Only detailed hydrographic assessments, and the monitoring of the seabed substrates and biological communities can demonstrate as to whether any significant changes within the Harbour are occurring.

The movement of vessels

The effects of the passage of vessels through navigational channels depends on several factors, 1) the vessel characteristics, the size, the form of the hull, the method of propulsion, 2) the frequency of passage, and 3) channel bathymetry (and hence the amount of clearance) and also the nature of the channel bed.

Disturbances to the channel bed substrates and biological communities can occur without direct contact between the vessel and the seabed. Turbulences induced by the motion of screws, and also bow surge can disrupt the seabed where clearances are inadequate. In the case of totally inadequate clearances, where direct contact is involved, the seabed substrates can be affected by screw and keel gouging, although this obviously only occurs accidentally since it can cause damage to the vessel involved.

The largest vessels using the Harbour stand to have the greatest effects. Navigational clearances within sections of the Main Channel are minimal during certain states of the tide. Bow surge motion is often visible as vessels proceed, and screw induced turbulences are likely. According to the Harbour-wide distribution of channel bed substrates (fig. 8), higher energy sediments, i.e. medium and coarse sands and gravels, together with exposures of marine clay would be expected to dominate the Lower Main Channel (MCL). In comparison with other substrates these tend to be naturally relatively barren. In contrast, biologically rich, finer sediments may previously have dominated parts of the Upper Main Channel (except for the more current scoured point of union with the top of the Diver Channel). At present, several sections of the Main Channel can be described as being near biologically barren. Whereas in some areas, this does not represent a major departure from the natural state, in others, it does. Although navigational dredging is probably the primary cause of this departure, the effects of vessel movements may also be significant.

Extensive keel and screw gouging, evidence of regular groundings, was only evident within two sections of the channel network, the link between the Upper South Deep and Upper Wych Channels (SDU - WYU), and the very top of the Upper Wareham Channel (WCU), both extremely shallow sections floored by soft mud (hence liable to retain contact impressions) and only frequently used by small leisure vessels.

The impact of vessel movements is very dependent on the type of substrate. Bedrock (hard or soft), cobble, shell and gravel beds, are more likely to damage the vessel than vice versa. Coarse and medium sandy areas would be little affected. It is only those fine sands and muds that are dominated by epibenthos which could be affected to any degree.

Reclamation

Reclamation programmes have affected many parts of the Northern Sector of the Harbour, but are rare within the Southern Sector (fig. 25). The cumulative effect of these on the Harbour environment has been significant, directly involving of the order of 10% of the total Harbour area, and indirectly much more. Reclamation can be subdivided into, 1) **impoundment**, the annexation of particular areas, using breakwaters, bunds, etc..., and 2) **infilling** (often following on from impoundment), usually to above the high water mark, to create land for development.

IMPOUNDMENT

Impoundment programmes have significantly changed several sections of the Harbour (fig. 25). Within the Harbour approaches, a 1000m 'Training Bank', peaking intertidally, was constructed to concentrate tidal flow and so improve scouring and navigable depths within the Swash Channel and on Poole Bar (SWC). Within the Harbour, several bays and inlets along the northern shore have been partly or completely isolated, by the construction of railway embankments. One was constructed across the inner recesses of Parkstone Bay (MCU), so forming the lake within Poole Park. The narrow duct linking this to the main Harbour basin is usually kept closed and so the lake cannot be considered as being part of the Harbour. Another embankment was constructed across Holes Bay (HBU). In this case two more substantial ducts were incorporated to span the natural trajectories of the subtidal channels such that the northern, inner basin, although in effect nearly isolated, still experiences reasonable tidal exchange. Lytchett Bay (LBC) has been impounded in the same way, this time with only a single link-channel within the embankment. An area of intertidal flats and marshes on the north eastern corner of Brownsea Island was impounded totally by the construction of a large bund, and this area has also ceased to be part of the Harbour (HAC / WYL). The extension of berthage on both sides of the entrance of the Holes Bay Channel has led to the further isolation of all upstream areas within the Bay (HBL & HBU). On a much smaller scale, the same effect has been achieved at the mouth of the Blue Lagoon to the east (MCL), and still smaller areas of the Harbour have been impounded for the construction of marinas, i.e. Poole Yacht Club Marina (WCL), Cobbs Quay Marina (HBU), Poole Harbour Yacht Club Marina (MCL), and the only such development on the south side of the Harbour, the Ridge Quay Marina which branches off the mouth of the River Frome (above WCU).

The direct effects of such developments are limited in that only small areas are actually covered and hence lost beneath the bunds, breakwaters, etc... Of more importance are the indirect effects, i.e. particularly on the impounded area, but also, albeit to a lesser extent, on the surrounding areas beyond. Impoundment programmes can create systems with the characteristics of lagoons. This process of 'lagoonization' leads to the reduction of tidal exchange within the impounded area, and increased shelter against wave action. This combination of shelter from currents and waves can lead to the accumulation of finer sediments than would otherwise occur and greater shallowness, together producing a shift in the colonizing biological communities. However, within the link-channel of the impounded system (if there is one), the converse can happen. By virtue of the constriction of tidal flow, currents and scour are strengthened, producing greater depths and higher energy channel bed substrates and biological communities than would otherwise occur. 'Lagoonization' produces miniature artificial versions of the what constitutes the gross natural structure of the Harbour. Since the Harbour in general already exhibits these characteristics, the effects within the artificial subsidiary 'lagoons' are even stronger and more pronounced than would otherwise be the case, e.g. compounding natural characteristics of the Harbour such as poor tidal circulation. The area of the Harbour with characteristics which may be regarded as the most lagoonal is the inner basin of Holes Bay (HBU in part).

The 'lagoonal basins' within Holes Bay and Lytchett Bays, together with the various marinas, are floored by soft muds, generally inbenthos dominated, whereas their link channels, the entrance to Holes Bay (HBL), and the ducts through the railway embankments within Holes and Lytchett Bays (HBC, LBC) all experience strong tidal flow and scour and are floored by a coarse substrate regime, particularly of gravels. Stones and shells within these areas support a diversity of hard substrate colonizing species, including some generally rare sessile epibenthic invertebrates, proliferating there to unnatural levels (see below).

It is not possible to refer to the recovery of the impounded biological communities since the impoundment programmes are usually permanent.

By decreasing flushing levels, 'lagoonization' leads to water quality problems which are considered within the sub-section on **POLLUTION**.

INFILLING

The developments

Infilling programmes have also been undertaken on a large scale within the Harbour. Originally, this was for the provision of berthage within the Port area on the shores of the entrance to Holes Bay (HBL). Areas of what are now Holes and Parkstone Bays have also been infilled to accommodate the growing town of Poole. More recently, a significant area of Holes Bay was infilled to provide land for the construction of Poole Power Station (now closed)(HBU). A further area of Parkstone Bay, to seaward of the Boating Lake, has been reclaimed for recreational purposes, i.e. the 'Baiter' (MCU). During the early 1970's, an area off the Hamworthy foreshore was infilled for the continental ferry terminal (see **NAVIGATION**), and during 1982 / 83 this was extended westwards for

expansion purposes. In another programme, the eastern flank of Holes Bay has been infilled to provide land for a relief road for the town and Port of Poole (HBU) the last phase of this being in 1982 (see Dyrinda, 1983). Further infilling in Holes Bay is planned in connection with this relief road project (for more details on reclamation projects, see P.H.C. 1982).

The effects

The direct effects of infilling are the total loss of the infilled areas from the marine environment. As is the case for impoundment, because the developments are permanent, there is no recovery. To date, most infilling has been confined to intertidal areas, these being essentially beyond the scope of consideration of the current report. Very small areas of the subtidal have been lost locally, close to the embankments of Holes and Lytchett Bay and at the entrance to Holes Bay. The most significant loss to the subtidal has occurred off the Hamworthy foreshore as a consequence of the Port expansion programmes

One feature of these developments has been the provision of artificial hard substrates. The binding wharfs, walls and bunds of the reclaimed areas provide surfaces which can be colonized by the same kinds of sessile epibenthos which normally colonize natural hard substrates. The areas involved are small because the surfaces involved, tend to be vertically or steeply sloping. In Poole Harbour, these are significant because naturally hard substrates are very rare.

Species rich, high occupancy sessile epibenthic communities occur on artificial hard substrates within many parts of the Northern Sector, particularly where the tidal currents are strong. These assemblages are typically dominated by algae within the intertidal, but in cryptic intertidal locations (recesses beneath wharfs, etc...), and all subtidal locations, the domination is by sessile **invertebrates**. Such communities occur on piers and seawalls within the Haven (HAC2), along the Town and New Quays of the Port (HBL), and along the recently constructed bund of the Port expansion Area (WCL), and on a more local scale within the link channels of the railway embankments spanning Holes Bay (HBU) and Lytchett Bays (LBC). The hard substrates of the Haven area are most notable for the species diversity of the sessile fauna which can be described as 'reduced marine'. Within the Port Area (HBL) the fauna is highly unusual, a polyhaline, sponge - ascidian community which is dominated by the sponge Suberites massa, present there in very considerable quantities, but otherwise rare in British waters. Seven other sponge species occur within this community: Halichondria bowerbanki, Hymeniacion perleve, Haliclona oculata, Haliclona cinerea, Microciona atrasanguinea, Cliona celata, and Raspailia hispida, together with ascidians, particularly Ascidiella aspersa, Styela clava and Botryllus schlosseri, and also a diversity of subsidiary species (see species list for HBL, Appendix II). A totally different but comparably unusual artificial hard substrate community has also developed within the link channel to Lytchett Bay (LBC). This mesohaline community is dominated by **hydroids** and **bryozoans**, the former including Sertularia cupressina and Obelia bidentata, and the latter Anguinella palmata and Farella repens (both little known in British waters) together with Valkeria uva (see species list for LBC, Appendix II).

It is clear that the provision of artificial hard substrates has allowed some hard substrate colonizers, which otherwise would have been confined to small hard substrates such as cobbles and shells, to proliferate to levels which would otherwise have been impossible in

P
o
o
l
e
H
a
r
b
o
u
r
.
H
o
w
e
v
e
r
,
t
h
i
s
g
a
i
n
m
u
s
t
b
e
w
e
i
g
h
e
d
a
g
a
i
n
s
t
t
h
e
l
o
s
s
o
f
n
a
t
u
r
a
l
c
o
m
m
u
n
i
t
i
e
s
r
e
s
u
l
t
i
n
g
f
r
o
m
t
h
e
d
e
v
e
l
o
p
m
e
n
t
s
i
n
q
u
e
s
t
i
o
n
.

Fisheries

A diversity of marine species are commercially harvested from the Harbour by numerous part or full time fishermen. Although, with some exceptions, stocks are small, the combined total value of the fishery is significant. The Harbour may be still more important as a breeding and nursery ground for species which are commercially exploited off the adjacent open coast.

Although this report is mainly concerned with the overall environment of the Harbour, commercially important species are a significant consideration in that 1. they are constituents of the natural biological communities, and 2. their commercial exploitation can have consequences, not only for the exploited species themselves, but indirectly, also for non-commercial species.

The following section deals with the major, commercially exploited groups:

ANNELIDS (MARINE WORMS)

Both bait digging and dragging for marine worms take place within the Harbour, undertaken by both private individuals and commercial operators. However, operations are mainly confined to the intertidal zone where the target species, Arenicola marina (Lugworm) and species of Nereis (particularly Nereis diversicolor, the common Ragworm, and Nereis virens, the King Ragworm) are most common and most accessible. In disrupting the sediment column by turning or ploughing, significant damage may be done to the areas involved. The subtidal zone is unaffected by bait digging, and only marginally by bait dragging.

CRUSTACEA - PRAWNS

Species such as Leander are common within the Harbour, being caught by push netting on sandy shores at around the chart datum line. This activity is most prevalent within the north eastern area of the Harbour, where sandy shores are most extensive. Push netting on this scale probably has little effect on natural communities.

CRUSTACEA - CRABS AND LOBSTERS

Carcinus maenas is extremely abundant within all parts of Poole Harbour. The commercial significance of this vigorous carnivore and scavenger relates to its use by fishermen as bait, and also its role as a pest species by being a major predator of bivalve molluscs. Private and commercial rod fishermen collect crabs by turning stones and boulders on suitable shores, or by setting crab pots baited with fish meat within the subtidal zone. Stone turning can be damaging since these are rarely restored to their former orientation, such that the associated species are lost. Boulder shores are generally rare in Poole Harbour, but artificial ones do occur on South Haven Beach (the remnants of South Haven Pier) (SDL) and also beneath the nearby jetties of the North Haven Point (HAC). Both sites are current scoured and were identified from shore surveys as supporting very species - rich biological communities (pers. records). The use of pots to catch crabs is not considered to have any adverse effects, other than stock depletion, which, in view of the very prolific numbers of shore crabs within the Harbour, and the problems they cause, is unlikely to be regarded as unfavourable. However, their major role as scavengers of dead material is an ecologically important one.

Cancer pagurus, the common edible crab, has penetrated well into Poole Harbour (fig. 27). During the current survey, Cancer was recorded from the Swash, Haven, Main, Blood Alley, Lower Wych, and Lower Holes Bay Channels (HAC, MCL, MCU, BAC, WYL, HBL), generally in very small numbers and usually colonizing cryptic habitats ranging from sea bed debris to boulder bunds, particularly that fringing the reclaimed areas of the Lower Wareham Channel (WCL), to natural bedrock underhangs within the Haven Channel (HAC). Some of these specimens are undoubtedly escapees from fishermen's 'keep pots'. Although not present in commercial quantities, their occurrence within the Harbour is ecologically significant.

Maia squinado (edible spider crab) was found to be common within the Haven Channel (HAC) and the most downstream sections of the Lower South Deep (SDL) (fig. 27), apparently confined to those areas because of a low tolerance to reduced salinities. Its occurrence within the Harbour is an early summer phenomenon at which time the crabs move inshore to breed. Returns from crab potting within the Harbour would not be commercially significant.

Homarus vulgaris (European lobster) is a fully marine species inhabiting cryptic habitats. It is able to tolerate turbid conditions and several juveniles were recorded beneath ledges in the Haven Channel (HA5), all of which were below the minimum commercial size. Although of no commercial value, the stock is significant as a nursery one.

GASTROPOD MOLLUSCS

Littorina littorea (edible winkle) constitutes a small scale commercially viable resource, essentially confined to the intertidal but mentioned here because accumulations of winkle shells are a locally common feature within subtidal channels (stations in the Lower Main and Lower Wych Channels - MCL & WYL) and can occur more generally if colonized and transported by the hermit crab Eupagurus (particularly within the channels of the north eastern sector - Upper & Lower Main, Diver, Lower Wych Channels - MCL, MCU, DVC, WYL). Artificial hard

substrate shores examined recently have been found to be noticeably devoid of winkles (pers. obs.). Since these occur along the readily accessible northern shores of the Harbour, collecting may be the cause of the low numbers. Alternatively, pollution may have contributed to the decline (see below). Winkle shells may be recycled within the subtidal zone for long periods of time (years or more) such that their abundance cannot be regarded as being indicative of the current state of the living populations.

Buccinum undatum (edible whelk) is typically associated with current-swept gravelly, shelly or stony channel beds within the more marine areas of the Harbour including the Swash and Haven Channels (SWC, HAC), and the Main and Diver Channels as far as their upstream junction (MCL, MCU, DVC). It is locally common, but, because of the small size of the channels, populations would quickly be fished out if commercially exploited.

BIVALVE MOLLUSCS

Both natural and farmed stocks of the native oyster Ostrea edulis are fished within the Harbour (figs. 19, 29). However, current natural stock levels for Ostrea are clearly only a small fraction of those which formerly (in previous centuries) prevailed, and most of the current yield of the Harbour is constituted by the produce of farmed stocks (fig. 29). Records show that a substantial fishery for Ostrea has existed within the Harbour since the Roman occupation, but peaked during the last century. Indeed, a proportion of the waterfront of the early Port of Poole is constructed on deposits of oyster shells accumulated by the fishermen. Onshore dumping proved so problematical that eventually the dumping of oyster shells on land within the Port was prohibited. Discarded shells subsequently dumped within the Harbour have formed an intertidal accumulation, still visible off the Old Town Quay. It is likely that the natural oyster populations occurred within much of the Harbour, except for the Upper Wareham Channel (WCU) where salinities are too low. The early part of this century saw a crash in natural oyster stocks in many parts of Britain including Poole. Several factors were responsible, possibly including a disease and certainly the arrival of the slipper limpet Crepidula fornicata. Introduced along with imports of live oysters from North America during the 1880's, this species subsequently spread to a number of brackish water coastal basins within southern Britain. This prolific and superior space competitor favours the same habitats as oysters. It outcompetes for space and can occur at very high densities, and where it occurs in beds, relegates the oysters to a subsidiary status. Crepidula is the most common and widespread invertebrate within Poole Harbour, forming dense beds at a variety of locations. Ostrea features as a subsidiary within several of these. Another factor which may well have contributed to the demise of the oyster is overfishing. Particularly within the narrow channels which characterise Poole Harbour, it is very easy to blanket dredge such as to substantially deplete the stocks. It may be significant that with the exception of the farmed areas, the largest accumulations of oysters were identified within Holes Bay (HBL, HBU), which has (officially) been unfished for several years, as a result of it having been designated a reserve for scientific research by M.A.F.F. (Maj. A. Parker, pers. comm.).

Whatever the cause, Ostrea has now been relegated from its probable top or second position in the league of abundance within the Harbour to its present, more subsidiary status.

It is likely that Ostrea was particularly abundant within the midstream sections of channels where tides are not sufficiently vigorous to mobilize the live oysters, yet the bed is stable and firm. Ostrea was probably most abundant from the low water spring level downwards. It was probably possible to hand collect commercially viable quantities of oysters at just below the low water spring mark - one major oyster farm within the Harbour still uses a bed at this level.

The present survey has shown dead shells to be very abundant indeed within certain areas of the Harbour. However, it is not possible to assume that this is a reflection of the level of recent populations since, as with many molluscs, oyster shells can persist intact for very long periods of time. Although many shells are 'lost' to the system by becoming incorporated into accumulating muds and sands, others are transported to current scoured areas where they may accumulate to very high densities, in extreme instances, such as to dominate the structure of the sediment (see Fig. 19 and dive transects HAC2, MCL4, MCU6, MCU8, WCU9). Whereas some of these accumulations are clearly the result of transport of shells from natural populations of oysters, others may be the result of oyster shell dumping.

The present distribution of live oysters within the Harbour is largely the product of human control. Although natural stocks are depleted, the conditions favourable for oyster growth persist (although increasingly at risk from pollution) and oysters are at present grown in various parts of the Harbour. The fishery is regulated by the Southern Sea District Fisheries Committee. Sectors of the Harbour bed are leased to individuals, to be managed as natural or farmed stocks, the lease holder being required to mark off the area with buoys (fig. 29). Other areas of the Harbour have been designated 'public' fisheries for oysters, which anyone may dredge during the open season. As mentioned above, yet another area, Holes Bay, has been designated a reserve for Scientific Research, no dredging being permitted there. Several of the leased grounds were included in the current survey.

Two farmed areas were examined (dive transects SDL5 within the Lower South Deep, intertidal area off the Upper Wych Channel, WYL). Significant numbers of Ostrea occur within what are very localised sections of these areas. The oysters, first grown elsewhere within the S.S.D.F.C. region are imported to the Harbour and deposited for fattening, perhaps for 1 year. The areas affected are very localised, this probably being necessary since the oysters must be readily retrievable as required. The effects of this activity on the natural benthos are fairly comparable to some traditional land farming techniques. A prerequisite operation is to clear the areas of other benthos, by intensive dredging (= ploughing). This also serves to 'firm-up' the ground by mobilizing finer sediments but leaving constituent shell, etc..., behind. The dive transects SDL5 and WCM4 (see Dyrinda, 1985 & Dyrinda, 1987a) illustrated the effects of this action. Within the affected area, other benthos is very reduced or absent, but even immediately beyond this area, even within the same transect, the natural communities appear to be little affected. In addition to naturally occurring stones and shells exposed by the dredging, more hard material accumulates from the farming process itself, e.g. the shells of cultured oysters which die before harvesting. Subsequent to the laying of the stock, recolonization (recovery) by natural benthos is suppressed by the periodic redredging. However, only the most rapid colonizers have any chance of taking a hold. Ascidrella is the most problematical species in this respect in Poole Harbour, and often must be stripped in substantial quantities from the oysters as they are harvested. Carcinus is a major predator of

oysters in Poole Harbour and as such constitutes an (uncontrollable) pest to farmers (see above).

Oyster farming clearly has a significant effect on the natural ecology of the directly affected areas, by reducing the natural species content and modifying the substrate regime. In this context, although some of the leased grounds fall within areas of the Harbour where the most species rich and highest biomass natural communities occur, at present, farming is confined to definitive small sectors of the leased grounds, and the effects of the operations beyond the directly farmed ground, even further afield within the same leased areas, are negligible. Additionally, so long as the farmed areas remain small, once farming has ceased, recovery is rapid.

The more general dredging that takes place within the public grounds could, potentially, be more harmful since, in view of the generally low densities of natural oysters, extensive areas would have to be dredged intensely to produce adequate returns.

In the past, the Portugese Oyster Crassostrea gigas has been introduced into the Harbour as a farmed species. Evidence of depositions by the former 'Poole Oyster Company' (who ceased operations in 1982) within the Lower South Deep (SDL) still persist. Several large and old live specimens, and also dead shells were recovered from one section of that channel, east of Goathorn Point (fig. 28). The absence of juveniles suggests that Crassostrea is not breeding naturally within the Harbour (although it does in other British localities - S. Fowler, N.C.C., pers. comm.) and that once the remaining commercially laid individuals die-off, the population will cease, although the shells will persist for some time. A valve of Crassostrea was also recovered from the Lower Wych Channel (WYL), possibly a remnant of farming within that area.

Venus mercenaria (American clam) was unsuccessfully, experimentally introduced to Poole Harbour during the 1970's. An imported population was deposited within a sector of the Lower Wareham Channel (WCL), just offshore to the former Power Station Outfall. However, the population did not take (see ALIEN SPECIES & POLLUTION, this section). Very extensive breeding populations of Venus are harvested commercially within the Solent area.

Both Venerupis decussata and Venerupis semidecussata have been imported, deposited (the latter in cages) and grown in small quantities on an experimental basis within one farmed area of the Harbour (at the east end of the Upper Wych Channel (WYU)).

What are probably natural populations of Mytilus edulis were identified within the South Deep (SDU) and also the Middle Wareham Channel (WCM) (fig. 21, 28). Whereas these are small from the viewpoint of commercial exploitation, they are indicative of the favourable conditions for the growth of mussels that exist within the more upstream, siltier sections of the subtidal channel network. Mussels are farmed within an intertidal area off the Upper Wych Channel. This involves the fattening of juveniles introduced from other U.K. areas.

FISH SPECIES

Although only a small number of fish species are harvested within the Harbour in what can be regarded as substantial commercial quantities, the greater diversity caught in small numbers constitutes a

significant yield when considered together. Methods employed include rod fishing, trapping, seine and gill netting, and trawling.

Although the emphasis of this survey is towards benthic (seabed) communities, samples and records have also been gathered for fish species, commercial and non commercial, as listed in the species inventory (appendix II). These records are in part based on returns provided by some commercial fishermen operating within the Harbour (see acknowledgements), in addition to observations from dives and from dredge and grab samples. The records are slightly biased towards the more lethargic epibenthic species more likely to have been observed during dives, e.g. pipefish, flounders, etc....

Anguilla anguilla (Common European Eel) occurs within the Harbour in very large numbers. Overwintering fish burrow into the mud and enter a dormant phase. During summer, in the general absence of good cryptic habitats, some eels periodically burrow for refuge. Recent eel burrows (in instances still occupied) were observed in soft mud in several parts of the channel system, the largest numbers being on one channel flank immediately adjacent to Goathorn Point within the Lower South Deep (SDL). Eels are most effectively caught using a system of traps, and several fishermen within the Harbour use this procedure on a commercial scale. Traps are unlikely to disturb the seabed to a significant degree but can be non-selective, catching large numbers of incidental species including the juveniles of other commercial species. Some hold the view that the eels are the staple diet of shags within the Harbour and that the latter may be appreciably reducing the eel stocks.

Platichthyes flesus (Flounder) is, as would be expected within an estuarine system, the most widespread of flatfish within the Harbour, observed at many dive stations, but particularly over sands and muds with low epibenthic cover. Some of the channels, such as the Diver Channel (DVC), have been periodically trawled for flounder and other flatfish. The effects of this on the areas of seabed in question are likely to be small, although this would not be the case in the areas where the epibenthos is more substantial

Chelon labrosus (Grey Mullet) is very common as a grazer within all parts of the Harbour, but particularly within the upstream areas flanked by mud flats. Mullet are caught by netting at low tide. Fishermen often select the narrowest creeks of the inner recesses of the channel network, e.g. Holes Bay (HBU) where large numbers of fish occur and can be readily entrapped by netting.

Dicetrarchus labrax (Bass) are very common within many areas of the Harbour, but particularly so within the downstream sections where they are caught commercially by seine and gill netting, and by rod fishing.

SUMMARY OF SOME POTENTIAL EFFECTS OF FISHING TECHNIQUES

ON THE ENVIRONMENT

All effective fishing techniques are significant at least in that they have the potential to deplete / reduce stocks of the target species, as well as of species incidentally retained within catches, e.g. juveniles of commercial species and adults or juveniles of other biota.

a) Rod fishing - Of the various techniques employed, this is probably

the least damaging procedure.

b) Gill and seine netting. Operated during low tide periods within the confines of narrow subtidal channels, these procedures can be extremely effective (possibly with consequences for stock depletion).

c) Traps - Probably not harmful, except for the often substantial incidental catches.

d) Trawling - This can be very efficient when undertaken within the confines of the narrow channels, with consequences for stock depletion. The degree of any physical damage to benthos depends on the weighting of the ground line, but would be expected to be very much less significant than the results of dredging.

e) Shellfish Dredging - Probably the most harmful fishing technique as far as physical and biological damage to the seabed is concerned. Shellfish dredging has the capability to strip virtually any epibenthic species from the seabed and to substantially disrupt the inbenthos by ploughing through the surface of the sediment column. The effect would be greatest on the epibenthos dominated communities of fine sediments, and on Sabella beds in particular.

Alien Species

The establishment and consolidation of populations of alien species introduced from other parts of the world has had a very major effect on the subtidal ecology of Poole Harbour. Directly or indirectly, many of these arrivals have been attributed to international shipping movements or the movements of live oysters and other shellfish (the easier pathway of introduction, but now more controlled). With growing internationalism, ship born introductions are bound to continue, although because of the very unfavourable consequences of certain previous introductions, the movement of shellfish not only into, but also within the U.K. is now more tightly monitored than was previously the case. Some of the most important alien arrivals, and how they have altered the Harbour environment, are described below:

ACCIDENTALLY INTRODUCED SPECIES

Sargassum muticum - Japanese Seaweed

Over the past eight years, this large and fast growing alien has progressively invaded the outer Harbour to the extent that it now forms a community in its own right as well as featuring as a subsidiary within many of the other communities of the Harbour. In doing so, it has partially (but not completely) displaced various native organisms, some of which are of conservation interest. Although it is a locus for substantial biological productivity, the resulting copses are less species-rich than some other major epibenthic communities. The consequences of the invasion by this species are not so appreciable as might have been anticipated. Mature Sargassum copses form in sandy areas previously largely clear of epibenthos. Sargassum can also occur as a major subsidiary within Sabella and Crepidula communities.

Navigators regard Sargassum as a pest since the dense copses, which often form within navigational waterways, are capable of immobilizing small boats. Dense propellor entanglement can interfere with steering or even stall the engine, even a few fronds trailed from an engine shaft can appreciably reduce power, and jet boats can be immobilized if Sargassum is drawn into their intakes. The navigational effects of Sargassum are more serious in Poole Harbour than in many other places because of the very large numbers of small boats using the Harbour. Problems occur along the Lower South Deep, Blood Alley (SDL, BAC), and

parts of the Upper South Deep, the Lower Wych and the Diver Channels where the greatest quantities of this species occur (fig. 11, 17)(SDU, WYL, DVC). Some degree of control is attempted within certain areas within summer months when the plants are at their largest (Lt. G. Wareham, P.H.C., pers. comm.). However, it is very important to kill the collected plants, and if possible, to lift the substrates as well (if stone or shell).

Sargassum is also of interest from the navigational viewpoint since, as dense copses, it has the potential to locally alter the bathymetric regime by producing elevated net accretion of finer particles than would otherwise accumulate. However, this is only temporary since Sargassum grows on a seasonal cycle, commencing in winter. The fronds attain their maximum length in late summer, before being shed in autumn, after which time, any accumulated sediments would be remobilized.

Sargassum also has the potential to be a pest on oyster beds by proliferating on the live and dead shells within the bed and so reducing the yield per dredge haul, or worse still, by colonizing live oysters and by 'stealing' these from the oyster beds by flotation and drag (tidal transport).

Irrespective of the above viewpoints, Sargassum, a weed in every sense, is here to stay. Attempts at eradication were futile even whilst it was confined to the Isle of Wight area. It can only be controlled by physical means, in the immediate areas where it causes the greatest problems. Chemical control would be totally inviable, being ineffective and potentially harmful to many other species.

Crepidula fornicata (American slipper limpet)

Crepidula fornicata, introduced along with shellfish from North America a century ago, is now the most common subtidal species, and the major community former within the Harbour. Its preferred habitat strongly overlaps with that of Ostrea edulis, in comparison with which it is very much a superior competitor for space, forming very dense beds within former oyster beds (see sub-section on the FISHERIES).

It is difficult to envisage what the subtidal environment of the Harbour looked like before the arrival of Crepidula. It is known that previously, Ostrea edulis was very much more common than it is now. The crash in oyster populations and also its inability to recover since may be largely attributed to the space competitive superiority of Crepidula (among other factors). Although Crepidula has brought about a major change in the natural ecology of the Harbour, with unfavourable consequences in the suppression or elimination of native species, it must now be accepted as a permanent feature. From a more positive aspect, some of the Crepidula beds are among the most species rich communities of the Harbour. The vast numbers of dead shells released from the Crepidula beds also greatly contribute to the resource of small hard substrates colonized by sessile epibenthic species.

The barnacle Elminius modestus which dominates intertidal hard substrates (whether natural or artificial) throughout the Harbour was first introduced into British waters from New Zealand during the 1940's by shipping, and has since spread to many of our estuarine coastal basins. Whereas it has displaced most intertidal barnacles, within the subtidal zone it occurs only as a subsidiary to the native Balanus improvisus. The only obviously unfavourable effect of this introduction

has been in the displacement of native barnacles.

Styela clava (the Korean Sea Squirt), first introduced to the Plymouth area during the early 1960's, has since spread to a number of estuarine habitats within Southern Britain including Poole Harbour, where it is now sufficiently common to feature in terms of biomass as one of the 'lesser' dominant species. It occurs as a colonizer of small hard substrates through most of the Harbour, e.g. as a subsidiary constituent of Sabella and Crepidula beds (fig. 20, 21). Its distribution peaks within the epibenthos-dominated communities characterising the more turbid sections of the Harbour (fig. 21). It also features strongly on artificial hard substrates, particularly the subtidal sea walls of the Port area. Its major impact may only lie in the partial displacement of native biota.

Petricola pholadiformis, the American Piddock, commonly colonizes soft consolidated substrates within the Harbour, clays, peat and lignite. It is feasible that this has displaced native species, i.e. species of Barnea, the presence of which would normally have been expected.

COMMERCIALLY INTRODUCED ALIENS

Various non-native commercial shellfish have been purposely introduced to leased oyster grounds for farming. Most of these introductions have not gone past the experimental phase (see FISHERIES). The introduction of unwanted associates has been minimized by using laboratory reared juveniles, or in the case of adults, only those from other localities within the same Sea Fisheries District.

Crassostrea gigas (Portuguese oyster) was introduced to farmed beds within the South Deep (grounds of the former Poole Oyster Company). This practice was not continued, and at present, what appears to be only the remnants of a declining population occurs there (see FISHERIES).

Venus mercenaria (American Clam) was unsuccessfully experimentally introduced to an area of the Lower Wareham Channel (see FISHERIES).

Venerupis semideccussata has recently been grown in cages on ground off the Upper Wych Channel (see FISHERIES).

Control of the movements of alien or native food shellfish are now much tighter, not only into the U.K. but also between Sea Districts within the U.K., controlled by M.A.A.F. to avoid the co-introduction of diseases and aliens such as Crepidula which could cause self inflicted damage to the shellfisheries, as well as taking a hold beyond the shellfish beds, within the natural communities. The transfer of healthy live shellfish carries a very great risk of carrying other unwanted transfers, some of which may not survive, e.g. Dendrodoa grossularia (Ascidiacea) (not a particularly problematical species) which does not occur naturally within the Harbour, was observed growing on oysters recently introduced to the South Deep from the Solent area. Certainly the deposit of laboratory reared juveniles, now more common, provides for a much smaller risk of unwanted introductions.

Pollution

Two natural features of Poole Harbour, 1. near total land-locking, and 2. the double high tidal cycle, have combined to produce exceptionally poor natural flushing characteristics which render the Harbour at high risk from pollution. Impoundment developments within the Northern Sector of the Harbour have increased the degree of isolation of the affected areas still further, in effect, producing artificial lagoons, very sensitive areas which are much more likely to retain and incorporate introduced pollutants to above natural levels (see sub-section on RECLAMATION)(fig. 25). Holes Bay is the best case example. Infilling at the entrance has increased its already naturally high degree of isolation (fig. 25). The construction of a railway embankment across the Bay has further isolated the innermost section from the remainder of the Bay. Falconer (1981), using mathematical modelling techniques, found the flushing characteristics of Holes Bay to be exceptionally poor. Other examples of artificially impounded sub-systems within the Harbour include Lytchett Bay and a succession of marinas (see RECLAMATION)

For the purposes of this report, areas are regarded as polluted if the agents in question occur at above natural levels. This is quite different to the consideration of pollution in the context of human health.

The measurement of pollution levels was beyond the scope of the current survey. However, monitoring is undertaken by the Wessex Water Authority, Ministry of Agriculture, Fisheries and Food, the Marine Biological Association of the U.K., British Petroleum, and by others. These programmes have different emphases, i.e. in terms of the agents being monitored and the areas of the Harbour covered, according to the particular interests and responsibilities of the organisation in question. Broad range data portraying variations in the levels of pollutants on a Harbour-wide scale are not available for any agent at present.

Holes Bay has frequently been regarded as the most polluted area of Poole Harbour, this view having been reinforced by published studies on trace metal levels (e.g. Boyden, 1975, Langstone, 1982). Potential sources of pollution include the outfall for the sewage treatment works at Fleetsbridge (which discharges into the inner recesses of the Bay), urban, commercial and industrial waterfronts fringing the Bay, and numerous vessels moored within channels and marinas.

However, Holes Bay is not the only developed area of the Harbour with the potential to cause pollution. Other potential sources feature throughout the Northern Sector. On the other hand, by comparison, the Southern Sector is relatively clear, although a newly emerging factor there is the development of oil production well heads on Furzey Island (and related activities).

The various rivers discharging into the Harbour can introduce pollutants arising beyond the immediate vicinity. A less likely source of pollution is the open sea, a net export of pollution through the Harbour entrance is much more likely than a net import.

Pollutants are of importance in the context of this report because they have the potential to influence the nature and distributions, not only of the biological communities, but also indirectly, the Harbour bed substrates, i.e. if a species such as Sabella which substantially governs its substrate regime should be affected.

Since the various published pollution surveys and monitoring programmes published to date undertaken by others have not uniformly covered all parts of the Harbour, it is not possible to correlate the distributions of plants and animals as identified during this survey with Harbour wide trends in any of the polluting agents. However, it can be confirmed that no part of the Harbour is biologically barren in the context of pollution, e.g. Holes Bay was found to support the full compliment of major species which would have been expected for an unpolluted area with equivalent hydrographic and substrate regimes. As to whether, for example, the distributions of subsidiary species have been affected, or whether there have been any sublethal effects such as on growth or reproductive potential, such questions can only be answered by more detailed assessments of the particular species in question, e.g. the results of a pilot study on Crepidula arising from this survey suggest that the Holes Bay population of slipper limpets may be less healthy than those occurring within other areas of the Harbour (Rogers, 1986).

FLUID DISCHARGES

Fluid effluents are discharged from numerous points along the northern shores of the Harbour e.g. the outfall for the sewage treatment works at Fleetsbridge (HBU), and a succession of storm drains. Categories of polluting agents likely to be released via fluid discharges are briefly considered within the following paragraphs. The carrier medium itself - freshwater - can also have a polluting effect although this cannot be regarded as a harmful one, i.e. the generation of mini-estuaries within the immediate vicinities of outfalls, the scale of these being dependent on the scale of discharge, e.g. much of the eastern limb of the Upper Holes Bay Channel (HBU) has been rendered mesohaline, largely because of the effluents discharged from the Fleetsbridge outfall, and this has resulted in the establishment of mesohaline species there. The same may be happening within the proximity of a storm drain outfall that discharges from the Town Quay (at the entrance to Holes Bay - HBL). A substantial but very local population of the mesohaline bryozoan Electra monostachys was identified there, but no where else in the Harbour.

Another major source of fluid effluent entering the Harbour used to be the outfall of Poole Power Station which discharged into the Lower Wareham Channel from the Hamworthy foreshore (WCL). During the time of regular power production, this constituted a source of thermal

pollution which significantly raised water temperatures within range of the outfall. During the summer of 1978, tidal pools, formed in the immediate path of the outfall were found to be filled by very large quantities of the bryozoan Bowerbankia gracilis, a species which has been known to proliferate within several Power Station Outfalls around the U.K.

SOLID WASTES

Solid wastes can range from fine particulate materials carried in suspension within fluid effluents, to large items of refuse. With respect to fine particulate materials, their physical effects on turbid environments such as exist within most of Poole Harbour may be insignificant since the biological communities are naturally adapted to very high levels of particulate material and hence to the risk of clogging of feeding and respiratory mechanisms, etc...). However, adverse effects would be possible if the particulate materials in question also had toxic properties.

Organic particulate materials are discharged within treated sewage wastes, and to an unguaged extent from boats using the Harbour. Human health aside, such materials contribute to the eutrophication of the system, as well as providing food for many of the multitude of suspension feeding invertebrates which flourish upon and within the Harbour bed.

Refuse of various kinds is sometimes illegally dumped into the channels of the Port and Holes Bay areas, in particular where access roads pass close to the waters edge. The multitude of items dumped even includes cars, several of which are recovered from the Harbour by P.H.C. each year (often well colonized by sessile marine species). The subtidal channel bed within the remaining, majority of the Harbour was found to be virtually clear of refuse. The impact of solid refuse on the subtidal biological communities is not considered to be problematical.

EUTROPHICATION

Poole Harbour constitutes a naturally eutrophicated and hence very productive biological system. In recent years, the strong suspicion has been expressed that a proportion of the eutrophication is derived from human sources. Two areas, Holes Bay and the Blue Lagoon (fig. 1), have been highlighted as being particularly affected (Portsmouth Polytechnic, 1981; Ho, 1975). Symptoms were believed to include the excess growth of algae, particularly of Ulva, Enteromorpha and other **chlorophytes**, and the incorporation of excessive quantities of organic matter into intertidal and subtidal sediments, leading to greater than natural degrees of anoxia. In addition to the depreciation of the appeal of the environment, e.g. piles of rotting seaweeds accumulated on the foreshores, and foul smelling black muds featuring intertidally, the suspected above normal proliferation of Ulva has caused problems for the C.E.G.B.. Whilst Poole Power Station (oil fired) was operational, water was drawn from just inside the entrance of Holes Bay (HBL) and discharged into the Lower Wareham Channel of the main Harbour (WCL). Masses of drifting Ulva were found to clog the intake screens and to interfere with power production.

The present survey has shown Ulva lactuca to occur throughout the Harbour and, in terms of standing stock, to be among the ten most

common species (see table at beginning of this section). With particular reference to pollution, the centres of distribution for attached weeds, i.e. the downstream sections of the Diver Channel (DVC) and Lower South Deep (SDL) do not correspond with the areas believed to be particularly eutrophicated, but do correspond with areas experiencing other naturally favourable conditions for growth, i.e. strong currents and clear water, which together promote benthic algal growth. However, with respect to unattached weeds, these drift with the tidal currents in very large quantities throughout the Harbour. Harbour-wide variations of drifting weeds have not been fully assessed, however it may be significant that, with specific reference to Holes Bay, the greatest quantities were located at the top of the east branch of the Upper Channel (HBU).

What is unclear is whether there has been any improvement in the situation over the past few years. Eutrophication has become less of an issue because several aspects in which the effects were most noticeable have disappeared. The problem of excess drift weed clogging up Poole Power Station was solved by incorporating a combined screening and maceration plant into the intakes. Although preventing clogging, this may have exacerbated the fundamental problem by shredding the weed into smaller fragments, each with the potential to regenerate upon discharge. Poole Power Station went on to intermittent production during the 1970's and was finally closed during the early 1980's (and is currently being demolished).

Intertidal areas of Sterte Bay within Holes Bay where the problems of eutrophication were particularly evident, i.e. in terms of algal growth and sediment anoxia, have been infilled as part of the Route 9 relief road development (see RECLAMATION).

MICROBIAL POLLUTION

Bacteria and viruses of a nature or in a quantity not normally encountered within the Harbour environment can be introduced along with organic wastes of plant, animal or human origin. The reduced salinities, flushing, and warm summer temperatures which characterize some areas of the Harbour may favour the survival of these for longer than might be the case under more normal marine conditions.

It is known that many of the invertebrate suspension feeding groups, and sponges in particular, are able to feed and grow on a diet of bacteria such as Escherichia coli, of which several strains occur in human sewage. This may be a factor favouring the dominance of sponges within the sessile epibenthic communities which colonize the subtidal surfaces of the berths lining the entrance to Holes Bay (HBL) (see RECLAMATION).

HYDROCARBONS

Until recently, the only major polluting sources of oil-derived hydrocarbons within the Harbour were fuels and lubricants, potential sources being the cooling effluents and bilge waters discharged from the multitude of motorised vessels using the Harbour, together with the loading berths for refined hydrocarbon products within the Port Area. In view of this, the highest levels of hydrocarbon pollution would be expected within the Port. In a study related to the current survey, Walker (1986) assessed levels of hydrocarbons within the sponge Suberites massa within several areas of the Harbour. Levels within the

Port area (HBL) were found to be significantly higher than at a station within the Southern Sector (SDU).

The distribution of potential sources of hydrocarbon pollution has now shifted with the onset of crude oil production from well heads on Furzey Island within the Southern Sector of the Harbour (SDL, SDU, BAC).

TRACE METALS

A number of trace metals, e.g. cadmium and mercury, have been recorded at above natural levels within sediments, **algae** and **invertebrates** from the Harbour, the highest values for some of these having been recorded within Holes Bay (e.g. Boyden, 1975; Langstone, 1982). Most recently, high levels of organotin have also been recorded within Holes Bay (W. Langstone, Marine Biological Association of the U.K., pers. comm.). Problems associated with organotins have been highlighted within recent years in the context of their widespread use as the active agents within antifouling paints (e.g. tributyl tin). The effectiveness of these paints in preventing fouling is attributable to their intense toxicity to marine **algae** and **invertebrates**. Some of the antifouling paints containing this ingredient are known to release the agent from the treated surfaces. It is suspected that within enclosed, poorly flushed areas containing large numbers of boats protected by these antifouling treatments, concentrations of the agent could build up sufficiently to be generally harmful to the marine life of the system in question. Poole Harbour may fulfill all of the prerequisites of a case location in this context.

It is known that when polluting trace metals occur in combination, the effects can be totally different to those produced if single metals are involved. This makes the correlation of cause and effect within areas such as Poole Harbour particularly difficult.

Appendix I

FIGURES

- Fig. 1 Map of Poole Harbour.
Fig. 2 Subtidal Survey stations and zones.
Fig. 3 Subtidal channel network.
Fig. 4 Bathymetry and tidal currents.
Fig. 5 Tidal cycles
Fig. 6 Salinity regimes.
Fig. 7 Depth of the infralittoral zone.

Dive Transect Survey:

- Fig. 8 Incidence of Harbour bed substrates.
Fig. 9 Incidence of Sabella (Peacock Worm).
Fig. 10 Incidence of Crepidula (Slipper Limpet).
Fig. 11 Incidence of Sargassum (Japanese Seaweed).
Fig. 12 Incidence of Lanice (Sand Mason).

Dredge Survey

- Fig. 13 Occurrence of invertebrates.
Fig. 14 Occurrence of macroalgae (seaweeds).
Fig. 15 Occurrence of Crepidula (Slipper Limpets).
Fig. 16 Occurrence of Ascidella (sea squirt).
Fig. 17 Occurrence of Sargassum (Japanese Seaweed).
Fig. 18 Occurrence of Ulva (Sea Lettuce).
Fig. 19 Occurrence of Ostrea (Common Oysters).
Fig. 20 Occurrence of Styela (Korean Sea Squirt).

- Fig. 21 Distribution of silt-preferring **invertebrates**.
- Fig. 22 Numbers of species per zone.
- Fig. 23 Numbers of principal species per dredge station.
- Fig. 24 Navigational activity within the Harbour.
- Fig. 25 Reclamation, and navigational dredging.
- Fig. 26 The Port of Poole.
- Fig. 27 Economic species - **Lobster, Spider Crab, Edible crab**.
- Fig. 28 Economic species - **Whelk, Mussel, Oyster**.
- Fig. 29 Leased **oyster** grounds.

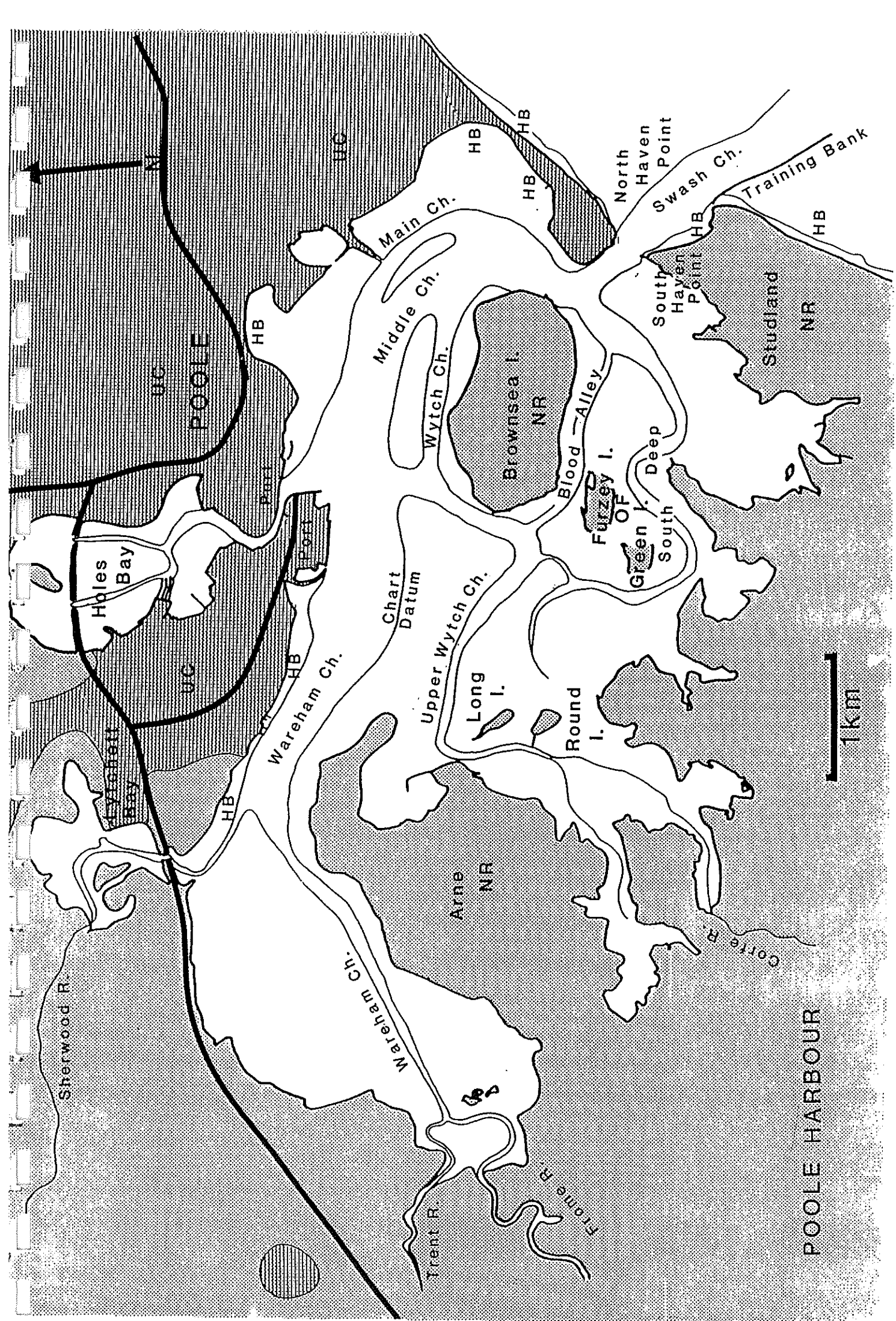


Figure 1 - Poole Harbour.
 Shaded terrain: Urban conurbations (UC), Solid line - Railway lines.
 HB - Holiday beach. NR - Nature Reserve. OF - Oilfield development.





Figure 2 - Poole Harbour Subtidal Surveys: Sampling stations.

Solid circles - Dredge / Grab Stations. Bars - Dive transect Stations.

Holes Bay Survey	- 1982
Southern Sector Survey	- 1984
Northern Sector Survey	- 1985
SWC - Swash Channel	1985
HAV - Haven Channel	1985
MCL - Lower Main Channel	1985
MCU - Upper Main Channel	1985
WCL - Lower Wareham Channel	1985
WCM - Mid- Wareham Channel	1985
WCU - Upper Wareham Channel	1985
SDL - Lower South Deep	1984
SDU - Upper South Deep	1984
BAC - Blood Alley	1984
WYL - Lower Wych Channel	1985
WYU - Upper Wych Channel	1984
HBL - Lower Holes Bay Channel	1982 / 1985
HBU - Upper Holes Bay Channel	1982
LBC - Lytchett Bay Channel	Shore stn.

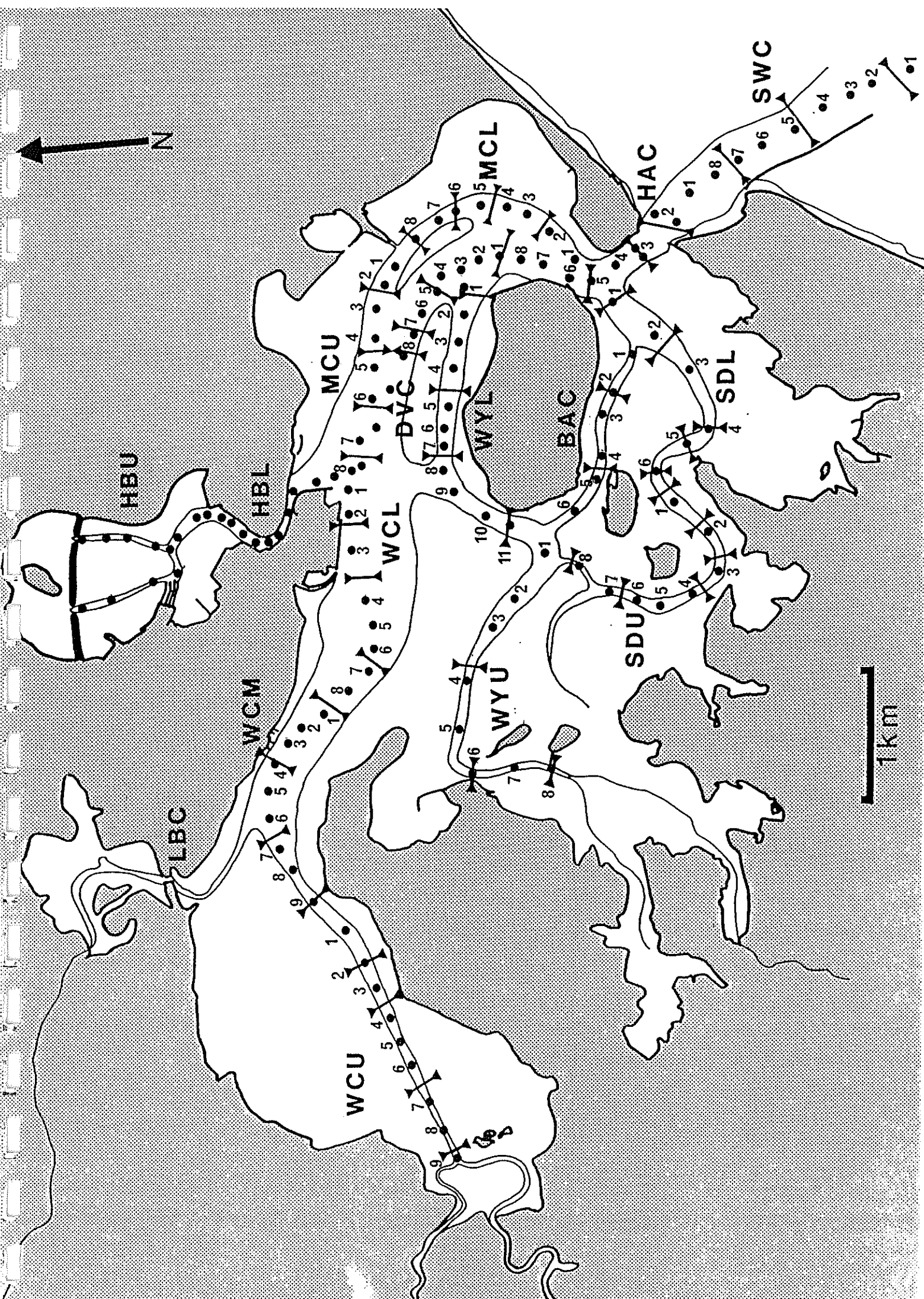
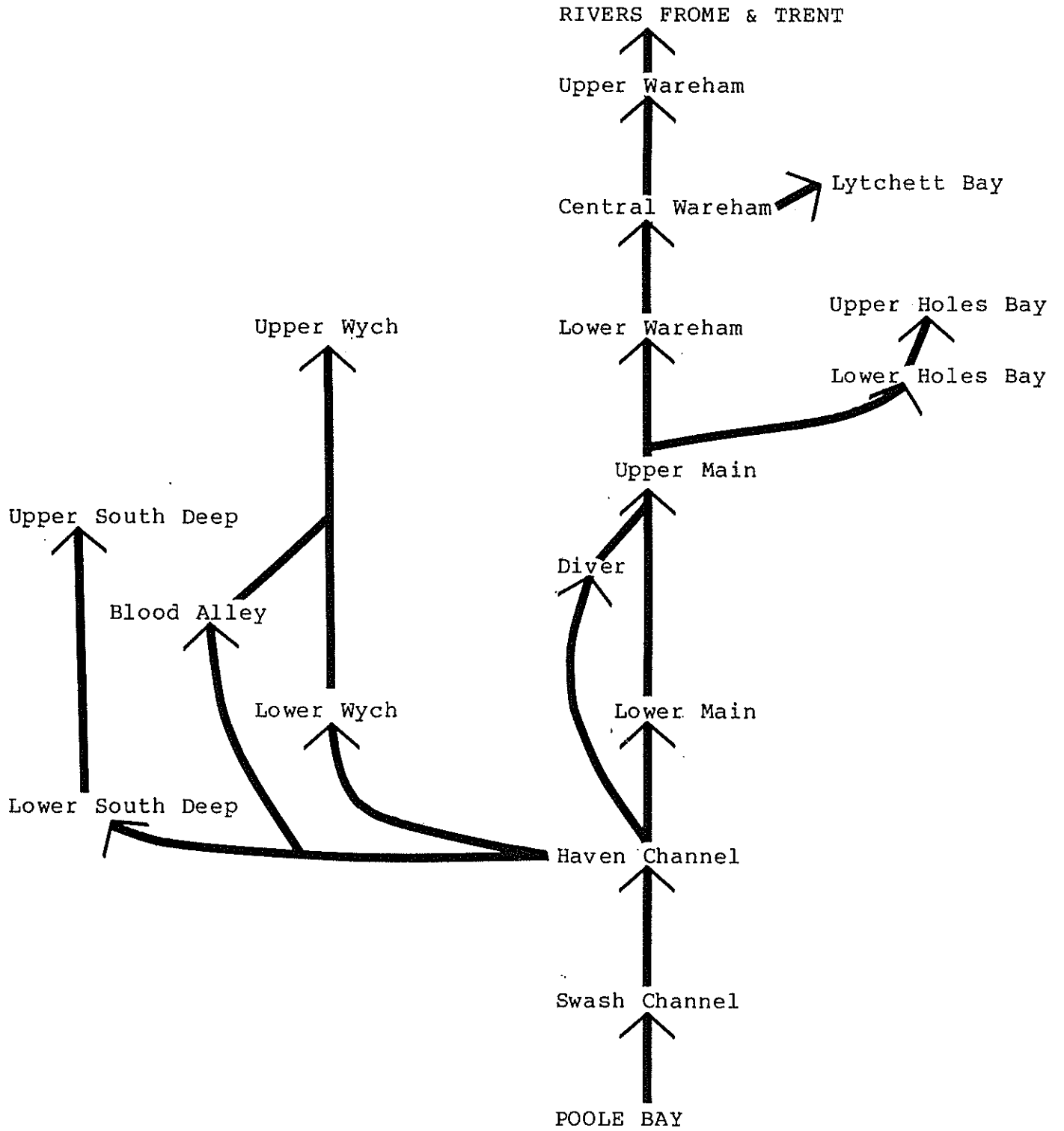




Fig. 3

Schematic Representation of the Poole Harbour subtidal channel network.



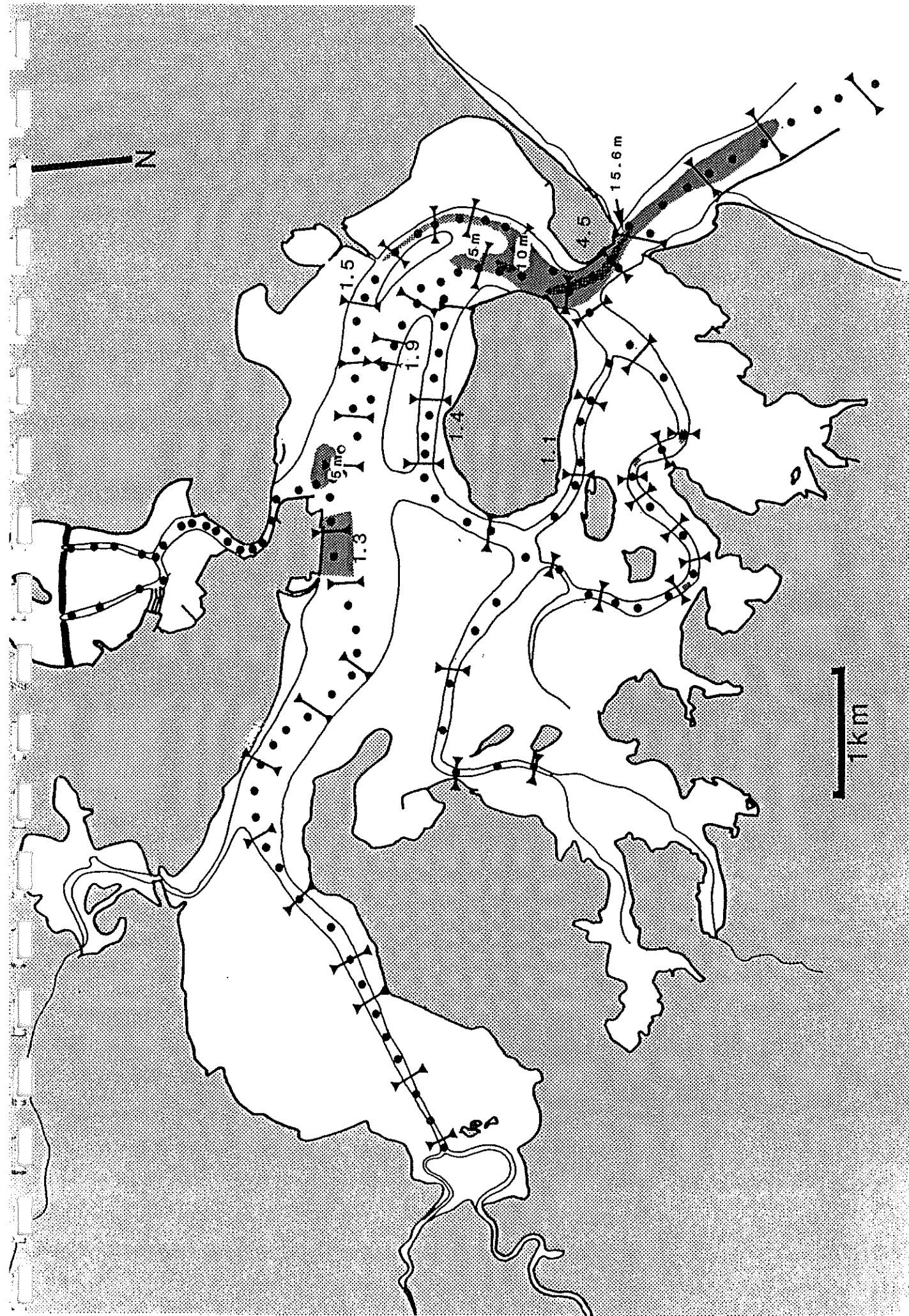


Figure 4 - Bathymetric regimes and tidal current velocities within Poole Harbour. Bathymetry: Unshaded - from around chart datum to 5m below. Light shading - from 5 to 10m below chart datum. Heavy shading - from 10 to 15m below chart datum. Maximum spring tidal values shown in knots, according to data made available by the Hydrographic Unit of Poole Harbour Commissioners.



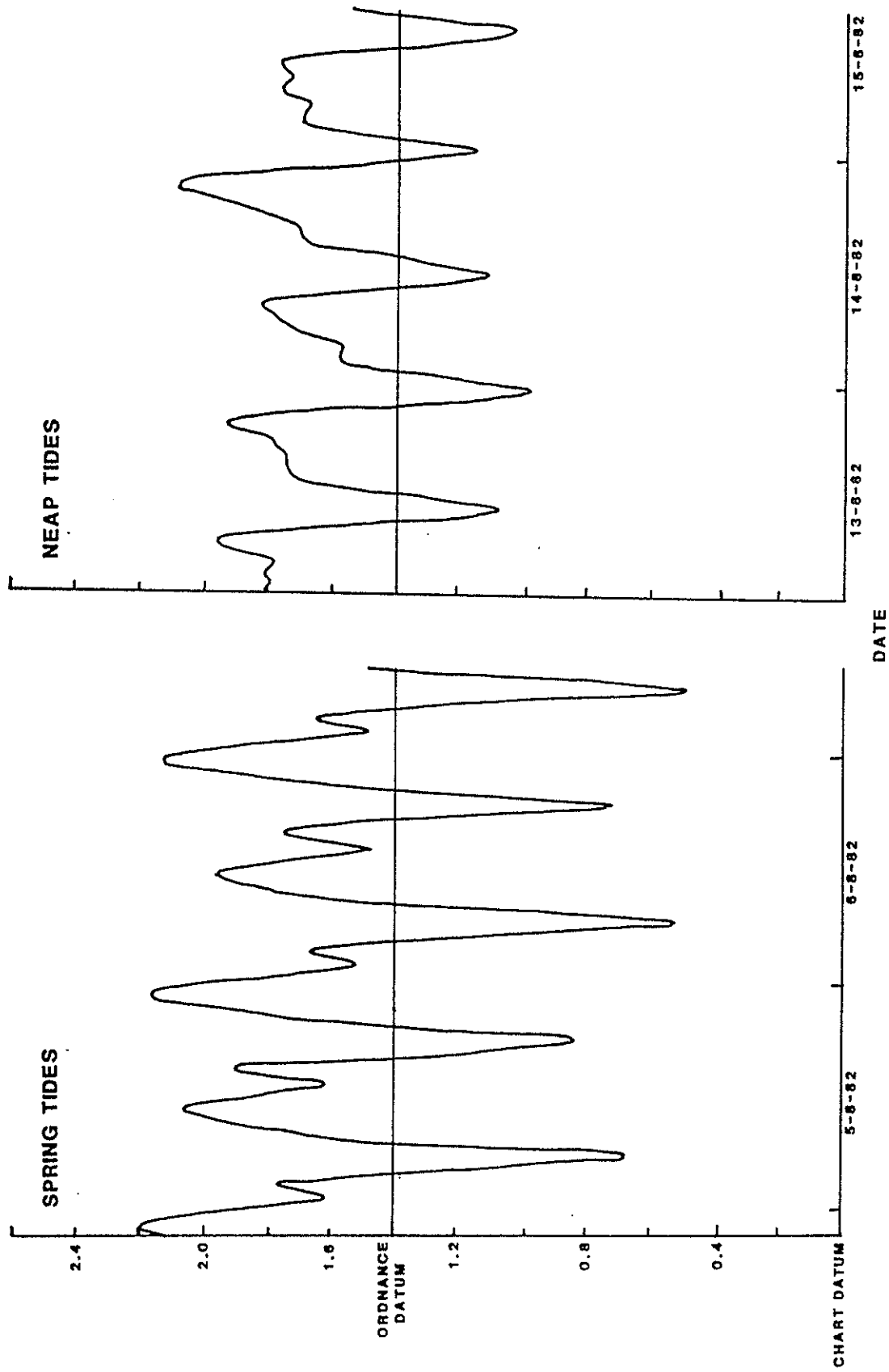


Fig. 5. Comparison of spring and neap tidal cycles at Poole Town Quay. Data from permanent tide gauge maintained by P.H.C. Hydrographic Section.





Fig. 6. Broad salinity regimes within Poole Harbour, as identified by the pooling of Harbour-wide measurements, supplemented by readings from particular areas.
 ma = marine, po = polyhaline, me = mesohaline, ol = oligohaline.



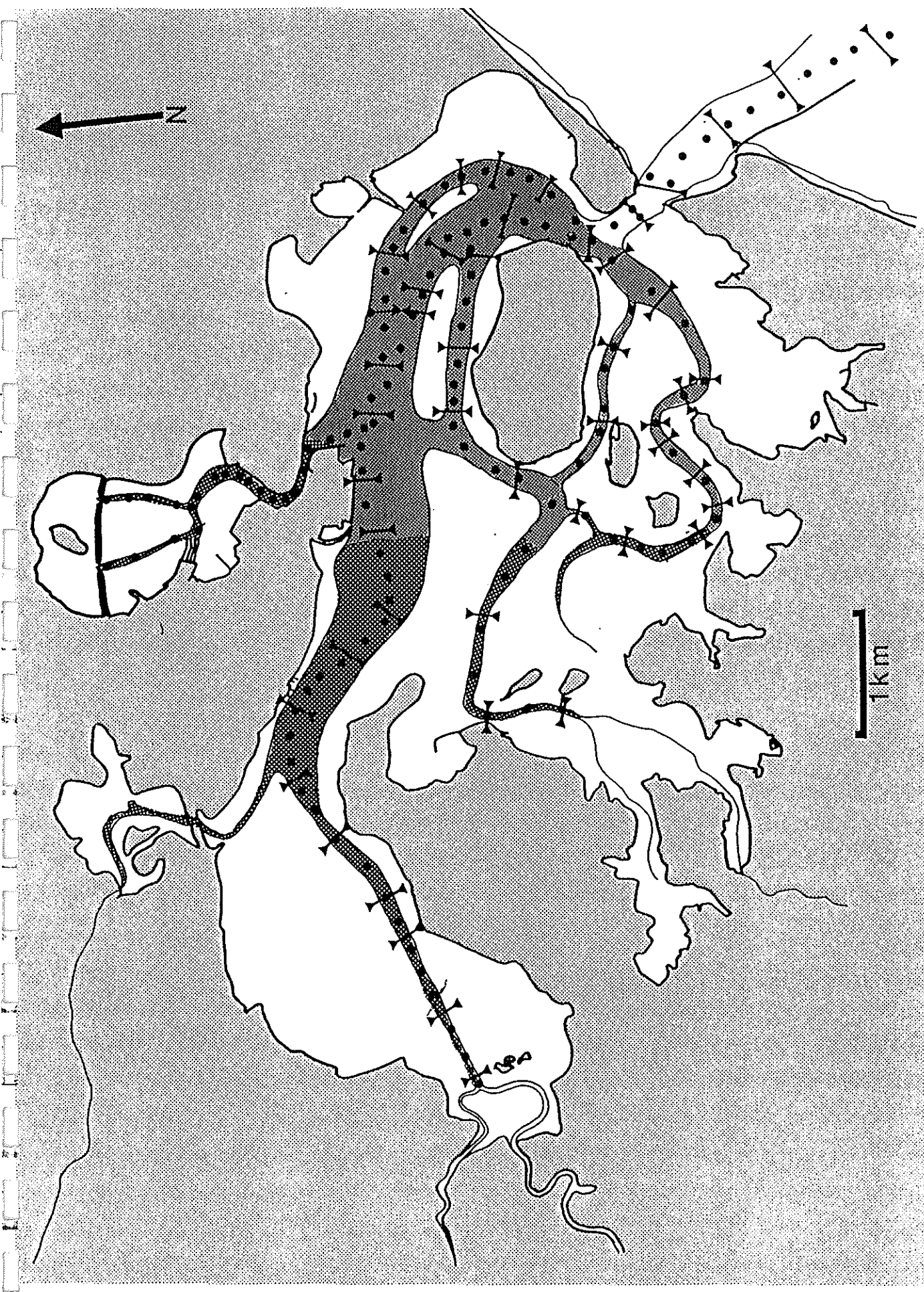


Figure 7 - Depth of penetration of the infralittoral zone within the Harbour (according to survey data).
Heavy shading - maximum depth at or above chart datum. Lighter shading - maximum depth between chart datum and 5m below. No shading - maximum depth between 5 and 10m below chart datum. Heavy shading - maximum depth below 10m below chart datum.



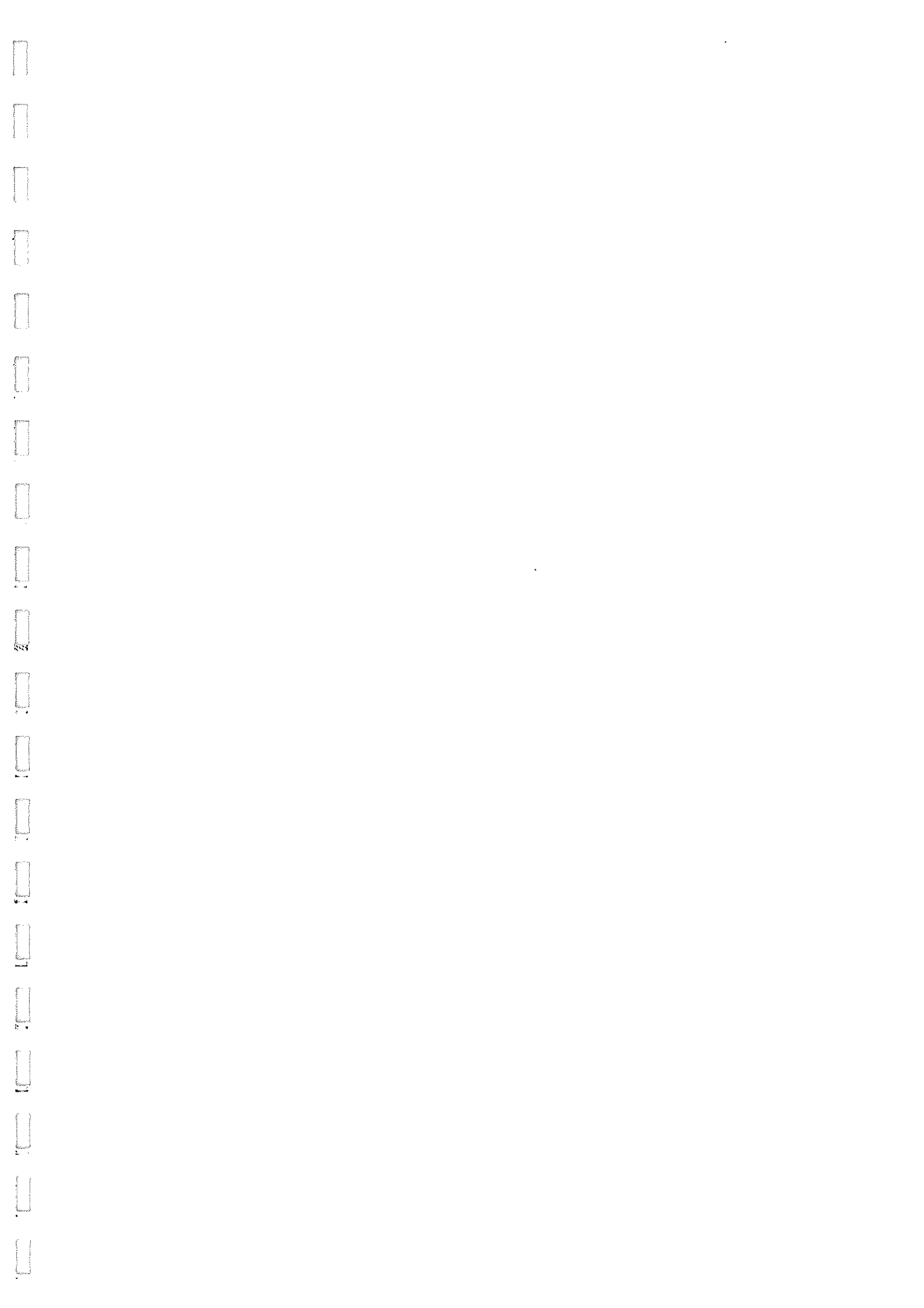


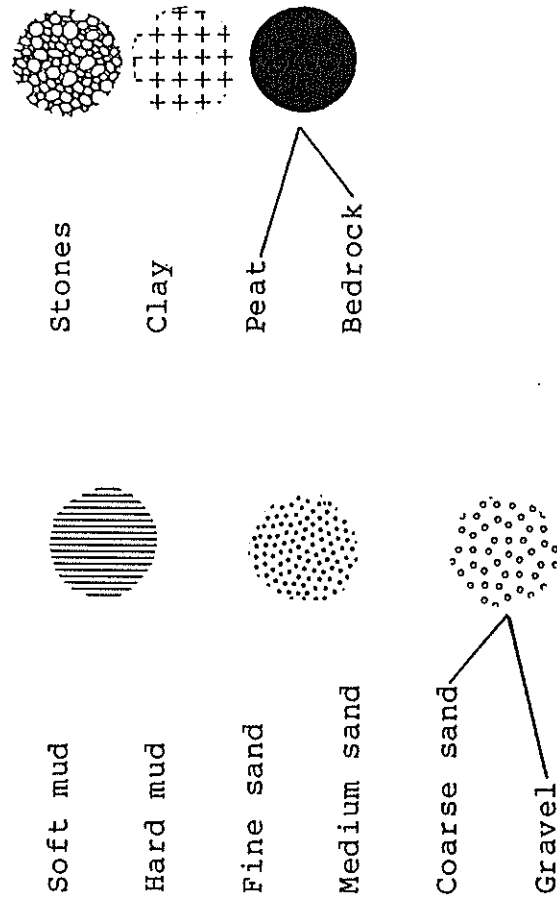
Figure 8

DIVE TRANSECT SURVEY

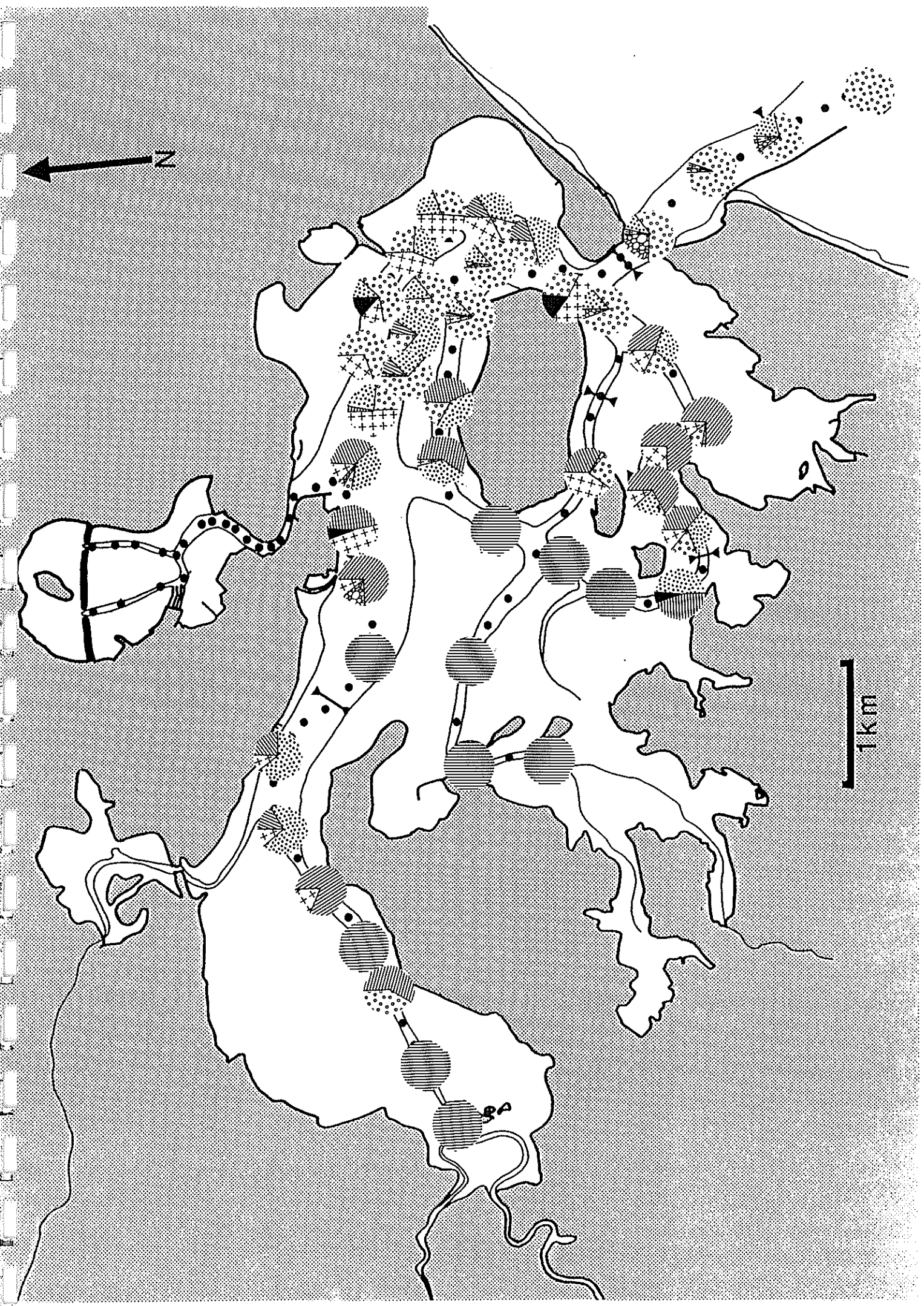
Substrates

Incidence (percentage occurrence along each transect).

Key:



Where the predominant cover is of live *Crepidula* or mollusc shells, the grain size category below the actual size of the shells has been used to compensate for differences in particle density between calcareous and siliceous substrates.





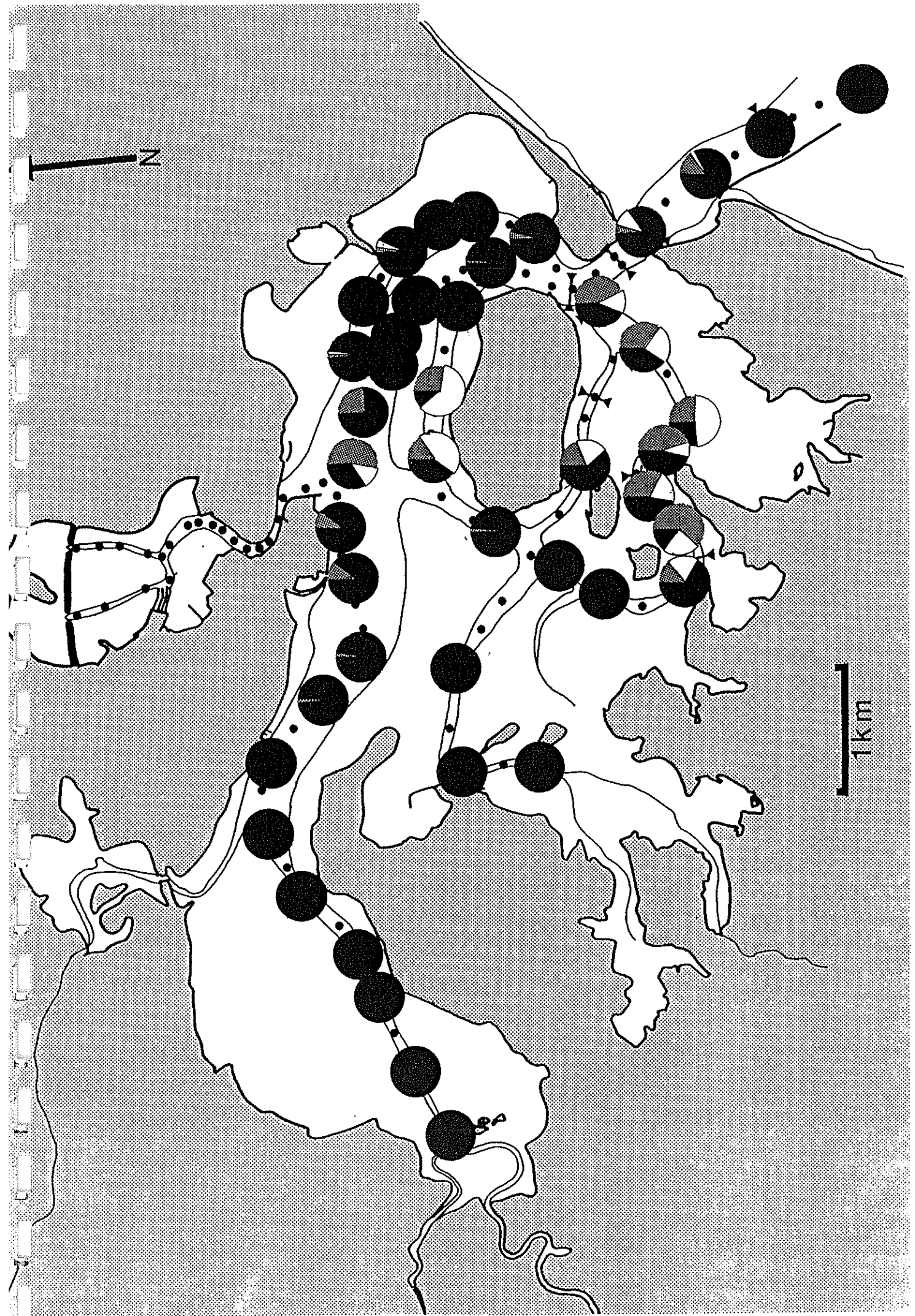


Figure 9 DIVE TRANSECT SURVEY
Sabella pavonina - Incidence (percentage occurrence along each transect).
Black - absent; Shaded - present; White: high density.



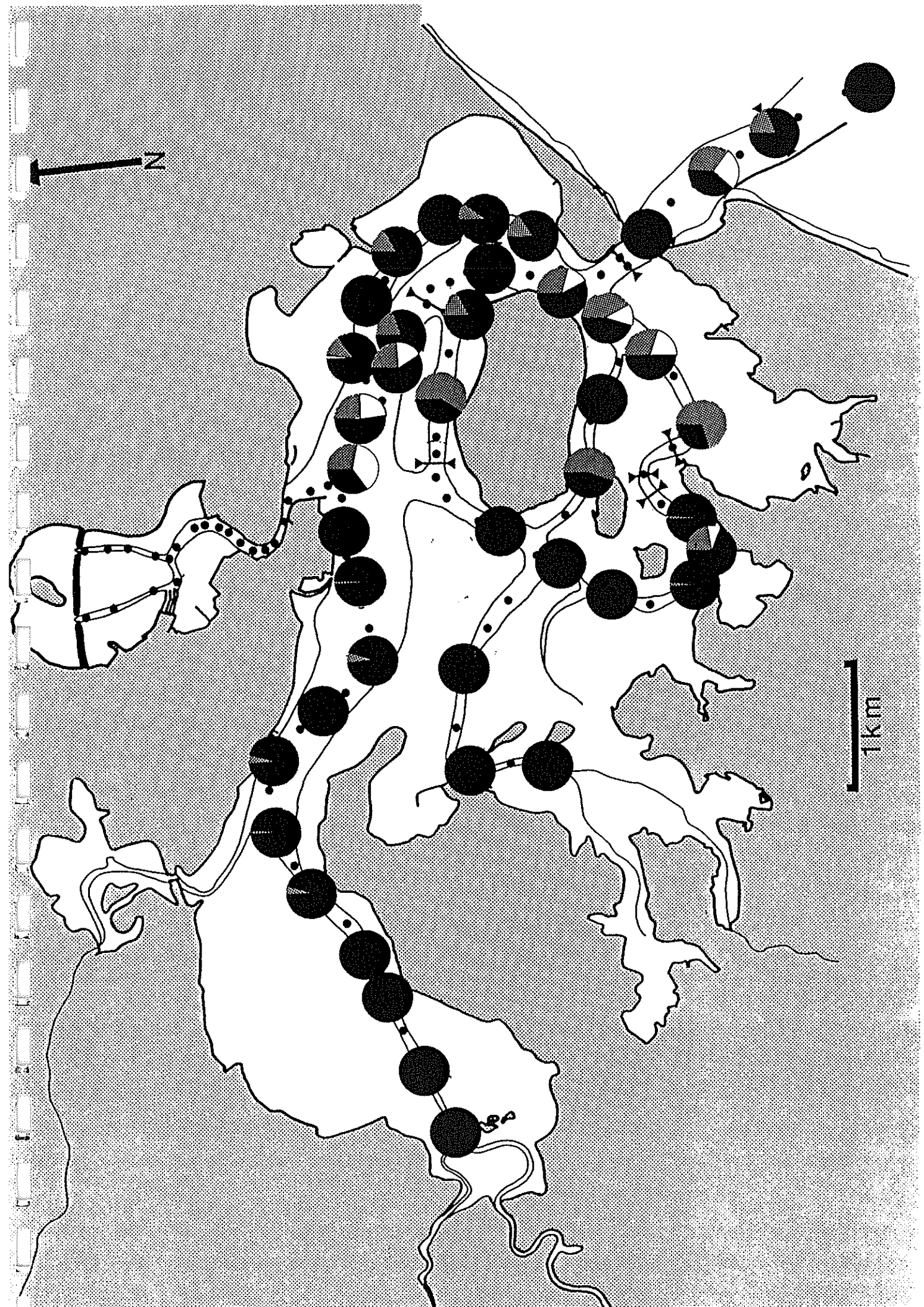


Figure 10 DIVE TRANSECT SURVEY
Crepidula fornicata - Incidence (percentage occurrence along each transect).
 Black: absent; Shaded: present; White: high density



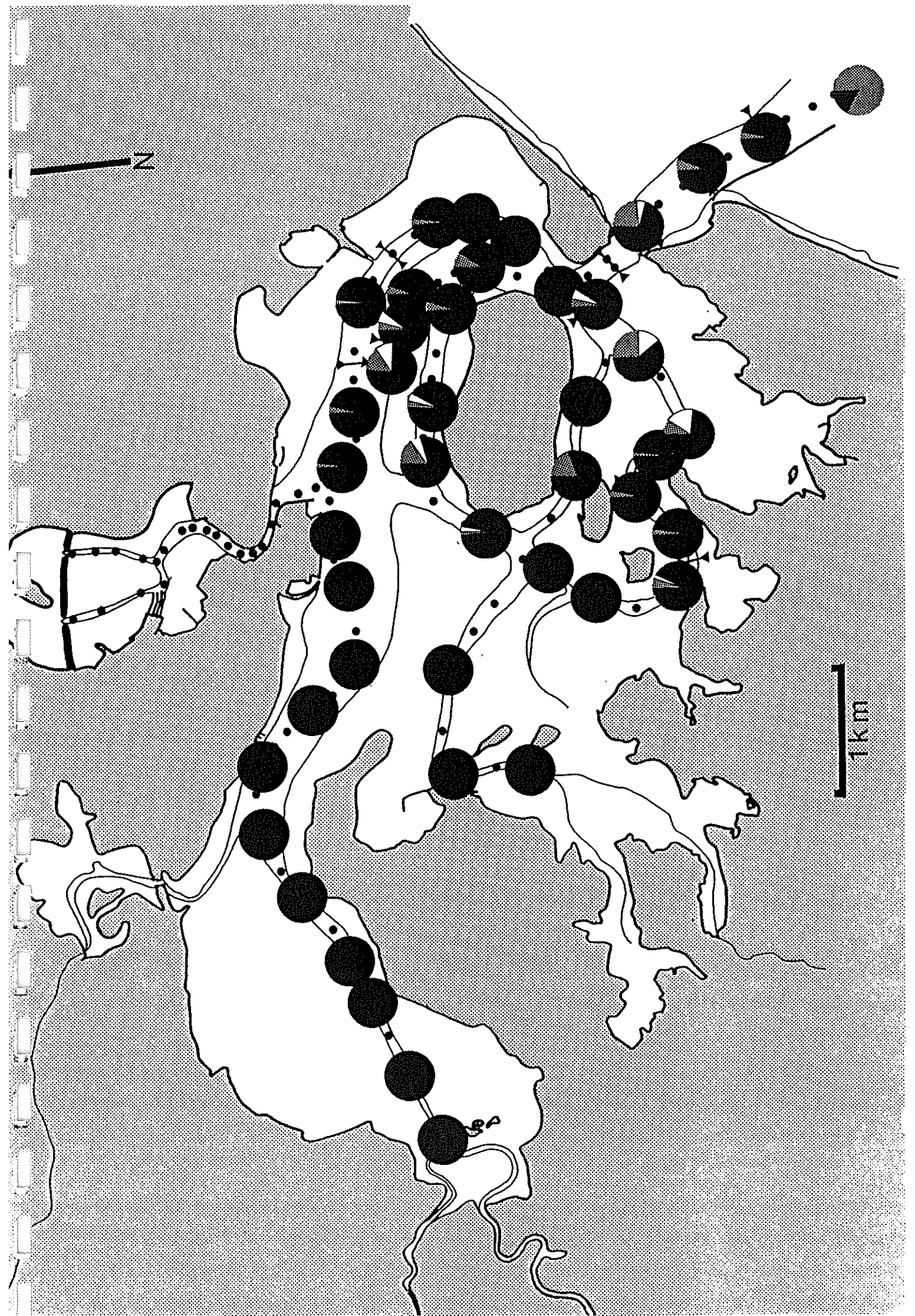


Figure 11 DIVE TRANSECT SURVEY
Sargassum muticum - Incidence (percentage occurrence along each transect).
 Black: absent; Shaded: present; White: high density

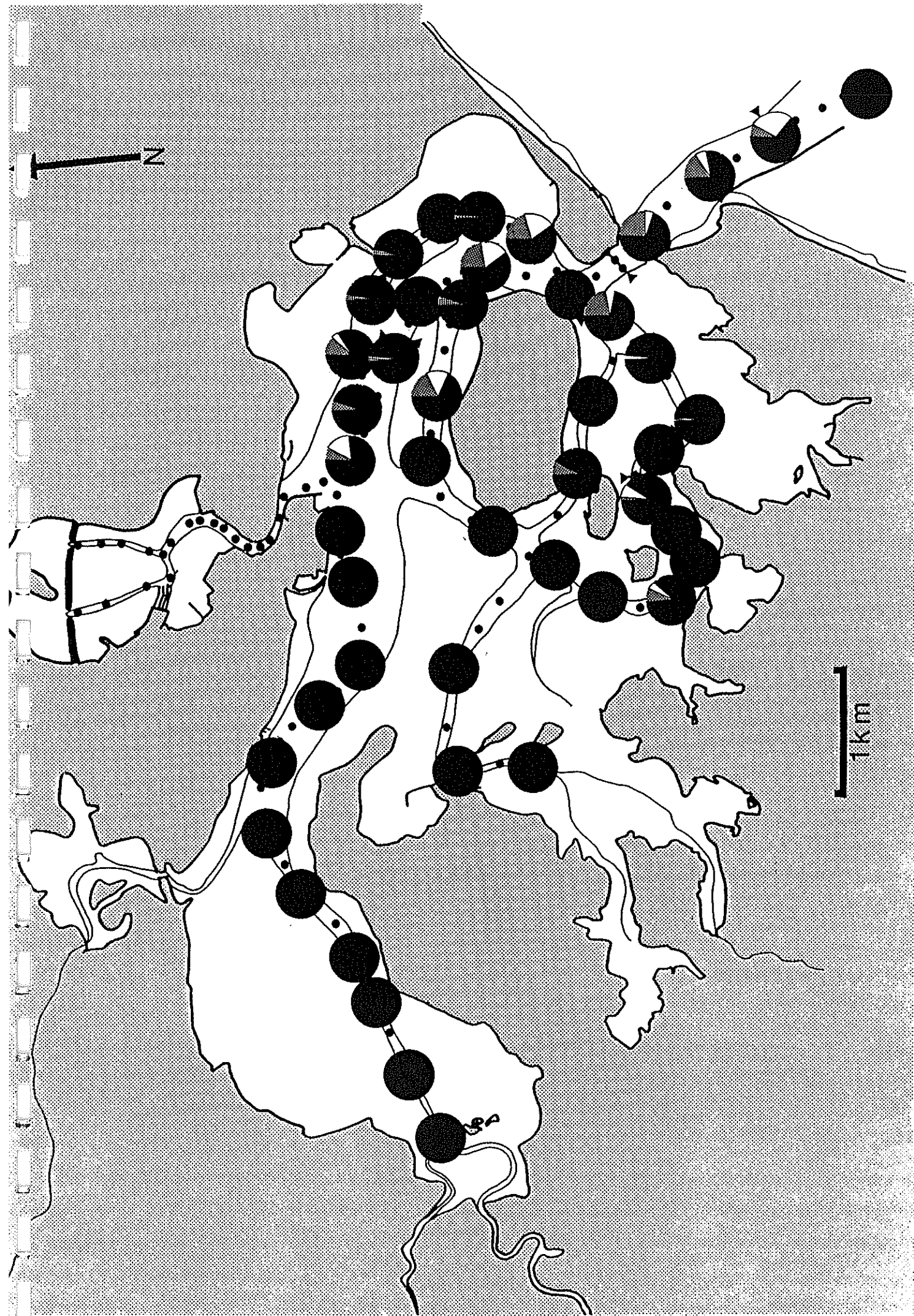


Figure 12 DIVE TRANSECT SURVEY
Lanice concheligata - Incidence (percentage occurrence along each transect).
 Black: absent; Shaded: present; White: high density.



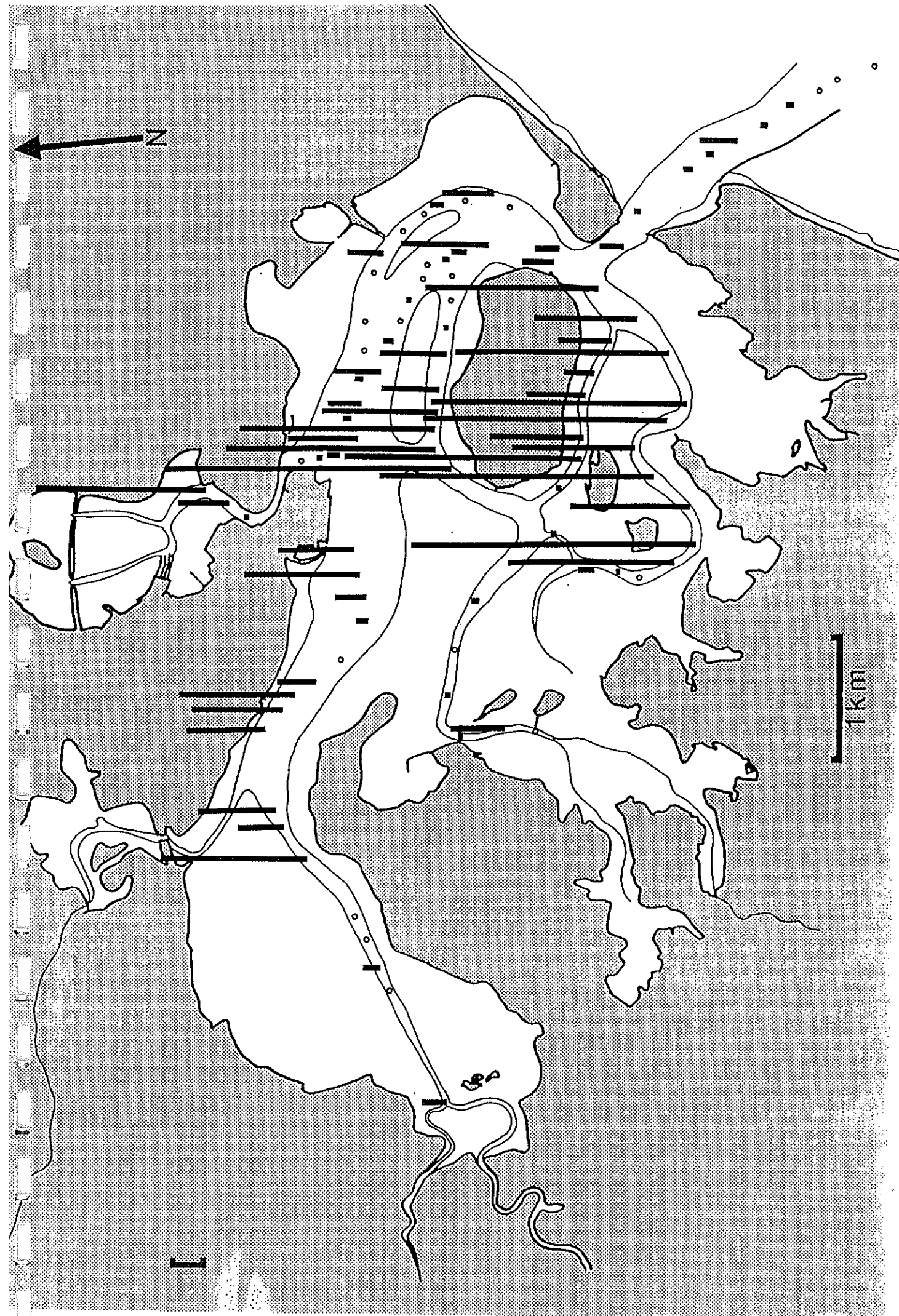


Figure 13 - Dredge Survey.
invertebrates (total) - Variations in the standing stock biomass (wet weight per channel centre haul per station) within the Harbour.
Solid bar: present, height of bar proportional to weight per station. Open circle: absent.



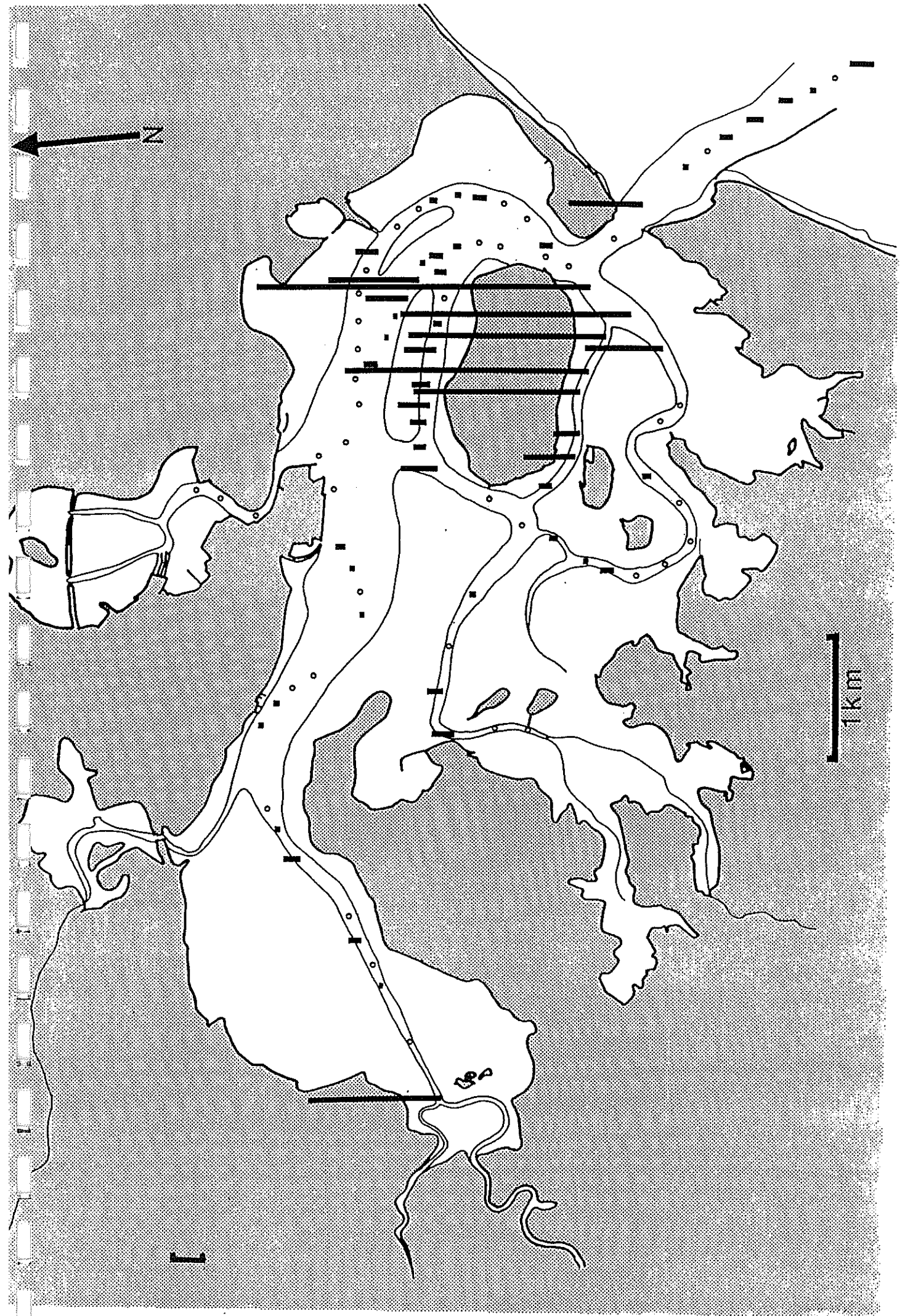


Figure 14 - Dredge Survey. Macroalgae (total) - Variations in the standing stock biomass (wet weight per channel centre haul per station) within the Harbour. Solid bar: present, height of bar proportional to weight per station. Open circle: absent.



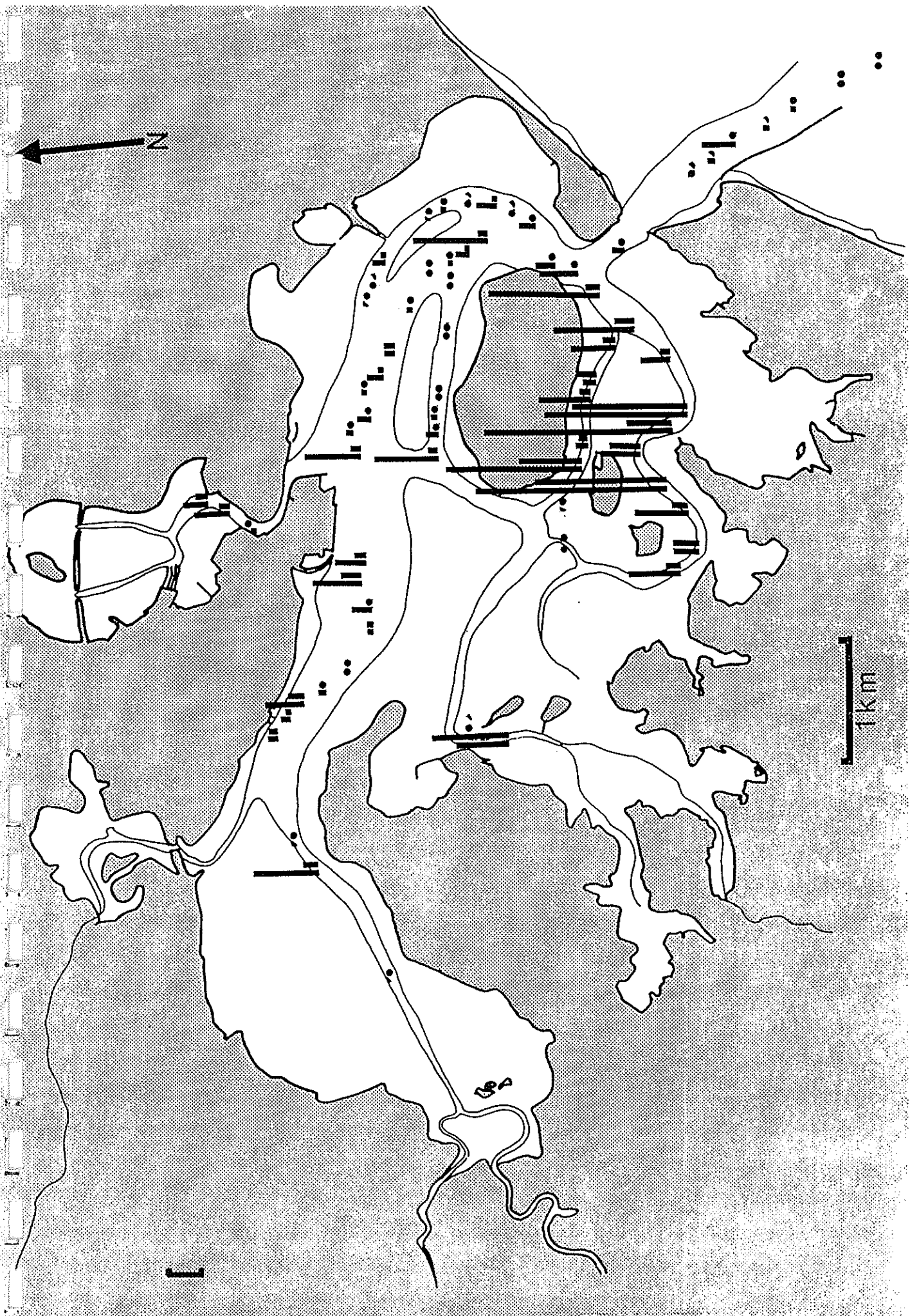


Figure 15 - Dredge Survey
Crepidula fornicata - Variations in the standing stock biomass (wet weight per channel centre haul per station) within the Harbour.
 Left hand bar: live individuals; Right hand bar: dead shell. Solid bar: present, more than 0.1kg, height of bar proportional to weight per station. Solid circle: present, less than 0.1kg; half solid circle: absent.



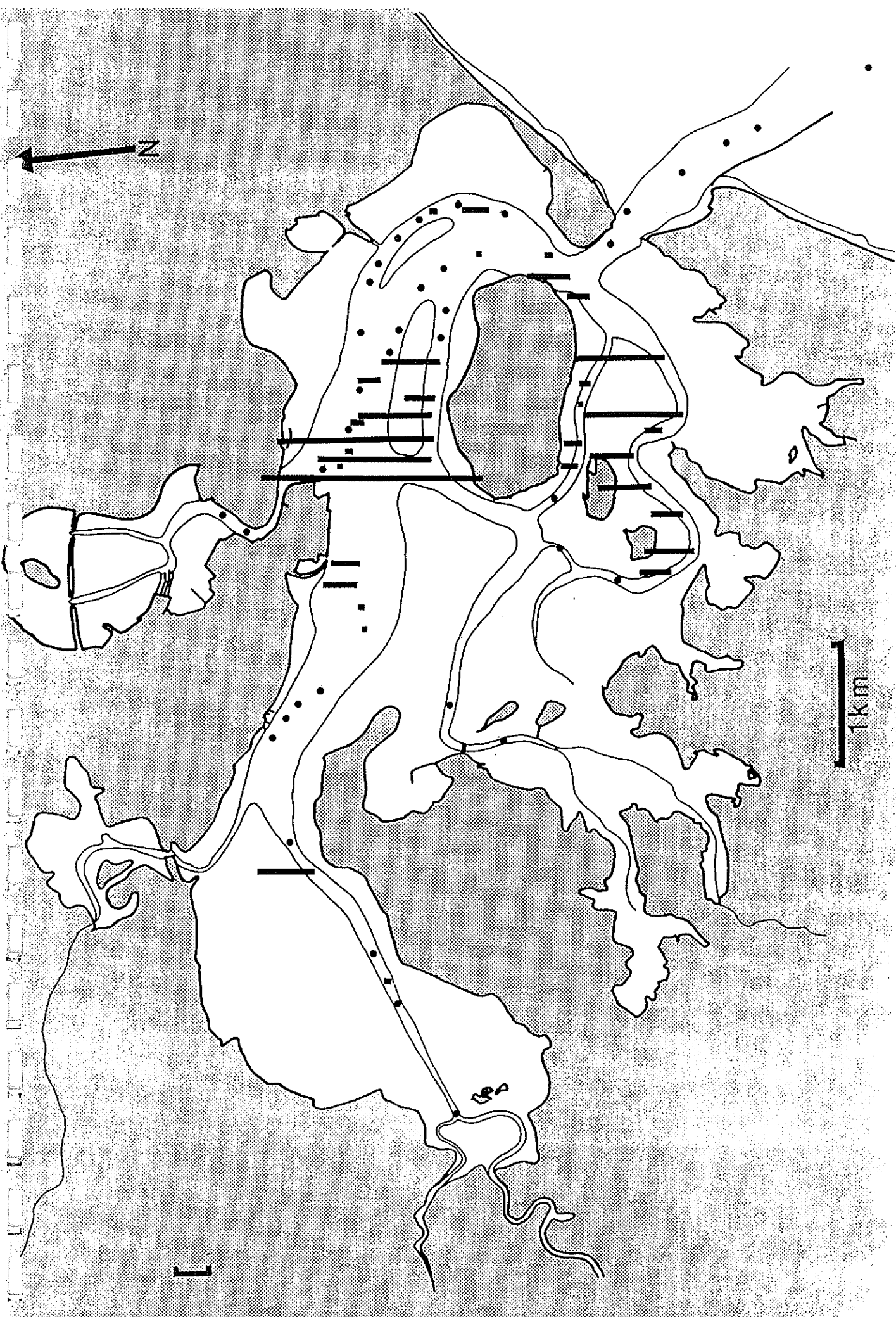


Figure 16 - Dredge Survey.
 Ascidiella aspersa - Variations in the standing stock biomass (wet weight per channel centre haul per station) within the Harbour.
 Solid bar: present, more than 0.1kg, height of bar proportional to weight per station. Solid circle: present, less than 0.1kg.



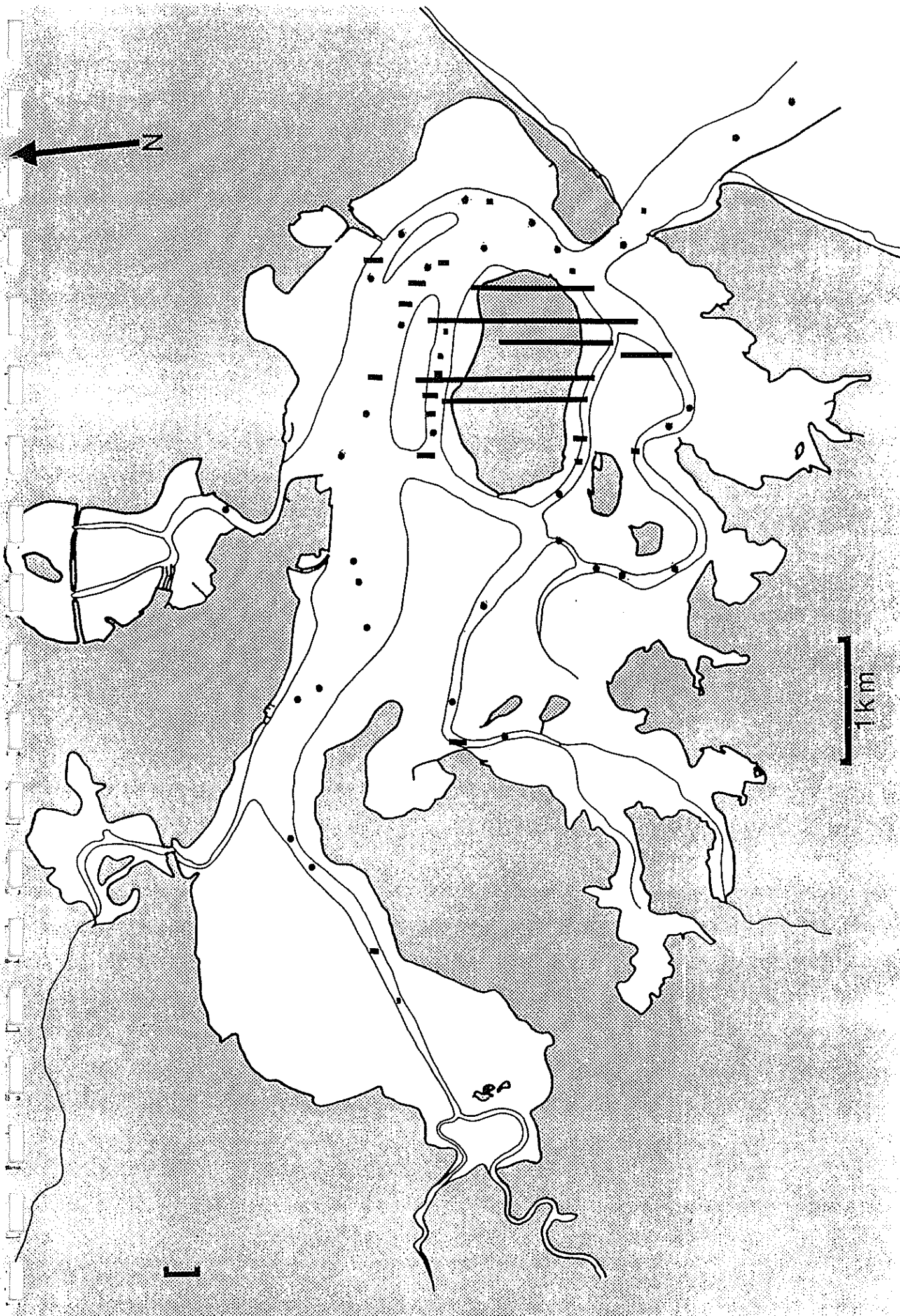


Figure 17 - Dredge Survey.
Salgassum muticum - Variations in the standing stock biomass (wet weight per channel centre haul per station) within the Harbour.
 Solid bar: present, more than 0.1kg, height of bar proportional to weight per station. Solid circle: present, less than 0.1kg



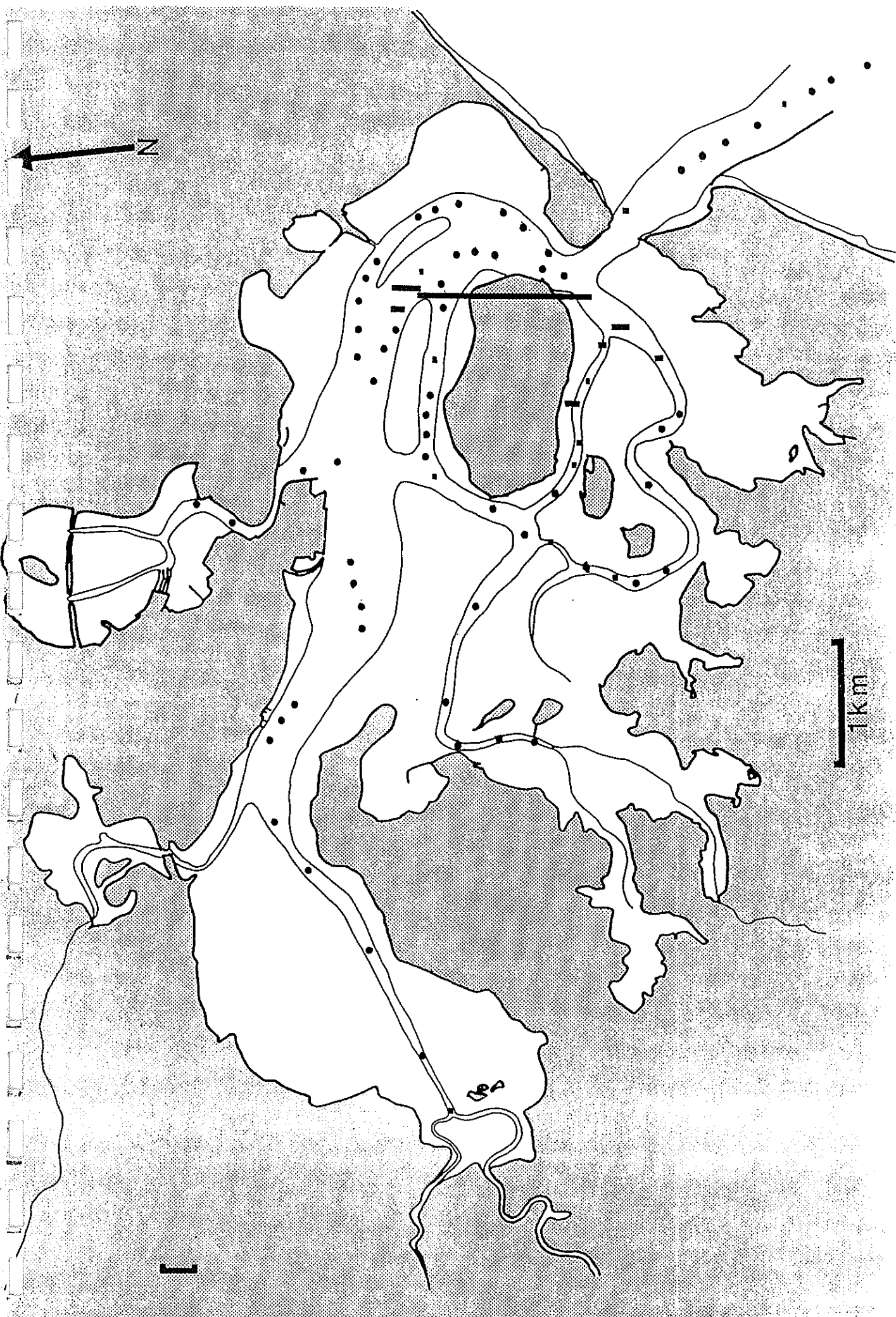


Figure 18 - Dredge Survey. *Ulva lactuca* - Variations in the standing stock biomass (wet weight per channel centre haul per station) within the Harbour. Solid bar: Present, more than 0.1 kg, height of bar proportional to weight per station. Solid circle: Present, less than 0.1 kg.



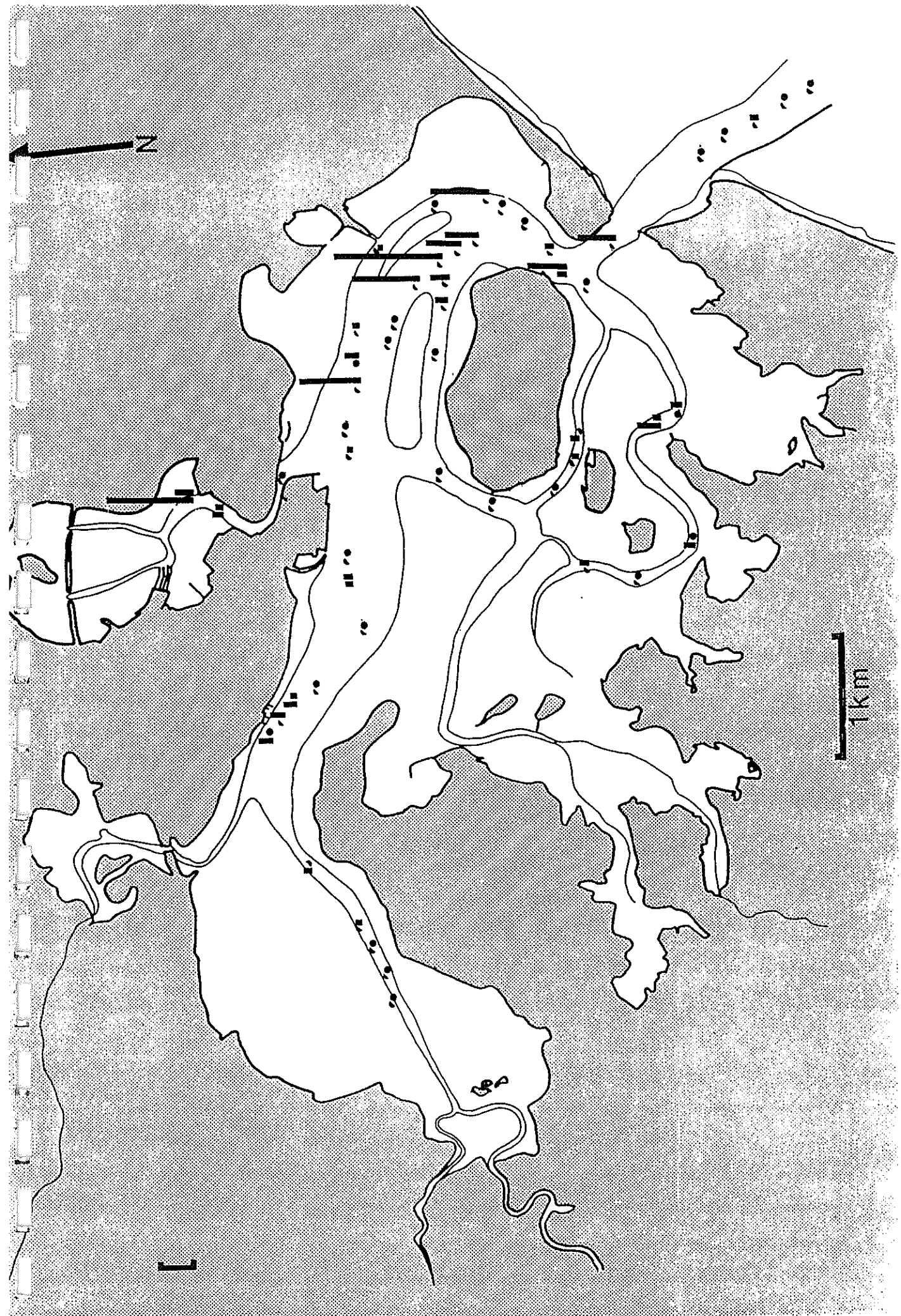


Figure 19 - Dredge Survey.
Ostrea edulis - Variations in the standing stock biomass (wet weight per channel centre haul per station) within the Harbour.
 Left hand bar: live individuals; Right hand bar: dead shell. Solid bar: present, more than 0.1kg, height of bar proportional to weight per station. Solid circle: present, less than 0.1kg; Half solid circle: absent.



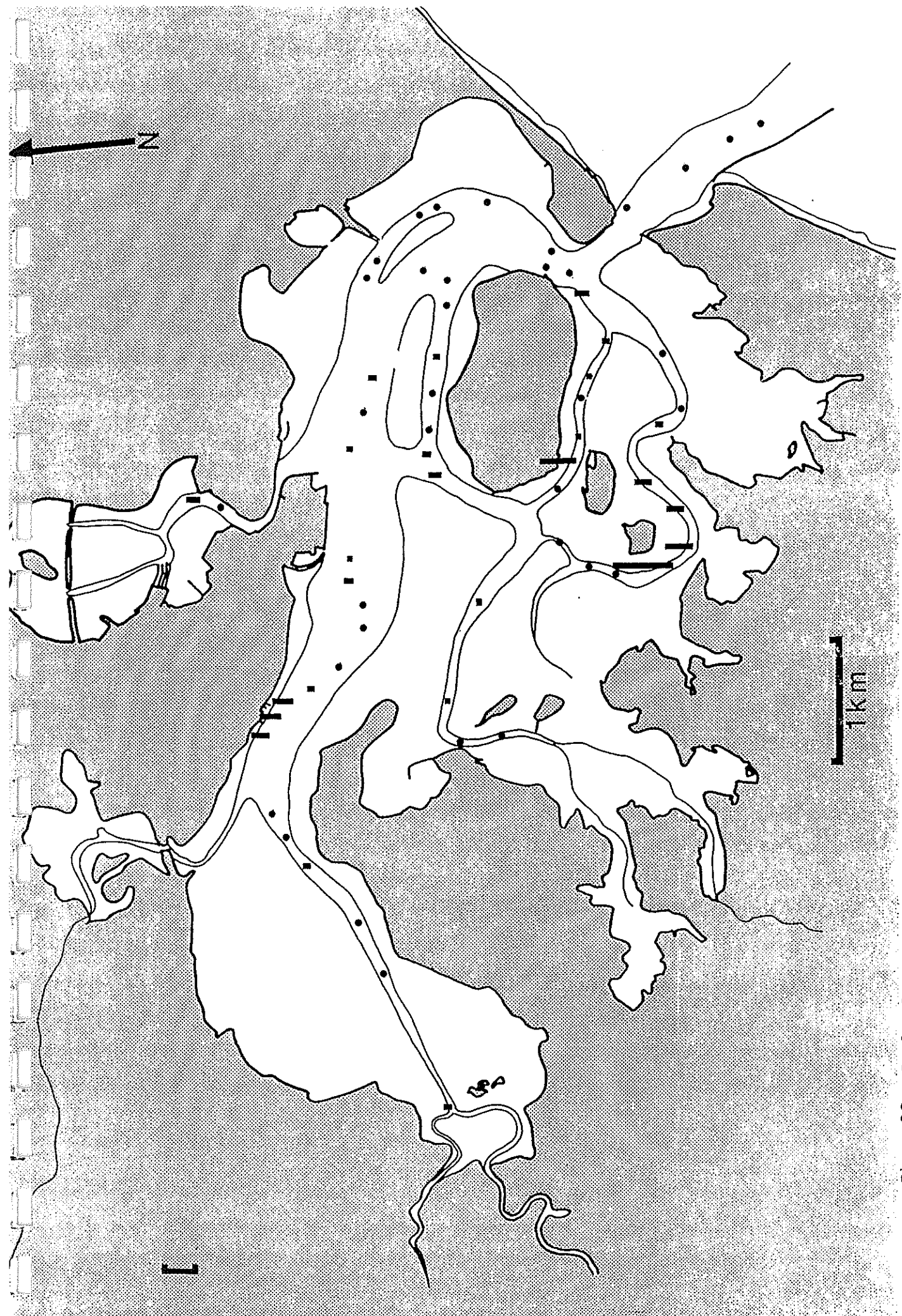


Figure 20 - Dredge Survey.
 Styela clava - Variations in the standing stock biomass (wet weight per channel centre haul per station) within the Harbour.
 Left hand bar: live individuals; Right hand bar: dead shell.
 Solid bar: present, more than 0.1kg, height of bar proportional to weight per station. Solid circle: present, less than 0.1kg; Half solid circle: absent.



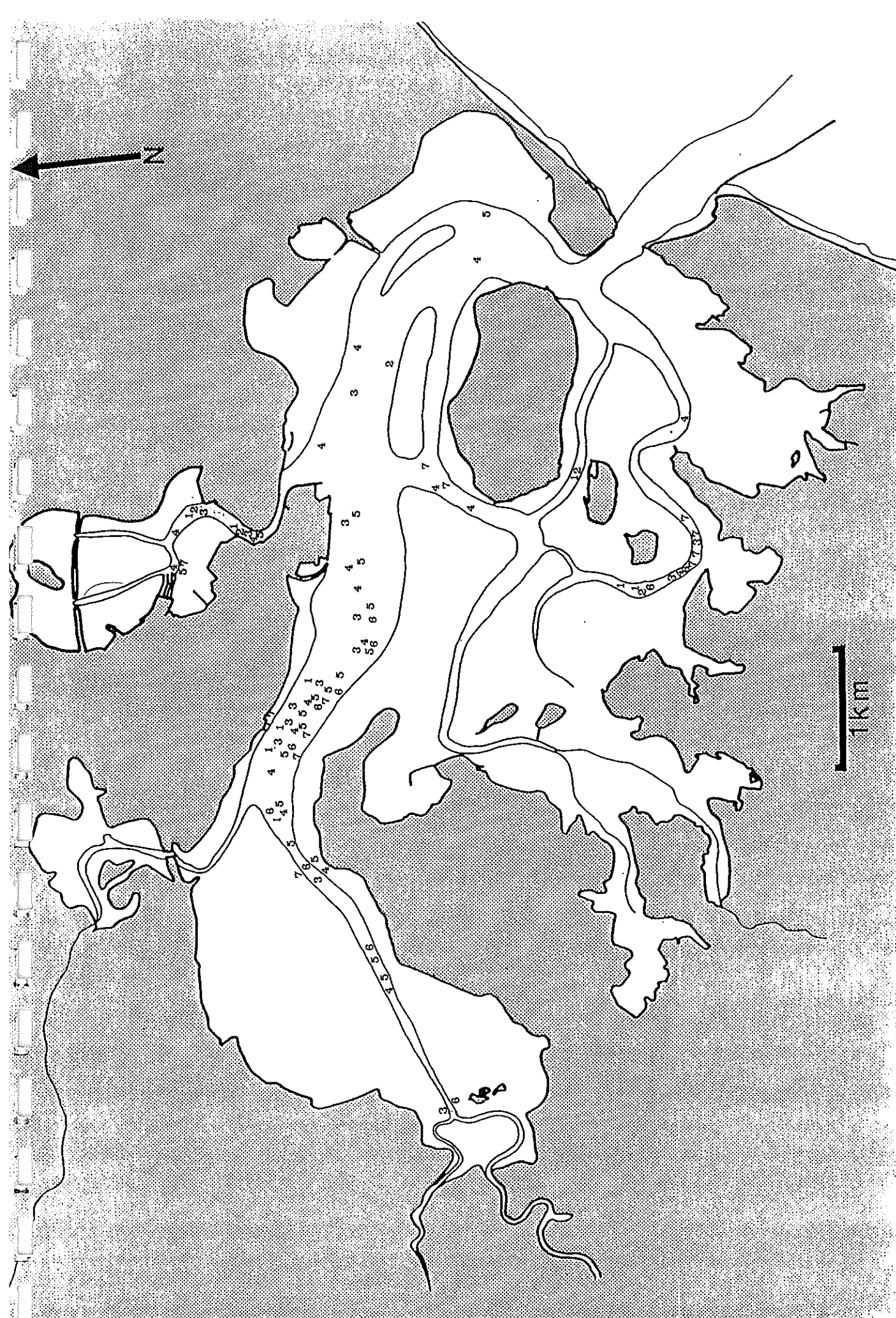


Figure 21 - Subtidal survey. The distribution of epibenthos dominated communities within turbid waters, identified according to the occurrence of silt tolerant 'indicator' species. 1 beta (massive) form of *Cliona celata* (Porifera), 2. *Suberites massa* (Porifera), 3. *Haliclona oculata* (Porifera), 4. *Metridium senile* (Coelenterata), 5. *Styela clava* (Ascidiacea), 6. *Anguinella palmata* (Bryozoa), 7. *Mytilus edulis* (Mollusca). Distributions are absolute, based on the compilation of all dive, dredge and grab records; except for *Styela*, for which only peaks in abundance are shown (see fig. Gm).



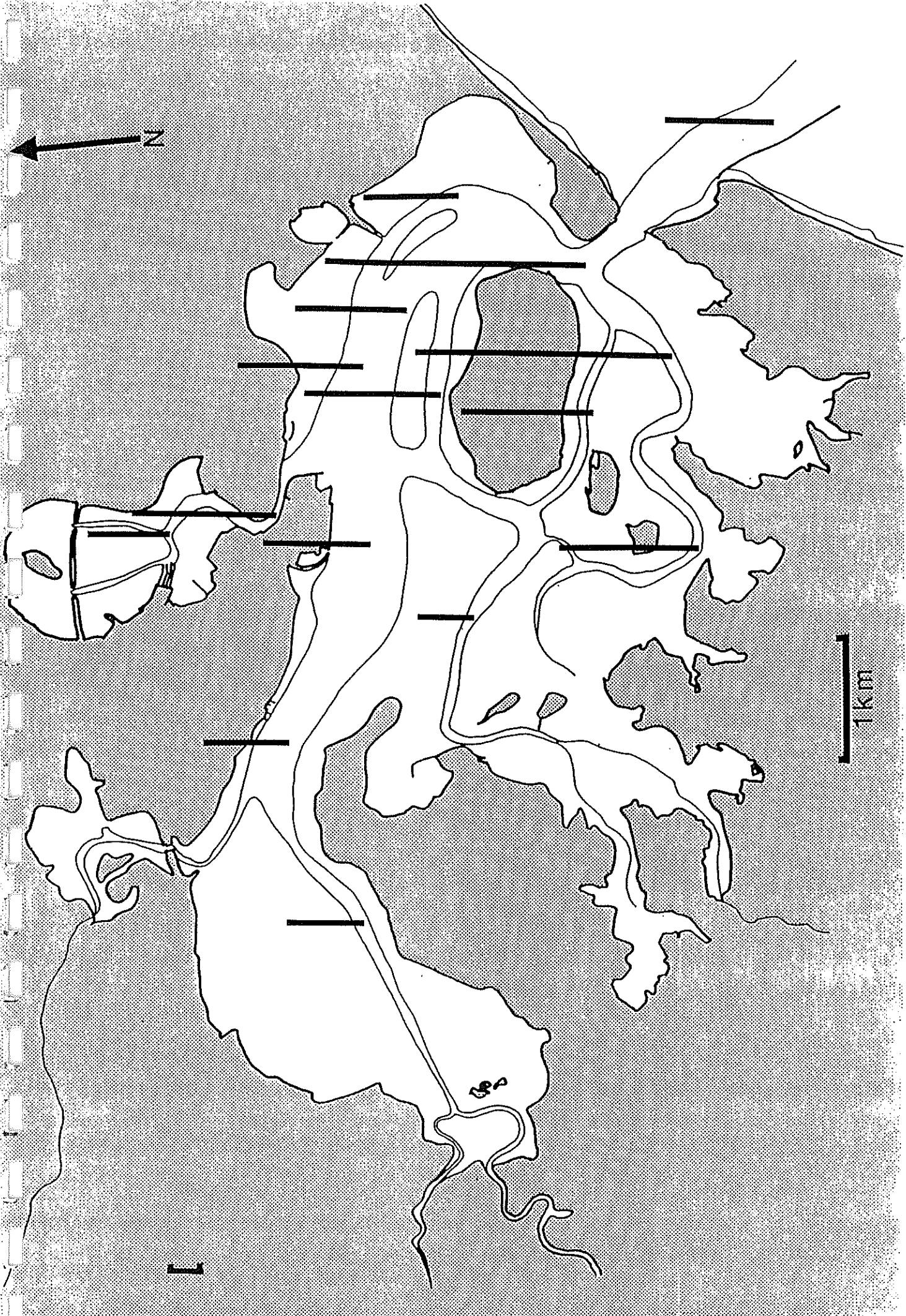


Figure 22 - SPECIES RICHNESS
Total number of species identified from all survey sources per sampling zone (refer to the overall species list for details, to section D for sampling zones).



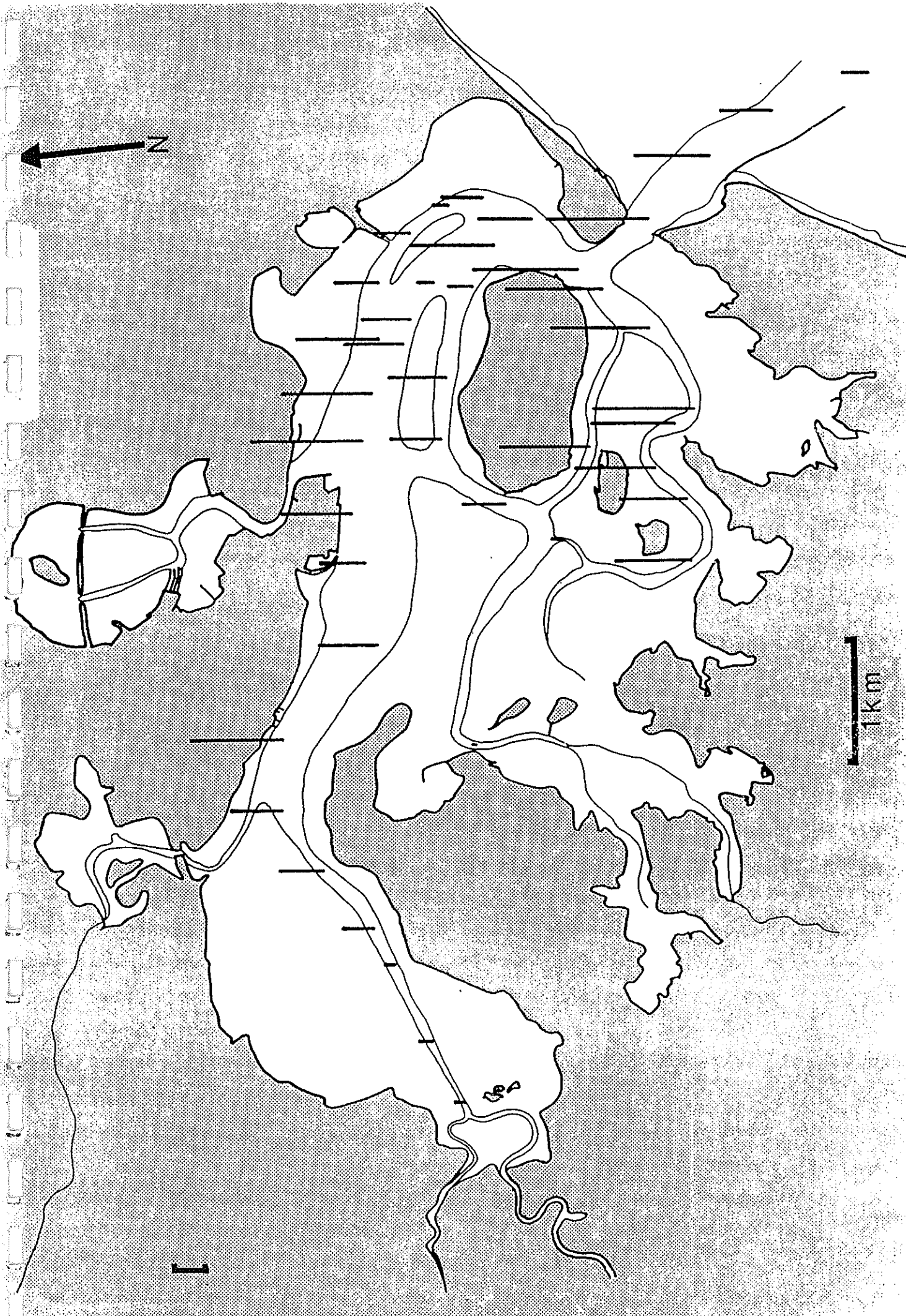


Figure 23 - SPECIES RICHNESS
Dredge survey: Incidence of the most abundant (in terms of biomass) species sampled per dredge station (i.e. species recording more than 100g per haul at any one station).





Figure 24 - Navigational channel use and berthing facilities within Poole Harbour.

Unshaded subtidal channels, and intertidal areas - generally only experience movements of light shipping, i.e. < approx. 10m length.

Cross hatched areas - light, and intermediate shipping, i.e. approx. 10-50m length.

Light stippled area - light, intermediate and heavy shipping traffic, i.e., > 50m length.

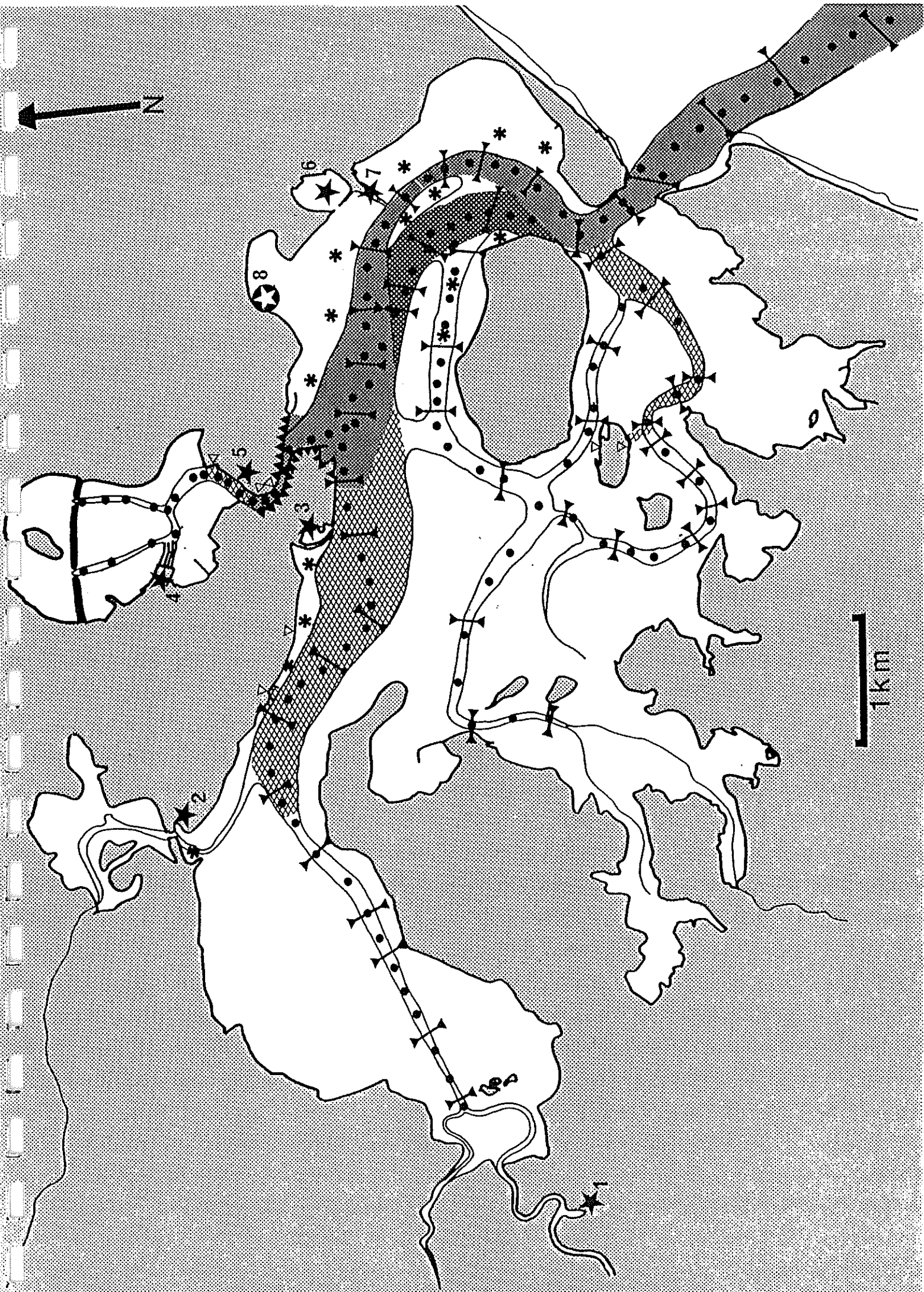
Heavily stippled area - Diver Channel, to April 1986, light & intermediate shipping only; from April 1986, heavy shipping too.

Stars - Marinas for leisure vessels (and some light / intermediate working boats). 1. Ridge Quay, 2. Rockley Point, 3. Poole Yacht Club, 4. Cobbs Quay, 5. West Quay (Mariner), 6. Blue Lagoon, 7. Poole Harbour Yacht Club, 8. Parkstone Bay - currently proposed marina scheme (1986), the bay to be enclosed by a new bund.

Asterisks - Areas of moorings for leisure vessels (approximate).

Open triangles - berthage for intermediate sized vessels.

Solid triangles - berthage for large sized vessels.





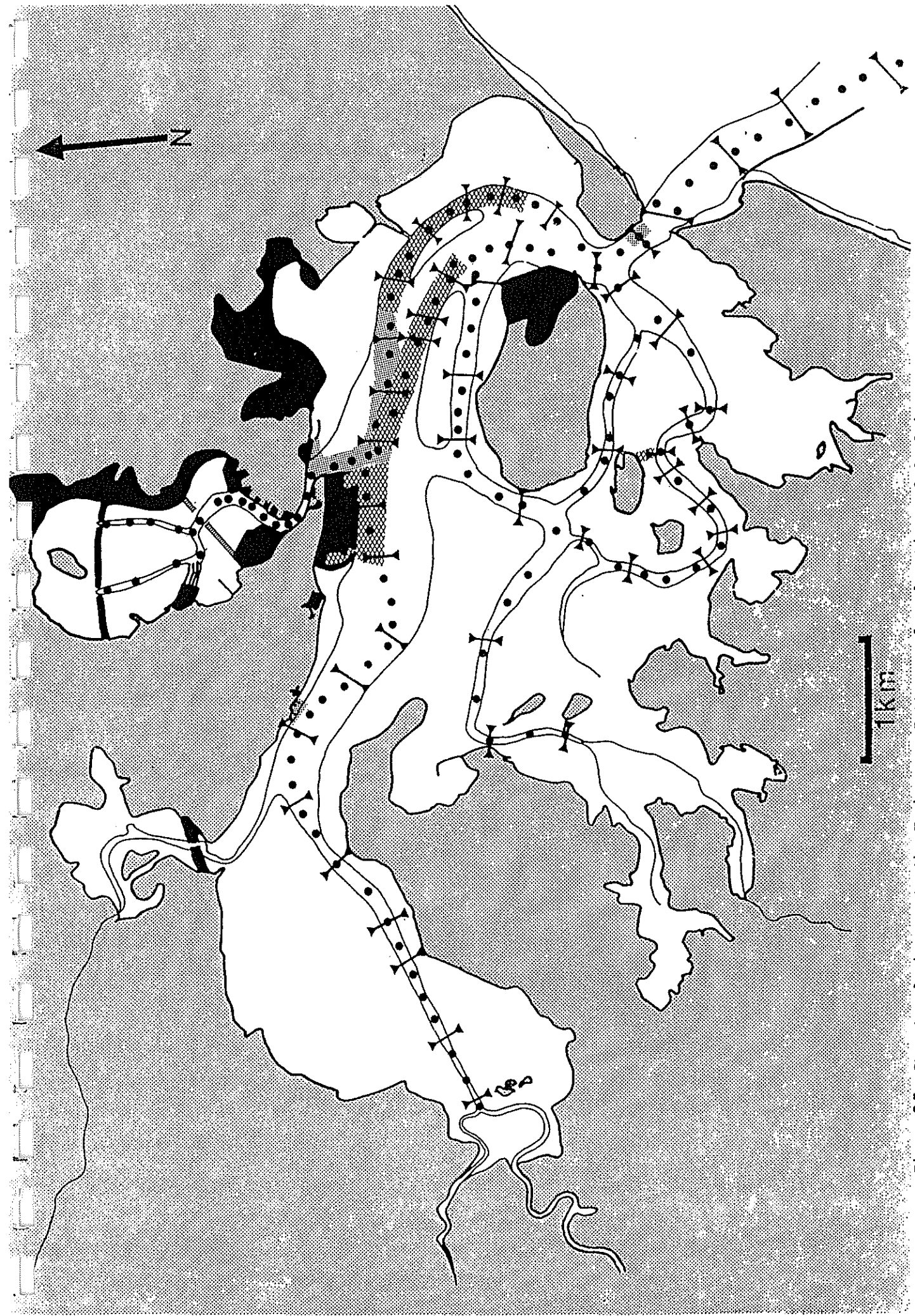


Figure 25 Structural changes to the Harbour - Patterns of reclamation and dredging. Reclamation since approx. 1845 (Black areas). Dredging since approx 1970: Stippled areas - maintenance dredging; Cross hatched areas - major / structural dredging. (All areas are approximated). For details, see sections K, M and N.



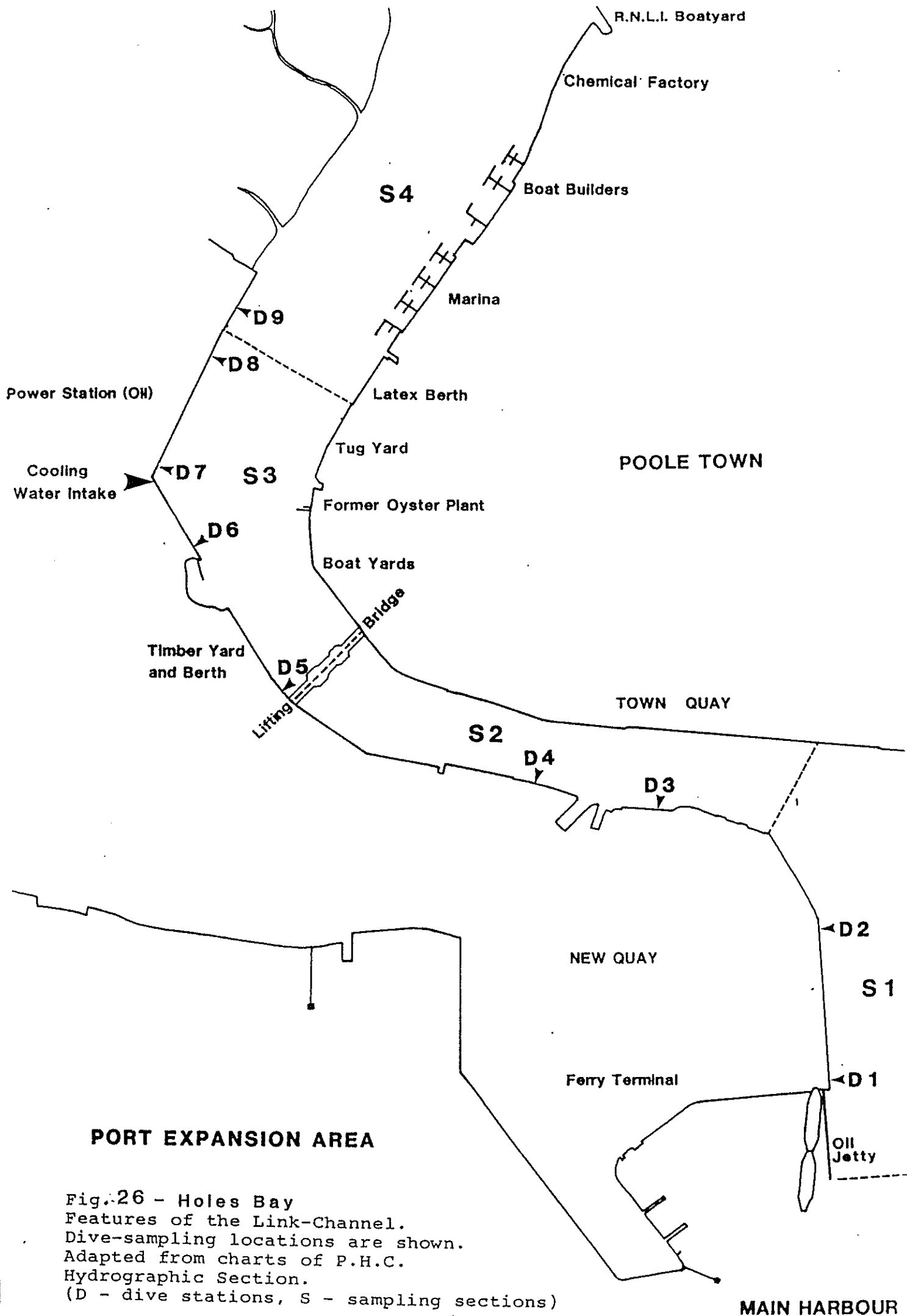


Fig. 26 - Holes Bay
 Features of the Link-Channel.
 Dive-sampling locations are shown.
 Adapted from charts of P.H.C.
 Hydrographic Section.
 (D - dive stations, S - sampling sections)

MAIN HARBOUR

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100

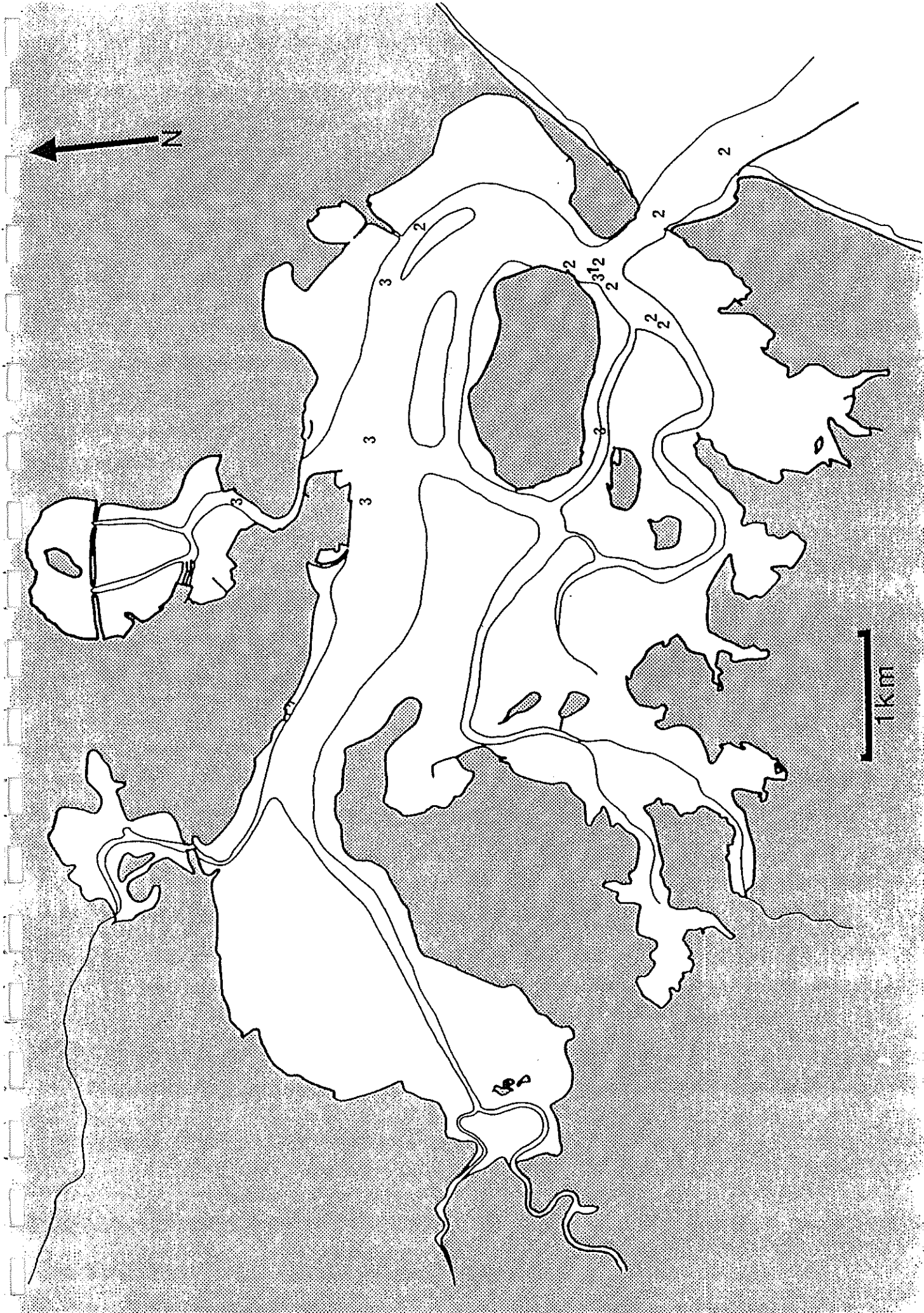


Figure 27 - Subtidal survey - distribution of economic species within Poole Harbour. 1 Homarus vulgaris (lobster), 2 Maia squinado (edible spider crab), 3 Cancer pagurus (edible crab).



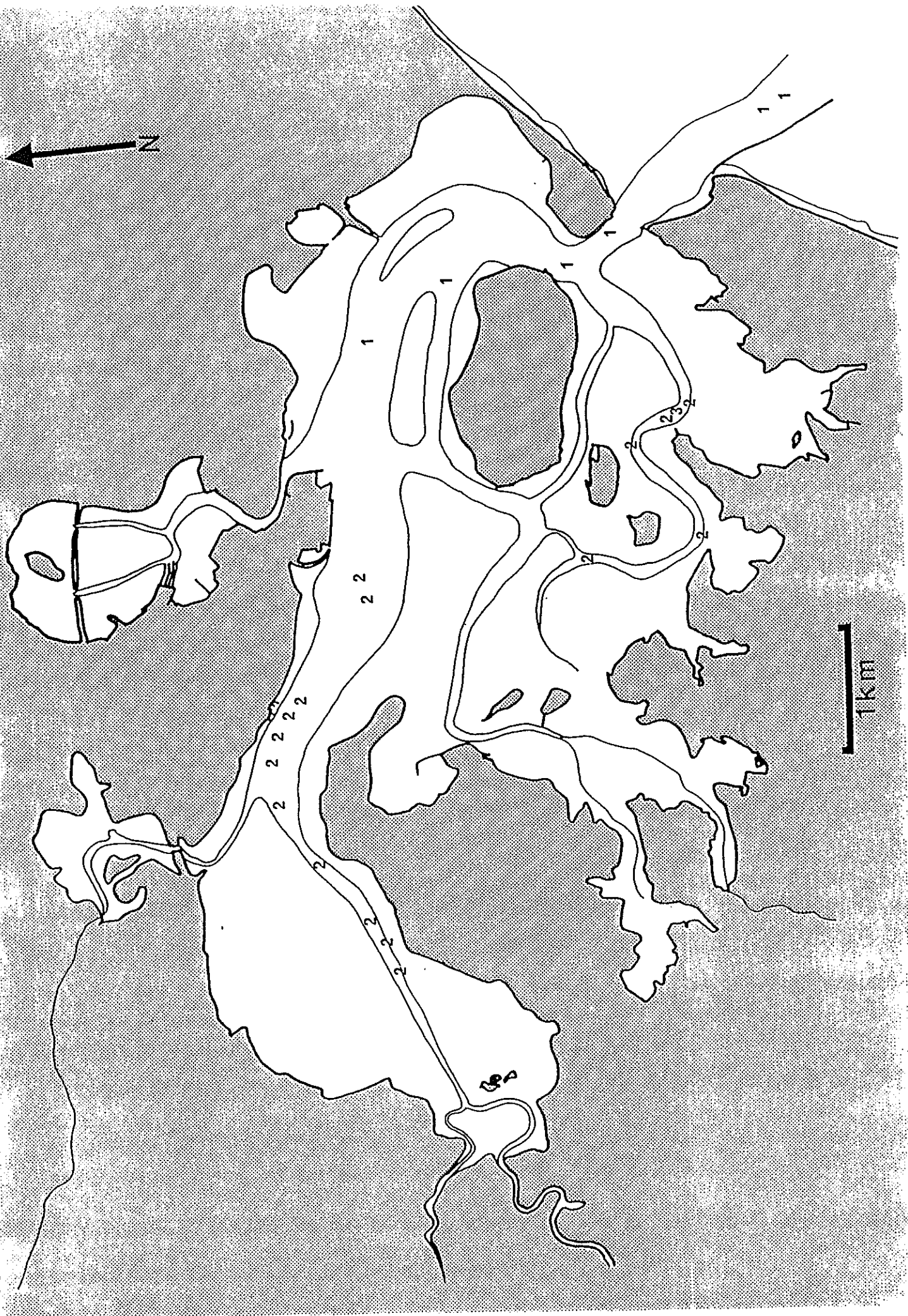


Figure 28 - Subtidal survey - distribution of economic species within Poole Harbour.
 1 *Buccinum undatum* (edible whelk), 2 *Mytilus edulis* (edible mussel), 3 *Crassostrea gigas* (Portuguese oyster).



Appendix II

FULL SPECIES LIST GLOSSARY OF COMMON NAMES

SURVEY ZONES WITHIN POOLE HARBOUR.....	II - 1
FULL SPECIES LIST.....	II - 2
GLOSSARY OF COMMON NAMES.....	II - 8

STATION	SWC	HAC	MCL	MCU	WCL	WCC	WCU	SDL	SDU	BAC	WYL	WYU	TW	DVC	HBL	HBU
Terebellid				*												
CRUSTACEA-CIRRIPEDIA																
<i>Balanus crenatus</i>			*					*		*						
<i>Balanus improvisus</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	⊙	⊙
<i>Balanus perforatus</i>			*					*							⊙	
<i>Elminius modestus</i>	*	*	*	*	*			*	*	*	*	*	*	*	⊙	⊙
<i>Semibalanus balanoides</i>															⊙	
CRUSTACEA-AMPHIPODA																
<i>Amphipelisca brevicornis</i>										*						
<i>Corophium acherusicum</i>	*			*	*			*	*		*	*		*	⊙	⊙
<i>Corophium volutator</i>									*		*	*				
<i>Jassa falcata</i>	*							*								
<i>Phtisica marina</i>	*	*		*				*								
Caprellids															⊙	
CRUSTACEA-DECAPODA																
<i>Cancer pagurus</i>			*	*						*	*				⊙	
<i>Carcinus maenas</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	⊙	⊙
<i>Eupagurus bernhardus</i>	*	*	*	*		*		*	*	*	*			*		
<i>Galathea strigosa</i>	*	*	*								*					
<i>Homarus vulgaris</i>	*															
<i>Inachus dorynchus</i>	*	*						*						*		
<i>Leocarcinus</i>	*															
<i>Macropodia rostrata</i>	*			*				*								
<i>Maia squinado</i>	*	*	*					*								
<i>Thorulus cranchii</i>								*								
Prawns				*			*								⊙	
CRUSTACEA-ISOPODA																
<i>Sphaeroma serratum</i>										*		*			⊙	
PYCNOGONIDA																
<i>Achelia echinata</i>	*	*	*	*				*			*			*	⊙	
<i>Nymphon sp.</i>	*							*								
<i>Pycnogonum littorale</i>	*			*					*	*						
MOLLUSCA-GASTROPODA																
<i>Archidoris pseudoargus</i>	*							*								
<i>Aeolidiella sanguinea</i>								*								
<i>Buccinum undatum</i>	*	*		*				*		*					⊙	⊙
<i>Crepidula fornicata</i>	*	*	*	*	*	*	*	*		*	*	*	*	*	⊙	⊙
<i>Gibbula cineraria</i>																
<i>Hydrobia ulvae</i>								*		*					⊙	⊙
<i>Littorina littorea</i>				X		*				X					⊙	⊙
<i>Nassarius reticulata</i>				X						X						
<i>Nucella lapillus (eggs)</i>	*															
<i>Patella vulgata</i>	*															
<i>Trivia arctica</i>								*	*							
MOLLUSCA-BIVALVIA																
<i>Cerastoderma edule</i>	*	X	X	X	X	X	X	*	*	*	*	*	*	X	⊙	⊙

ECHINODERMATA

<i>Asterias rubens</i>												*				
<i>Ophiothrix fragilis</i>								*	*		*					⊙
<i>Psammechinus miliaris</i>								*	*							

ASCIDIACEA

<i>Asciidiella aspersa</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*		⊙
<i>Botrylloides leachi</i>								*	*	*						
<i>Botryllus schlosseri</i>	*	*			*			*	*	*	*					⊙ ⊙
<i>Ciona intestinalis</i>					*			*								⊙ ⊙
<i>Clavelina lepadiformis</i>					*			*		*						⊙
<i>Dendrodoa grossularia</i>								*								
<i>Didemnum candidum</i>					*			*	*	*	*	*				
<i>Diplosoma listarianum</i>					*			*	*	*						
<i>Molgula sp.</i>																⊙
<i>Norchellium argus</i>					*			*		*						⊙
<i>Styela clava</i>	*	*	*	*	*	*	*	*	*	*	*		*	*		⊙ ⊙
Species subtotals:	57	143	53	67	56	46	41	138	76	73	74	31	30	61	77	44

CHORDATA-PISCES

<i>Agonus cataphractus</i>																
<i>Anguilla anguilla</i>																
<i>Anguilla (burrows)</i>																
<i>Belone belone</i>																
<i>Blennius gattorugine</i>																
<i>Blennius pholis</i>																
<i>Clupea harengus</i>																
<i>Callionymus lyra</i>																
<i>Conger conger</i>																
<i>Cottus bulbalis</i>																
<i>Cyclopterus lumpus</i>																
<i>Gadus morhua</i>																
<i>Gobiusculus flavescens</i>																
<i>Gobius niger</i>																
<i>Morone labrax</i>																
<i>Mugil labrosus</i>																
<i>Mullus surmulletus</i>																
<i>Nerophis lumbriciformis</i>																
<i>Platichthyes flesus</i>																
<i>Pleuronectes platessa</i>																
<i>Pholis gunnelus</i>																
<i>Pollachius pollachius</i>																
<i>Pomatoschistus minutus</i>																
<i>Salmo salar</i>																
<i>Salmo trutta</i>																
<i>Scomber scombrus</i>																
<i>Scophthalmus maximus</i>																
<i>Scophthalmus rhombus</i>																
<i>Solea solea</i>																
<i>Spinachia spinachia</i>																
<i>Spondylisoma cantharus</i>																
<i>Syngnathus acus</i>																
<i>Trachurus trachurus</i>																

GRAND TOTAL - 257 species

Glossary of Common Names

Common names for species and groups of seaweeds and animals recorded during the subtidal surveys is provided below. Only widely used names are included.

ALGAE.....SEAWEEDES

ALGAE - CHLOROPHYCEAE GREEN SEAWEEDES

Blidingia minima
Bryopsis plumosa
Cladophora rupestris
Cladophora vagabunda
Chaetomorpha linum
Codium fragile tomentosoides
Enteromorpha intestinalis
Enteromorpha prolifera
Microspora ficulinae
Spongomorpha lanosa
Ullothrix flacca
Ulva lactuca

SEA LETTUCE

ALGAE - CYANOPHYCEAE BLUE GREEN SEAWEEDES

Oscillatoria submembranacea

ALGAE - RHODOPHYCEAE RED SEAWEEDES

Antithamnion plumula
Apoglossum ruscifolium
Audouinella sp.
Broggiartella byssoides
Calliblepharis ciliata
Callithamnion sp.
Ceramium flabelligerum
Ceramium pedicellatum
Ceramium rubrum
Champia parvula

<i>Chondria dasyphylla</i>	
<i>Chondrus crispus</i>	Irish Moss
<i>Compsothamnion thuyoides</i>	
<i>Cystoseira baccata</i>	
<i>Delesseria sanguinea</i>	
<i>Erythrotrichia carnea</i>	
<i>Gigartina stellata</i>	
<i>Gracilaria verrucosa</i>	
<i>Griffithsia corallinoides</i>	
<i>Griffithsia flosculosa</i>	
<i>Halarachnion ligulatum</i>	
<i>Heterosiphonia plumosa</i>	
<i>Hypoglossum woodwardii</i>	
<i>Laurencia pinnatifida</i>	Pepper Dulse
<i>Palmeria palmata</i>	Dulse
<i>Plocamium cartilagineum</i>	
<i>Polyneura gmelinii</i>	
<i>Polysiphonia denudata</i>	
<i>Polysiphonia elongata</i>	
<i>Polysiphonia macrocarpa</i>	
<i>Polysiphonia nigrescens</i>	
<i>Porphyra umbilicalis</i>	Purple Laver
<i>Rhodymenia pseudopalmata</i>	

PHAEOPHYCEAE	BROWN SEaweEDS
<i>Ascophyllum nodosum</i>	Knotted Wrack
<i>Chorda filum</i>	
<i>Cladostephus spongiosus</i>	
<i>Cystoseira baccata</i>	
<i>Desmarestia lingulata</i>	
<i>Dictyota dichotoma</i>	
<i>Ectocarpus sp.</i>	
<i>Fucus serratus</i>	Serrated Wrack
<i>Fucus spiralis</i>	Spiral Wrack
<i>Fucus vesiculosus</i>	Bladder Wrack
<i>Laminaria digitata</i>	Car Weed (kelp)
<i>Laminaria saccharina</i>	
<i>Sargassum muticum</i>	
<i>Spongonema tomentosum</i>	

PROTOZOA	SINGLE CELLED ANIMALS
tubicolous ciliate species	
<i>Quinqueculina sp.</i>	

PORIFERA

Amphilectus fucorum
Cliona celata
Halichondria bowerbanki
Halichondria panicea
Haliclona oculata
Hymeniacidon perleve
Microciona atrasanguinea
Myxilla incrustans
Suberites ficus
Suberites massa
Sycon ciliatum

SPONGES

Breadcrumb sponge

COELENTERATA - HYDROIDEA

Dynamena pumila
Gonothyraea lovenii
Hartlaubella gelatinosa
Hydractinia echinata
Hydrallmania falcata
Kirchenpaueria pinnata
Laomedea flexuosa
Obelia geniculata

SEA FIRS

COELENTERATA - SCYPHOZOA

Rhizostoma octopus

JELLYFISH

COELENTERATA - ANTHOZOA

Actinia equina
Cereus pedunculatus
Diadumene cincta
Metridium senile
Taelia felina
Sagartia troglodytes

ANEMONES, CORALS, ETC..

Beadlet Anemone
Snakelocks Anemone

Plumose Anemone
Dahlia Anemone

NEMERTINII

Lineus ruber

RIBBON WORMS

ANNELIDA

Arenicola marina
Audouinia tentaculata
Hydroides norvegica
Lanice conchiliga
Lepidonotus squamatus
Melinna palmata
Nephtys hombergi
Nereis diversicolor
Oligochaete species
Ophelia bicornis
Pectinaria koreni
Phyllodoce sp.
Platynereis dumerili
Polydora ciliata

ROUND WORMS

Lugworm

Sand Mason
a scaleworm

Catworm
Ragworm

II-II

Pomatoceros lamarki
Sabella pavonina
Sabellaria alveolata
Spirorbis pagenstecheri

Keelworm
 Peacock Worm
 a tubeworm
 a tubeworm

CRUSTACEA-CIRRIPEDIA
Balanus crenatus
Balanus improvisus
Balanus perforatus
Elminius modestus

ACORN BARNACLES

CRUSTACEA-AMPHIPODA
Amphipelisca brevicornis
Corophium acherusicum
Corophium volutator
Jassa falcata
Phtisica marina

SANDHOPPERS ETC...

CRUSTACEA-DECAPODA
Cancer pagurus
Carcinus maenas
Eupagurus bernhardus
Galathea strigosa
Inachus dorynchus
Macropodia rostrata
Maia squinado
Thorulus cranchii

SHRIMPS, PRAWNS, CRABS, LOBSTERS ECT...
 Edible Crab
 Shore Crab
 Common Hermit Crab
 Squat Lobster

CRUSTACEA-ISOPODA
Sphaeroma serratum

Spider Crab
 a prawn

MARINE 'WOODLICE'

PYCNOGONIDA
Achelua echinata
Nymphon sp.
Pycnogonum littorale

MOLLUSCA-GASTROPODA
Archidoris pseudoargus
Aeolidiella sanguinea
Buccinum undatum
Crepidula fornicata
Gibbula cineraria
Hydrobia ulvae
Patella vulgata
Trivia arctica

MARINE SNAILS ETC...
 Sea Lemon
 Common Whelk
 Slipper Limpet
 Grey Top Shell
 Laver Spire Shell
 Common Limpet
 European Cowrie

MOLLUSCA-BIVALVIA
Cerastoderma edule
Cerastoderma glaucum
Crassostrea gigas
Mytilus edulis
Ostrea edulis
Petricola pholadiformis

SHELLFISH, ETC...
 Edible Cockle
 Lagoon Cockle
 Portugese Oyster
 Common Mussel
 European Oyster
 American Piddock

<i>Scrobicularia plana</i>	<i>Peppery Furrow Shell</i>
<i>Venerupis decussata</i>	<i>Cross Cut Carpet Shell</i>
<i>Venerupis pullastra</i>	<i>Fullet Carpet Shell</i>
<i>Venerupis semidecussata</i>	
<i>Venus mercenaria</i>	<i>North American Clam</i>
PHORONIDEA	<i>(no common name)</i>
<i>Phoronis psammophila</i>	
KAMPTOZOA	<i>(no common name)</i>
<i>Pedicellina cernua</i>	
BRYOZOA	SEA MATS
<i>Alcyonidium polycom</i>	
<i>Alcyonidium diaphanum</i>	
<i>Amathia lendigera</i>	
<i>Anguinella palmata</i>	
<i>Bicellariella ciliata</i>	
<i>Bowerbankia gracilis</i>	
<i>Bowerbankia gracillima</i>	
<i>Bowerbankia imbricata</i>	
<i>Bowerbankia pustulosa</i>	
<i>Bugula fulva</i>	
<i>Callopora dumerilii</i>	
<i>Celleporella hyalina</i>	
<i>Conopeum reticulum</i>	
<i>Crisia aculeata</i>	
<i>Cryptosula pallasiana</i>	
<i>Disporella hispida</i>	
<i>Electra pilosa</i>	
<i>Flustra foliacea</i>	<i>Hornwrack</i>
<i>Schizomavella linearis</i>	
<i>Scruparia scrupea</i>	
<i>Scrupocellaria reptans</i>	
<i>Scrupocellaria scruposa</i>	
<i>Valkeria uva</i>	
ECHINODERMATA	SEA URCHINS, STARFISH, ETC...
<i>Asterias rubens</i>	<i>Common Starfish</i>
<i>Ophiothrix fragilis</i>	<i>Common Brittle Star</i>
<i>Psammechinus miliaris</i>	<i>a Sea Urchin</i>
ASCIDIACEA	SEA SQUIRTS
<i>Asciella aspersa</i>	
<i>Botrylloides leachi</i>	
<i>Botryllus schlosseri</i>	
<i>Ciona intestinalis</i>	
<i>Clavelina lepadiformis</i>	
<i>Dendrodoa grossularia</i>	
<i>Didemnum candidum</i>	
<i>Diplosoma listarianum</i>	
<i>Morchellium argus</i>	
<i>Styela clava</i>	<i>Korean Sea Squirt</i>

VERTEBRATA

CHORDATA-PISCES

Agonus cataphractus
Anguilla anguilla
Anguilla anguilla (burrows)
Belone belone
Blennius gattorugine
Blennius pholis
Clupea harengus
Conger conger
Cottus bulbalis
Cyclopterus lumpus
Gadus morhua
Gobiusculus flavescens
Gobius niger
Morone labrax
Mugil labrosus
Mullus surmulletus
Nerophis lumbriciformis
Platichthyes flesus
Pleuronectes platessa
Pollachius pollachius
Pomatoschistus minutus
Salmo salar
Salmo trutta
Scomber scombrus
Scophthalmus maximus
Scophthalmus rhombus
Solea solea
Spondyllosoma cantharus
Syngnathus acus
Trachurus trachurus

ANIMALS WITH BACKBONES

FISH

Pogge
Common Eel
As above
Garfish
Tompot Blenny
Common Blenny
Herring
Conger Eel
Long Spined Sea Scorpion
Lump Sucker
Cod

Black Goby
Bass
Thick Lipped Grey Mullet
Red Mullet
Worm Pipefish
Flounder
Plaice
Pollack
Sand Goby
Salmon
Sea Trout
Mackerel
Turbot
Brill
Dover Sole
Black Sea Bream
Greater Pipe Fish
Scad

Appendix III

DIVE TRANSECT RESULTS -

Examples

Index

Introduction.....	III - 1
Key to dive transect.....	III - 2
Locations of dive transect stations.....	III - 3
Dive Transect HAC2.....	III - 4
Dive Transect SDU8.....	III - 8
Dive Transect WCL2.....	III - 10

Introduction

A new Dive Transect method for evaluating seabed variations has been developed for the Poole Harbour Subtidal Survey. The procedures are described in the SURVEY DETAILS within the GENERAL and SCIENTIFIC ASSESSMENTS (Sections 3 & 4). The methods proved effective in the evaluation of inter-relationships between bathymetry, the substrates and biological communities, providing three dimensional impressions of gradients of change across the bed of the Harbour. The data obtained was used in the preparation of figs. 8 - 12 within Appendix I, and provided much of the basis for Sections 3 and 4. Examples of results obtained from individual dive transect stations are given below. 1) **Station HAC2**, spans the Harbour entrance (between the Haven Points) where the strongest currents, greatest depths and coarsest seabed sediments occur. 2) **Station SDU 8**, spans Ramshorn Lake, the small channel that links the top of the South Deep with the Upper Wych Channel. This represents the opposite extreme to HAC2, the profile there being indicative of weak tidal currents in that it is very shallow and floored by soft muds. 3) **Station WCL2** off the reclaimed Continental Ferry Terminal, spans what is a totally changed channel bed, in part constituted by the boulders fringing the reclaimed land of the ferry terminal, and in the main dominated by the dredged channel bed.

39 cross-channel dive transects were undertaken in all covering all areas of the Harbour (see fig. 2 overleaf). The detailed results for the Southern Sector (Lower and Upper South Deep, Blood Alley, Upper Wych Channels - SDL, SDU, BAC, WYU) are provided in Dyrynda, 1985 (note that the Southern Sector Stations have now been recoded, see fig. 2 overleaf). The results for the remaining, Northern Sector are given in full in Dyrynda (1987a).

Results for each cross-channel diving transect are presented as follows:






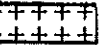


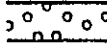
i) General description.

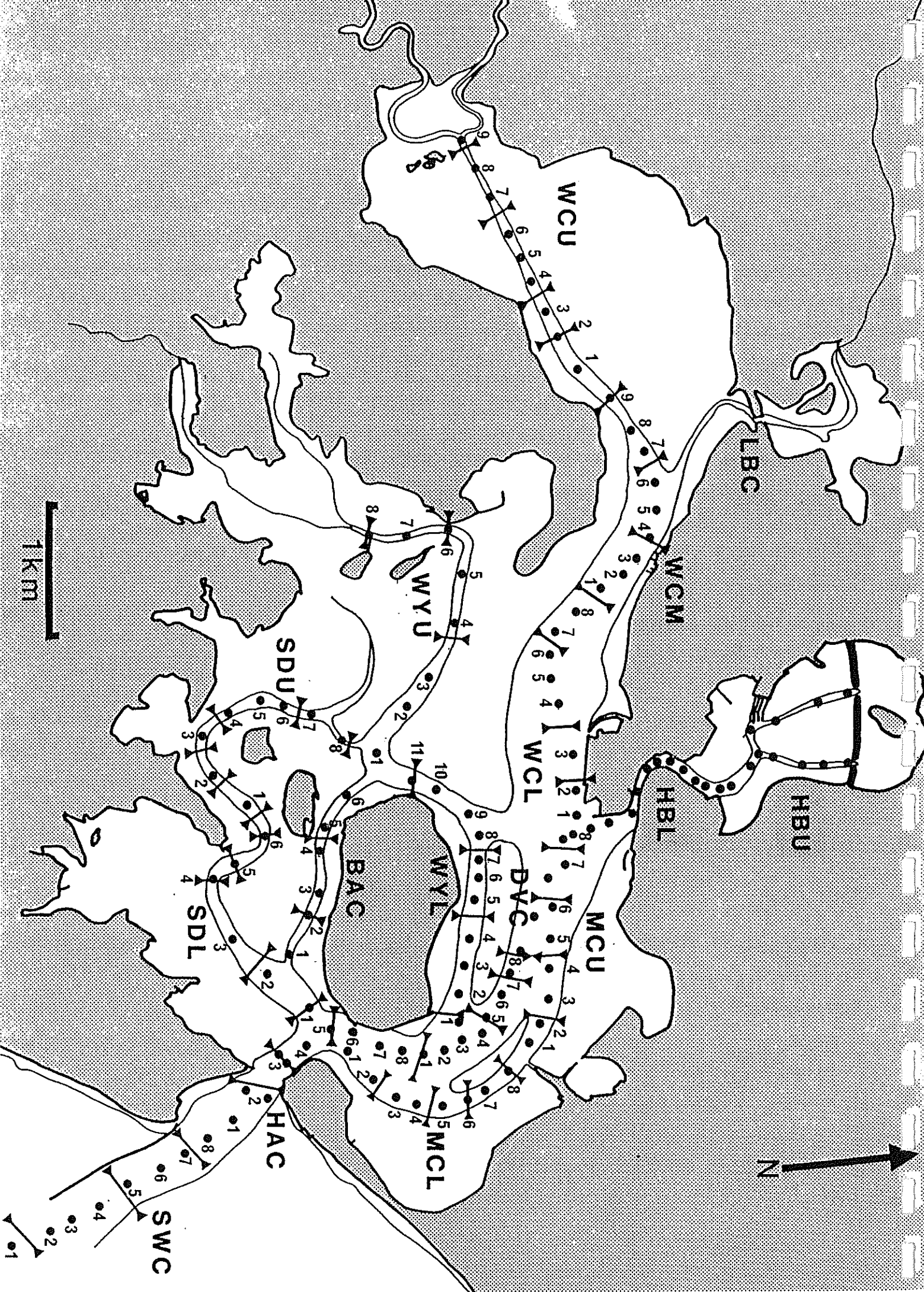
ii) Detailed description of cross channel variability in terms of substrates and biological communities. Values in square brackets [] refer to specific points or zones along the transect, expressed as the horizontal distance in metres from the starting point of the transect (corrected for bathymetric variation).

iii) Cross channel bathymetric profile showing variations in bathymetry and substrates. The vertical and horizontal axes are to scale. Depths are in metres, corrected to Chart Datum according to tide gauge data provided by P.H.C. Hydrographic Unit. See key to substrates below.

iv) Cross-channel bathymetric profile with exaggerated vertical scale. depths are in metres.

Key to substrates:

Soft mud		Gravel	
Firm mud		Cobbles	
Fine sand		Clay	
Medium sand		Hard substrate (natural or artificial)	
Coarse sand			



Cross channel transect HAC2Haven Channel (central)

Between North and South Haven Points, immediately downstream of the chain ferry route.

Seabed distance covered: 239m

Transect direction: South to north.

Depth range covered: South end = 2.5m; maximum: 17.3m*;
North end = 1.8m

Deepest point in Poole Harbour and Poole Bay.

Substrate range: Medium sand
Coarse sand
Gravel
Stones
Cobbles
Boulders
Clay.

Infralittoral to a depth of approximately 11m

The central Haven Channel experiences the most extensively strong tidal currents within the Poole Harbour system for the following reasons: 1, It is within the most downstream section of the channel network, 2. it is a zone where channels merge, 3. the channel (or at least the deeper section of the channel) changes direction several times, 4. above all, it is a zone where tidal flow is constricted (between North and South Haven Points). Velocities of 4.5 knots have been recorded (but may locally be still higher), resulting in the greatest levels of scour and greatest channel depths within Poole Harbour (17-18m). Comparable depths are not attained within Poole Bay, the offshore 15m contour being well beyond the entrance of the Harbour. A 239m transect was undertaken to cover all but the periphery of the cross-channel profile, immediately downstream to the path of the chain ferry. The subtidal trough takes a zig-zag path between the Haven Points. Moving upstream, the trench first heads north-west up to the point of this transect, then south-west as far as HAC3, and then north-west again towards Brownsea Island. The profile at HAC2 is steep sided and strongly skewed towards the north, i.e. the steeper section of the outer (northern) flank of the bend is much closer to shore than is that of the inner (southern) flank. The upper sections of both flanks are characterized by sands. The northern flank, by a steeply sloping bed of coarse sand, largely clear of material but featuring occasional boulders supporting Flustra (typical of very strong tides). Coarse and medium sands which dominate the less current-scoured upper, southern flank support scatterings of stones, mainly colonized by large macroalgae, e.g. Ceramium rubrum, growing to exceptional size under the favourable conditions of shallowness, relatively clear water and good nutrient supply.

Deeper down, the southern flank increasingly resembles that of the north, in that it is steep and of coarse sand but with greater epibenthic cover. The lowest sections of both flanks are very current-scoured and support a cover of stones and cobbles which increase in size and abundance with increasing depth, and in the case of the northern flank, there is also a bed of oyster shells. In contrast to the shallower areas, deeper water shells and stones are dominated by sessile fauna, particularly by Alcyonidium diaphanum and Hydrallmania, the first of which is typical of such substrates under strong current conditions. The deepest section of the profile is dominated by a cover of the largest cobbles. To the immediate north of the bottom of the trough, there is a high density field of Sabella, the tubes being embedded within the gravel between the cover of cobbles. At the very deepest point of all the cobbles are more mobile, supporting barnacles and Pomatoceros. To the south of the deepest point, a seam of consolidated clay is exposed, forming a 1m high vertical face and overhang (Bagshot clay).

Although this is the deepest section of the subtidal channel network, it is not the most exposed. HAC3, just upstream of this transect, was found to be still more exposed and near biologically barren.

CROSS CHANNEL TRANSECT HA2 -SOUTH TO NORTH

[1-10] Coarse sand with gravel and stones, heavily colonized by scrub algae, especially Ceramium rubrum. Occasional Laminaria saccharina, small Sargassum, Taelia.

[11-42] Coarse sand with gravel and stones, the latter now dominated by large plants, Sargassum, Halidrys siliquosa, Ceramium rubrum (attaining large sizes), Laminaria saccharina, Ulva, occasional Lanice.

[43-65] Medium sand, occasional stones and gravel. At first, brown weeds still present, but these give way to reds, particularly Ceramium rubrum, Gracilaria verrucosa and Plocamium cartilaginium. The frequency of gravel and stones and their colonizers declines with increasing depth. Further down, fauna like Hydrallmania, Sertularia, Valkeria begin to replace algae (Gracilaria is the most persistent seaweed). Pomatoceros and barnacles colonize small stones. Clear sandy areas separate 'copses' of weeds and invertebrates. Sabella begins to feature.

[66-88] Coarse sand, at first in waves and undulations, these declining as the slope becomes steeper. Occasional stones. After [82] algae becoming much thinner, mostly Gracilaria. Smallest stones with Pomatoceros and barnacles, larger ones with Gracilaria and Hydrallmania, also Kirchenpaueria and Styela. Occasional Lanice, and towards [88], Crepidula.

[89-99] Moderate to high densities of stones set in gravelly coarse sand. Colonizers as above.

[100-111] Stones and cobbles covering gravel. Fairly dense bed of Sabella growing among stones. Colonizers of stones: barnacles, Pomatoceros, Alcyonidium diaphanum, Flustra foliacea (a little), Ascidiella, Styela.

[112] Outcrop of clay, scattering of stones.

[113-115] Stones and cobbles on gravel. No Sabella. Otherwise as for [100-111].

[116-120] Stones in sandy gravel. Some Sabella in clumps. On a boulder - Flustra, on stones - Pomatoceros, barnacles, Alcyonidium diaphanum.

[120-124] Large outcrop of clay forming a 1m high near vertical face with underhang. Virtually clear of benthos.

[125-131] Deepest section, 17.3m below C.D., high density of (mobile) stones and cobbles on gravel. Heavy colonization by barnacles and Pomatoceros, some with Hydrallmania, some Sabella, some Flustra (on boulders).

[132-136] High density of (stable) stones over gravel. Dense field of Sabella growing between stones. Stones mainly colonized by Pomatoceros.

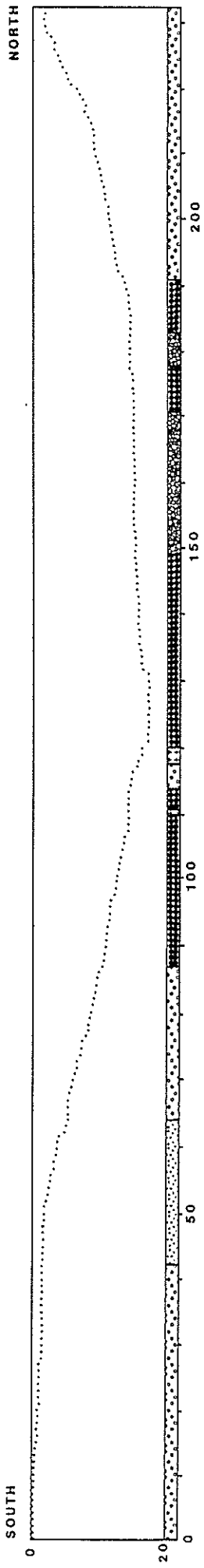
[137-178] High density of stones on gravel. Size of stones increases with depth. Some Ostrea shells. Major colonizers are Alcyonidium diaphanum, then Hydrallmania. Also some Ulva, Valkeria, Ascidiella, Styela. Occasional Lanice.

[179-188] Gravel with scattering of small stones. High density of Lanice in places, occasional Sabella. Alcyonidium diaphanum is major colonizer of stones.

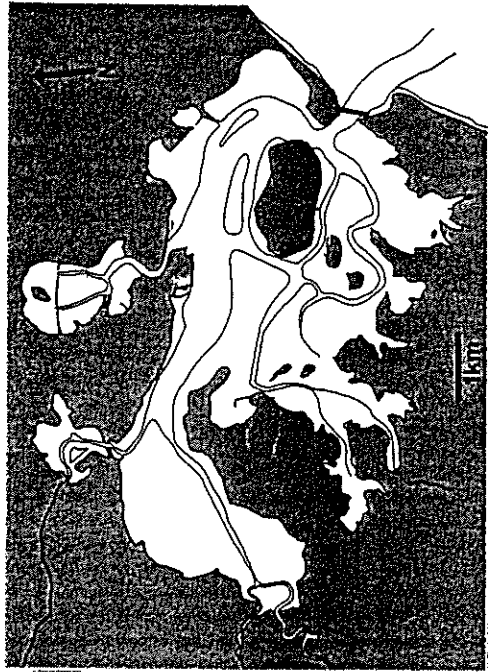
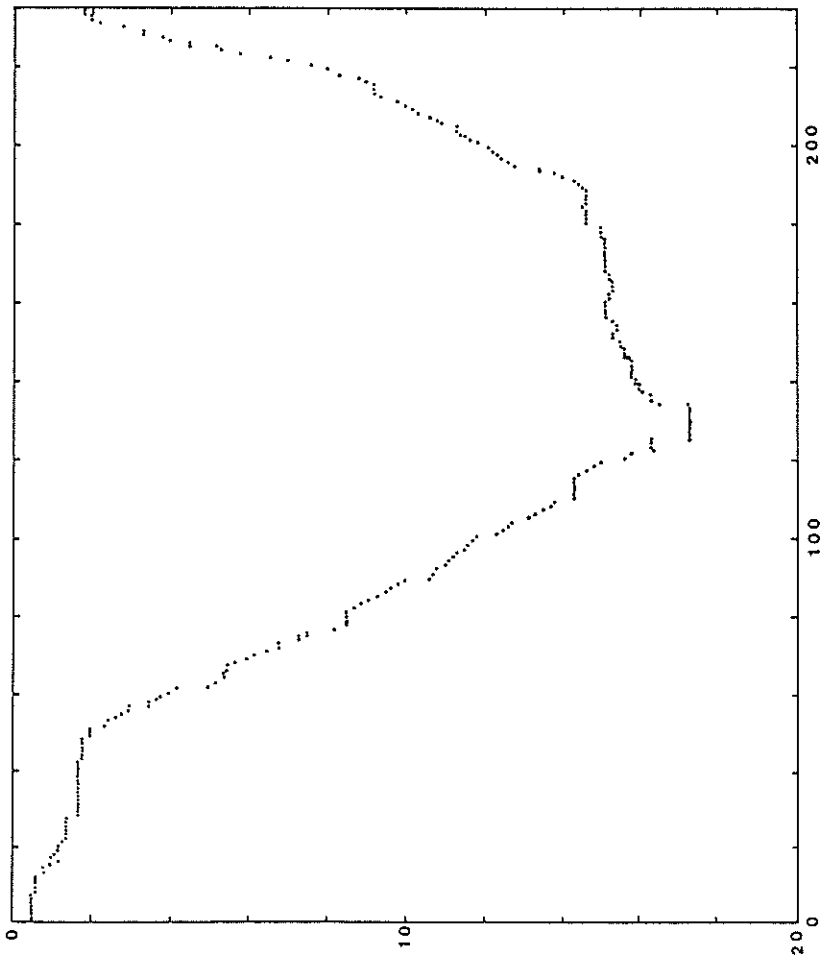
[189-196] High density of Ostrea shells, colonized particularly by Pomatoceros with some Sargassum, Hydrallmania and barnacles.

[197-239] Coarse sand on a slope, rippling decreases with increasing depth, coarseness increases with depth. Scatterings of stones with Gracilaria, Valkeria, occ. Sargassum. Boulders support Flustra.





HAC2





Cross channel transect SDU8Ramshorn Lake

Link between the South Deep and the junction between the Upper Wych, the Lower Wych, and Blood Alley Channels. Due west of Furzey Island.

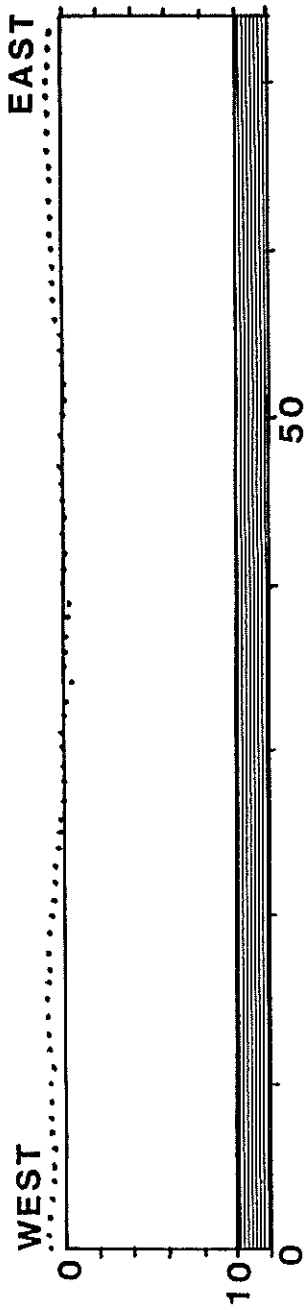
Seabed distance covered: 73m (complete cross-channel transect).

Transect direction: West to east.

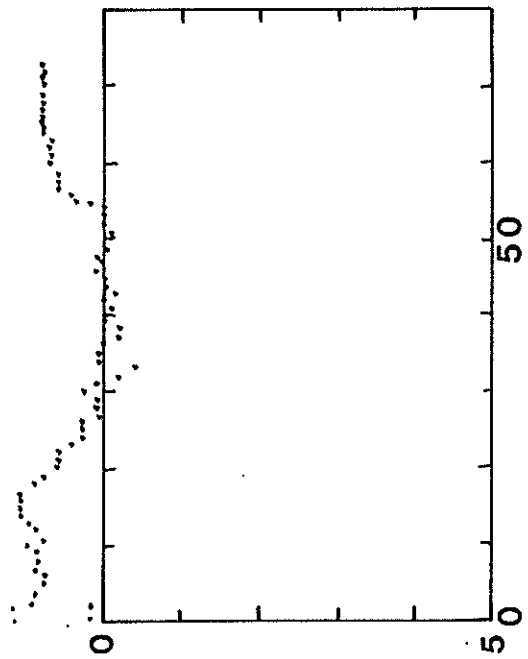
Maximum depth: 0.4m

The narrowness and extreme shallowness of this section of the channel reflects its characteristics as a link between two major channel systems, through which relatively little tidal exchange takes place. It is floored by deep organic mud, oscillating in depth above and below chart-datum line. The central section [27-38m] is notable for the presence of an appreciable concentration of Anguilla burrows. Otherwise, the only epibenthic features are occasional drift clusters of Ascidella and Sargassum, and very occasional small shells with scrub algae. The mud surface also features keel and screw gouges produced by the grounding of small boats: Ramshorn Lake is the only access point into the upper end of the South Deep and as such is a main route for boats circumnavigating the Harbour.





SDU8



Cross channel transect WCL2Lower Wareham Channel- lowest section

Most downstream section of the Lower Wareham Channel, off the reclaimed Port Expansion Area (dredged) adjacent to the point separating the the earlier (1972) and later (1982) developments.

Seabed distance covered: 135m
 Transect direction: South to North
 Depth range covered: 8.7m to 8.8m to -1.3m

Extensively dredged, in part reclaimed

Substrate range: Soft mud
 Hard mud
 Clay
 Boulders

This transect covers the area off the Port Expansion Area, at the divide between the section constructed in 1972 and that constructed in 1982. This reclaimed area extends to the former subtidal channel which has been dredged to a depth well below the natural values, to accomodate vessels of large draught. The product is the only expanse of deeper water within the Harbour (measured on the transect to 8.8m)(with the exception of the Haven Channel). The subtidal section of the retaining bund of large limestone boulders enclosing the reclaimed area provides the most substantial resource of subtidal 'hard' consolidated substrates within the Harbour, and is well colonized by sessile biota characteristic of such substrates. Below this, there is a steep, dredged slope, virtually clear of epibenthos. Sections of this are of soft mud, but elsewhere there are tracts of hard clay exposed by dredging. Beyond this slope is the deep channel floor, a near horizontal tract of consolidated clay and hard mud, clearly current swept, in places with appreciable dredge sculpturing, and generally barren of epibenthos. Ascidiella is the most significant colonizer represented. The evidence suggests that strong tidal scour (no doubt contributed to by the construction of the reclaimed area itself) is scouring the seabed free of finer sediments such that maintenance dredging may not be required. A significant epibenthic cover may be allowed to form here in due course.

CROSS CHANNEL TRANSECT WCL2 - SOUTH TO NORTH

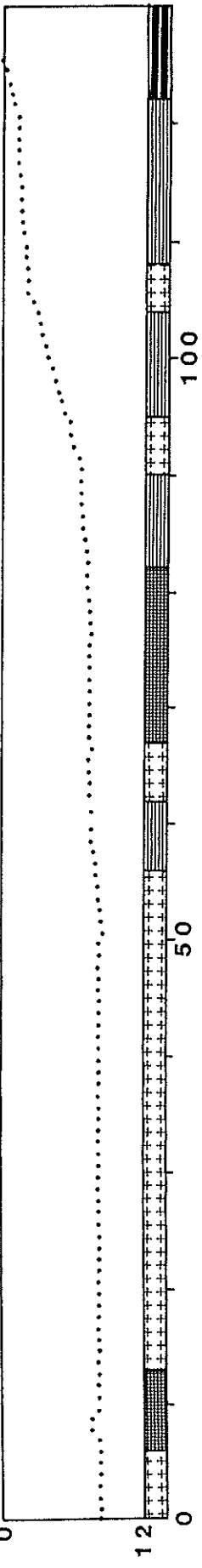
[1-67] Dredged, deep water area (1972 / 1982), largely barren, in places exposed consolidated clay with dredge sculpturing, i.e. both trenching and cratering. The area is clear of finer sediments. Scatterings of shells, some colonized by Ascidiella.

[68-82] Firm mud on lowest section of the dredged slope. Some (pioneer?) Sabella. Some shells (including Ostrea) and stones with Ascidiella, Metridium and Styela.

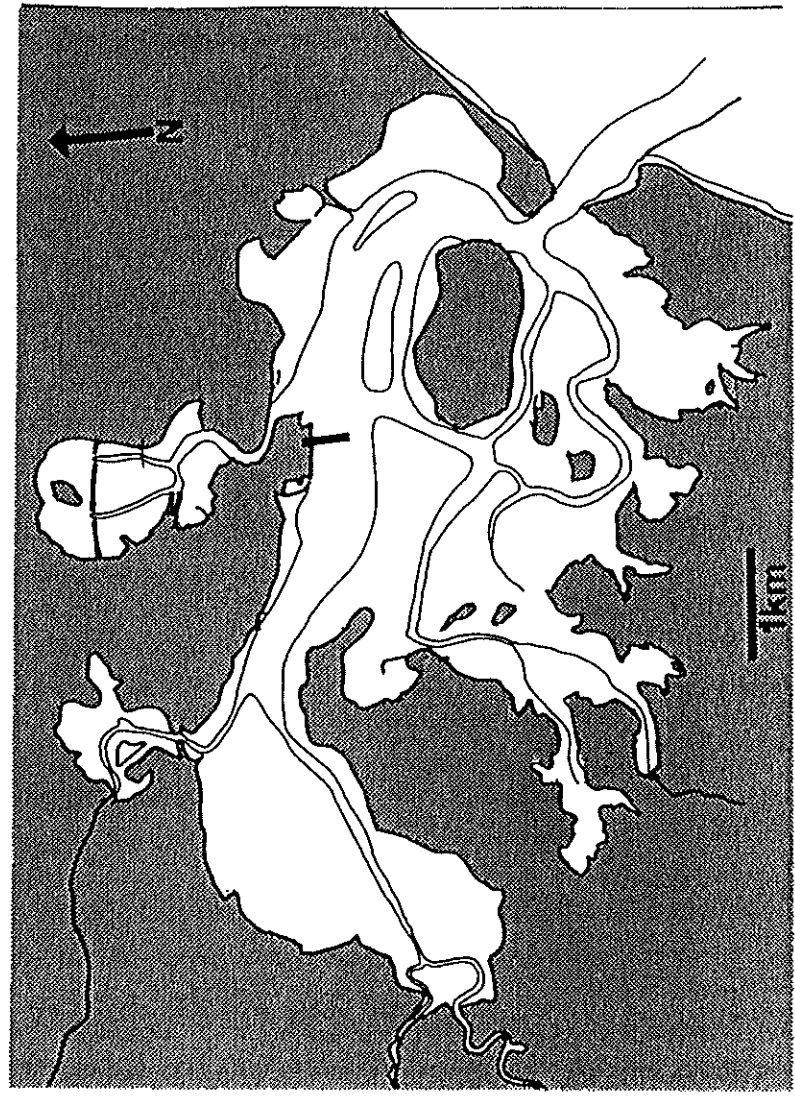
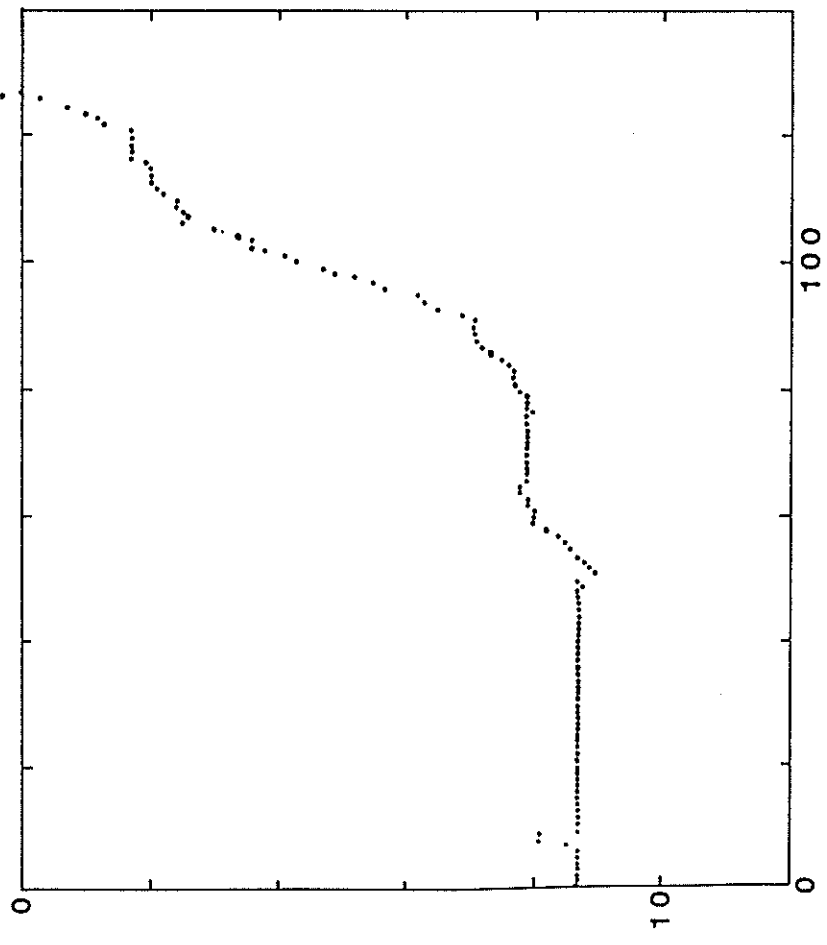
[83-122] Steep dredged slope, exposures of hard clay with intervening tracts of soft mud (post-dredging accretion). Generally very clear.

[123-131] Boulder slope, lower section of limestone bund fringing the reclaimed area, fairly heavily colonized by sessile biota up to a depth of 1.2m. Circalittoral cover dominated by sponges, e.g. Haliclona oculata and by Ascidiella (see species list). Above 1.2m, dominant cover is of scrub algae.

SOUTH NORTH



WCL2





Appendix IV

REFERENCES

- BOYDEN, C.R. 1975 Distribution of some trace metals in Poole Harbour, Dorset. Marine Pollution Bulletin 6, 180-187
- COLLINS K.J. 1980 A survey of the oyster population off the Hamworthy shore, Poole Harbour May 1980. A Report to the Poole Harbour Commissioners
- COLLINS K. J. 1983 A survey of the oyster population in leased grounds off Hamworthy Poole Harbour. March 1983. A Report to the Poole Harbour Commissioners
- CRITCHLEY A. T., FARNHAM, W.F., MORREL, S.L. 1983 A chronology of new European sites of attachment for the invasive brown alga Sargassum muticum, 1973-1981. Journal of the Marine Biological Association of the U.K. 63, 799-811
- DOODY, P., DENNIS, E. 1984 Poole Harbour - Dorset. An appraisal of ecological research. Nature Conservancy Council
- DYRYNDA, P.E.J. 1983 Investigation of the subtidal ecology of Holes Bay, Poole Harbour. Report to the Nature Conservancy Council
- DYRYNDA, P.E.J. 1985 Poole Harbour Subtidal Survey - Southern Sector - 1984. Report to the Nature Conservancy Council
- DYRYNDA, P.E.J. 1987a Poole Harbour Subtidal Survey - III. Dive Transect Survey - Northern Sector, 1985. Report to the Nature Conservancy Council
- FALCONER, R.A. 1981 Numerical model study of flushing and mixing in Holes Bay. Report to Wessex Water Authority
- GRAY, A. 1985 Poole Harbour: Ecological sensitivity analysis of the shoreline. A Report prepared for B.P. Petroleum
- HO, Y.B. 1975 The uses of Ulva lactuca L. as an indicator organism for marine pollution. Ph.D. Thesis. University of Liverpool

LANGSTONE, W.J. 1982 The distribution of mercury in British estuarine sediments and its availability to deposit feeding bivalves. Journal of the Marine Biological Association of the U.K. 667-684

NATURAL ENVIRONMENTAL RESEARCH COUNCIL, 1975 Estuaries Research. N.E.R.C. Publications, London Series B, No.9

POOLE HARBOUR COMMISSIONERS, 1982 Poole Harbour. Master Plan Study

PORTSMOUTH POLYTECHNIC, 1981 Ulva and Enteromorpha in Poole Harbour and Holes Bay. Report to the Wessex Water Authority

ROGERS, A. 1986 A comparison of populations of the slipper limpet Crepidula fornicata in Poole Harbour. University of Wales Dissertation

WALKER, J. 1986 Levels of hydrocarbon contamination within the sponge Suberites massa in Poole Harbour. University of Wales Dissertation

N.B. This is by no means an exhaustive listing of the literature concerning the subtidal or marine ecology of Poole Harbour. This was not attempted since recent literature reviews already exist. The most complete is that of Doody and Dennis (1984), and other reports are summarized in Poole Harbour Commissioners (1982).