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A regional coastal zone management system

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by

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Abstract

This thesis investigates research and practice in coastal management along with the concurrent growth in information technology that can usefully support the management process.

Through the example of a few countries, the text gives evidence of an integrated approach to the coastal zone, which has brought together the extensive range of users and uses. The development and operation of coastal management in the UK along sectoral lines rather than through a holistic approach is illustrated.

The definition and relevance of management at a regional scale is considered along with the range of data for successful management of the coastal zone. The thesis identifies the opportunity for a local study into data supply and use, with a broad base for enquiry amongst coastal users. Thus, this thesis investigates one of the core issues in the successful operation of coastal management - the supply and use of appropriate data.

A literature search determined the existence of a large and distributed constituency and a structured approach to users was developed in order to investigate:

- the local, current view of coastal management;
- views on the appropriate region for holistic management;
- issues relating to data requirements and data management;
- issues of data supply.

A documentary research methodology was utilised, building upon the literature search to a structured set of interviews with a selection of key players, and thence to a questionnaire sent to a wide range of agencies and individuals. Analysis at the various stages gave rigour to the system.

The results of the thesis indicate that:

- despite good reasons for establishing a regional approach to coastal management in harmony with the broad effects of the natural world, many individuals are focused on their local projects;
- the hierarchy of issues and data requirements identified through the investigation permit a phased implementation of coastal management, initially addressing the more significant elements of a holistic approach;
- despite developments in information technology there is significant dependence on paper-based records and interpretation;
- there is a large measure of interest amongst the coastal user group in improving the understanding of and increasing the use of modern analytical techniques.

The thesis introduces a suitable model for integrating the results of the work.

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Glossary[1]

Accuracy

Closeness to the truth; may include a measure of precision; may come with accuracy boundaries; may require statement of an appropriate reference frame; may apply to time, place or attribute.

AONB (Countryside Commission, 1978, p.4)

Area(s) of Outstanding Natural Beauty – formally designated, and commonly "to a) conserve the beauty and character of the designated area, b) help the public to enjoy the area ..., c) ensure that the policies of planning authorities, government agencies and other statutory bodies are working in harmony".

Bayesian probability (Chambers, 1992)

Proceeding from a measurement of probability as a measurement of belief; considering statistical inference as a process of re-evaluating such probabilities on the basis of empirical observation.

Comprehensiveness

A measure of completeness of a dataset.

Consistency

Imperative through data capture and modification; requires good metadata records. Secondary data will have been gathered for other purposes by a variety of techniques and equipment and to a variety of standards. The imposition of consistent reference systems, of attestation to accuracy levels and other metadata issues will be vital to the production of reliable information.

Correlation (Fink, 1995, p.3)

A method of estimating the relationship between two variables.

Currency

A measure of how up-to-date is a dataset.

Data

Values gathered by measurement or experiment (original or primary data) or extracted from a pre-existing dataset (secondary data).

Dimensions – 2D, 2.5D, 3D, 4D

The ability of GIS to work in multiple dimensional space. 2D, plane two-dimensional geometry allows an attribute at a point, e.g. height, but not height and another attribute. 2.5D, use of an attribute surface on a 2D co-ordinate system allowing a view of the surface; it does not allow a view of the thickness of the surface nor the use of multiple attributes. 3D space gives true three dimensions, plus an attribute. 4D allows 3D and attribute variations over time.

Frequency count

... of questionnaires. A simple sum of responses.

Fuzzy sets

Where classifications involve uncertain boundaries, fuzzy sets utilise a gradual progression from one area of certainty to a different area of certainty.

Heritage Coast

Non-statutory designations using management by co-operation to a) conserve the quality of the scenery and b) foster leisure activities which rely on natural resources. Determined by the Countryside Agency (formerly the Countryside Commission).

Information

Data processed in some form, e.g. by combination, comparison, commentary or other to produce data with more or less interpretation.

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[1] Dale, 1990, pp 27-32, AGI, 1991 and others.

Integrity

... of topological geometry; of attribute data; within and across databases; during updates. Any variations in reference systems, terminology or definitions will result in spurious analyses. Cross-referencing must result in change in one part of the database being automatically reflected in relevant change to all other areas.

Lineage

Source of a dataset; information on its origin and changes.

Metadata

Information on a dataset that should include type, location, accuracy, comprehensiveness, consistency, currency and format.

National Nature Reserve

Formally designated. There are three Marine Nature Reserves, one of which is at Lundy.

National Park

Formally designated to preserve and enhance areas of natural beauty for public enjoyment.

Precision

i) a measure of repeatability; ii) the number of significant digits.

Protection

Use of regular back-up procedures including a journal of activities and off-site storage.

Reliability (Litwin, 1995, p.6)

... of questionnaires. A statistical measure of how reproducible are the results, usually affected by random and measurement error.

Security

Use of passwords for individuals or groups to allow access only to certain geographical areas and/or certain layers and/or certain attributes. The use of passwords is well established and is common on the Internet.

SSSI

Site(s) of Special Scientific Interest is an area of land or water notified under the Wildlife and Countryside Act, 1981 (as amended) as being of special nature conservation interest. Applies down to low water.

Topology

Relationship between data (often of points or arcs defining lines and polygons in a vector-based system).

Transfer

... of data by common file types, e.g. DXF, NTF, or (US) Tiger file formats, by generic type (e.g. ArcInfo export format with the postscript .E00), or by HTML. Remote access will encourage the utilisation of older data sets not undergoing revision, but used due to their ready availability.

Validity (Litwin, 1995, pp.33,34)

... of questionnaires. A measure of accuracy; an assessment of how well the results reflect the intention of the questions.

Acknowledgements

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Thanks to my parents, my own family and to Geraldine for her steadfastness and support.

AUTHOR'S DECLARATION

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award.

This study was financed through the departmental resources of the Institute of Marine Studies.

Relevant scientific seminars and conferences were regularly attended. External institutions were visited for consultation purposes.

Presentations:

"Data and information for regional coastal zone management", Institute of Marine Studies Seminar Series, University of Plymouth, 30th April, 1998
"Introducing GIS into the curriculum", RICS Geomatics Division, one day workshop at Reading, 4th November, 1998
"Marine GIS", a presentation given at an RICS one day workshop and seminar at Devon County Council, Exeter, 20th January, 1999
"Information for the Coastal Zone", a presentation given at The Cornish Coast 99, a one day seminar at Camborne, 3rd November, 1999

Conferences attended:

"Managing the UK marine coastal zone environment", Association of Geographic Information seminar, University of Manchester, 24th July 1996
"Loads of Data – but where is it ?", Association of Geographic Information regional meeting, Bristol, 19th February 1997
"Hydro 99 – Information Management", The Hydrographic Society, University of Plymouth, 5th-7th January, 1999
"Maximising the use and exchange of coastal data", HR Wallingford, 11th February, 1999
"Info' coast: the local challenge" one-day workshop on indicators and information exchange, Atlantic Living Coastlines, University of Plymouth, 7th May, 1999

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Signed .....

Date 10/11/2000

Chapter One

Introduction

This thesis documents research undertaken to investigate the operation of coastal zone management in and around south Devon in the south west of the United Kingdom.

The concept of coastal zone management has brought an integrated approach to the coastal zone in many places around the world and examples of these are given (Chapter Two) to illustrate the mature nature of coastal zone management in these places. These are contrasted with the current UK use of a sectoral rather than a holistic approach.

The thesis has been developed from a literature search that determined the existence of a large and distributed constituency with interests in coastal management. In order to give rigour to the results of this work and to take the research further, a structured approach to investigate the views of these practitioners was developed. From this, a documentary research methodology was utilised, building upon the literature search to a structured set of interviews with a selection of key players, and thence to a questionnaire sent to a wide range of individuals and agencies.

Thus, this thesis identifies the opportunity for a local study into data supply and use with a broad base for enquiry amongst coastal users, and investigates one of the core issues in the successful operation of coastal management - the supply and use of appropriate data. Various original results have been derived and these, together with a model for its implementation, are presented and discussed.

1.1 Methodology

In order to include adequate opinion in this study, a classification of coastal zone users was determined. The total population of holistic coastal management is the whole coastal user group. This group is largely inaccessible with the majority being tourists (there were 10 million tourist trips into the South West in 1996 (Devon County Council Tourism, 1998)). However, it came to be accepted during the initial interviews that coastal management, even in its widest definition, was not a subject of concern to tourists or others who are, in this context, the general public. This left those with rôles more closely associated with the coastal zone as being the core parties.

The research identified classifications by Smith & Lalwani (1984) and Rickman & Miller (1995).

Smith and Lalwani (1984) identified eight major user groups within the coastal zone:

- transport and communication, including ports, shipping and navigation;
- mineral and energy resources;
- biological resources and fisheries;
- waste disposal;
- strategic (military) uses;
- research and education;
- recreation and tourism;
- conservation.

This grouping of users laid the foundation of a stratified approach to the further work. Rickman and Miller (1995) mirror such sectors in a bibliography of coastal applications of Geographical Information Systems (GIS). This bibliography uses seven designations for grouping titles, namely:

- coastal processes,
- natural resources,
- wetlands,
- coastal planning,
- disaster management,
- water quality,
- geology,

all of which could be elements of holistic coastal management.

Table 1.1 addresses these classifications together with other users of the coastal zone, coupled with non-user, geographical areas. These coastal sections of the South West ensure that the thesis will consider all areas and that natural forces along the coast will not be artificially divided by current administrative divisions such as county boundaries. The classifications are not exclusive and indeed individuals came to be associated with more than one tile in the table. The range of classifications did ensure that a broad and relevant approach to the investigation was undertaken.

The raison d'être of coastal management is the optimal use of a coastal zone. It is normally defined in terms of natural and anthropic influences, using relevant information to resolve current conflicts and aiming to minimise the effects of future conflicts. The classifications chosen in this study (Table 1.1) permit a review of a wide range of interested parties and thus a broad view of influences and conflicts.

Code	Policy development	Code	Implementation	Code	Land type	Code	Water depth
1	European Union	11	Directorates	21	Agriculture	31	0-15 m deep
2	Government	12	Agencies	22	Rural/non-farm	32	15-90 m deep
3	County Councillors	13	County Council staff	23	Industrial	33	> 90 m deep
4	District Councillors	14	District Council staff	24	Commercial		**User**
		15	Parish Councils	25	Housing	35	Manual
6	Earth summit	16	Agenda 21	26	Estuary/coast	36	Professional
7	NGO	17	Non-governmental	27	Cliff	37	Managerial
8	Wildlife Trusts	18	Local Trust	28	Beach/sand/mud	38	Academic
9	Nature Reserves	19	Local Reserve			39	Politician
	Use		**Management**		**Coastal stretch (N)**		**Coastal stretch (S)**
41	Transport	51	Commercial	61	Land's End – Kelsey Hd.	71	Land's End-Lizard Pt.
42	Resource	52	Nature Reserve	62	Kelsey Hd. – Hartland Pt.	72	Lizard Pt.-Dodman Pt.
43	Biological/fish	53	Estuary mgt.	63	Hartland Pt. – Bull Point	73	Dodman-Rame Head
44	Waste	54	Shoreline mgt.	64	Bull Point – Minehead	74	Rame Hd.-Start Pt.
45	Strategic/military	55	Oil pollution	65	Minehead – Bristol	75	Start Pt.-Torquay
46	Research/education	56	Major incident	66	SW Peninsula	76	Torquay-Budleigh
47	Recreation/tourism		**Distance inland**	67	Cornwall – whole county	77	Budleigh-Seatown
48	Conservation	58	<10 km inland	68	Devon – whole county	78	Seatown-Portland Bill
		59	>10 km inland	69	Dorset – whole county	79	UK (external to SW)

Table 1.1 Classification for coastal zone users by employment and working area
The code numbers are arbitrary identifiers. (Author)

The methodology required to address the users so classified was determined by reference to Barnes (1992). He set out four contrasting research methods (pp.111-117):

- hypothetico-deductive
- documentary
- ethnographic
- action

The hypothetico-deductive method is common in the physical sciences. Two or more investigations could have been determined to compare results for consistency. More combinations would have been required to quantify variability in the results.

Documentary research is suited to gathering data from a wide variety of sources and the hypothesis is determined during the consideration of the resulting dataset. Particular problems in this method of missing or unreliable data (and hence, validity) are discussed below.

The ethnographic approach could have been attempted by gaining employment, say, as a coastal manager, but was impractical for the author. It would also have had limitations, swapping one narrow view for another and missing out on the wider views of the coastal user group. The documentary approach could have been undertaken from the position of the new employment, but with no particular advantage apart from a change in perspective.

Finally, the action-research method is particularly applicable to the social sciences, but less so for this task as it requires active participation in all relevant areas of employment. Observer status in seventeen areas of policy development and implementation would need

the best part of a year and working across all the large canvas illustrated by Table 1.1 would have been impractical.

The documentary research technique was chosen as being the most applicable. The investigation could have been undertaken through a literature search alone, or by supporting it with interviews, or additionally by wider sampling. Experimental work on a newly developed coastal management system was considered but rejected. Such work would have been premature without the groundwork undertaken here. A literature review would not be relevant in this situation as the work is intended to be new, not a review, but the widest approach was chosen in order to reach the relevant people in the area. The literature search on implementation and research forms the basis of Chapters Two to Four. The interviews and questionnaire are reported in Chapter Five. The process is illustrated as a flow chart in Figure 1.1.

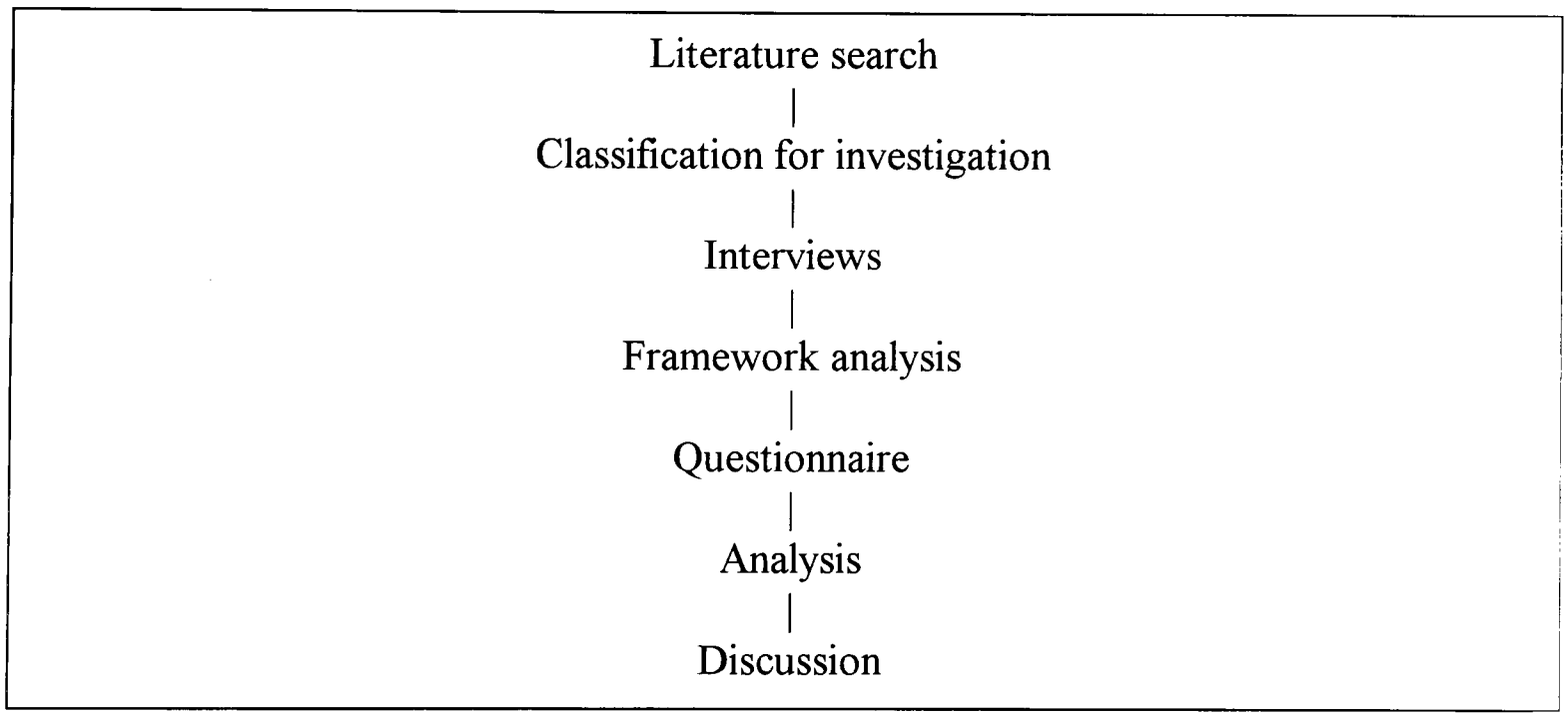

Figure 1.1 Flow chart illustrating the research methodology (Author)

Interviewees were selected in order to elicit views associated with many of the classes given in Table 1.1 and to ensure a systematic spread of opinions. Some individuals were

contacts known to the author, others known to colleagues and two by searching a coastal resort for suitable people. All these individuals were asked to identify further interviewees and potential respondents to the questionnaire. The interviews were open-ended, allowing the development of the interviewees' own views (albeit the theme of holistic coastal management and the use of information were the framework for the talks). This interview method was chosen in order not to limit the author's investigation due to his preconceptions. The interviews permitted the development of an informed questionnaire.

Interviews were recorded by note-taking and/or by tape recording with subsequent transcription. The former suited the author and provided a hard-copy backup. The latter permitted a review of the interview complete with nuances and a check on the limitations and errors in note-taking.

The cross-section of coastal users contacted produced a first impression of local coastal management and its needs from people working in the area. The majority of interviews were held face-to-face, with two by telephone. The venue of the interviews in the interviewees' offices or homes gave an improved context to an understanding of the interview; three provided useful site visits. Telephone contact was necessary due to i) a time constraint on the interviewee, and ii) the distance to the interviewee in Kent.

After transcribing and précising, the interviews were assessed for common themes by condensation and categorisation (Kvale, 1996, p.192) to determine priority issues. This enabled the themes to be identified and the questionnaire to be formulated. This framework analysis of the initial interviews identified common and unique topics, such as the cost of data access and units of measurement, respectively.

A study of interview and questionnaire techniques was undertaken (Dixon and Leach, 1978; Cook, 1981; Jarboe, 1993; Jones, 1998; Gadd, pers com; Witt, pers com; McDermott, pers com) which permitted the development of a rigorous approach to the next survey. Opinions on questionnaire design (Dixon and Leach, 1978, p.9), the numbers within the trial sample, the number of questionnaires to be sent out, and the likely percentage of returns varied widely. Inherently, the larger the sample, the more likely that the answers will represent general opinion (Litwin, 1995, p.5), but a questionnaire may only receive a 10% return from the population surveyed. Conventional statistical techniques require more than thirty returns unless an allowance is made for small groups (Spiegel, 1972, p.142) and such a minimum dataset also applies to analyses of sub-sets of the returns. If the interviews were adequately stratified through the relevant population and if the questionnaire returns were also representative of the population, then a large return would help to minimise missing and/or unreliable data and hence the analysis is more likely to be valid.

A postal questionnaire was chosen due to the geographical spread of the potential respondees (Dixon and Leach, 1978, pp.5,6). The questionnaire also allowed contact with many more individuals than would otherwise have been possible due to time and location constraints. The questionnaire design followed the conventional refinement (Cook, 1981, p.3) from the broad idea (i.e. the aim of the thesis and the interview framework analysis) to a set of subtopics and thence to a specific set of questions. The questionnaire variously required yes/no answers, a choice between two or three options, or a selection from a list. Terminology is a major problem in questionnaire design, where brief phrases are often used, and some may be "jargon" terms to non-cognate members of the public. Therefore, there may be some uncertainty in the responses. There is so much social, educational and

experiential context associated with our understanding that responses are necessarily subjective.

The questionnaire was trialed (technically a "content validity measure", Litwin, 1995, p.35) and various corrections incorporated. The questionnaire was also given to the Faculty Ethics Committee to ensure it did not transgress University requirements on the use of questionnaires. 604 questionnaires were sent out and there were 170 completed replies. This is a successful return rate of 28.1%. Anonymity was guaranteed, although 60 of the sample (35.3%) chose to identify themselves in order to receive feedback on the results and 64 identified themselves without requiring feedback.

A computerised database of the questionnaire responses was set up, with detailed analysis using a statistical package. The research had an essentially quantitative rather than qualitative bias, having a detached focus on the results from a large number of respondents. As such it fits into the more traditional physical science approach to research despite the interviews and questionnaires.

1.2 The presentation of the thesis

The issues are developed and discussed in the following chapters. Chapter Two reviews the current state of coastal management, setting the context for the study and expanding terms such as integrated and holistic. Chapter Three considers data and information requirements associated with coastal management. The application of the broad ideas of coastal management to a local area is undertaken through Chapter Four where regional issues are considered and a variety of boundaries discussed. A survey of coastal users is reviewed in Chapter Five in which the initial interviews and the more extensive

questionnaire are described and analysed. The analysis feeds into a model for future implementation described in Chapter Six. Chapter Seven, with its conclusions and suggestions for further work, brings the thesis to a close.

Thus, the core of this thesis is the currency of coastal management and its relevance to the South West of the UK. The original work is the rigorous consultation with a wide range of people that lays the foundation for a relevant and effective information system to support coastal management. The use of interviews and a questionnaire not only produces a regional view from interested parties (see particularly Chapter Five), but also informs the earlier background research on coastal management (Chapter Two), on relevant datasets (Chapter Three) and in an estimation of the extent of the region (Chapter Four). As examples, i) the interview with Cornwall Sea Fisheries (Derriman, pers com) produced a cautious, even cynical, view on the possible achievements of integrated coastal management; ii) the questionnaire indicated a wide interest in all datasets suggested and in many others.

The study developed in parallel with local, national and international initiatives in this field. Local examples are included in the text and should a new proposal to the European Union's 5th Framework Programme (Information Technologies) (Morris, 1999) receive funding then the ideas advanced in this thesis may develop into practice.

1.3 Summary

The thesis has been introduced within an initial setting of holistic coastal management but coupled with the promise of further explanation of this concept in a following chapter.

The methodology for undertaking the thesis was described at length, with a detailed justification of the chosen technique of a questionnaire to investigate issues of current interest within coastal management. In general terms this technique is classified as a documentary research technique and this was compared and contrasted with thee other methods for research.

The methodology for determining a relevant constituency was described. The development and use of a classified approach (Table 1.1) in the work to follow was justified. Further details of the research techniques were given, including the questionnaire and the analysis.

Finally, the following chapters of the thesis were described, permitting the reader an insight into the content and development of the work.

Chapter Two

An assessment of the coastal zone

The coast is of major significance to most populations and especially to island nations. It has gateways for trade, locations to gather food and sinks for waste. It impinges directly on many as a place for living, for working or for recreation. The coast is complex, affected by many natural and anthropic influences and the term "coastal zone" is used to avoid focusing on the coastline, which produces a very limited approach with which to view coastal processes and human interaction with the ocean's edge.

The UK registered some concern for the coast sixty years ago, instituting a study of the coast by J A Steers in 1943 at the request of the Minister of Town and Country Planning (Steers, 1978). A government report in 1972 recommended that management should aim at the establishment, maintenance and improvement of the diversity of the biota and habitats both in the body of the water and along the shores (Department of the Environment, 1972).

Urbanisation of the coast and the ease of access of the coast to non-coastal dwellers produce many multiple-use conflicts within the coastal zone. Wildlife Link produced examples of such conflicts for the House of Commons Environment Committee (1992). The three examples in Table 2.1 illustrate gaps in development controls, legal complexities and unresolved responsibilities.

Attempts to integrate the multiple and sometimes conflicting interests in the coast gave rise to Coastal Zone Management, a useful definition of which is:

> "A dynamic process in which a co-ordinated strategy is developed and implemented for the allocation of environmental, socio-cultural and institutional resources to achieve the conservation and sustainable multiple use of the coastal zone." (Campnet, 1989)

This chapter will investigate these issues, assess the maturity of coastal zone management by some examples from around the world and address the research to be undertaken for this thesis.

Sewage outfall planning near wreck site: A wreck site was protected from many disturbances by dredging, fishing or the recovery of artefacts but became susceptible to the building of a sewage outfall which would have increased the local temperature and nutrient supply leading to increased activity by marine organisms. There was no protection against this activity under the legislation. Jet skis: It is possible to zone the use of personal water craft (often known as jet skis) in harbours, but not on beaches outside the area of jurisdiction. Simply banning launchings within a District Council area passes the problem along the coast but is a simplistic approach to planning for the coastal zone. Tourism: A temporarily unused offshore drilling rig was moored near the "tourist" village of Mevagissey and none of then Departments of Energy or Transport, the Ministry of Agriculture, Fisheries and Food nor the Crown Estate Commission had the authority to have it moved. "The Department of the Environment intervened on the grounds of visual impact."

Table 2.1 Three examples of multiple-use conflicts
(first: Brown, 1988; others: Environment Committee, 1992)

2.1 A review of coastal management

The term Coastal Zone Management was made common parlance through developments in the United States culminating in the Federal Coastal Zone Management Act of 1972 (with later amendments). This was based upon prior US legislation applied to specific problems, but the Coastal Zone Management Act was designed as a comprehensive framework to manage the competing uses of diminishing coastal resources.

Many developments around the world followed the US lead in coastal management. Vallejo (1987) listed eleven national programmes, Clark (1992) listed eighteen and Cicin-Sain *et al* (1998) gave sixty three. There were many sub-national programmes as, for example, in Australia (Cullen, 1982). Although each programme is country specific, their

general intention is similar to that of the 1972 US Act. An example from New Zealand (Coastal Zone '78, 1978 and Table 2.2) refers to coastal legislation with items on earthquakes and geothermal and volcanic activity. However, the wide scope of the schedule and specifically clauses "i)" and "j)" which are general and integrative, give encouragement to a comprehensive approach.

Nevertheless, that Campnet was still producing a definition of coastal management in 1989 (above), illustrated that the subject was not clear, albeit the range of developments around the world.

However, in the UK a holistic approach has been slower in coming. The implementation of coastal management across the UK has been piecemeal, dispersed, duplicative and discontinuous (Gubbay, 1990, pp.1-4). King (1994, p.4) recognises a change to integration which remains within a sectoral approach and is therefore still not holistic.

The UK's disaggregated approach to coastal management is in contrast to an often uniform and well-regulated land planning system. The pressure of human development, where disease or detrimental treatment of the environment can be in close proximity to country or urban life, has forced developed countries to control their own populations' standards. Land planning is evident in many aspects of living and legislation with supplementary planning guidance is a common influence on society. Such developments have gone no further than the coastline, i.e. the limit of the planning authority for the land (County Structure Plans extend to the Low Water Mark under the Town and County Planning Act, 1971, being the limit of planning control).

a) Protection, conservation and management of the resources of the area,
b) The preservation or conservation of -
    i) Flora and fauna and their habitats, and stretches of coastline of scientific, fisheries or wildlife importance, historic interest, or of visual appeal,
    ii) Structures, objects and areas of historic or other interest, or of visual appeal,
c) Provision for the establishment or carrying out of the following facilities or activities, if appropriate to the circumstances and to the purposes and objectives of the scheme -
    i) General recreation including bathing, swimming, surfing and other facilities,
    ii) Recreational boating and water-skiing,
    iii) Boat ramps, jetties, moorings and similar facilities for public, club or private use,
    iv) Non-commercial fishing,
    v) Commercial fishing,
    vi) Marine farming,
    vii) Wharf facilities for fishing and other commercial vessels,
    viii) Port facilities and other requirements for cargo and passenger transportation including facilities for amphibian aircraft, flying boats and hovercraft,
    ix) Dredging and disposal of dredged material,
    x) Navigation aids and the safety and convenience of navigation,
    xi) Reclamation, infilling and impoundment,
    xii) Erosion and silting control,
    xiii) The proving or winning of minerals including sand, metal and gravel,
    xiv) Any other facility or activity,
d) The maintenance or attainment of water quality appropriate to the circumstances,
e) Public access to and on the foreshore and water of the maritime planning area,
f) The requirements of ... the Disabled Persons Community Welfare Act ...
g) Aesthetic considerations and the preservation of views,
h) The avoidance or reduction of danger, damage or nuisance caused by -
    i) Earthquake, geothermal and volcanic activity, flooding, erosion, landslip, subsidence, silting and wind,
    ii) The emission of noise, fumes, dust, light, smell and vibration,
i) The relationship between maritime activities and the activities on the adjacent land,
j) Provision for commercial, industrial or recreational activities and the need for them to be located within the area.

Table 2.2 New Zealand coastal legislation (Coastal Zone '78, 1978). It is from the Third Schedule of the 1977 Town and Country Planning Act, under "Matters to be dealt with in Maritime Schemes".

Despite partial moves (Table 2.3), there is still no close parallel between UK developments and the holistic operation of coastal management in other countries. Indeed duplication between local plans and the scarcity of planning to connect them along the intervening coast reinforces the old problems, cloaked as they are in new clothes.

National Coastal Fora
Seeks to promote understanding of coastal zone initiatives; to build upon existing liaison; to assist evaluation and monitoring of initiatives. Organised by the Department of the Environment, Transport and the Regions (most publicly through their newsletter *Wavelength*);

Estuary Management Plans
Aimed to achieve the sustainable management of estuarine areas. Pump-primed by English Nature.

Local Environment Action Plans (LEAPs)
Aimed to integrate and co-ordinate the Agency's objectives with those determined by consultation with organisations and individuals. Led by the Environment Agency;

Special Protection Areas
A means of providing a network of bird habitats to maintain bird populations. Established as a result of the EU Directive on the Conservation of Wild Birds.

Table 2.3 Examples of national developments on coastal issues (ALC, 2000 and author).

Initiating coastal management from individual issues such as the above would require the integration of a wide set of data, one example being the Environmental Agency's Anglian Region Geographical Information System (GIS) (Table 2.4). This is a very good demonstration of a computerised information system being able to integrate multiple data sets and producing output from a variety of combinations of such data.

Agriculture	Currents	Coastal Movement	Coastal Works
Ecology	Fisheries	Sediments	Waves
Infrastructure	Industry	Jurisdiction	Water Levels
Morphology	Birds	Conservation Sites	Water Quality
Rainfall	Temperature	Wind	

Table 2.4 The nineteen main variables of the Environment Agency's, Anglian Region Geographical Information System (Fleming, 1989, pp.159-161)

Civil engineering issues dominated this example of determining relevant datasets. The GIS was set up to support coastal engineering and it is common for civil engineers to

concentrate on coastal defences rather than on the wider issues. Their use of the term, "shoreline management" suggests an apparently broad remit of the coastal defence engineer's work but in fact refers to a narrower approach than holistic management of the coastal zone (e.g. Leafe, 1994).

Searches in the literature and on the web failed to identify studies where the practitioners are asked for their assessment of data requirements. Current abstracts at Doctorate level were searched for similar research, to no avail. There is no evidence of other academic work of this nature and indeed, the following quote dates from July 2000 (author's highlighting).

> "I am looking for some information concerning the users of coastal and marine monitoring/observation type data. I would like to find any user surveys done in the past (local, regional, national, international) that have attempted to determine the types of data and data products needed for management of the coastal and marine environment...
>
> **I've done some searching on the web and through the literature and am not turning up anything.** About all I've come up with so far is a EuroGOOS publication entitled "Operational Oceanography: Data Requirements Survey" by J. Fischer and N.C. Fleming. Any and all leads will be greatly appreciated. Thanks in advance for any help.
>
> Jim Boyd, TPMC at **NOAA Coastal Services Center**, 2234 S. Hobson Ave. Charleston, SC 29405-2413
> Tel: (843) 740-1278, Fax: (843) 740-1224, E-mail: james.boyd@noaa.gov"

Studies such as Estuary Management Plans and Local Environment Action Plans tend to be top-down, i.e. using datasets determined to be most useful in a situation. The shortfall is in undertaking bottom-up studies, i.e. enquiring of practitioners their most used or valuable datasets.

2.2 Developments in coastal management

There was a growth in interest in British coastal management in the early 1990s, evidenced by publications (Gubbay, 1989; Gubbay, 1990; RSPB, 1991) and witnesses to the House of Commons Environment Committee investigation into Coastal Zone Protection and Planning (Environment Committee, 1992). Funded research included studies of coastal resources and of current management practice (Clark, 1992, Rendel Geotechnics, 1993). Current research includes the use of GIS to aid integration (Johnston, 1998). Interactive Internet sites permit a selection of geographic images and combinations of images through GIS (Cannessa, 1998[2]). A recent spate of contributions to a discussion list considered the nature of integration (Appendix A).

Gubbay's work is important for its growth from an environmentalist seeking to establish coastal management as 'good for the country' to one of wider acceptance both of other practitioners and by these other practitioners (Gubbay, pers com, 1990). Thus, Gubbay came to see that others had similar interests, although perhaps for their own reasons: the former to protect the countryside at it was; the latter interested in, say, maintaining the coastline for economic reasons.

The well-resourced Royal Society for the Protection of Birds (RSPB) had its own agenda, but saw it fitting in well with this holistic approach. Environmentalists certainly saw their cause had greater acceptance in the politics of the day – although it was European politics that most strongly favoured such developments. Even today, coastal management is strongly supported by European funds (evidenced by foundation studies such as Atlantic Living Coastlines (ALC, 2000).

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[2] This is an Internet reference. An assessment of the quality of Internet references is given at the start of the References section.

The coastal management interests in the UK, Europe and further also took up current technological developments. Studies such as those by Rendel Geotechnics (1993) were poorly presented on paper compared to what is achievable by digital display systems and the developments reported by Johnston (1998) and others are natural outworkings of current facilities. Yet, the questions and answers do not come naturally. Many GIS displays are of poor quality compared to the mature, national paper mapping portfolios whose cartographic symbolisation has become part of the national culture.

Topics similar to this thesis (which commenced in 1994) are of current interest in other research. In February 1999 there were three conferences: "Maximising the use and exchange of coastal data" at HR Wallingford, a similar study - "Infocoast" in the Netherlands, and "Environmental Data & Information – availability, acquisition & application" an Association of Geographic Information (AGI) meeting in Carlisle. Thus, providing adequate data and information is seen as crucial to the development of coastal management programmes.

There has been an extensive growth in the number of Estuary Management Plans and Local Environment Action Plans (LEAPs) (the latter being slightly more extensive that the former), and growth in support of integrated coastal management at pseudo-national level through the National Coastal Fora (for England, Wales and Scotland). Consortia (see, for example, Table 2.5) aid development of the Estuary Management Plans to co-ordinate sustainable use of a river and its surrounding land. However, there is little to connect Estuary Management Plans along the coast except for civil engineering biased Shoreline Management Plans and issue-based plans such as for oil pollution incidents.

Not all reports are seen as achieving positive results:

> "CZM has long been the domain of academics, NGOs and political types, hence the extended discussions which produce mounds of paper, but little practical action. Effective management of resources leading to sustainability is predicated on the development and use of reliable databases containing verifiable information. Of course, then one needs to "listen" to what the data says and work within the limits it affords." (Ramcharan, pers com)

A management system may be designed by an authority and enacted by decree (a top-down approach) or it may be developed to formalise and enact commonly-held opinions and local interests (a bottom-up approach). Using one or other of these approaches, policy and local management plans have been instituted from supra-national to local level in both the statutory/administrative and voluntary/practical fields.

The former exist in the government–led initiatives such as the Coastal Fora and the latter in the Estuary Management Plans as evidenced by the participating bodies (Table 2.5).

Data management in the coastal zone has been raised on Internet discussion lists, and the following is relevant here:

> "Data management is a crucial component of any CZM plan, yet it seems to be, in my experience, not particularly well addressed - especially when compared to the CZM issues themselves. Some of these issues, e.g. over exploitation of fish stocks, would be better understood and possibly better solved by improved data management and data exchange between organisations and individuals.
>
> Aside from the 'who owns the data' arguments, one of the big problems facing data management in CZM is that data is collected using different techniques for different parameters and across different media. Some of these records are very long, covering decades of measurements. Storing and integrating these data together is not straightforward." (Millard, pers com)

Thus, the current development of holistic coastal zone management theory, the state of computing technology and the opportunities offered by modern software to allow integration, invite research into the provision of data and information for a management system.

2.3 The research

This thesis examines the operation of coastal management, assessing the current developments in theory and practice, and analysing these to determine the requirements for implementing coastal management locally.

Some of the issues affecting the successful implementation of coastal management are considered, such as dealing with large datasets, integrating data held by many collectors and owners (not necessarily the same institutions), the use of different data formats, and their residence at different physical locations. The consideration of these topics is undertaken with regard to the geographical area of the study, i.e. the South West of England, which imposes its own requirements and limitations.

A discussion of the relevance of this work to the South West is argued within the context of the local, regional, national and supra-national setting for coastal issues.

Two principal themes run through the thesis:

- the structure and operation of coastal management
- the management, use and provision of data to provide suitable information for such an undertaking.

Lead Co-ordination through

Fowey HC Chief Executive Administration
Environmental Consultant
Selected others

Using an Advisory Group of

Fowey Harbour Commission
Environment Agency

Commercial Users	Land Owners
Leisure Users	Local Councils
Nature Conservation	County/District Councils

Selected from the following consultees

Commercial Users
ECC Ports
British Rail
JC Toms
Ships' Agents
Licensed Boatmen
Licensed Fishermen

Land Owners
Fowey Harbour Commission
National Trust
Treffry Estate
Boconnoc Estate
National Farmers' Union
British Rail
Forest Enterprise

Leisure
Sailing Clubs
Gig/Rowing Clubs
Fowey Diving Club
Fowey River Canoe Club
Fowey Swimming Club
Fowey Tightliners
Polruan Fishing Clubs
Ramblers Association

Local Councils
Fowey Town Council
Lostwithiel Town Council
St. Sampsons
St. Veep
St. Winnow
Lanteglos

Nature Conservation
Cornwall Wildlife Trust
English Nature
MAFF
RSPB

County/District Councils
Cornwall County Council
Restormel Borough Council
Caradon District Council

Commercial/Environmental
South West Water
Haul Waste Ltd
Sealand Services
Sea Trials SW

Historic Environment
Cornwall Archaeological Unit
English Heritage
RCHME
Old Cornwall Society

Table 2.5 Structure of the Fowey Estuary Management Plan consortium
(after Oke and Burfoot, Figure 2, p.7)

Thus, the study sets out to determine the issues relevant to establishing an effective data and/or information system to support policy making for holistic, integrated, regional, sustainable coastal zone management. These terms are used in the context of:

- coastal zone - where the term "zone" is utilised rather than the coastline in order to encompass the cross-boundary effects on and by the water, and in terms of geography, human utilisation, ecology or other;
- coastal management - optimising use of the coastal zone according to independently determined objectives allowing a variety of multiple uses;
- sustainable - allowing continuing use of the same or similar resources, without a detrimental effect curtailing those uses;
- regional – as defined by one or more natural or anthropic influences such as geological units or travel-to-work areas and in contrast to a more restricted approach such as the county boundaries of Cornwall and Devon bisecting the Tamar's waters;
- integrated – i) allowing multiple use, especially when otherwise there may be conflict (where conflict might arise due to coincident but incompatible use - be that in time, place, physical presence, noise, visual impairment, chemical presence, or other), and ii) inter-sectoral, and Thus, by information provision and utilisation about coastal users and uses;
- holistic - wide ranging/all encompassing to allow for interaction and inter-dependence, within a broad context and yet with sufficient detail to set a local agenda;
- policy - determined by authorities other than the information providers;
- information system – being i) of paper or electronic records, but with such analytical capability that will support decision making, and ii) able to derive information from datasets by analysis and interpretation;

- data - of adequate scale, currency, quantity and quality;
- information – interpreted data optimised by comprehensibility and ease of use;
- effective – useable - by i) availability at relevant sites and ii) enabling decision-making.

The application of Campnet's 1989 definition of coastal zone management is influenced by many factors, including:

- coastal management is widely affected by natural and anthropic influences;
- the natural processes are not confined to administrative or other similar artificial boundaries;
- a number of authorities have several responsibilities for the management process, but there will be gaps and overlaps;
- data is held by many parties, in many forms, in many places.

The want of an integrated, holistic coastal management structure in the UK inhibits experiencing its effects first hand, although examples of overseas programmes are available (for example, Chart, 1999). The UK government continues to publish around the topic (section 2.1), and there are a number of organisations active in the area, such as:

- the Countryside Agency,
- English Nature,
- the National Trust (with Enterprise Neptune),
- the Coastal Heritage Network with their bulletin CoastNET, and
- the National Coasts and Estuaries Advisory Group.

The EU demonstration programmes, such as the Atlantic Living Coastlines and Dorset Coast Forum, have done much to take forward the principles of integrated management.

2.4 Summary

The scope of coastal management and current research was reviewed and increasing the holism in the approach seems likely to bring improvements. Treatment of the coast as a zone is one such step. Establishing rational regions of operation and relevant data provision are other aspects of successful management.

At this stage, a number of issues are of current interest:

- for local application - the determination of a relevant area to contain and highlight an initial interest in South Devon;
- to establish an apparently under-researched bottom-up approach - the issues and datasets in which the practitioners are interested;
- currently queried by researchers - the management and manipulation of data

Thus, from the preliminary investigation into the nature of coastal management, the maturity evident in some countries and the apparent scarcity of investigations into coastal management from a practitioner's viewpoint, the aim of the thesis is set to determine:

i) the issues in setting up a regional coastal zone information system, and

ii) the potential benefits of setting up such a system.

This aim is to be achieved through a series of objectives, namely by:

i) establishing the current nature and state of coastal management;

ii) establishing the facilities and limitations of computerised information systems;

iii) investigating the coastal management requirements for the South West region;

iv) determining the applicability of computer-based information systems to optimise the management of the regional coastal zone.

Chapter Three

Data and information

The research for this thesis covers the two principal themes, namely:

i) the issues in setting up a regional coastal zone information system, and

ii) the potential benefits of setting up such a system.

Chapter Two reviewed the principles of and developments within coastal management and the methodology for the study was determined. Section 2.1 highlighted the range of activities relating to the coast that are of interest. Potentially these lead to such a large quantity of data as to almost make holistic data handling unmanageable. Historically, the sectoral approach to the coastal zone enabled practical management to be undertaken, addressing specific problems as they arose. Thus, Victorians countered the spread of cholera through filtered sewage disposal from short sea outfalls; currently, greater recreational use of the sea requires further treatment of sewage sometimes accompanied by disposal from long sea outfalls together with tertiary treatment. Data relating to each activity may be complete in itself but unshared with others.

Data are best held by the data gatherer or data owner as data may become out of date quite quickly, and there may be a requirement for their revision. If so, changes in data gathering techniques, changes in instrumentation, changes in precision, the aggregation method or the storage medium may all affect future comparisons of data sets. If the data are sold on, and the new owner is to update the figures, there is likely to be a greater chance of anomalies creeping into the work. Comprehensive metadata will help to avoid this problem.

Metadata, or dataset descriptions, are crucial to the effectiveness of the set. Metadata standards can be set nationally and "provide a common set of terminology and definitions

for documentation." Undertaking such practice costs money in the short term, but shows benefits over time and with personnel changes. It acts as a compact reference or indexing system, and aids data transfer.

This chapter proceeds to a review of data, information and communications.

3.1 Applicable data sets

The geographical and thematic setting of the research influences the exact choice of data for a coastal management system. The geographical area is reviewed in the next chapter, but for the moment, the comments are more general – 'applicable' referring to data for coastal management.

English Nature, supported by other authorities, has part-funded the production of estuary management plans (English Nature, 1993). The Fowey Estuary Management Plan comprises two documents, one of which (Oke, undated) is a comprehensive compilation of current data and references to data for the Plan. The Tamar Estuaries Consultative Forum has produced attractive and comprehensive publications. In the Executive Summary of the Dart Estuary Environmental Management Plan, the sparseness and discontinuity of existing datasets is highlighted by such statements as:

> "Estimates of residence times for pollutants are available from limited data sets. ... Turbidity levels are generally high and although some work has been carried out on turbidity maxima there is little data on total sediment budgets or seasonal variations. There have been no detailed studies on sediment dynamics on which to base a policy for dredging" (Humphreys, 1997a, pii);
>
> "There is a rich and diverse archaeological heritage but although reasonably well documented there is no unified catalogue of this resource. ... The terrestrial ecology of the estuary is less well studied or documented ... There are some 84 sites ... and further investigation work is required on them. ... There is a large body of water quality data held by [South West Water Services Ltd.] and [the Environment Agency]. Unfortunately it has been collected for a variety of purposes

> and there is no comprehensive, integrated data set. Continuous monitoring data is more scarce and sediment quality data relatively rare." (Humphreys, 1997a, piii)

The Environment Agency's Anglian Region dataset (Table 2.4) and Rickman & Miller's bibliography (section 2.1) are pointers to relevant data. Support for economic activities is at least as important as those mainly ecological and environmental data. In order to determine the relative importance of specific datasets, the interviews and then the questionnaire were used to address this topic. The results are detailed in Chapter Five.

The nature of a dataset is quite complex. It can be enough for a data-broker to know of the existence and extent of a dataset – its metadata. For others, the detail of the dataset is important as it is used to determine change, describe the extent of a feature or enable the establishment of relationships. The detail can be extensive, as Table 3.1 indicates. Whether a feature is a polygon or a point is related to its scale of use. A house plot at large scale can show the outbuildings, a porch and the lie of the utilities. At medium scale it may be represented by just a square in order to indicate one dwelling out of many in an urban area. Indeed, at small scale the urban area may be just a shaded polygon in contrast to agricultural land. Scale is an underlying factor of all data use. Large scale and very high accuracy requirements are costly and may preclude the use of existing data. Coastal management may require:

> small scale/low resolution work - for example, in regional water movements (although vertical measurements may need to be precise);
>
> medium scale - for example, country lane road widths near a beach for parking where an accurate judgement over the availability of two car widths is important (parking and passing), but little else;
>
> large scale – for the seasonal change in an estuary's vegetation

Feature class: polygons

Feature type	Attributes	Parameters	Range	Intervals
Rural/ urban areas	Population density	Persons per square km	0 – 1000	25
Port areas	Handling facilities	Length of berths;	Metres	1
		Number of berths	Units	1
	Pilots	Numbers	Units	1
	Customs	Availability	Travel time	hours
	Police	Availability	Travel time	hours
	Tugs	Numbers	Units	1
	Storage	Cold	Temperature Area	Degrees C Square m
		Dry	Humidity Area	 Square m
		Open	Hectares	0.1

Feature class: Linear

Feature type	Attributes	Parameters	Range	Intervals
Rivers/ streams	Rate of flow	Cubic m per s	0 -	1
	Pollution of sediments			
Shipping	Shipping routes	Numbers of vessels	Units	1
	Draught	Metres	0.5 - 20	0.5
Beach type				
	Shingle	Ease on feet	Bare-shoes	
	Sand	Colour	White, yellow,..	
	Rock	Clambering		
	Cleanliness	Health		
	Sand dunes	Sea defence	Stability	m per year
	Rip currents	Safety	Lost children	1

Feature class: Points

Feature type	Attributes	Parameters	Range	Intervals
Car parks	Number of cars	Free/charging	Units	1
Slipways	Public/private	Launching facilities	Excellent - poor	Grade by facility & price
Outfalls	Type	Time of discharge	24 hour clock	0.1 hour
		Rate of discharge	0 - 100 cu.m per min	10 cu. m per min
Navigation marks	Floating or fixed	Colour	Red, green, yellow	Grade by meaning
Radio communication stations	Position	Range	0 - 2500 km	25 km
Tidal streams	Flow	Speed, kts	1 - 10	0.1
	Direction	Degrees, True	10	1
Tidal height	Range			
		Spring	0 - 7 metres	0.1
		Neap	0 - 4 metres	0.1

Table 3.1 Example detail in datasets (Author)

3.2 Software options

Computerised support for data handling can be ordered by its complexity, e.g. word processing, spreadsheets, databases, digital mapping, modelling software and Geographical Information Systems. Word processors undoubtedly ease the process of report writing and their compatibility with other software eases the inclusion of statistical information, accounting details, and others. Spreadsheets provide entry-level programming and suit multiple applications from accounting and simple statistical analysis to providing templates for raster (i.e. matrix) imagery. The latter makes their use in higher level software common as intermediate processing tools. Databases may be said to exist in all software, being the essence of functionality in a word processor or a spreadsheet, but are most commonly known as stand-alone, relational databases that provide multi-field updating, input into word processing mail-merge functions, and, as for spreadsheets, a function within higher level software.

Digital mapping systems provide a graphical interface for visual integration of data.

> "Digital Mapping involves the conversion of geographically distributed data, which are or might be mapped, into digital form, their storage in computer systems, and their subsequent manipulation and display on paper or on screen. By common usage it now includes the management of spatially referenced data with or without display in map form." (Select Committee on Science and Technology, House of Lords, 1983)

Digital mapping software may facilitate not only the production of quality graphical output, but be of use earlier, at the data gathering stage. Here, the most accurate method of data gathering - field surveys - may be undertaken semi-autonomously, e.g. in an urban, detail survey, gathering satellite positions in conjunction with feature codes, with data stored electronically for semi-automatic processing. Charts, maps and reports can be produced to consistently high and uniform standards (in, for example, Trimble's survey software, "Hydro", which permits the input of multiple positioning systems and multiple sensors and can output charts and profiles). Data may feed directly (i.e. in real time) into digital terrain

models, as in any swathe bathymetry processing system. More complex systems, such as specialised analytical and modelling software, suit distinctive applications such as needed to determine 1, 2, or 3-dimensional estuarine tidal models.

Integrating the analysis of spatially related data requires a particular stage in the complexity of the software, and therefore presents difficulties to the end-user operating the system. Geographical Information Systems (GIS) allow the skilled operator to analyse multiple data sets for multiple queries. GIS can aid day-to-day management by producing better cross-referencing, ease of updating and multiple uses of the same data. Modelling functions are available, especially with the more comprehensive systems, but do not run to all the specialities of all subject areas (e.g. oceanography). They do allow the opportunity to experiment with disaster scenarios or action plans. Decision support elements of GIS utilise multiple-evidence maps, probabilities and confidences in the evidence incorporated into the statistical software. Analysis results can identify gaps in the database, produce options for development, optimise information (often by ensuring completeness, consistency, currency and accuracy) to aid rigour in decision-making, and provide a benchmark against which change can be measured. They give the opportunity to judge the success, or otherwise of implementing decisions (Hall *et al.*., 1995, pp.161-173).

Therefore, GIS have the supplementary ability (over digital mapping) of being able to analyse or query spatial data and of being able to interrogate multiple layers with reference to one location or across an area. Analysis complicates the process; information can be processed centrally, in response to general or specific questions, or data can be supplied for analysis by the end user. The former option provides an answer in similar complexity to a digital map; the latter option requires skills in the particular software's analysis functions.

The use of GIS in the choice of a dredge dump site west of San Francisco, and in the subsequent monitoring for compliance with environmental regulations was reported with the following conclusions:

> "GIS enables technical analysts and managers to better assess the potential environmental impacts of ocean disposal. ... Analysis of ... time series will allow assessment of impacts, if any, due to dredged material disposal. When decision makers can easily view data, GIS becomes an essential part of developing policies to prevent and control risks to marine resources." (Hall *et al.*., 1995, p.170)

Yet, it is more effective to address any one particular problem with a concentration of available resources on the issue rather than setting up a GIS to solve just that single problem. However, once data is entered into a GIS, and can be added to, new horizons open up allowing further and more complicated analyses with less effort. Proving the benefit of GIS on an original, single-issue basis is not possible. Proving it across the application to wide-ranging problems is possible. For example (Thomas, 1994), on introducing a GIS to support their work, the City of Ontario, Canada, found large cost savings in map production (by an order of magnitude), in zoning analysis (by two orders of magnitude) and on direct mail for planning purposes (at a quarter of previous rates). On revenue collection to a value of $115 000, the cost of collection by conventional methods was originally $15 000, but using GIS personnel on a system already running the charge came in at $20.

The multi-discipliniarity of coastal management can mean that multiple specialists need access to data for the same region, possibly at the same time. Each needs the latest copy of a dataset to do their job satisfactorily. However, colleagues may be missing part of the whole picture unless the dataset is shared and a holistic analysis may be impaired or in error.

Most computerised systems are developed for specific purposes, and they are more or less effective in achieving those purposes. Their ability to work in other applications will normally be extremely limited. More complicated programs may try to integrate a number of tasks. GIS exemplify this, with the more able systems having a number of functions, such as a relational database, digital mapping and visualisation programs, analytical functions by attribute or place, and report generation capabilities. Nevertheless, they are normally unsuitable for the likes of, say, tidal height analysis or sediment movement. Specialist programs would still be required, although the transfer of digital data between programs will be easier and more error free, than entering the raw data each time from an analogue record. Data are commonly transferred from a GIS into a statistical package for more advanced analysis or software is used that automatically links a GIS with a statistical package. Recent experiments on two digital terrain modelling packages and two GIS have shown the better performance of the dedicated packages, the ready ability of the GIS to import the products and the advanced functionality of the GIS to aid the visualisation of the images (Smith, 1999).

A particular problem associated with marine GIS is their inability to deal with the multiple resolution of data (Li *et al.*, 1995, p.174), it being more dense in the coastal zone, but more sparse further offshore. The large datasets associated with large areas typically covered offshore and the associated processing difficulties of desktop GIS are becoming less of an issue with the increased capabilities of operating systems such as Microsoft NT and larger, readily accessible data storage.

3.3 Information systems in coastal management

The fundamental spatial basis for most planning activities is the paper map. In this country, Ordnance Survey (OS) mapping provides a reference framework (not just in a literal Cartesian co-ordinate sense, but also in that the mapping methodology, the cartography, and the very familiarity provide an assurance of validity). Nevertheless, OS mapping has in-built geodetic problems, scale related accuracy issues, and a cartographic symbology that affect the representation and interpretation of the real world.

The limitations of the paper medium affect the tasks carried out upon it. The paper is unstable, suffering unequal stretch and shrinkage, soiling, and difficulties in multiple annotation, or removal of redundant marks. Adding data from non-OS sources brings problems of compatible referencing.

Using a computerised, digital system eases the whole process. Co-ordinate systems, scale and symbols can be changed easily. There is no instability in the data, once it is within the computer (excepting changes occurring through data manipulation or on output). Multiple clean images can be produced over a long period, changes can be made by selecting parts of a dataset, or in combining the whole or part with more or less other datasets, and the new data can be modified to fit the reference system despite its origins.

Yet the digital system is not a panacea. The variety of co-ordinate systems can hide problems for the uninitiated; increasing scale may not increase usefulness due to significant errors in the system; use of unconventional symbols can mislead; "fitting" new data to old may introduce changes with unforeseen consequences.

Information systems benefit from digitisation and computerisation for a number of reasons (see below), but much data exists in analogue form, and many organisations operate with only a minimum of computerised support. One example was the Devon Wildlife Trust, which had its habitat records principally on paper maps (Carl, pers. com.; Camplin, pers. com.). Its output is usually through reports summarising the Trust's assessment of a site or consequences of development. Computerised support amounted to the provision of word processors, but not to any mapping tools.

The principal benefits of handling and manipulating digital data (and thus, via computers) are:

- ease of maintenance of the records;
- ease of inclusion in, and of, other data sets;
- savings on storage - both in the original location (e.g. of space) and of cost;
- security of backup of original data; and
- ease of analysis.

Cornwall Wildlife Trust has had access to a Geographical Information System as an aid to monitor habitat changes, and has seen such benefits (Howe, pers. com.). They are the common experience of many professionals (hydrographic surveyors have been capitalising on these benefits since the availability of portable "main-frames" and the early desktop computers in the 1970s). In coastal management, concerned with a mixture of the anthropic and natural environments, change is common. Updating (i.e. record maintenance) is a standard requirement; efficient storage is paramount with the quantity of the relevant data; security is part and parcel of any quality operation; ease of analysis is a requirement with such volumes and diversity of data.

The very availability of GIS, and their fashion, makes the comparison of the effectiveness of simpler information systems difficult to judge due the lack of examples. Nevertheless. Devon Wildlife Trust successfully used a paper-based system for some time. Facilities management has developed successfully with automated cartography (or digital mapping). Complex port operations utilise radar displays, digital mapping and icon-tagging on screen (Greenland, 1999; Greenland pers. com.). The "need" to develop a GIS based information system may be superfluous unless some analysis is to be undertaken, as otherwise cheaper, digital systems can provide many of the benefits given above.

3.3.1 Data analysis and visualisation

GIS' strengths over other digital software lie in their analytical functions. The systems typically utilise a relational database, digital mapping and visualisation programs, analytical functions by attribute or place, and report generation capabilities.

Cost-effectiveness studies, such as the Canada Land Inventory of the Canada Geographic Information System (Rhind, 1990; Thomas, 1994), have proved the investment in GIS worthwhile; their effectiveness can be summed up in abilities to query:

- by attribute;
- by place;
- across layers;
- over time.

The better systems include the advantages of many other specialist programs, such as digital mapping systems, cartographic display systems, relational databases, and reporting

software. They combine all of these with an ability to apply mathematical functionality to maps, i.e. to undertake spatial analysis. They are not, though, the "be all and end all", having particular limitations in modelling and the inclusion of three or more dimensions. Distance working is limited, although experiments in Internet-based information viewing are progressing (Green, 1995; Cannessa, 1998; Environment Agency, 1999a; CEFAS, 1999).

A particular problem of marine GIS is the multiple layers on which data may be gathered. Thus, objects may be sub-surface, on the seabed, in the water column, on the sea-surface or in the atmosphere. Objects also move in three-dimensional space (Lockwood and Li, 1995, p.159). Until developments free the user from the limitations within two, or two-and-a-half dimensional GIS, it will be necessary to have links with specialised modelling or other application software, which will be optimally usable with complementary data formats. Nevertheless, layers are a standard way of viewing the world, and the distinction must be made between layers for coincident attributes (administrative regions; shipping routes; seawater salinity), and those for which a difference in absolute height may be significant (wave height; seabed texture; archaeological artefact).

GIS have an established track record in solving complex planning and management problems by integrating and analyzing data. Typical benefits of GIS include (Hall *et al.*, 1995, p.162):

- "identifying data gaps and providing a base for improving sampling design for regional studies;
- co-ordinating between database managers and program staff;
- integrating multiple datasets;
- creating a database to share between other federal and state agencies;

- developing management options based upon GIS analyses;
- presenting options and displaying data visually for decision makers."

3.3.2 Example analyses

The following example (Figure 3.1), identifies coastal areas at risk from erosion due to four parameters:

- coastal aspect;
- wave direction;
- coast defences;
- geology.

With a GIS, these can be located by reference to a data type (coast at risk), by location (all geographical locations of coast at risk), or by a search through occurrences of the contributing parameters. Eastman (1995) states that the ability of GIS to perform database query based not only on attributes but also on the location of those attributes distinguishes it from all other types of database management software.

The GIS capability in aiding decision making is based partly on a full access to the database by attribute or by location and partly in the tools developed to support such work. The use of Fuzzy Sets and Bayesian Probability enable decisions to be made with the acceptance of uncertainty in the model. Then the real world is better modelled and the requirement for a professional decision-maker is more evident. Rather than determining a technical solution from a straightforward combination of circumstances as in Figure 3.1, the decision-maker can assess probability, risk and the associated consequences.

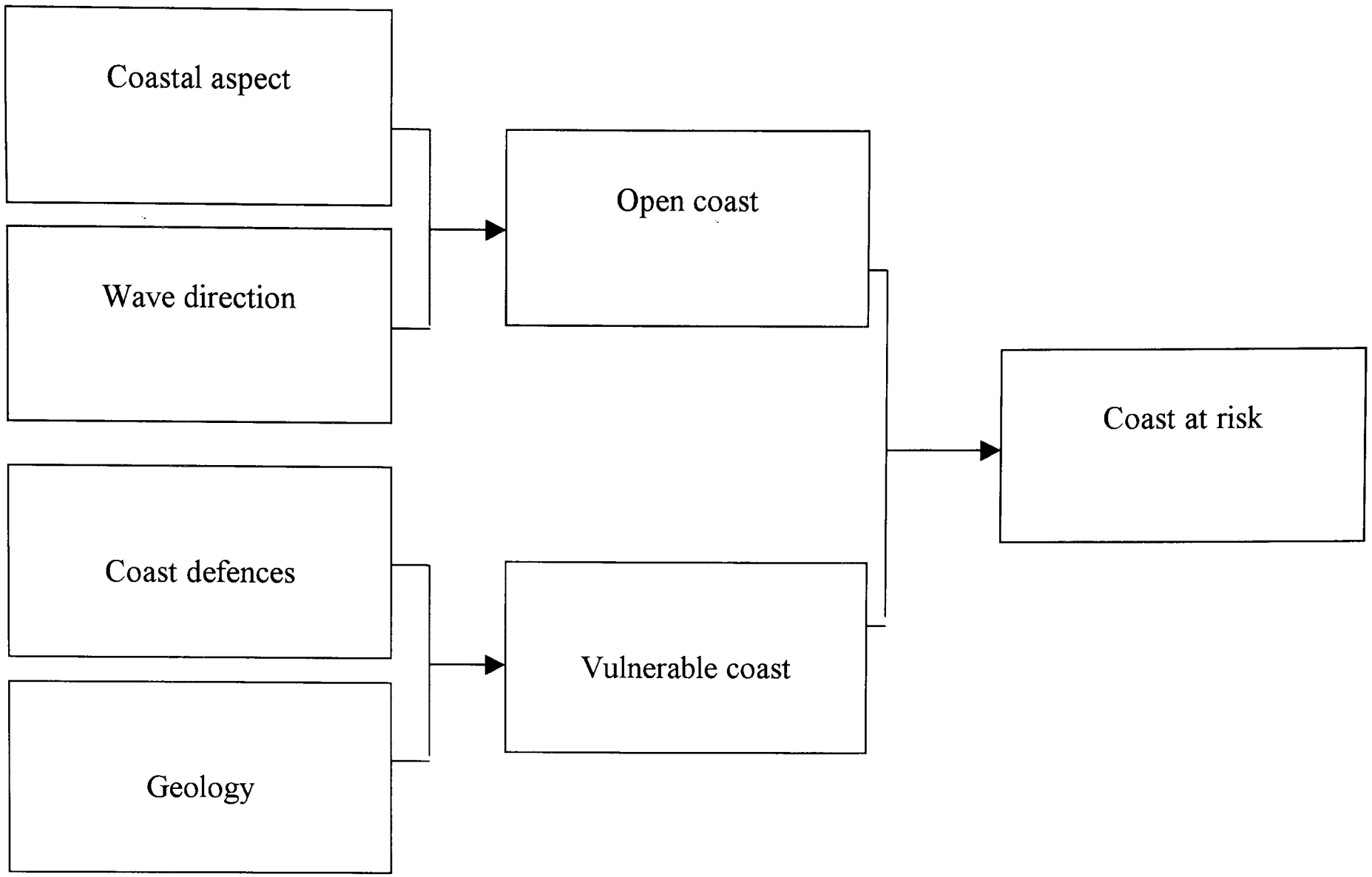


Figure 3.1 Simple dataset combination to aid assessment of coast at risk of erosion (Author)

A more advanced analytical query is illustrated in Figure 3.2, indicating a method of determining current locations of jet ski use and how those locations may change or develop. It is more "advanced" in that further processing is required to produce the result. Thus, the datasets on the left are unlikely to exist in a suitable original form, but will need processing to reach this point. For example, "future jet ski numbers" will need extrapolation from current trends and "coastal access" will need to take into account road widths, lengths of passing bays and parking facilities.

3.4 Source and availability of data

Referring to SSSIs, the National Audit Office reported only in 1994 that "English Nature holds a good deal of scientific information, much in paper form" (National Audit Office, 1994, p.1). This form does not necessarily halt its dissemination (and see section 5.7.3), but may well impede it. Some data is freely available, but the public's ability to access that data is limited by a lack of information about what is actually held, who holds it, how to ask for a relevant data set and how to interpret it. The Environment Agency (Environment Agency, 1999b) is obliged to maintain a set of Public Registers (Table 3.2). Information is held in a combination of paper and computer files that may be inspected at the Agency's Regional and Area offices. Other Registers (Table 3.3) hold information to which the public has only partial access or no access at all. Costs of access are given in Table 3.4.

Such issues are common to those that would be faced by a coastal manager where he or she would wish to make decisions based upon adequate information. Adequacy includes comprehensiveness, accuracy, integrity, consistency, and currency.

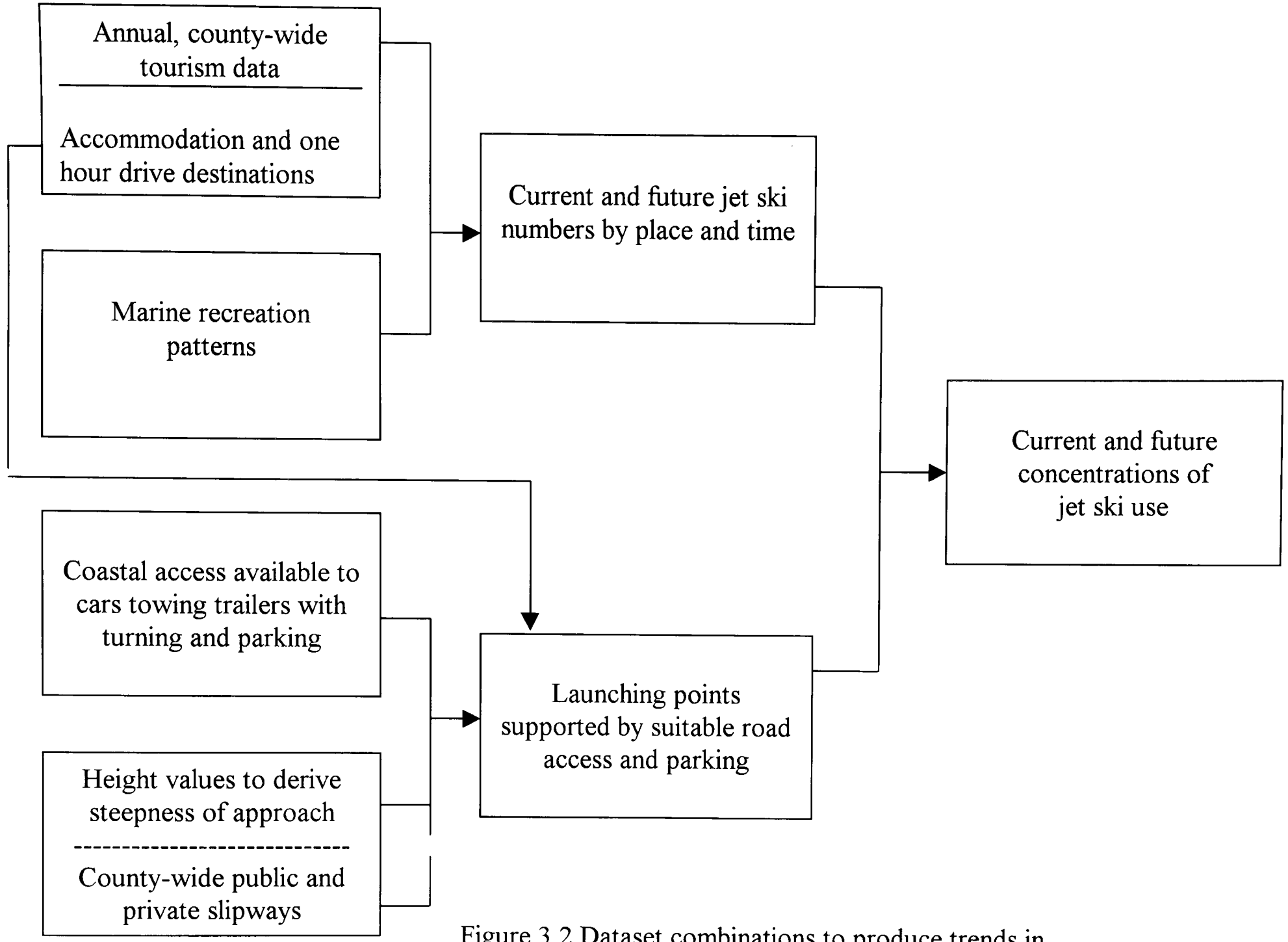


Figure 3.2 Dataset combinations to produce trends in jet ski use by location. (Author)

The Agency's principal Public Registers are:

Integrated Pollution Control (IPC) Register, holding information on industrial processes regulated under the IPC regime:

applications, authorisations, variations, appeals, restrictions, monitoring records, enforcement; prohibition notices, revocations, convictions/appeals

Register of Industrial Works (the Air Register), holding information on certain industrial processes with the potential to cause air pollution. These processes are gradually being incorporated into the Agency's Integrated Pollution Control regime.

Radioactive Substances (RAS) Register, holding information relating to the use, accumulation and disposal of radioactive materials:

Applications, registrations, authorisations, variations, cancellations, enforcement, prohibition notices, convictions/appeals.

Water Quality Pollution Control Register, holding information on:

discharge consent applications, decisions/appeals, changes of holder, revocations

water quality objectives, monitoring records (including for bathing waters), maps of freshwater limits, maps of controlled coastal waters.

Water Abstraction and Impounding Register, holding information on licence applications, decisions/appeals, successions, revocations.

Maps of Waterworks, holding information on the location of resource mains, water mains, discharge pipes or underground works.

Maps of Main Rivers, for each area covered by the Agency's Regional Flood Defence Committees.

Waste Management Licence Register, holding information relating to the recovery or disposal of waste:

applications, working plans, inspection reports, monitoring information modifications, revocations, suspensions, appeals, surrenders, convictions exemptions to licences.

Carriers and Brokers of Controlled Waste Register, holding information about applications to carry waste.

Table 3.2 Public Registers of the Environment Agency allowing full access to the data (Environment Agency, 1999b).

The costs of data under copyright can prohibit their purchase and use. This might not apply to a commercial organisation as the cost can be built into the contract price, but voluntary organisations and individuals can be thwarted in their investigations by the initial and maintenance costs of data. Most data are held under copyright and their cost can be fully justified with a comparison to collecting the data from an original survey.

Other Registers:

Works Discharge Register
Information on owners or occupiers of premises which abut watercourses and who have requested to be registered in order to receive notification of discharges caused by the Agency.
Genetically Modified Organisms Register
Information on releases of genetically modified organisms. This Register is held by the Agency on behalf of the Department of the Environment.
Chemical Release Inventory
Information on releases from processes regulated under Integrated Pollution Control.
Special Waste Notifications
Consignment notes: disposal and location records (non-commercially confidential)
Summaries of Special Waste (when prepared by the disposal authority).

Restricted information:

Confidential information which is part of a legal case, or to do with national security
Personal or commercially confidential information
Incomplete or draft reports at our discretion
Information where disclosure may lead to environmental damage

Table 3.3 Other registers of the Environment Agency where limited or nil information is made available to the public (Environment Agency, 1999b)

Restrictions under data protection legislation limit the use of the data for the purposes originally specified and aggregation of data limits its application to other uses. Therefore the use of data from other sources can be prohibitively difficult. The cost may not be limited to the purchase of the original dataset, but to the subsequent limitations imposed by copyright restrictions. Nevertheless, as paralleled above, the cost problem may not be such an issue to a coastal manager. This is a view, apparently generally held, amongst the participators in a workshop at HR Wallingford, February 1999 where it was anticipated that any costs would be built into the tender price for the work. However, continued use of an old dataset will provide a cost saving over updating it and commercial considerations will be affected by price.

Usually information is provided free of charge. For large and complex requests there is a charge for staff time and materials. The following requests are provided free of charge:

All reasonable information requests made by the public
All personal visits to inspect a register at one of our offices
All reasonable information requests by students in full time education
All requests requiring less than two hours of staff time to process
All simple telephone requests and media interviews agreed in advance
All requests for which the total charge, including staff time, is less than £50.

Example charges:

Paper copies at 10p per side of paper
Data transferred onto magnetic media (e.g. computer diskette) at £25 per hour staff time plus the cost of materials.
Customer enquiries related to properties at risk from flooding, the status of watercourses, etc. at the following rates:

Residential properties (single dwelling) - £35 per enquiry
All other searches - £50 per enquiry
A standard charge of £35 is payable for enquiries related to Environment Agency land ownership

Table 3.4 Charges for access to Environment Agency information (Environment Agency, 1999b)

An example of copyright restrictions is given in Table 3.5 that refers to the national Land and Ocean Interaction Study where further use of data outside the study was strictly prohibited.

Accurate, comprehensive metadata is essential to successful results from the combination of a variety of datasets. The principal uses of metadata have been defined by the US Federal Geographic Data Committee (1998) as:

- "to help maintain and organise an organisation's internal investment in spatial data;
- to provide information about an organisation's data holdings to data catalogues, clearinghouses, and brokerages; and
- to provide information to process and interpret data received through a transfer from an external source."

LOIS Licence Agreement

The Land and Ocean Interaction Study (LOIS) project holds a licence from the UK Hydrographic Office (HO) to use (subject to a set of terms and conditions of use) bathymetric contour information digitised from Admiralty Charts.
The terms of the licence are as follows:

> Crown Copyright digitised contours derived from UK Admiralty Charts are made available to bona fide researchers involved with the LOIS Project (licence number HO: 359/960613/01) subject to the conditions set out below. All prospective users of such data must sign the Conditions of Use form and lodge a copy with LOEPS Data Centre, BGS Coastal Geology Group before using any of the data.

1 You must fully accept and agree to the conditions set out in the Conditions of Use form.

2 Rights are limited to the reproduction of digitised contours ("reproductions") supplied to you by BGS. If you require data from any other charts, you must request permission from LOEPS Data Centre, BGS Coastal Geology Group.

3 Rights are limited to the use of these reproductions within the Land-Ocean Interaction Study (LOIS) research project and any resulting papers or reports generated by the project.

4 The reproductions may be used by researchers involved with the LOIS project, and included in their publications. However, should any results of the project that include reproductions be used outside of the project or in a commercial manner, prior written permission should be obtained from the BGS Copyright Manager who will liaise with the Hydrographic Office; a fee may be payable.

5 All rights are non-exclusive and non-transferable to a third party without the prior written consent of the UK Hydrographic Office. You should seek this consent via LOEPS Data Centre, BGS Coastal Geology Group.

6 The acknowledgement shown below shall appear at a suitable place against the reproductions. Alternatively, a similarly phrased acknowledgement (with reference to the page numbers) shall appear in the preliminaries of any publication containing reproductions:
- "Reproduced from Admiralty chart(s) [insert number(s)] by permission of the Controller of HMSO and the UK Hydrographic Office."

7 You shall not use, sell, or store the information for your own purposes.

8 If any display equipment is capable of producing an analogue copy of the data, or any part thereof, these copies must not be sold. Usage of this nature is subject to prior approval of the UK Hydrographic Office, via BGS.

Table 3.5 An example of copyright restrictions on data in a national study (from the LOIS study; data now held by BGS. Morris, pers. com.)

To these ends, the key characteristics of metadata are:

- "availability - data needed to determine the sets of data that exist for a geographic location;
- fitness for use - data needed to determine if a set of data meets a specified need;
- access - data needed to acquire an identified set of data;
- transfer - data needed to process and use a data set."

Thus, factors in the evaluation of data include data sources, precision, accuracy, currency and the choice of co-ordinate system. A critical factor is the original use to which the data was to be put - it affects the choice of data gathered, and issues of selection and generalisation. It may make a dataset inappropriate for some further uses.

3.5 Communications

Information supply can readily come by post, the radio and television (by general or specialist programmes). Textual information can be automatically downloaded from an Internet Bulletin Board which may include some sorting by subject headings, an opportunity to contribute and a facility for moderation of the group to avoid spurious messages. Digital mapping products can be provided simply on disc or over the Internet with simple use and require a shallow learning curve. The transfer of digital data between programs will be easier and more error free, than entering the data fresh, each time.

Data transfer of GIS datasets over the Internet is increasingly commonplace, although it still requires the help of specialist staff. Information transfer is more complicated, requiring some selection and combination of datasets. If the selection and combination is by an inexperienced operator at a remote site the operation may have to be simple or it may require the intervention of a skilled operator. This is discussed further in Chapter Six. Cannessa (1998) gives an example of the use of GIS and coastal issues over the Internet.

This site indicates the ability to access remote datasets and to perform simple analyses and may be a useful model for further developments.

Discussions at Wallingford ("Maximising the use and exchange of coastal data", HR Wallingford, February 1999) looked to the opportunities that may be available given a change in attitude amongst data gatherers, data holders and data users. One theme discussed the nature of barriers to access and concluded these may be only impediments (Rapporteur, Wallingford, 1999). In other words, the difficulties, such as:

- cost (NGOs versus commercial users);
- culture (peoples' responsiveness to requests, or knowing the right person to ask);
- copyright (use of original paper copies); or
- standards (adequate metadata) could be overcome.

As an example, advertising a forthcoming survey to invite requests for variations on the survey scale/survey data gathering interval or for supplementary data gathering might make the resultant dataset more widely useful.

A recent conference in Plymouth ("Using Marine Biological Information in the Electronic Age", Marine Life Information Network for Britain and Ireland (MarLIN), Plymouth, July 1999) addressed a number of issues. Papers on networking information (Whitfield, 1999), data analysis and modelling (Warwick, 1999), the compilation of expertise (Shipman, 1999) and the disparate data collected over spatially and temporally variable scales (Grassle, 1999) and species recognition by comparing visual images (Grist,1999) show current developments and relevance of the topics. Further, demonstrations of current or developing packages included one majoring on a 4D GIS front-end data viewer to store, access and visualise disparate environmental data, taxonomic information, blue-green algae and the inter-tidal zone (STEM, Bottrell *et al.*, 1999).

However, Green *et al.* (1995, p.13) state some reticence over the software, writing:

> "If GIS is to develop from its traditional role, as a research tool, into a legitimate tool for business then a fundamental requirement will be ease of access to information and ease of use of the functionality. Research into HCI [the Human Computer Interface] together with the emerging standards for OpenGIS may prove to be the watershed in bringing GIS to the desktop."

3.6 Current developments

Coastal management is diverse and complicated, with broad issues. Management for small geographical areas or of single issues is more easily treated but does not lead to an understanding of the inter-related issues of the coastal zone and its wider use. A comprehensive data management system is required, and if it can support decision making through an analytical capability, its usefulness will be increased.

A number of recent workshops and European Union funded research topics have addressed data and information issues. Of current importance are:

- Establishing the value of datasets in order that there may be a rational trade in them ("Envaldat", through the EU Directorate General XII and the Centre for Earth Observation);
- Establishing data exchange issues, such as properly defining the metadata, advertising the datasets' existence, establishing data exchange formats and establishing costs ("Maximising the use and exchange of coastal data", HR Wallingford, February 1999 and "Infocoast" in the Netherlands also February 1999. Similarly, through a Special Interest Group of the Association of Geographic Information in "Environmental Data & Information – availability, acquisition & application", February 1999);

- Data management and data visualisation system for supporting coastal zone management for the Mediterranean Sea ("Thetis", through the EU Directorate General XIII);
- Decision support for integrated coastal management ("Desima", through the EU Directorate General XII and the Centre for Earth Observation).

The actual production of an analytical system utilising multiple datasets to optimise decision support for integrated coastal management would be limited by the time involved in its creation, by commercial sensitivity over its development and by production costs. A current bid to the European Union for the development of a demonstration system is priced at Euro 9 million (Morris, 1999). Nevertheless, many paper and digital databases exist, and systems for using them in conventional (text-searches) and advanced (pattern-recognition) means are under development. Spatial and image analyses are common methods in these research fields.

The considerations in this chapter fed into the development of the questionnaire (Appendix D) to ask of practitioners those issues and datasets they regarded as most important. Earlier work (see Tables 2.2 and 2.4) had established items suited to a particular country's coastline and a particular profession. This chapter, and the interviews that followed, contributed to the questionnaire as distributed.

That the final choice may not have been perfect is discussed in Chapters Five and Seven. Other issues and datasets were to be identified by practitioners which could have been investigated further if identified earlier.

3.7 Summary

This chapter has reviewed a number of topics related to data and information. The overriding issue of scale (and its implications for resolution) was discussed before expanding on the nature of feature types and their constituent parts named, in this case, as

- Attributes;
- Parameter;
- Range; and
- Intervals.

The chapter reviewed the use of software with particular reference to benefits in handling digital data, the opportunities for analysis, and the limitations and opportunities for cost savings. Current uses of software and example analyses were intended to highlight the benefits of modern digital data handling.

The requirement for appropriate data highlights the need for data access. Difficulties in first discovering the existence of a dataset and then of accessing it are discussed. The chapter ends with a discussion on current developments.

These issues are treated in somewhat general terms, though a theme of spatial data in a coastal context permeates the text. The chapter produced a framework for the interviews and thus, from these two sources, the issues and datasets that were included in the questionnaire.

The next chapter investigates the geographical area of interest in order to determine applicable datasets.

Chapter Four

Regional review

This chapter builds on the earlier chapters (Chapter Two: the need for a holistic approach and the scope of that holism; Chapter Three: data, information systems, analysis and sources) to make a first assessment of the boundaries for a regional system together with land and sea management, and data availability.

Any subdivision of the whole detracts from holism; conversely it aids a practical approach by making the unit more manageable. The whole may be said to be the World, north west Europe or the nation state, yet too large an overview and the opportunity to address local issues is lost. Too narrow a view and the natural influences affecting the area will be unappreciated.

The author's original interest was coastal zone management for the south coast of Devon. Early discussions with staff at Devon County Council and Plymouth City Council (as was) highlighted wider interests in a coastal study. The Devon County employee was as interested in the north coast as the south. Later discussions with staff at Cornwall County Council indicated a belief that coastal zone management should encompass the whole of the county.

Therefore, rather than being too narrow about a south Devon coastal zone it became an aim of the study to establish a relevant region in which to fit the south Devon coast. As a first consideration, a wider region is examined for natural and anthropic limits and Thus, the next section considers the local peninsula.

4.1 The South West Peninsula

The South West of Britain is a long peninsula of some 320 km (200 miles), from Land's End to Bristol, or Land's End to Portland Bill (Figure 4.1). The population of Cornwall is some 0.49 million, Devon 1.06 million, Somerset 0.49 million and with about 0.38 million in Dorset. The principal road access from the north is via the M5 and from the east by the A303. The principal rail routes enter from the north via Bristol, the east via Taunton, with supplementary links and internal connections. There are airports at Newquay, Plymouth, Exeter and Bristol. Industrial activity is dispersed, but with a significant presence in Plymouth (the largest city in the region with 256,000 people). Tourism is of major importance along the Cornish, Devon and Dorset coasts, in addition to specialist locations inland.

Chapter 2 of this thesis identified eight major user groups of the coastal zone, namely (Smith and Lalwani, 1984):

- transport and communication, including ports, shipping and navigation;
- mineral and energy resources;
- biological resources and fisheries;
- waste disposal;
- strategic (military) uses;
- research and education;
- recreation and tourism;
- conservation.

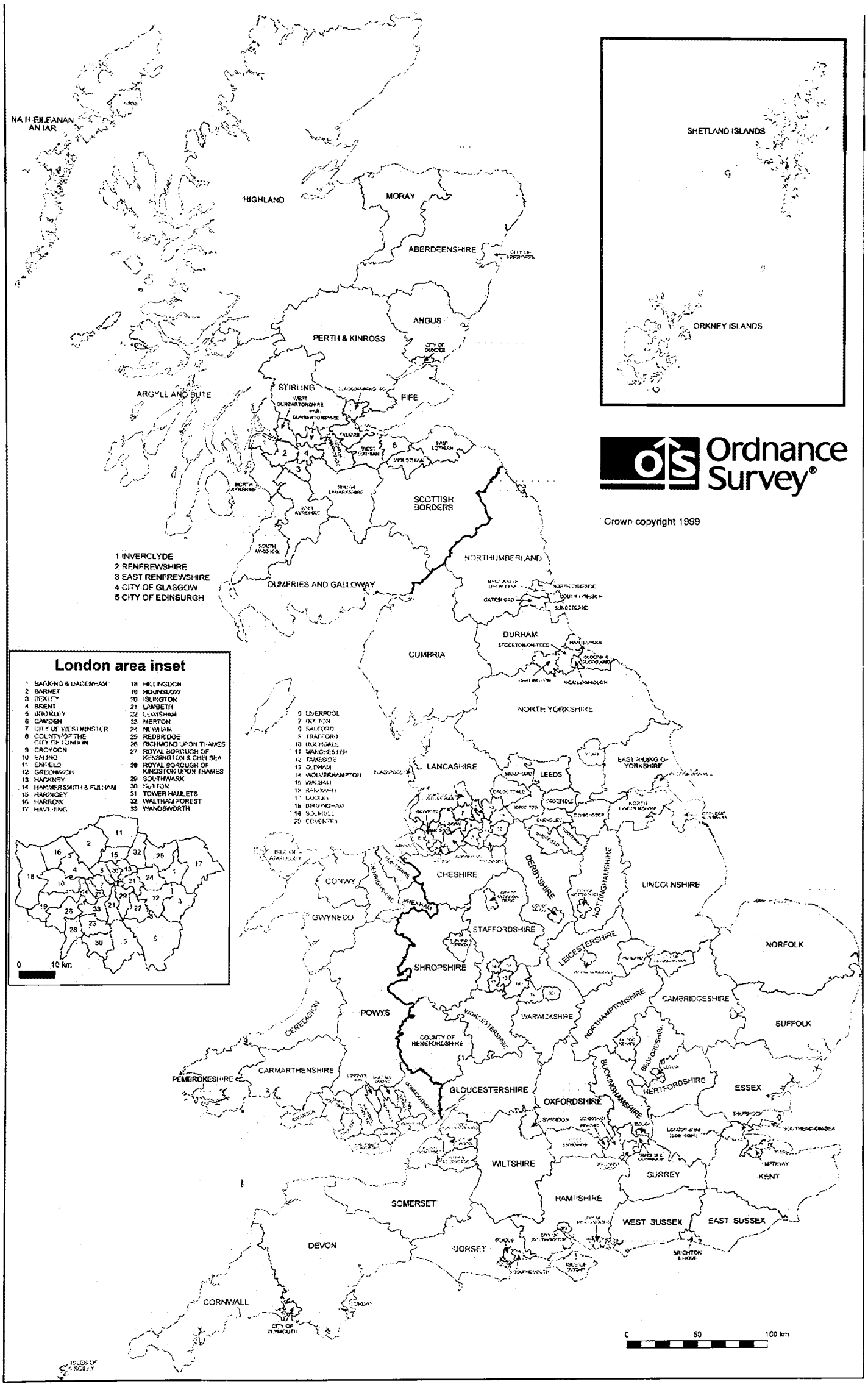


Figure 4.1 England, Scotland and Wales, where the South West peninsula of England includes the counties of Cornwall, Devon, Dorset and Somerset. (Source: Ordnance Survey).

Current local interests may be classified as:

- business (although given the comparatively low level of activity in the South West (in UK terms) the potential to expand may be more crucial than, say, conflicts with coastal environments);
- housing (particularly with new and expanding towns being promoted by central government);
- transport (with a vocal lobby against new roads and for the increased use of public transport);
- tourism (being a mainstay of the local economy); and
- the environment (being a mainstay of tourism).

Coastal management tends to be seen from a coastal defence or environmental stand point and it may be that integrated coastal management will be required when these two issues are in conflict with the population's interests. Such may be the case over the transport debate or if tourism is put off the region by poor infrastructure or environmental quality. A coastal management programme may be instituted because of a crisis, such as conflicts between users of the same sea area, a diminishing natural resource or because of natural or man-made disasters. Such events happen along the local coasts (sewage and surfers; fish stocks and oil pollution), but not to an extent which force government to introduce a comprehensive management system. However, an objective desire to improve the planning process may bring about a positive change in this direction and there are a number of local initiatives that point that way.

Devon, like the rest of the UK, suffers many low-level conflicts between user groups, e.g. water pollution and beach users, military uses of the sea and yachts, and the control of the waterfront and free access to, for example, slipways. Similarly, fisheries are suffering from

a decline in conventional stocks and this affects not only fishermen, but also their families and the dependent trades such as fish processing and transport. Storms can still cause extensive damage on the coast, not only to shipping, but also to coastal property and to land stability. All these issues are therefore of relevance to the Devon coastal zone, but it is nevertheless an area where many controls exist and much work to alleviate the problems has been undertaken.

Much of the area of Plymouth Sound and the adjacent coast is designated AONB, Heritage Coast and as SSSI. There is a Voluntary Marine Conservation Area at Wembury, also identified by English Nature as a Sensitive Marine Area and proposed as a Special Protection Area. Many of the minor estuaries leading into the Sound are designated SSSI, AONB, Heritage Coast and/or as Local Nature Reserves.

The environment around Plymouth Sound is vulnerable to the large population on its north coast and large influxes of visitors. Lacking a comprehensive management plan, detrimental effects could also spread to a managed area like Wembury, say through pollutants in the water. Present threats to the ecology include the contamination of shellfish by an accidental oil spill or toxic chemical release. Sewage pollution will be reduced under the new water-company-initiated treatment programme at Chelson Meadow.

There are many useful developments under the existing system. The water company is spending £900 million through their "Clean Sweep" programme to upgrade coastal discharges and sixteen schemes will improve forty three beaches. Military exercises must take place for the defence of the nation and they take place in well-defined areas and with adequate notice by "Notices to Mariners" published by the Admiralty both in local papers and more formally. The land planning system is a mature system, with adequate checks and

balances to allow it to operate to the public good. Fisheries management is well developed and intended to sustain the current £20 million Devon industry. Plymouth is fairly well protected by the Breakwater, which is regularly maintained, although occasional storm damage is never going to be entirely preventable.

Furthermore, the south Devon coast is mainly a hard coast, with strong cliffs able to resist erosion. Examples of cliff instability do occur – such as around Lyme Regis, including "the largest landslip and mudflow complex in Europe" (Posford Duvivier, 1998, p.10) and sometimes erosion is directly attributable to human action, e.g. that at Beesands (Mottershead, 1986, pp.32-40). Yet, the case for developing a management system is not simple to make, compared to that for East Anglia, where it is has been in the economic interest of the coastal protection agency to spend vast sums developing a nascent coastal management system - a coast protection information system. Similarly, local wetlands are not extensive, but the estuaries in south Devon (the Tamar, Plym, Yealm, Erme, Salcombe, Dart, Teign and Exe) together with other areas are deemed worth preserving and managing.

The tourism part of business is very important to the South West region with 10 million tourist trips in 1996 (Devon County Council Tourism, 1998) and 13% of the total UK tourist spend (CEC, 1999b) - the second largest for a UK standard region after London. The 1993 tourism spend in Devon was £845 million (Devon County Council, 1995, p.5).

This eclectic inventory illustrates the wide nature of South West interests that must be catered for in a comprehensive management system.

4.2 Regional influences

Regional boundaries for coastal management may be set by reference to one or more of a number of systems although a key feature is the existing administrative structure.

For particular issues, it may be best to consider quite a small area; for example, much detail is required to assess car access, parking and support facilities to a particular beach. However, the cleanliness of beaches and their attraction for recreation may need to be considered in a larger area - to consider public access via established infrastructure, and to assess pollution sources and the dispersal of pollution within the context of wide-area water movement. Counties, to which people claim some allegiance and which are the administrators of social services, tend to have their boundaries set by population groups, not by the ecology, so, for example, the Cornish boundary runs down the eastern side of the Tamar and most of Plymouth Sound. More recent regional boundaries include much more extensive areas, notably the UK Standard Region – the South West – which extends from Land's End to Swindon. Water companies come in between these with South West Water covering a little over two counties.

The regional influences of geology, sediment movement, economics & administration, climate and ecological environments are considered in the following sections for their influence on determining the wider boundaries. Acknowledging the influence of the natural, environmental processes may result in a sympathetic and successful approach to regional management. Nevertheless, in the words of Salm and Clark (1984, p.37), "to define a coastal management unit requires more pragmatism than theory, because the unit must be a realistic entity."

4.2.1 Underlying geology

Cornwall, and Devon to the Dart (and locally at the Dart estuary, east to Berry Head) has an underlying complex structure including isoclinal folds, metamorphic rocks and plutonic intrusions. Eastwards are post-Hercynian sediments with well-developed flexures. The solid geology consists of plutonic intrusions at Land's End and the Lizard, with Upper and Middle Old Red Sandstone (Devonian) between them, and east to Berry Head, and with Lower Old Red Sandstone stretching north of Plymouth Sound and of the Lynher River. North through Devon is Millstone Grit, returning again to sandstone. Eastwards around Lyme Bay from Berry Head to Portland Bill, the solid geology changes though many sedimentary rocks including sandstones, clays, greensand and chalk. Finally, the superficial deposits are limited to alluvium in some estuaries and clay with flints across the north of Lyme Bay (OUP, 1975).

The geology of the maritime zone of south Devon is well summarised in Evans (1990). Much of the scope of the report is concerned with deeper waters, but using the 12 nautical mile limit of the Territorial Sea he indicates (p.11):

- "A narrow, steep coastal zone extending down to 50 or 70 metres;
- A wide, almost featureless inner shelf extending down to about 120 metres;
- … rugged, rocky shoals which rise above the general level of the inner shelf."

There is a series of submerged cliffs and ancient submerged beaches. The coastline is mainly cliffs, especially in the west, with rias breaking through which extend to the base of the upper cliffs.

In Plymouth Sound (Devon Wildlife Trust, 1993, p.22) there is one of only two occurrences in the Southwest of coastal Devonian limestone, providing peculiar habitats for certain species. In addition there are igneous rocks (e.g. the volcanic plug of Drake's Island), shales, grits and slates.

Thus, the south coast geological, regional boundaries extend from Land's End east to Berry Head and then alter for the coast onto Portland Bill and beyond. The north coast is similar east from Land's End to Boscastle, change for a while to grit from Boscastle to north of Appledore, returning to the earlier solid geology east to Minehead. Areas such as the volcanic intrusions of Land's End and the Lizard, estuaries such as Plymouth Sound and the Dart, and the rapidly changing geology around Lyme Bay provide special, small breaks in the main picture.

There is a natural change in the geology that would interrupt the south Devon coast at Berry Head and there would be little to differentiate it from the north coast to Minehead. Small changes around Lyme Bay indicate no other obvious point to establish a boundary.

4.2.2 Sedimentary boundaries

The use of the term "coastal cell" is based upon sand and shingle drift direction changes, and applies particularly to coastal defence management on non-cohesive beaches. Although cells may be defined in units as small as cusps on sandy beaches, it is normally applied in the coastal defence context to sections of about 20 km in length. In an HR Wallingford report (Motyka and Brampton, 1993), cells are categorised as totally independent, partly independent and those whose direction varies with time. They can be defined as having a low, medium or high rate of littoral drift.

A major littoral cell encloses south Devon from Land's End to Portland Bill. This region has some geological similarity in the western half (see above) and a general WSW-ENE orientation. The unit is defined as totally independent, containing within it "sub-cells" that are partly independent. Sub-cells are nominated with boundaries at Land's End - drift divide; Lizard Point - drift divide; Rame Head - one way drift headland; Start Point - drift divide; Dawlish Warren - by a sediment sink; Portland Bill - by a drift divide. See Figure 4.2.

Thus, in these terms, there are natural boundaries encompassing the south Devon coast, with one (at Rame Head) close to a county boundary. As all except the western and eastern extremities indicate partly independent boundaries, use of them to define regional coastal management must allow natural processes to cross them. Land's End and Portland Bill are therefore more fundamental end-points, but any coastal management system will have to permit cross-boundary issues.

Sedimentary cells are currently crucial to the civil engineering-dominated approach to coastal management, but in a wider context, although their existence is important, it is not dominant.

4.2.3 Economics and administration

There are nine standard regions in England, with the South West covering 23,800 km^2 and 4.8 million people (CEC, 1999a). The unit is useful for some macro-economic planning, but the extreme west to east distance of 360 km brings more a sense of isolation of communities, than unification. Bristol, a possible regional centre, is only 200 km from London and the travel time to Penzance is more than double that of Bristol to London.

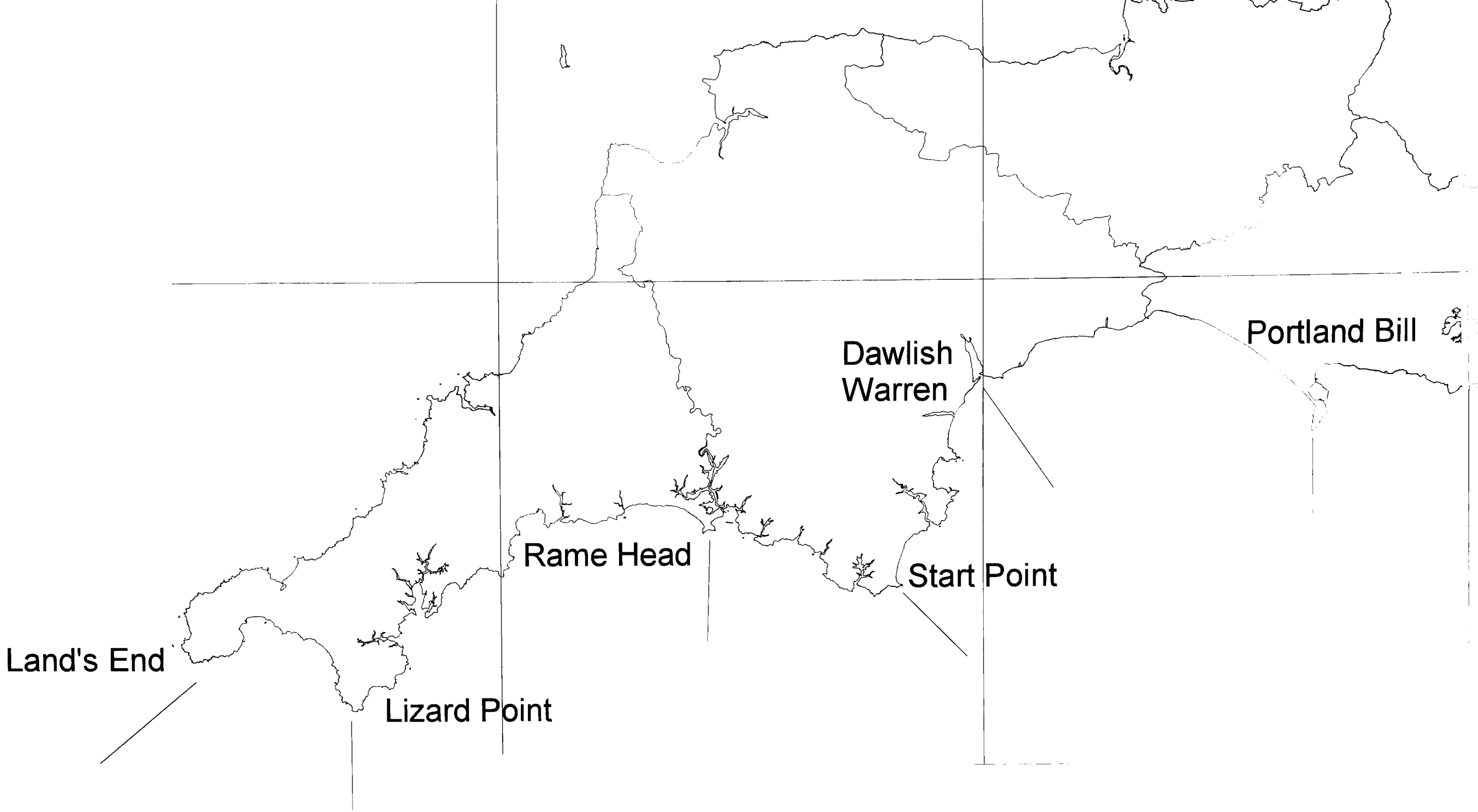


Figure 4.2 Land's End to Portland Bill littoral cell (after Motyka and Brampton, 1993, p.37)

Sub-regions of i) Cornwall and Devon, ii) Bath, Bristol. Somerset. Gloucestershire and Wiltshire and iii) Dorset and east towards Southampton have been recognised as more relevant to the population.

The south coast, maritime counties are Cornwall, Devon and Dorset (there are six counties in the region). These three match the sedimentary cell (above) bar Dorset's extension to Poole. The Unitary Authorities of Plymouth City and Torbay Borough are of similar status (there are another eight in the region). District Councils are the smallest administrative units with any power – a real power as they hold the planning authority. There are eleven such Councils (or thirteen counting the Unitary Authorities) along the south coast from Land's End to Portland Bill. Administrative responsibilities are confusingly split between Districts and Counties, and compete as the natural focus for many of the population. A smaller division, Parish, or (by their own choice of name) Town, councils have little authority.

Other local administrative dividers are the constituency boundaries for national and European Members of Parliament. There are seven MEPs for the UK South West European Parliamentary Electoral Region. There are twenty nine members of the UK Parliament in Cornwall, Devon, Somerset and Dorset.

The water company and their overseer the Environment Agency are also relevant organisations in coastal management.

Regional boundaries for coastal management may be influenced by any one of the above or a combination of them. The most powerful force is political. Strategic policy on coastal management may come from the European Union; implementation may be at District

Council/Unitary Authority level. The political boundaries of the constituencies may come to be significant in this context.

4.2.4 Climate

As an issue for tourism, climate is as important as water cleanliness, service and price. Although any one season's weather cannot be determined from one year to the next, long-term averages do point to differences in this area from other parts of Britain (OUP, 1975, pp.110-111):

- the January air temperature is warmer in the south west (5-7 °C) than the rest of England (3-5 °C);
- there are two hours per day of bright sunshine along the south coast in January and less elsewhere;
- the July temperature is similar to most of England and Wales (15-17 °C), but less than a band stretching from Oxford to London and down the Thames (17.5-18 °C);
- there are six to seven hours per day of bright sunshine in July from Land's End to Portland Bill and more (seven to eight) further east;
- there is 1000 to 1500 mm of annual rainfall equivalent from Land's End to Berry Head and less (750-1000mm) east to Southampton;
- wind at Plymouth is more usual from the west, southwest or east, but does occur around the compass.

No natural boundaries are readily discernible, although historic, real time and predicted climatic data would be useful background to any system supplying information to tourism and agriculture.

4.2.5 Ecology

The relevant coastal region as defined by the Marine Nature Conservation Review (Hiscock, 1996, p.49) extends from a line from Land's End passing north of the Isles of Scilly to Durlston Head, the headland south of Poole harbour. It is designated "Western Channel", but it has subsections as given by the Devon Marine Conservation Report of Plymouth Sound (Devon Wildlife Trust, 1993). As stated (section 4.2.1), the rare occurrence in the South West of coastal Devonian limestone, provides special habitats for certain species. Plymouth and this part of the channel are in the area where two significant water bodies meet: the warmer, Lusitanean waters of the south and the colder, Boreal waters of the north (op cit, p.22). The presence of the transition zone brings with it the limits of various species.

The south Devon coast is a particularly pleasant area for unspoilt and interesting coastline. This is evidenced by an Area of Outstanding Natural Beauty (AONB) along the Dartmouth estuary and another proposed for the Tamar. In addition (see also section 4.3), there are long stretches of Heritage Coast, Sites of Special Scientific Interest (SSSI) and from only 10 km inland, the Dartmoor National Park. There are many other local designations (well reviewed in ALC, 2000). These do not lend particular weight to settling the area of a relevant region in one way or another. Therefore the south coast from the Isles of Scilly to Durlston Head may be a natural area in which to establish a coastal management region.

4.2.6 Boundaries parallel to the coast

These boundaries are rarely easy to define. They range from those whose limits need to suit the issue in question and might vary as the paragraphs above, through those which need an arbitrary cut-off to bring some area into careful consideration, to those, quite clear boundaries which change temporally. The latter includes the land/sea interface which varies

four metres vertically and up to 400 metres horizontally (as, for example, at Bantham Sand, South Hams, Devon) twice a day.

One boundary, accepted by the International Hydrographic Organisation and national governments for the delimitation of international boundaries, may be useful. This, the "baseline", is Chart Datum. Being a low water datum, it will not be easily accepted by all, especially when legal ownership is based upon a different low water level, a median level, or a high water level. It does have the benefit of some scientific basis for its derivation, is checked and resurveyed occasionally and provides a safe link into the vertical datum for navigational charts which can supply much data for coastal management. However, the land-based bias to much understanding of the world may require the better known Ordnance Datum to be used. It has the advantage of being coincident with most land-based heights (except those measured directly using satellite positioning). Its use though could prove a danger to shipping - as recognised in the Ordnance Survey/Hydrographic Office (1993) joint venture Coastal Zone Series where diagrams and text illustrate the offset between Chart Datum and Ordnance Datum and result in a discontinuity at the coastline. Another low water level, Mean Low Water, is used in England and Wales for the boundary of local authorities.

Moving out to sea, a useful boundary, although arbitrary, is the Territorial Sea, 12 nautical miles from the "baseline". This encompasses:

- depths down to 95 m;
- shipping lanes off Land's End;
- particular routes when entering estuaries (for example in Plymouth Sound);
- firing ranges south of Wembury Point, Devon and Dodman Point, Cornwall;
- fishing grounds;

- international and local ferries; and
- mining areas for hard minerals.

Inland the limit of tidal influence, whether natural or imposed, may seem an obvious boundary to choose on the rivers and streams. Yet the limit of tidal flow on the Tamar is 17 km inland (32 km by river from the Narrows at Western King to Gunnislake) and 4.5 km on the East Looe River. Various solutions to cover the land, such as an arbitrary limit due to major transport routes have been proposed (for example, the A38 for south Devon), but the House of Commons Environment Committee (Environment Committee, 1992, p.2) rested with it being an issue-based problem (i.e., unquantified). Nevertheless, it is more convenient and practical in setting up an information system to plan to cover in more detail some more relevant area and to allow cross-boundary influences to affect the system.

4.3 Land and sea management

The type of management programme that is instituted depends partly upon the outcome that is desired. Thus, it can be (Clark, 1992, p.1) the aim is to encourage "... development that minimises negative impacts on living natural resources." Another aim can be the "... conservation of resources to ensure the combination of resource uses is sustainable." Whatever the case, they can be summarised within the need for "... controlling development and other human activities that affect the condition of economic resources and the quality of environment *(sic)* in coastal zones."

The overall land-use planning framework is determined within the County Structure Plans, devised locally, approved centrally and subject to regular consultation and update. The District Councils, who are the planning authorities, institute local plans within the Structure

Plan scheme. These also take notice of environmental designations such as Areas of Outstanding Natural Beauty, Sites of Special Scientific Interest, Heritage Coasts and Estuary Management Plans (or similar). Such environmental designations have a major influence on coastal management thinking. There is international status through Special Protection Areas and *Ramsar* Sites (such as Chesil and Fleet in Dorset and for the Exe Estuary). National status comes through:

- National Nature Reserves (the Lizard, Axmouth-Lyme Regis Undercliffs and seven others in Cornwall and Devon, one being the Lundy Marine Nature Reserve);
- Areas of Outstanding Natural Beauty (AONB);
- Sites of Special Scientific Interest (SSSI);
- Heritage Coasts.

Even land purchase by private companies, groups or individuals such as the National Trust (especially via Enterprise Neptune), the Royal Society for the Protection of Birds and local nature reserves can help to affect planning decisions.

The AONB along the South West coast are shown in Table 4.1.

	Length of Coastline	**AONB coastal frontage**	**Percentage of coastline**
Cornwall			
North and South	619 km	233 km	37.6 %
Devon			
South and East	214 km	103 km	48.1 %

Table 4.1 Length of South West coastal frontage and AONB
(after Gubbay, 1988 and Atlantic Living Coastlines, 2000)

The Heritage Coasts along the south west coast are shown in Table 4.2.

	Heritage Coast frontage	Percentage of coastline
Cornwall		
Penwith	54 km	
Lizard	27 km	
Roseland	53 km	
Gribben Head	24 km	South Cornwall
Rame Head	8 km	37.9 %
Devon		
South	75 km	South and East Devon
East	27 km	47.7 %

Table 4.2 Length of coastal frontage of South West Heritage Coasts
(Countryside Commission, 1995, pp.20-22)

Heritage Coasts lack statutory status and ownership varies from local authorities to private landowners. Management is founded on co-operation with local authority plans outlining management approaches and links with existing planning policies. Management commonly includes visitor infrastructure such as footpaths, signposting, visitor centres and leaflets.

There are 68 National Trust/Enterprise Neptune sites along south Cornwall, 22 along the south Devon coast and 8 in Dorset (Gubbay, 1988, pp.47-50). These range in area from about 1 ha to 2953 ha, commencing, where possible at the high water line and continuing inland. The Trust uses ownership to enable active management for public access and conservation. Similarly, the Royal Society for the Protection of Birds (RSPB) uses land purchase as a means of supporting management.

There are a host of other designations, such as Sensitive Marine Areas (identified by English Nature), Regionally Important Geological or Geomorphological Sites, and many others. There is a good review in ALC, 2000.

4.4 Data availability

Using the scope of coastal management identified in Chapter Two, the data requirements are wide. The results of the questionnaire, included in Chapter Five, indicate a prioritisation of data and are discussed in Chapter Six. In this section, the wide sources of data and data owners are illustrated.

In common with other UK regions, the principal data owners are central and local government (particularly the Department of the Environment and the Ministry of Agriculture, Fisheries and Food), the Environment Agency and the Ordnance Survey. Where the counties are maritime, then additional, crucial authorities are the Admiralty Hydrographic Office and port authorities.

The boundaries of administrations are important in as much as the correct authority must be addressed. The boundaries of occurrences of ecological systems or of soil types are important to the extent they affect or are affected by the issue at hand. Therefore, knowing not just the source for a dataset, but the responsible authority for the area covering the dataset, will aid the assessment of a problem.

National and local government are important in this, with County and District Council plans, structure plans, estuary management plans and thematic plans, such as oil pollution protection plans, disaster management plans, tourism, highway engineering or education. Subsidiary issues may include wider topics. For example, tourism benefits from advertising clean beaches, the European Union Blue Flag Award, the presence of lifeguards and a good track record of sunshine.

The Environment Agency holds open meetings, publishes and makes information available free or at a charge, from a variety of "Registers" (see Table 3.2). Large data suppliers, such as the Ordnance Survey issue paper catalogues regularly and there is a digital version (Ordnance Survey, 2000). Many local/estuary initiatives have their own catalogues such as Oke (undated). Studies such as Shoreline Management Plans may be key indices to little known data. A web-based catalogue, MarLIN (2000), acts as a reference to local and national archives on marine biological datasets. Table 4.3 gives examples of products.

OS data products

Digital maps	Business geographics	Superplan
Paper maps	Wall maps	Atlases
Guides	Historical & reference	Education products
CD-Roms	Videos	

Data from Oke (undated)

A paper publication of ninety one pages including:

Addresses, County and District Council policies, gazetteer, maps, tables of flora and fauna on:

landscape, nature, historic environment, commercial activities, fisheries, water quality, dredging, waste, tourism and socio-economic information.

Data from MarLIN

An electronic, biologically focused, reference system allowing interrogation via the Internet on the sensitivity, habitats and distribution of species.

Table 4.3 Examples of products from three data providers (Author)

Other readily available sources of data are:

British Geological Survey;

Cornwall County Council;

Devon County Council;

Dorset County Council;

English Nature
- paper maps;
- digital boundaries:
  - Candidate Special Area of Conservation;
  - Sites of Special Scientific Interest;
  - Special Protection Area;
  - National Nature Reserves.

Environment Agency Airborne Remote Sensing of Coastal Waters;

NERC Databases:

- Oceanographic Science – UKDMAP - British Oceanographic Data Centre at Proudman Oceanographic Laboratory;
- Marine Geosciences - British Geological Society;
- Groundwater Archive and Water Archive - Institute of Hydrology;
- Flood Event Archive - Institute of Hydrology;
- Marine Pollution - Plymouth Marine Laboratory;
- Remote Sensing - University of Dundee;
- Environmental Information Centre - Institute of Terrestrial Ecology;
- Land Classification of Coasts - Institute of Terrestrial Ecology.

4.5 Discussion

South Devon does not require a strong protectionist approach to the coast (most being hard coastline, not subject to erosion), nor, indeed, a strong protection from industrial pollution (notwithstanding that occasional oil spills, or industrial effluent do harm the local environment). However, these are inputs to the dominating concern for the coastal zone of south Devon, namely, tourism and tourism's requirements for scenic coastline, for clean water for bathing, of quiet, natural landscape, yet accessible and supplied with modern amenities. Such subjects do suggest a need for a holistic approach supported by a competent information system.

Key issues identified by Devon County Council (1995, ppiii,iv) are:

- failure to integrate statutory and non-statutory planning and management has resulted in a loss of opportunities; planning must account for natural changes such as sea-level rise;
- neglect or misuse of the coastal landscape has devalued the environment; access is not always adequate resulting in damage to economic and environmental interests;
- tourism, recreation and sport bring economic gain but can devalue the environment; recreation can affect successful agriculture; coastal areas cater for a disproportionate number of vehicles; low water quality affects an area's reputation with visitors;
- archaeological sites are vulnerable and some have been lost;
- changes to the utilisation of coastal towns has brought economic and architectural loss; the area's economy is affected by changes in the defence industry, port use, fishing and tourism.

It is evident that the number of administrative authorities and the number of relevant issues do not coincide within a simple area. The requirement for multiple boundaries has been identified before (Environment Committee, 1992) and particular issues may only require a subset of the data for the whole area. Nevertheless, for a comprehensive view of a section of coast (with the example here being the south Devon coast), input from an area outside of the county will be useful.

4.6 Summary

It has been shown that there are regional influences of:

- geology (with similarities in the area from Land's End to Berry Head (and Land's End to Minehead), but a wider area not having an obvious limit until Durlston Head (south of Poole));

- sediment movement (from Rame Head to Dawlish Warren, or more extensively from Land's End to Portland Bill);
- administration (utilising one or more of Cornwall, Devon and Dorset (and perhaps the Unitary Authorities of Plymouth and Torbay, or the UK South West Region); and
- ecological environments (from Land's End to Durlston Head).

Setting too small an area will degrade the possible benefits; setting the area too large will reduce knowledge of the situation on the ground. Nevertheless, no one set of limits seems suitable for all issues (as noted by the House of Commons Environment Committee, quoted in section 4.2.6) and any model of the area must allow for cross-boundary processes. To repeat the words of Salm and Clark (1984, p.37), "to define a coastal management unit requires more pragmatism than theory, because the unit must be a realistic entity."

The boundaries suggested for further consideration of the south Devon coastal zone are the counties of Cornwall, Devon and Dorset, offshore to twelve nautical miles and upriver to the tidal limit. Relevant issues are those affecting the people living and working in the coastal zone, its environment and the wider ecology.

Further work is needed to establish the veracity of this theoretical study and that the general can be refined to the particular. To this end, Chapter Five reports on a survey of interested parties.

Chapter Five

Survey of interested parties

The earlier chapters reviewed the current practice of coastal management, relevant datasets and the local area. The new work detailed here took the form of interviewing potentially interested parties to establish issues of relevance in the coastal zone and then to develop a questionnaire which would confirm or disprove these ideas and determine correlations between respondents' answers. There were initially consultations with four people in Cornwall and Devon to help identify one of the foci of the research (see also Chapter Four). After an extensive literature search, the results of which are largely documented in Chapters Two to Four, there were thirteen structured interviews with fifteen people and these are reported here. This chapter also records the development and analysis of a questionnaire derived from these interviews. The analysis forms the original results of the thesis.

Interviews and a questionnaire were chosen in order to reach the relevant people in the area, with the initial interviews helping to form the questionnaire. Coupled with a systematic approach to identifying further interviewees and potential respondents to the questionnaire, a regional view of coastal management was established.

5.1 The interviews

The majority of interviews were undertaken in Devon and Cornwall with practitioners working on various aspects of coastal management. The interviewees were selected to cover the stratification identified by the user groups (Table 1.1, altered and re-used as Table 5.1). It became apparent that there was a range of reactions including those who:

i) operate at a regional or national level, and

ii) have more localised interests.

The interviews were open-ended and were recorded by note-taking and/or by tape recording. Ten interviews took place in the interviewee's office, although for one, this was a motor home driven to his shellfishery. Three took place in homes and two by telephone (one to an office and one to a home).

Individuals were contacts known to the author, known to colleagues, as recommendations from earlier interviewees or by searching Dawlish Warren for people. The classification of user groups had already been developed and the author attempted to fill as many slots as possible.

Table 5.1 indicates the classification of those interviewed against the range of interests originally determined, and displayed in Table 1.1. It is strong on those involved in implementation, but shows a shortage of individuals involved in policy development. Other classifications show a good geographical spread and involvement in a wide range of activities. Interviewees were often in more than one class and the nineteen people interviewed (given at Appendix C) fitted at least thirty nine of the sixty seven classes given in the table. The stratification of the interviewees helped in the development of a suitably focused questionnaire.

The context of these interviews included their views on those issues previously discussed in this thesis, namely:

- a review of coastal management together with the expected improvements through integrated coastal management and how coastal management should develop;

Code	Policy development	Code	Implementation	Code	Land type	Code	Water depth
	European Union		Directorates	I	Agriculture	I	0-15 m deep
	Government		Agencies	I	Rural/non-farm	I	15-90 m deep
	County Councillors	I	County Council staff		Industrial	I	> 90 m deep
	District Councillors	I	District Council staff	I	Commercial		**User**
			Parish Councils	I	Housing	I	Manual
	Earth summit	I	Agenda 21	I	Estuary/coast	I	Professional
	NGO	I	Non-governmental	I	Cliff	I	Managerial
	Wildlife Trusts	I	Local Trust	I	Beach/sand/mud	I	Academic
	Nature Reserves	I	Local Reserve				Politician
	Use		**Management**		**Coastal stretch (N)**		**Coastal stretch (S)**
I	Transport	I	Commercial	I	Land's End – Kelsey Hd.	I	Land's End-Lizard Pt.
	Resource	I	Nature Reserve	I	Kelsey Hd. – Hartland Pt.		Lizard Pt.-Dodman Pt.
I	Biological/fish	I	Estuary mgt.		Hartland Pt. – Bull Point	I	Dodman-Rame Head
	Waste		Shoreline mgt.		Bull Point – Minehead	I	Rame Hd.-Start Pt.
	Strategic/military		Oil pollution		Minehead – Bristol	I	Start Pt.-Torquay
I	Research/education		Major incident		SW Peninsula	I	Torquay-Budleigh
I	Recreation/tourism		**Distance inland**	I	Cornwall – whole county		Budleigh-Seatown
I	Conservation	I	<10 km inland	I	Devon – whole county		Seatown-Portland Bill
		I	>10 km inland		Dorset – whole county	I	UK (external to SW)

Table 5.1 Classification for coastal zone users by employment and working area, where the code, I, indicates an interview took place with at least one individual identifiable with this class. (Author)

- applicable data sets, data handling, data analysis and visualisation and issues such as data ownership, access, maintenance, decision-support tools and distance working with data sets and software;
- the optimal region for coastal management, having due regard to issues such as geology, sedimentary boundaries, economics and administration, climate and ecology;
- data availability, including data sources, the influence of government and non-governmental organisations and integration for coastal management.

Each interview was intended to be open, allowing the respondent to discuss the issues freely; nevertheless, the interview was guided by the following topics, which encapsulate the application of integrated coastal management and its possible support via computerised information technology (IT):

- The state of coastal management locally and regionally;
- The potential benefits of coastal management;
- The value of background information to aid management;
- Accessibility to information;
- Current use of IT and opportunities for evolution of IT within the organisation;
- The suitability of data for a secondary use when originally gathered for another purpose;
- Plans for development of IT in this context and the timescale for its implementation;
- Availability of external supporting data;
- The use of appropriate software to manage data and support decision making;
- Whether IT was readily available in the office (or the field, if that is where the work is done).

The interviewees were relaxed, being in their own surroundings. Some knew of coastal management concepts from specific or general knowledge (e.g. the Estuary Project Officer and the Sea Fisheries Officer, respectively). Others needed to be given background (e.g. the householder and the sheep farmer), whilst trying not to lead their views in the process. Some (e.g. the householder) had knowledge of computer data handling from other settings.

The complete set of interviews took place from October 1995 to August 1998 and from Penzance to Exeter (plus a single individual from Kent). A number provided useful site visits, e.g. a view of a shellfishery at low water with its land and water access, navigation marks and the local terrain. Here an example of multiple-use conflict was cited (see section 5.1.09). More widely, the venue of the interviews in the interviewees' offices or homes gave an improved context to the understanding of the interview. Thus, charts, reference texts, moorings, raw and interpreted data and the presence of numbers of tourists were all valuable object lessons to aid the conversations.

The following sections give précis of the major thirteen interviews involving fifteen people. They are given in their geographical order from west to east, but there is no particular significance in this.

5.1.01 A fisheries organisation

The interviewee explained the nature of his organisation and its links with other organisations. He was sceptical about integrated, holistic coastal zone management believing there are too many variables, too many vested interests and that environmentalists know too little of the sea. He stated further that monitoring and control are difficult and

little understood. He commented on the return of lobsters to his area and of the contribution to this of much less general pollution.

He was satisfied that coastal management could inform managers and users of other people's interests and problems and improve information provision. He referred to some confusion brought about by the range of units and terminology in use.

He was working on a proposal for a Special Area of Conservation and saw this as a means of drawing people together and providing a legal framework. More generally, legislation and accompanying paperwork have resulted in a massive increase of workload – much associated with a Sea Fisheries boundary extension from 3 to 6 miles and he would be pleased to have updates by disc with a search capability.

5.1.02 A harbourmaster

A harbourmaster was interviewed along with his local environmental consultant. The harbourmaster was quite positive that Cornwall needs the rest of the peninsula for effective business operations. The Harbour Authority has computers together with specialist software, the Internet and email. It does not charge for the analogue data and information that it gives out. The harbourmaster discussed the Authority's relationship with various other administrations and data holders:

- the Environment Agency (EA) holds a series of datasets in different offices. The Authority uses the data in hard copy format. They can be difficult to obtain and the Authority only uses part-copies of datasets to keep down costs. The Harbour Authority receives no digital data from the EA despite perceived advantages such as ease of download and improved storage;

- the County Council is co-operative with the Authority's work in the river and its surroundings, but the Authority's offer of collation of a wrecks' database was refused as it would have involved a transfer of the data holding;
- the water company supplies background information but not new data and co-operation stops at any funding requirement.

The harbourmaster explained how local authorities and Harbour Authorities have separately managed their estuaries and how English Nature is fronting an integrating process, setting comparable, workable, achievable targets and links into the EA catchment plans.

On specific local issues, the harbourmaster stated that:

- it is apparent that previous sampling work did not look for Tri-butyl tin (TBT) nor heavy metals;
- there is no suitable or comprehensive database, no comprehensive sampling, and any analysis is incomplete;
- there is an inappropriate sampling regime that would be unsuitable under extreme conditions such as during and after a flood;
- the river's natural run-off includes rainwater over granite sediments with related concentrations of heavy metals;
- oil interceptors have decreased the pollution level brought down to the river by run-off;
- the dredging requirements for navigation may change if there is a shift from shipping to yachts, of which the estuary already has some 7500 visiting yachts a year.

5.1.03 A planner

This interviewee was particularly concerned with raising awareness of Agenda 21 and co-ordinating, developing and monitoring activities. He stated that his local authority:

- enables activities, but does not fund them;
- has a waterfront strategy;
- would benefit from sub-regional planning but that there is currently too little information on hinterland activities.

The planner described the limited computer facilities with email, one Internet connection and an IT strategy that is overwhelmed. He stated that he had access to EA data, but nothing from the privatised utilities. He saw a need to identify indicators of change that involve social and economic planning and that these have to be "real indicators for real people". He enunciated this in terms of a number of questions:

- is it measured ?;
- can it be measured ?;
- who measures it (50% don't know) ?;
- does it tell us anything ?;
- can targets be set ?

The planner stated that the local authority needs partnerships in information, especially at regional and sub-regional level. He thought information bartering may be a way forward and that electronic data would be useful and easier to integrate.

5.1.04 A sheep farmer

Working three miles from the mouth of the River Erme, this gentleman recognised no affects on his land by the sea and claims not to affect the sea. He said he had a Site of

Special Scientific Interest (SSSI) at the bottom of his valley and he believed he has no affect on it.

The farmer had no computing facilities and stated that he received all relevant information by post, the radio, the TV and the press. He said he had never used a computer nor seen the Internet working on a computer.

5.1.05 An urban householder

This interviewee recognised little affect of the sea on the land apart from the climate. He said of the region that the A38 is useful, as are ferries and regional airports.

He "uses" the sea for coastal walks, requiring access points, parking, weather reports, maps and signposts. He sails on the River Dart requiring information on the weather, wind, tide (and for which he used the TV on Fridays) and river traffic. He thought that real-time satellite pictures could be useful to support his leisure activities. His current experience of the Internet was its domination by advertising and products for sale.

5.1.06 A warden for a specialist environmental area

Based in the South Hams, this gentleman's work was project based, concerned with beach cleaning, water quality and car parking.

He said he was not interested in wider information, although "data is nice to have". He worked around the coastline mainly with notes scribbled on paper and found computers and electronic communication difficult – especially when working in the field. Nevertheless, he said he does need support to trawl wider sources of information.

5.1.07 A lecturer

The interviewee worked at a naval college. He knew little about coastal management. He said that the River Dart's harbour limits changed, perhaps partly to ensure compliance with environmental standards. He did not know of the level of success of the primary sewage treatment and stated that there is only an 80% level of understanding of the complete sewage system. He said no one is sure of the final destination of the waste.

He had used some data from the EA. His work is project based, currently using a databuoy in the River Dart, and he was expecting requests for the data.

5.1.08 A coastal manager

This coastal manager stated that:

- the largest budget for coastal issues is dedicated to flood defence/ coast protection;
- coastal management can be applied to local issues and that despite the lack of a statutory basis for integrated coastal management, existing legislation can be applied for its implementation; there are overlaps in the legislation rather than gaps;
- there is no funding for implementation, only for development;
- English Nature is the lead agency in any coastal management project;
- Special Areas of Conservation siphon off any resources and yet their primary concern is conservation.

The manager said he was the sole employee of the Dart Forum, representing 50 organisations. His work required wide consultation but he has found the public apathetic to coastal issues. He defined his own job in terms of responsibility rather than geography.

He stated that relevant boundaries are natural limits but that there are other influential boundaries.

He found that data is easily accessed but that it does not all come in the format expected.

5.1.09 An oyster farmer

This gentleman raised foreshore ownership as a significant issue. Devon Sea Fisheries had tried to establish a single plan of the area and had identified twenty three land owners. Its development had not been continued, with Devon County Council expecting costs to outweigh the perceived benefits.

He said that the pollution warning system worked well, with compensation paid for lost sales. Yet, he believed water quality was an outstanding issue in order to be able to establish new aquaculture developments in minor bays and inlets. He wanted data to be at large scale to allow for small geomorphological changes, but decisions on water quality were taken centrally on too sparse an information input.

He reported on one local development where work had left the riverbed as a death trap for those walking the low water line due to unconsolidated sediments. Dredging showed historic massive pollution.

He cited an example of a multiple-use conflict resulting from the hire of small motor boats to tourists in Teignmouth and the use of the riverbed for oyster farming. The journey up the River Teign gives safe passage for the new "sailors", but they are sometimes ignorant of the channels marked by willow stakes and their lack of navigational understanding leads

them to ground their vessels on the oyster beds. Significant damage can be caused to the beds and evidence of boats' tracks was to be seen in the mud.

He believed that there was much data in existence, but that it is not readily available.

5.1.10 A facilities manager

This interviewee's main concern was with Health and Safety. He stated that the water boundary to the tourist facility was not clearly delineated on the ground, but that there was a change from Teignbridge District Council jurisdiction to that of South West Water. There had been much work on storm defences along the coastline and also much recent work at improving local amenities. Boat launching was prohibited and zoning prevents landing at Dawlish. There was also zoning restricting areas for dogs.

Much of his work came from general public enquiries. He said that tourists lack basic understanding of tidal movements and marine life. He could have 10,000 people on site.

5.1.11 A ranger on a Nature Reserve

The Ranger Service was described as seasonal, concentrating on education. Judgements had to be made on "acceptable" damage, with a focus on the tourist facilities at the accessible (western) end of the Warren and paths to the other end. The local Exe Estuary Management Plan was not statutory, was difficult to institute, had no policing and litter was evident around the area. Employees of South West Water (SWW) were never seen and the actual boundary line between the Reserve to SWW's property was unknown to him.

He said that there was no easily accessible record for analysis. He knew that information is stored but it was not easily accessible.

5.1.12 Wildlife Trust officers

These interviewees were very protective of their raw data, wishing to preserve the data's interpretation to themselves. All their data was on paper, but they were planning to convert them to a computerised system (this was underway by October '97). They have land and marine habitat and species data.

5.1.13 A county council employee

This gentleman spoke by telephone of the use of GIS for a whole council. It had cost a lot to set up and was expensive to run. Most expense had been in the gathering and conversion of data and this was an ongoing cost. He commented that computerised simulations tended to be static and that there are difficulties in managing and displaying data in flux.

His experience was that constraint maps tend to dominate the GIS output but increased usability in IT would make it more useful in terms of visualisation. He also thought that built-in indicators would increase its usefulness. Yet, he said, if all data were in a GIS it would still not give a local view.

He believed that managers suffered from information overload and utilised less than 5% of available data. Conversely, despite the supposed portability of digital data, it could be of no use unless it was recognised. Pertinent questions needed to be asked to determine what data was needed and in what form it should be provided. He said the end-user should be asked:

- what do they use now ?;
- what don't they use ?;
- where do they go ?;

- should there be a terminal in a pub ?

5.2 The framework analysis

The interviews were transcribed, précised and assessed for common themes by condensation and categorisation (Kvale, 1996, p.192) to determine priority issues. The context of the interviews (section 5.1) necessarily influenced the conversations that took place and the range of views elicited from the interviewees. Thus, six of the eight headings in the framework analysis are:

- a review of coastal management;
- benefits and development;
- data requirements;
- data access;
- data availability;
- IT use: hardware and software.

New headings in the analysis resulted from the interview material, namely:

- data suitability;
- IT development.

The framework analysis is in Table 5.2.

	Review	Benefits and development	Data requirements	Data access
Derriman	Sceptical-too many variables, too many vested interests. Environmentalists know too little of the sea	Can inform managers and other users of wide ranging interests. SACs integrate	Legal requirements	
Sutherland/ Porter	Harbour Authority lead agency in EMP; Cornwall needs peninsula	Central holding would be useful	Still use paper	Collection expensive; many charge (we don't); actual supply costs are cheap
Anonymous	Agenda 21 is to do with awareness raising, co-ordinating, developing and monitoring		To support sub-regional planning – too little information on the hinterland. Need indicators for social and economic planning	Have EA data but not from privatised utilities
Squire	Farm three miles from sea-do not affect it; not affected by it.			All by post, radio, TV, press
Marriott	No affect of sea on land except general climate		Coastal access points, parking, weather, maps, signposts, wind, tide, river traffic	TV
Twogood	Work is project based; emergency planners available for specialisms		Do not need external information; [yet] beach cleaning, environmental health, water quality, car parking	Electronic communication can be difficult
Porter	Knows little of coastal management	Appreciates current data is incomplete	Had a little data from the EA	

Table 5.2 Framework analysis, part 1 of 5. (Author)

	Review	Benefits and development	Data requirements	Data access
Humphreys	Accepted by government; most money to civil engineers; operates locally, has no money, is not statutory; many local plans; quality varies; natural and other influential limits; EN lead development of plans; no money for implementation; SACs require spending and Thus, take money, SACs for conservation – narrower than cm; Dart - one employee, 50 inputs; public apathetic; Solent Forum better resourced; current legislation available for implementation, overlaps rather than gaps; job defined in terms of responsibility; nominally tidal limit	CZ Agency would require core funding; solutions by finite projects; international developments benefit local developments	Organophosphate sheepskin dipping discharges; other contaminants; water quality including sediments and heavy metals	Easy – ask
Gibbons	Devon Sea Fisheries tried to establish a single plan of the Teign estuary. Centralised decisions (in Teignmouth) over-ride local views. Dredging left river bed unsafe	DCC said costs of ownership plan outweighed benefits	Foreshore ownership – 23 in Teign. Pollution. Water quality at large scale	

Table 5.2 Framework analysis, part 2 of 5. (Author)

	Review	Benefits and development	Data requirements	Data access
Hayden			Health and safety. Boundary definition. Public information and enquiries – tidal movements, marine life	
Holley	Ranger Service is seasonal, educational and practical. EEMP not statutory, difficult to institute, no policing	N.R. use judged on "acceptable" damage		Records not easily accessible for analysis
Carl/ Camplin			Land and marine habitat and species data	Protective of own raw data
Gilbert	Constraint maps dominate; simulations static but coast dynamic; will not supply [large scale] local view; needs to involve local opinion	Ecological database under construction	Build indicators into system; add in SMPs	Gathering and conversion of data is expensive and an on-going cost

Table 5.2 Framework analysis, part 3 of 5. (Author)

	Data suitability	**Data availability**	**IT use: hard and software**	**IT development**
Derriman	Beware units and terminology		Have computers	Only personal Internet access. Would like updates on disc with search capability
Sutherland/ Porter		EA public register; two months for few papers; lots jealously held; others want data	Computers, Internet and email available	Would like to use digital data but don't at present
Anonymous	Regional and sub-regional level	Need partnerships in information; information bartering ?	Currently restricted computing facilities	Electronic data would be useful – easier to integrate
Squire			No computing facilities	
Marriott	Internet dominated by advertising and products for sale			Real-time satellite pictures
Twogood	Uses notes scribbled on paper			Cynical over cost/benefit ; Resigned to modem and network problems
Porter	Data boundaries change (possibly at a "political" whim)		Has computing facilities	Setting up real time data provision on the Internet

Table 5.2 Framework analysis, part 4 of 5. (Author)

	Data suitability	Data availability	IT use: hard and software	IT development
Humphreys	Secondary data not always applicable	Digital data is available	No PC at work	
Gibbons		Pollution warning system works well. There is lots of data, but it's not readily available		
Hayden		Needs to supply info to public		
Holley		Data stored but not accessible		
Carl/ Camplin	Preserve interpretation to themselves	Data gathering is very expensive		Converting from paper to a GIS
Gilbert	Data needs continual updating; published documents out of date; ask end-user what needed, what used, what not; user needs only 5% of dataset	Put terminal in pub?; Digital data may be portable but it still has to be located	Kent have GIS for whole council	GIS very expensive; intelligent system would be useful; visualisation; data in flux cause difficulties

Table 5.2 Framework analysis, part 5 of 5. (Author)

This framework analysis categorises the responses of the interviewees into common themes. They indicated that coastal management was not a subject of general public concern and left those with a closer role in the coastal zone as being the core parties (see in particular, the sheep farmer, the urban householder and the planner). There was a generally held view that a more integrated approach would be beneficial, that access to wider information would help their own work and that current technologies in digital data communication could benefit the process.

What was also commonly held, was an acceptance of the protection of information (whether stated from the data owner (e.g. the Wildlife Trust), or from the potential user (e.g. the Harbourmaster). Computing access was common - even to a Teign Estuary shell-fisherman (although not at his workplace, but at home). Also, there was a commonly held view that the Environment Agency's (EA) information supply had improved - mainly through (in the shell-fisherman's case) the conventional means of broadcasting pollution warnings by the EA, or by postal access to the EA's data.

Not all interviewees addressed all of the issues and they certainly raised a number of different aspects not expected before the particular interview took place. Examples are:

- Derriman's intense interest in legal issues;
- Squire's dismissal of the effects of his farm and farming on the coast;
- Sutherland's free offer of data yet rejection by a partner authority of his management of data;
- Humphreys' view on the non-applicability of secondary data.

The review of coastal management indicated a range of positions from ignorance and dismissal through to individuals working in the topic area. The benefits and development

of coastal management were commented on by those already aware of the system. Thus, both of these led to a particular form of introduction to the questionnaire.

5.3 The questionnaire

The framework analysis produced a set of topics and thence a specific set of questions.

The "Data requirements" section was wide ranging and led to a major section of the questionnaire, "Section C - Topical issues, datasets and co-operation", in an attempt to identify the most important issues and datasets for the user group. The views within "Data access" varied from issues of cost and means of data transfer to ease or difficulty of access. In the questionnaire, these were represented by part of "Section D – Data management and information technology", as were issues from "Data availability". The "Section D" also covered some of the topics from "Data suitability", such as units and the use of computerised information technology (IT). Another "suitability" issue, the secondary use of others' data, was covered by "Section E – Odds and ends". IT was also covered in "Section D", preceded by an introduction, i.e. a covering letter, as an attempt to clarify the terms and opportunities to the respondents.

Finally, scattered through the questionnaire were indirect and direct questions to elucidate personal information on the respondents. Thus, they were asked their closest place of work, their most important sectors of interest and given an opportunity to identify themselves by name and employment.

Therefore, along with questions to help identify a relevant region for coastal management, the questionnaire was also designed to investigate:

- Regional boundaries;
- Principal issues of concern to undertake work or leisure;
- The data requirements;
- Accessibility of data;
- Availability of IT.

The survey's inclusion of questions on places and types of employment aided a check on how the range of responses related to the initial classifications of Table 1.1.

The questionnaire was piloted (Litwin, 1995, p.35, technically a "content validity" measure) on nine people (supervisors, lecturers, scientists, and two colleagues experienced in questionnaire design and use) and various corrections were incorporated. The introduction was modified to aid the understanding of holistic, integrated coastal management as an attempt to encompass the non-specialists and resulting from the experience in the interviews (Twogood, Hayden, Holley, Table 5.2). Changes were made to the wording of questions and supporting text to reduce ambiguity (but see section 5.4, following). Finally the questionnaire was coded by giving a unique number to each possible answer to aid the analysis. This final version consists of four principal sections (regional limits; topical issues, datasets and co-operation; data management and information technology; data gathering) in 28 main questions and 388 possible responses. Allowance is made for further comments. It is available at Appendix D. The questionnaire was previewed by the Faculty Ethics Committee to ensure it complied with University requirements that particularly relate to the maintenance of confidentiality.

As referred to earlier, the total population is the coastal user group, but as a result of the interviews (particularly Squire, Marriott and Porter, section 5.2), the practical target population became those with rôles more closely associated with the coastal zone. A large collection of names and addresses was made available by the Atlantic Living Coastlines study group (the administrators of an EU funded study into a coastal zone management demonstration system). A selection was made to include those directly relevant to the South West, principally by sorting due to country and county. A further selection was made to avoid the over-representation of particular groups (there was a very large number of academics), culminating in 332 (out of an original list of 514) potential contacts with names and addresses. From an assessment of user groups based upon job descriptions and on the geographical location or area of influence of the individual it was obvious that there was a shortage in some fields (particularly in Dorset and amongst policy makers). A trawl for further contacts increased the sample, overcoming the Dorset shortage with 220 (out of a list of 272) contacts from the Dorset Coastal Forum. Members of the UK and European Parliaments were added, and a few other individuals as discovered during the interviews. The questionnaire was distributed to 604 people and those who responded are kept confidential. Those who requested such have received a summary of the results of this work. Table 5.3 indicates an assessment of the classifications of those to whom a questionnaire was sent. The total is greater than 604 as an individual can be identified with a number of classifications.

Code	Policy development	Code	Implementation	Code	Land type	Code	Water depth
6	European Union	11	Directorates	3	Agriculture	30	0-15 m deep
41	Government	23	Agencies	8	Rural/non-farm	4	15-90 m deep
1	County Councillors	35	County Council staff	8	Industrial	1	> 90 m deep
3	District Councillors	76	District Council staff	5	Commercial		**User**
		7	Parish Councils	3	Housing	9	Manual
5	Earth summit	16	Agenda 21	10	Estuary/coast	*	Professional
32	NGO		Non-governmental	4	Cliff	*	Managerial
3	Wildlife Trusts	9	Local Trust	4	Beach/sand/mud	92	Academic
	Nature Reserves	7	Local Reserve			53	Politician
	Use		**Management**		**Coastal stretch (N)**		**Coastal stretch (S)**
35	Transport	2	Commercial	9	Land's End – Kelsey Hd.	8	Land's End-Lizard Pt.
10	Resource	9	Nature Reserve	9	Kelsey Hd. – Hartland Pt.	18	Lizard Pt.-Dodman Pt.
28	Biological/fish	19	Estuary mgt.	15	Hartland Pt. – Bull Point	15	Dodman-Rame Head
7	Waste	10	Shoreline mgt.	3	Bull Point – Minehead	19	Rame Hd.-Start Pt.
5	Strategic/military	8	Oil pollution	8	Minehead – Bristol	9	Start Pt.-Torquay
94	Research/education	5	Major incident	12	SW Peninsula	14	Torquay-Budleigh
30	Recreation/tourism		**Distance inland**	23	Cornwall – whole county	23	Budleigh-Seatown
19	Conservation	6	<10 km inland	24	Devon – whole county	52	Seatown-Portland Bill
			>10 km inland	43	Dorset – whole county	83	UK (external to SW)

Table 5.3 Classification of those receiving a questionnaire, where the number is the gross sum of the individuals within each class. The professional and managerial groups (starred, *) are difficult to establish from the contact list, but are assumed to make up the bulk of the 450 recipients not classified in these two tiles. (Author)

5.4 Replies and respondents

604 questionnaires were sent out and there were 170 completed replies (28.1%). The response rate is acceptable both as a percentage of the number sent out and as an absolute total for statistical validity. Any analysis of subsections would need to be assessed on their own sample characteristics to estimate likely validity.

The database of the questionnaire responses was originally established using a Microsoft Excel spreadsheet and initial analysis used this software. After a review of the extent of the results, some tidying of the figures and editing of anomalies, the data were imported to the advanced analysis software, SPSS. However, most work was still undertaken on Excel. The questionnaire variously required yes/no answers, a choice between two or three options, or a selection from a list. The respondents were requested to scale this selection in order of importance (e.g. to show the relative importance to the respondent of one of twenty seven coastal towns by indicating with a 1 and places of supplementary interest with 2, 3 or 4). However, not all respondents did scale as asked, but gave multiple 1s, 2s, or other values instead. These examples count differently from those who took a literal interpretation of the questions. This problem of different forms of scaling, or of not scaling, did not become apparent despite trials on both the ordinary public and on those used to answering questionnaires.

Many respondents were scrupulous in trying to answer the questionnaire rigorously and corrections to their answers were proof of this. There were few anomalies in mutually exclusive answers and many respondents were comprehensive in answering lists. Occasionally they answered awkwardly. For example, for the question, "If you access any data on paper, is it by personal visit, post, fax or other" eleven respondents crossed

"other", adding the comment "email". All eleven to do this also responded to "If you access any data digitally, is it by floppy disc, via email, via other electronic transfer" by crossing the box for "email".

A couple of respondents completed the questionnaire, despite commenting that it was "difficult", or that they "didn't understand" it. Brief phrases contributed to some uncertainty in the responses so that some answers may be subjective. An example from the questions on respondents' primary areas of interest exemplifies this. One made the term "line fishing" (answer 36) more precise in his/her terms by annotating it "(angling)". It leaves the question, would his/her answer be unsuitable against the term "line fishing" ?

Further, it is now apparent that if the questionnaire has been answered from the beginning as someone responding under "Leisure" rather than "Work", then the question "Do you use computers for your work ?" and following may be regarded as anomalous. Although the argument is not clear, inclusion of the "leisure" answers within the "work" answers will affect only 8 replies out of 170, or 4.7%. It is possible that the answers are not incorrect. For example, those answering for leisure interests (e.g. one who supports a canoe club) could see "work" in supporting members. However, some may have changed the thrust of their reply from leisure to work from this point on.

Four Members of the UK Parliament or Members of the European Parliament (MEP) sent letters stating they would not be completing the questionnaire (at least one MEP did complete it). Three other respondents returned blank questionnaires indicating that another would be completing a separate copy on their behalf. Of the replies, 151 related to work and 24 to leisure (which includes eight stating they were answering to both; three did not

claim a connection). Replies came in from within days of sending out the questionnaire in November 1998 and until January 1999.

The 170 respondents associated themselves 28 times with the towns in Avon and Somerset, 33 times with those in north Devon, 169 times with Cornwall, 109 with south Devon and 81 with Dorset (a total of 420). Their association with particular towns is shown in Figure 5.1. The high figure for Weymouth seems likely to result from the questionnaire nominating no other towns to the eastern end of the study area.

57 people expressed further geographical associations in addition to placing themselves within 50 km of the nominated coastal towns. They chose to be associated with a District, a County, the South West, another part of the UK or the whole of the UK. Adjusting the county figures for these 57 gives the figures in the middle column in Table 5.4. Also shown are the numbers of individuals identifiable with only one county – 91, leaving 79 associated with more than one county or a region.

Counties	Total Associations	Individuals associated with only one county
Cornwall and Isles of Scilly	173	21
Devon	148	43
Dorset	113	24
Avon and Somerset	30	3
South West	10	
UK	3	
Total	**477**	**91**

Table 5.4 Respondents by county and region (Author)

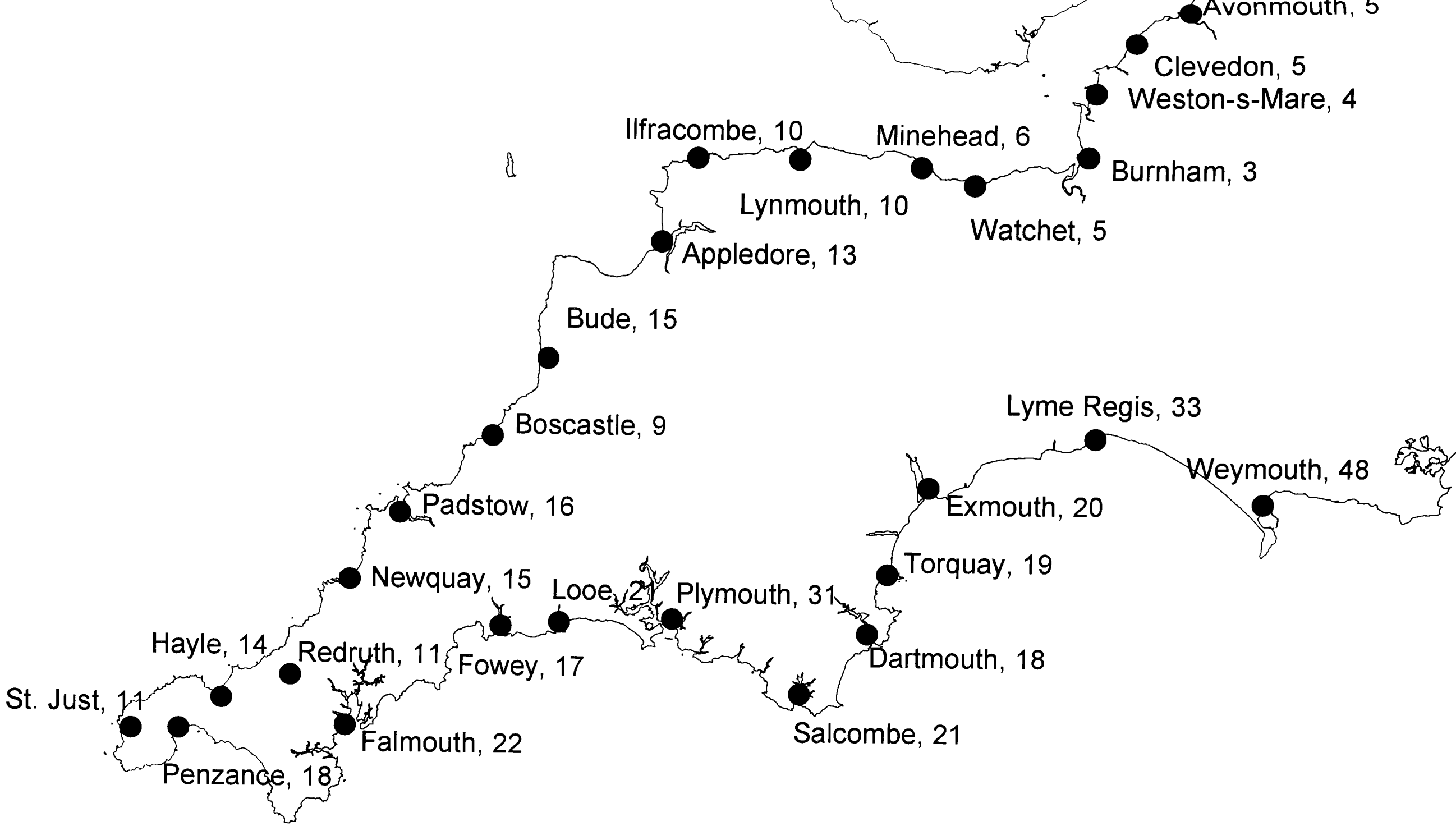


Figure 5.1 The results from 170 respondents asked to give their affiliation with 27 coastal towns. Many gave more than one town, resulting in 420 affiliations. (Author)

This total indicates respondents' affiliation with more than one centre (3:1 ratio of places to respondents). As implied earlier, an attempt to elicit a scaled response to centres of interest failed. Whereas the questionnaire (Appendix D, section B) asked,

> "Does your work/leisure occur nearest to (1 in the box ❑ for your primary area of interest; 2, 3, and 4 in the boxes ❑ for supplementary centres)",

many answered with multiple "1"s. It may be that they would not, or could not differentiate between places of importance. The affiliations indicate a reasonable balance of responses for the peninsular counties, although it is not possible to determine any finer balance of individual respondents with particular towns.

The individuals associating themselves with only one county allow some further work to be done. There are only sufficient numbers to work with Cornwall, Devon and Dorset, and even then the numbers for Cornwall and Dorset are rather low for statistical significance. The county results are commented on below, in section 5.6 (Issues in the coastal zone) and section 5.7.1 (Data requirements). The questions relating to the respondents' sectors of interest (Appendix D, section C) gave the opportunity to establish the range of interested parties and to check the classification of respondents. Once again, the answers were too complicated to identify a primary interest for each respondent and the analysis gives a more simple result of areas of interest. The results are simplified by accepting any expression of interest (equivalent to substituting a 1 wherever any interest was indicated, and totalling the 1s, i.e. using the Microsoft Excel function "Count" instead of "Sum"). The figures for the ten major classifications are shown in Table 5.5 and Figure 5.2.

There is the strongest showing from "Environmental support", which is to be expected given the source of the address list. Nevertheless, there are strong responses from other areas, and more than enough for statistically valid samples.

The total expressions of interest is 2418, from 170 returned questionnaires (on average, respondents associated themselves with 14 working environments). However, Table 5.5 and Figure 5.2 present biased views of the respondents due to the varying number of opportunities to register an interest under each of the sections. Thus, under each of the government sections there are only four classifications in each. Under Environmental Support there are nine classifications.

Environmental support	621
Local government	291
European or national government	288
Biological resources and fisheries	228
Recreation and tourism	222
Research, education and training	182
Transport	177
Waste disposal	167
Mineral and energy resources	132
Strategic uses	110

Table 5.5 Respondents' sectors of employment (Author)

An improved representation of the responses is possible using the forty two sub-groups and ten opportunities to state "other" specialisms (which average 14.6 for the major ten areas). The 2418 expressions of interest are as seen in Figures 5.3a and 5.3b. Government and environmental interests are the largest nine groups of respondents.

Consideration was given to redistributing certain responses under "Other" to seemingly more applicable, classifications. However, this was not done. For example, in response to a question on primary area of interest, one respondent identified the Royal National

Figure 5.2 Respondents' interests within ten major sectoral groups

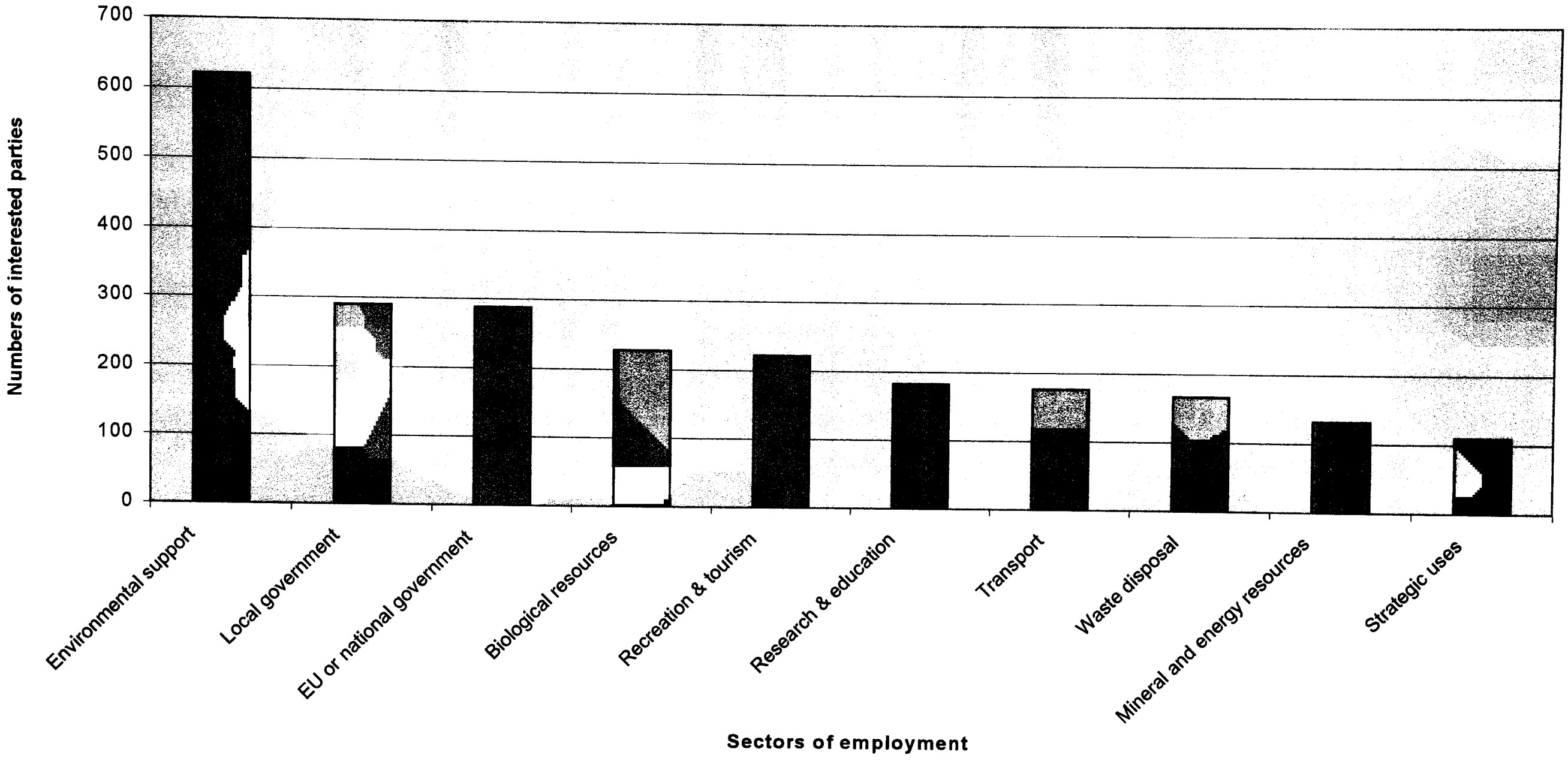


Figure 5.3a Respondents' areas of interest (see also Figure 5.3b)

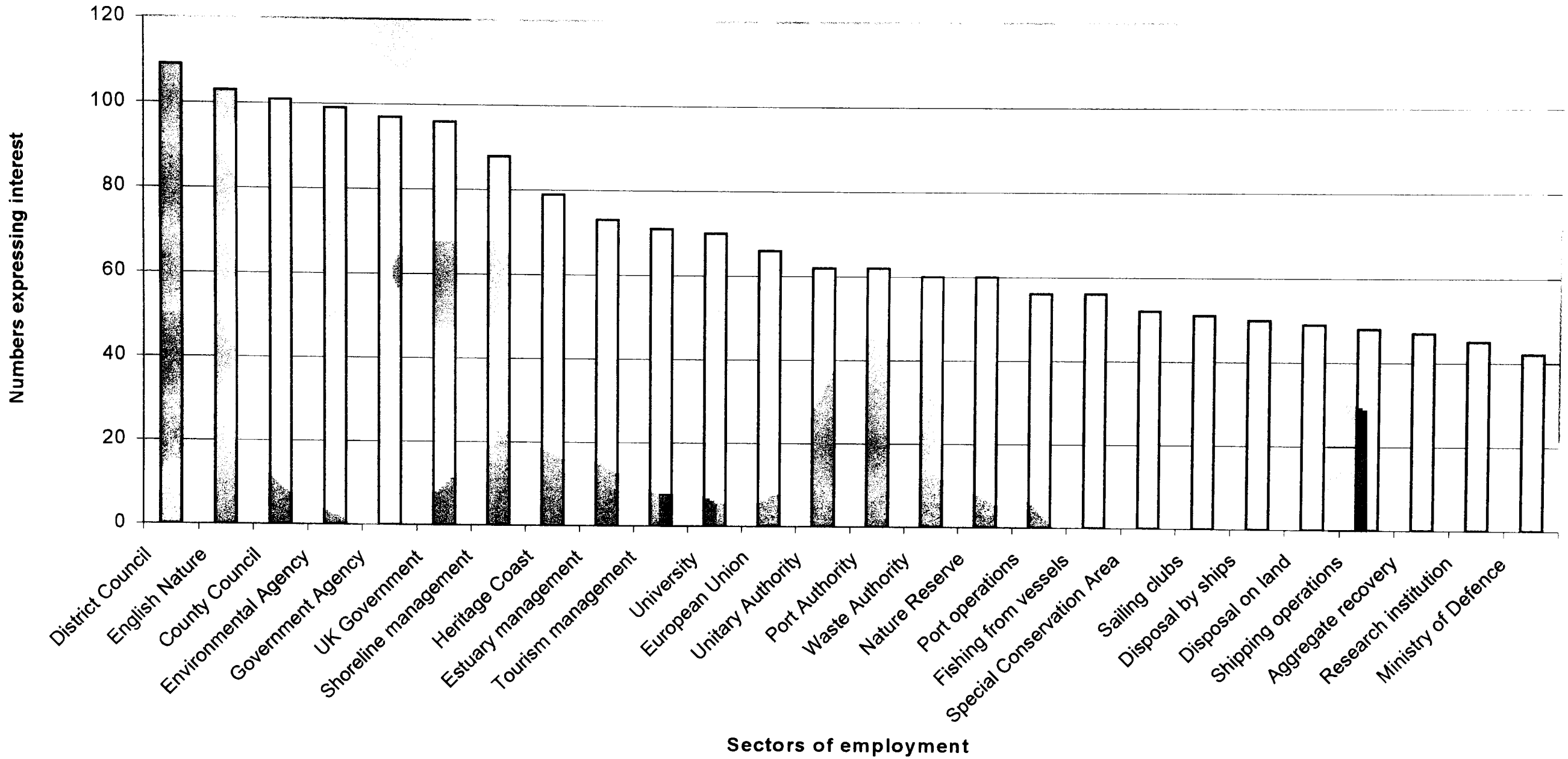
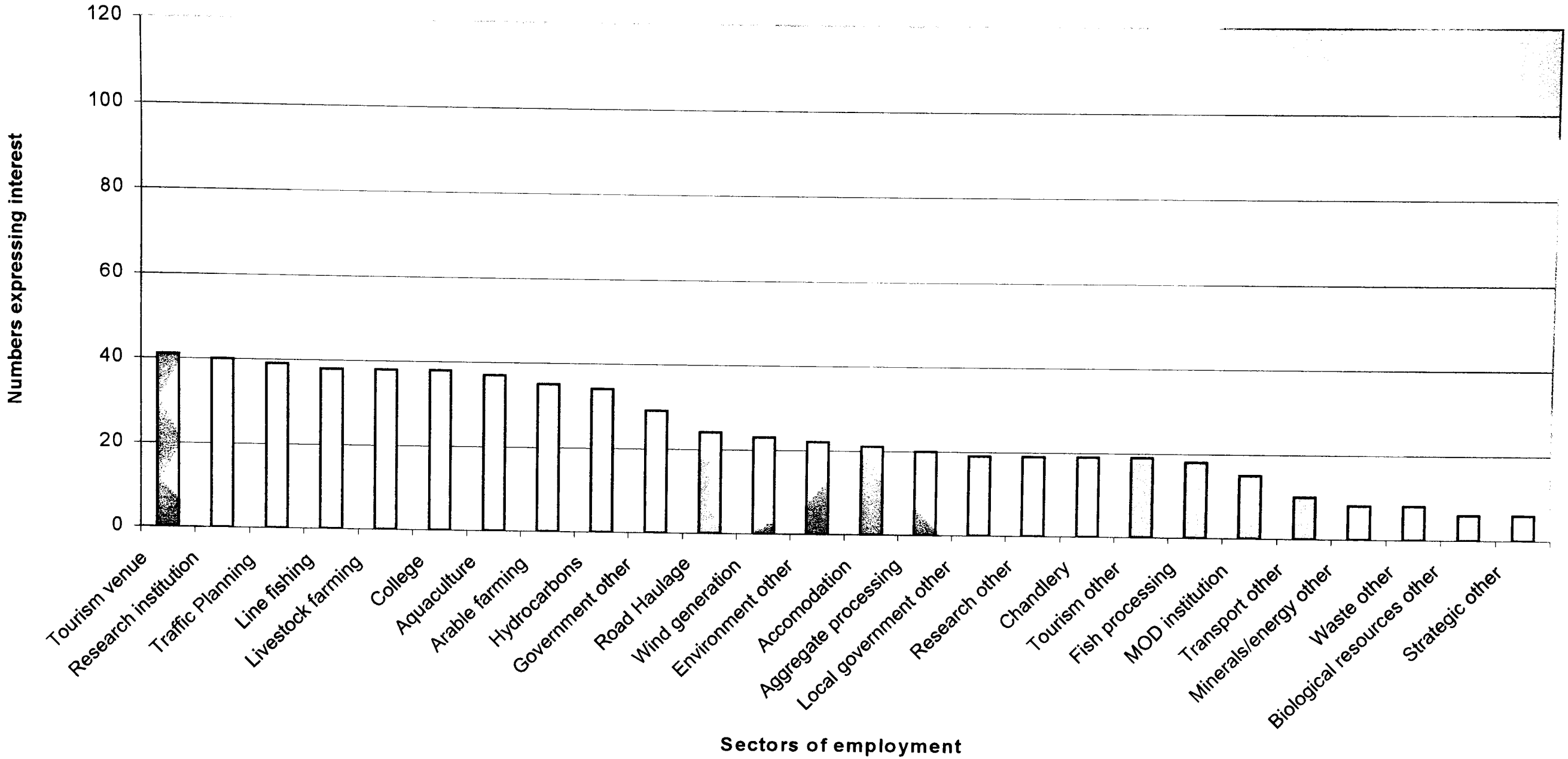


Figure 5.3b Respondents' areas of interest (see also Figure 5.3a)



Lifeboat Institution (RNLI) with European or national government. He/she might have been expected to choose transport, strategic uses or recreation and tourism, yet it is quite possible that he/she has particular responsibility within the RNLI for liaison with government.

Table 5.6 classifies the responses and there are a number of anomalies in comparison to Table 5.3. It would be expected that a 28% response rate would give lower numbers of respondents than received a questionnaire, but a majority of the tiles have a larger number. The classification in Table 5.3 resulted from the author's judgement of a contact's job title, employer and address on the original lists. Table 5.6 results from the responses in the questionnaires and, for example, most respondents associated themselves with more than one location. Similarly, they associated themselves with multiple uses of the coast, parts of the coast and management tasks. The higher responses for policy implementation (such as agencies, councils and nature reserves) indicate a similar association rather than a place of employment. Although anonymity was offered to respondents to the questionnaire, two thirds supplied some personal details. A further assessment of respondents, based upon these data, is classified in Table 5.7. Table 5.7 exhibits significantly lower numbers than Table 5.6. This is a result of taking information from the bare contact details supplied on the returns rather than accepting the respondents' own assessments of their areas of interest. However, Table 5.7 also exhibits some higher numbers and new occurrences over both Table 5.6 and Table 5.3. This is likely to indicate a problem in exactly classifying respondents and therefore to a potential instability in the resulting analyses. Some respondents had the questionnaire passed to them from the original addressee.

No.	Policy development	No.	Implementation	No.	Land type	No.	Water depth
1	European Union	66	Directorates	73	Agriculture	20	0-15 m deep
	Government	95	Agencies		Rural/non-farm	4	15-90 m deep
	County Councillors	101	County Council staff		Industrial	20	> 90 m deep
	District Councillors	109	District Council staff	19	Commercial		**User**
		7	Parish Councils		Housing	45	Manual
	Earth summit		Agenda 21		Estuary/coast		Professional
	NGO		Non-governmental		Cliff	105	Managerial
	Wildlife Trusts		Local Trust		Beach/sand/mud	70	Academic
	Nature Reserves	60	Local Reserve			1	Politician
	Use		**Management**		**Coastal stretch (N)**		**Coastal stretch (S)**
167	Transport		Commercial	36	Land's End – Kelsey Hd.	18	Land's End-Lizard Pt.
124	Resource	60	Nature Reserve	54	Kelsey Hd. – Hartland Pt.	22	Lizard Pt.-Dodman Pt.
222	Biological	73	Estuary mgt.	13	Hartland Pt. – Bull Point	38	Dodman-Rame Head
159	Waste	88	Shoreline mgt.	26	Bull Point – Minehead	52	Rame Hd.-Start Pt.
104	Strategic/military		Oil pollution	22	Minehead – Bristol	18	Start Pt.-Torquay
148	Research/education		Major incident	10	SW Peninsula	19	Torquay-Budleigh
133	Recreation/tourism		**Distance inland**	169	Cornwall – whole county	33	Budleigh-Seatown
263	Conservation	34	<10 km inland	142	Devon – whole county	48	Seatown-Portland Bill
		39	>10 km inland	81	Dorset – whole county	3	UK (external to SW)

Table 5.6 Classification of respondents, where the number is the gross sum of individuals identified with these classes. For example, with eleven towns named in the questionnaire, such a response for Cornwall (169) could originate with just sixteen people. (Author)

No.	Policy development	No.	Implementation	No.	Land type	No.	Water depth
1	European Union		Directorates	3	Agriculture	10	0-15 m deep
	Government	4	Agencies	6	Rural/non-farm	3	15-90 m deep
1	County Councillors	5	County Council staff	1	Industrial	2	> 90 m deep
2	District Councillors	13	District Council staff	5	Commercial		**User**
			Parish Councils	4	Housing	4	Manual
	Earth summit	5	Agenda 21	8	Estuary/coast	20	Professional
1	NGO	2	Non-governmental	6	Cliff	13	Managerial
	Wildlife Trusts	4	Local Trust	6	Beach/sand/mud	13	Academic
	Nature Reserves	5	Local Reserve			4	Politician
	Use		**Management**		**Coastal stretch (N)**		**Coastal stretch (S)**
8	Transport	5	Commercial	3	Land's End – Kelsey Hd.	2	Land's End-Lizard Pt.
2	Resource	3	Nature Reserve	1	Kelsey Hd. – Hartland Pt.	2	Lizard Pt.-Dodman Pt.
7	Biological	3	Estuary mgt.	3	Hartland Pt. – Bull Point	3	Dodman-Rame Head
	Waste	2	Shoreline mgt.		Bull Point – Minehead	6	Rame Hd.-Start Pt.
2	Strategic/military	1	Oil pollution	1	Minehead – Bristol	3	Start Pt.-Torquay
6	Research/education		Major incident	6	SW Peninsula	5	Torquay-Budleigh
11	Recreation/tourism		**Distance inland**	5	Cornwall – whole county	4	Budleigh-Seatown
20	Conservation	6	<10 km inland	8	Devon – whole county	17	Seatown-Portland Bill
		4	>10 km inland	7	Dorset – whole county	3	UK (external to SW)

Table 5.7 Classification of respondents where information was supplied. (Author)

Tables 5.6 and 5.7 indicate that the spread of responses is reasonable across the pre-determined levels of coastal management, coastal user groups and geographical areas. The questionnaire is a satisfactory vehicle on which to draw inferences for further work as long as the wider group is assessed. It would be statistically unsound to compare one small group of respondents against another.

Figure 5.4 is a simplified version of Figure 5.3. The horizontal scale is halved, two out of every three category names are missing, but all data points are included. It indicates the similarity between the county responses (Table 5.4) and the regional responses. To highlight this similarity Figure 5.5 uses trend lines even though each plotted point is independent.

The graphs of Figures 5.4 and 5.5 show that where inferences are drawn later (sections 5.6 and 5.7.1), the county responses are not based on a biased dataset of, say, mainly government administrators, but that the cross-section of respondents is similar to the wider group.

5.5 Regional boundaries

One major problem for coastal zone management is the establishment of boundaries for a relevant region for coastal zone management. The questionnaire attempted to elicit views on these (Appendix D, section B), both parallel to the coast (such as the low water mark) and across the coastline (such as a county boundary).

Figure 5.4 Respondents' interests with county values - i) bar chart

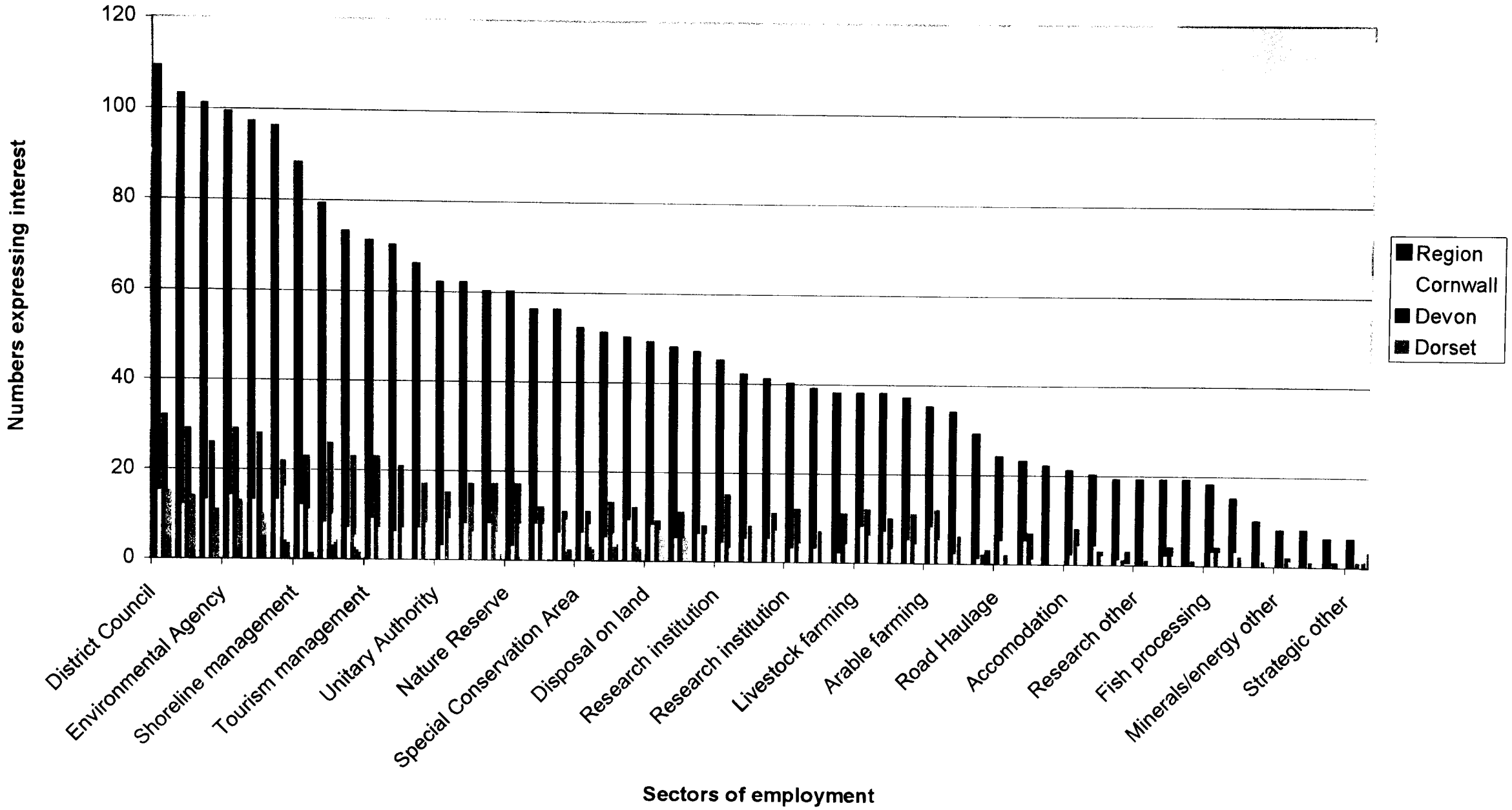
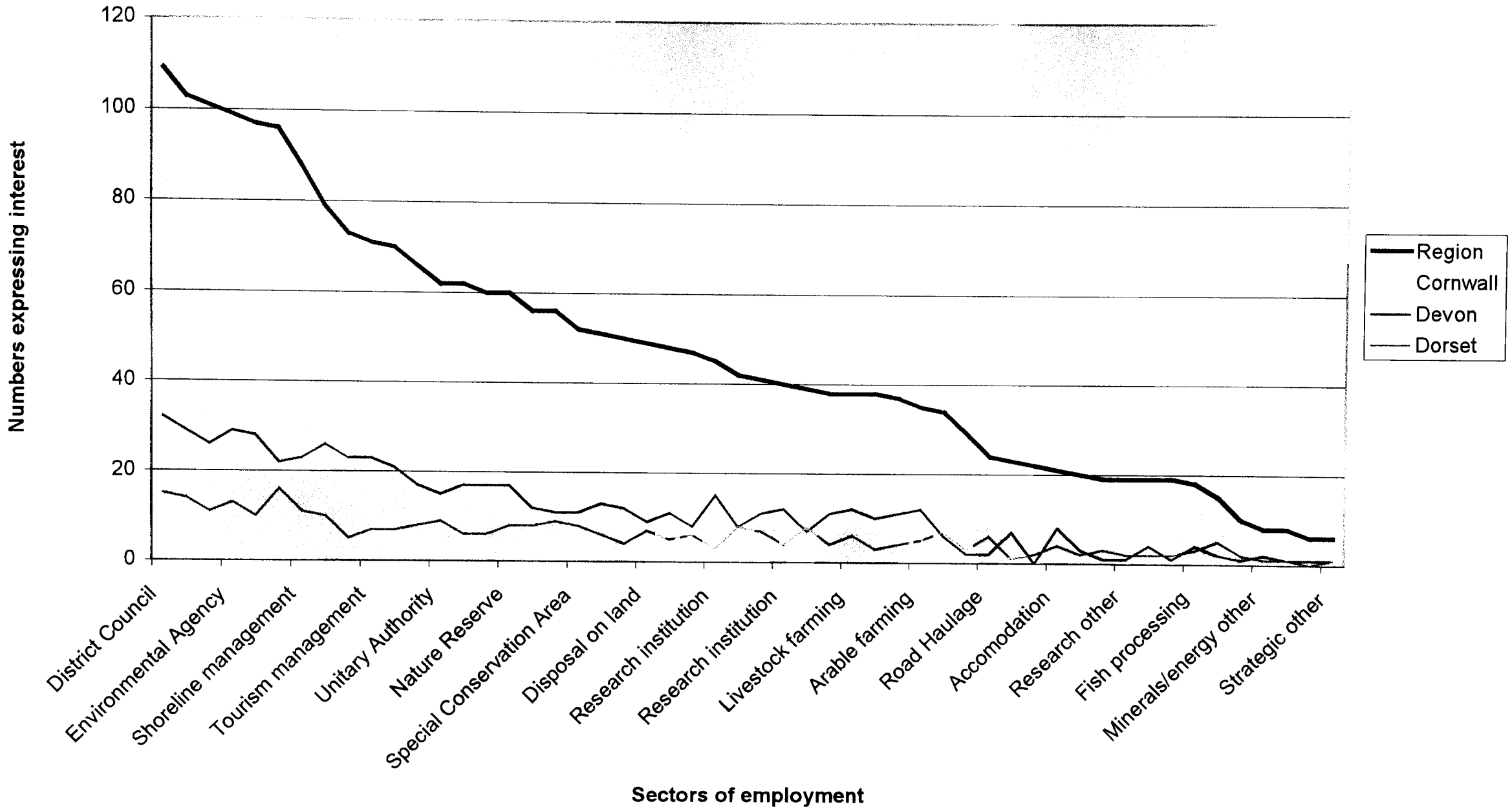


Figure 5.5 Respondents' interests with county values - ii) trend lines



The inland limit was variously suggested as being defined by ownership, tides or heights, roads, environmental designations, administrative regions, fixed distance, coastal limits, river catchment, or by site or issue-specific activity.

Thirty four responses suggested one of a variety of current political or environmental limits, fifty five suggested one of a variety of height or distance limits and twenty three suggested one of a variety of specific activities.

The offshore limit was predominantly defined by distance (subsequently re-classified (due to the variety of responses) into six groups ranging from 0-500m to 100km-continental shelf). Depth of water was also seen as significant. There were a few other definitions which could be covered by the foregoing (e.g. low water mark, 50 metre contour), some definitions that were activity based (e.g. bathing areas, sea fishing zones) and some completely out of the scope of the study.

Seventy one responses used a horizontal distance and twenty one a depth. Fifty nine of the former and twenty of the latter fit within one legal boundary, that of the 12 nautical mile (nm) Territorial Sea.

For these boundaries parallel to the coast, the range of results does not strictly identify a single encompassing area – without extending coastal management in the south west to include the world. However, a suitable compromise can be determined, resulting in

- An inner land boundary coincident with the maritime District Councils or Unitary Authorities, with identifiable sub-sections of
  - Environmental designations, the high water mark and the limits of specific projects.
- An outer sea boundary at 12 nm, with sub-sections of

- Chart Datum, and contours at 10 and 50 metres.

Questions 38-43 requested responses on the influences determining the boundaries along the coast. Politics had the most affect (seventy two responses) and climate the least (twenty four). Further suggestions from the respondents were grouped into business opportunities, an organisation's area, and the natural environment.

Of forty six responses about boundaries influenced by travel (e.g. travel to work times and distances, and limitations imposed by public transport), forty were encompassed by the South West peninsula, although most of these (twenty six) are more local, such as Poole Harbour or the South Hams. Suggestions for boundaries influenced by the economy ranged from business (such as ship repairs, tourism and the fishing industry) to budgets – mainly as South West or more local. Politics could be covered by the South West peninsula, often represented by District or County boundaries, but these terms were used in geographical as well as political senses. Further suggestions included a twenty mile offshore sea danger zone by a respondent working with the Ministry of Defence. The climate produced no clarifying geographical limit to the boundary issue, although people's concerns (e.g. about sea level rise) were stated. Similarly geology and ecology repeated much of the above, with a few specialisms like "local Jurassic cliffs", "oil and gas prospects" and "underwater cliffs". Finally under "Other", ownership, travel to work areas, grazed common, landscape, geographic location from ships and lorries, geomorphology, cliffs, access & launching requirements for lifeboats, catchments and any interesting venue completed the list.

Not all limits were expressed in geographical terms - one suggestion under economics was the limit of departmental budgets and another of private disposable income. A suggestion under climate was summer and migratory birds under ecology.

Totalling responses across the variety of interests that may point to a relevant coastal management boundary resulted in the areas shown in Table 5.8.

South West region	84
County	72
District	39
Individual or local	79

Table 5.8 Grouped responses to areas of regional interest (Author)

These figures do not produce a convincing argument for selecting a coastal management boundary at any of the above to the exclusion of another. Although the South West gives the largest response, and would encompass the others, many people's affiliations are to a more local level. Yet at the other extreme, concentration on local projects would not aid integration or a holistic approach.

The boundaries issue is returned to again in the discussion, section 5.8.1.

5.6 Issues in the coastal zone

The questionnaire was used to identify those issues that users of the coastal zone saw as important and to scale those issues in an order of importance. All the topics suggested in the questionnaire were taken up by at least some respondents as being crucial, influential or of minor interest. The most significant topics identified by the term "crucial" were water

quality (61), safety implications (57), non-compliance with regulations (57), chemical pollution (54) and conflicting multiple-use (53). The least significant were interference (13), duplication of effort (16) and management divergence (17).

The numbers for these responses are shown in Table 5.9.

Significance	Topic least cited; value	Topic most cited; value	Range of values
Crucial	Interference; 13	Water quality; 61	48
Influential	Interference; 37	Pre-existing & conflicting use; 59	22
Minor	Inadequate resources; 16	Interference; 40	22
Irrelevant	Safety implications; 4	Congestion & deficit of authority; 23	19

Table 5.9 Comparison of respondents' assessment of issues (Author)

The results indicate the more important issues by larger totals and that respondents did not easily dismiss other issues as irrelevant. Further, there would seem to be significance in the ranges of results given above with the responses under "crucial" having a five to one ratio of the most to the least important issue.

Total responses under each of crucial, influential, minor and irrelevant were 681, 899, 524 and 255. There was not a simplistic approach to the answers – "all issues are crucial" – but a consideration of importance reflected in a higher total of responses for influential rather than crucial. Some particular status should be given to the topics nominated as "crucial".

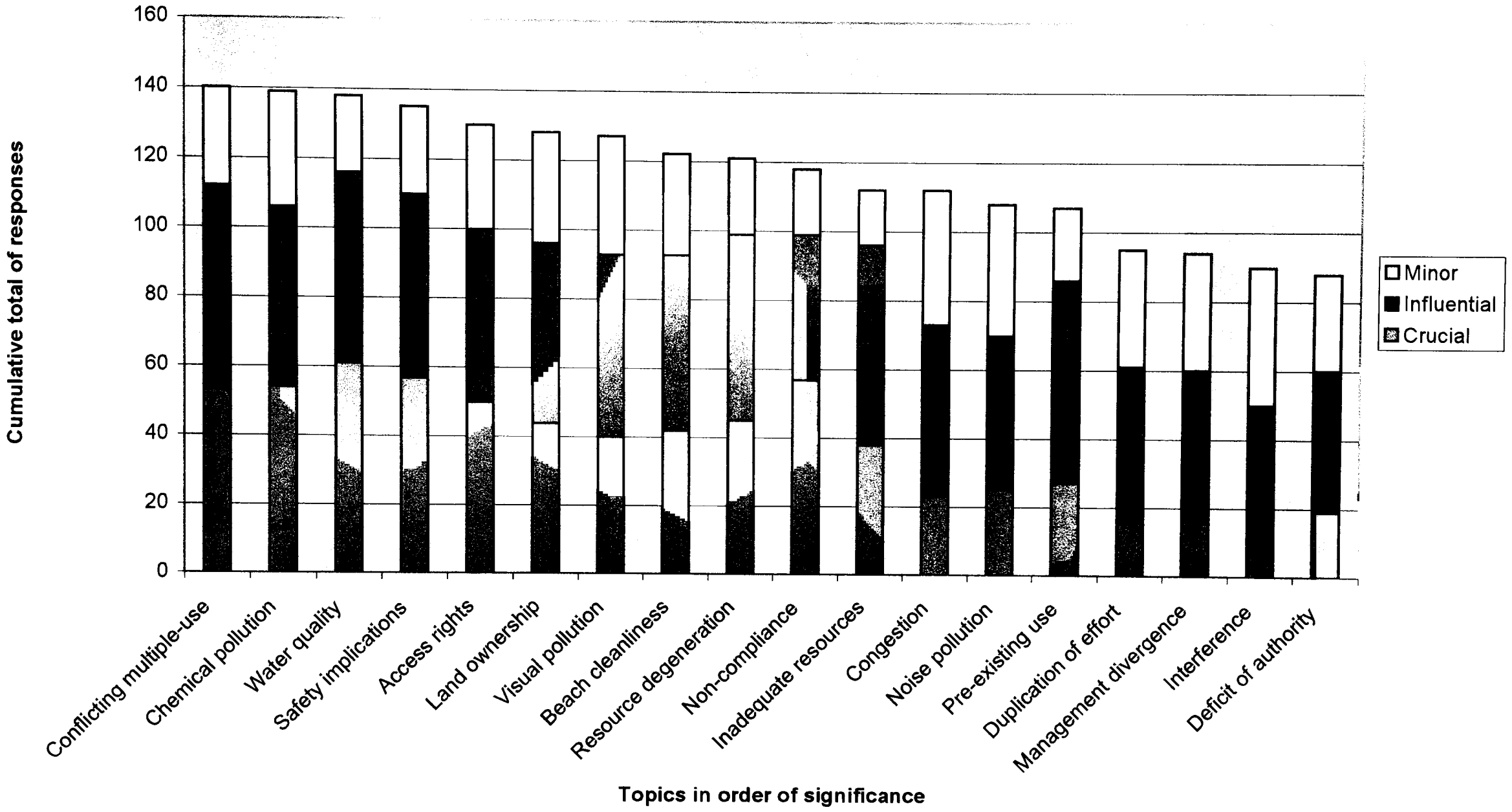
An order of importance using all positive references to the topics (crucial, influential and minor) can be established, as shown in Table 5.10 and Figure 5.6.

Order	Issue	Total responses
1	Conflicting multiple-use	140
2	Chemical pollution	139
3	Water quality	138
4	Safety implications	135
5	Access rights	130
6	Land ownership	128
7	Visual pollution	127
8	Beach cleanliness	122
9	Resource degeneration	121
10	Non-compliance	118
11	Congestion	112
12	Inadequate resources	112
13	Noise pollution	108
14	Pre-existing use	107
15	Duplication of effort	95
16	Management divergence	94
17	Interference	90
18	Deficit of authority	88

Table 5.10 Order of importance for issues from summing responses (Author)

Any information system should address all the above, but with any constraints on its development, there is a clear order of importance. The position in Table 5.10 of "Conflicting multiple-use" is significant as it requires a multiplicity of datasets to resolve. "Chemical pollution" and "water quality" may be represented by a number of different datasets, but they can be treated with some independence from each other. "Safety implications", "access rights" and "land ownership" are also likely to be complicated issues. Thus, a number of issues will need to be addressed to understand the full picture. This has implications for the software appropriate for the purpose. This is addressed in Chapter Six.

Figure 5.6 Issues in the coastal zone



There is no obvious break-point in the range of totals in Table 5.10 or in Figure 5.6. There is a gradual diminution of the totals from 140 to 88. However, the first eleven issues are more significant under "crucial" than the next seven. The total responses for the first eleven range between 38 and 61; the totals for the last seven range between 13 and 27. Bar the issue, "pre-existing use", a similar break-point exists when summing only crucial and influential responses. If a selection of less than eighteen issues had to be made then the first eleven in Table 5.10 seem a suitable sub-set.

Other nominated topics were:

i) Crucial issues

Biological occurrence; Public relations/ public image; Sea defence/ erosion/ coast protection/ flooding/ coastal defence; Resource evaluation; Contaminated land; Planning law/ land use planning/ land use; Wave climate; Fisheries management/ fisheries/ fishing; Geological research; Continuation of funding; Waste disposal; Political commitment; Development pressures; Habitat loss; Commercial opportunities; Amenity.

ii) Influential issues

Coast protection/ coast structures/ coastal change; Geological conditions/ geology/ geological interest; Shoreline management plans; Co-operation of local users with authorities/ of all user groups; Public perception; Preservation of existing highway; Oil pollution; Engineering; Technology; Education-codes of practice; Sustainability indicators; Level of responsibility; Fish Stocks; Bylaws; Scenery; Exposure; Partnerships; Tourism.

There were no further suggestions classified as minor or irrelevant.

In any further work it would be useful to investigate the general importance of these issues. As they were nominated on the questionnaire returns no further work on them has been

carried out, but given the opportunity, the wider community of coastal users may rate these highly.

The county variations are shown in Figures 5.7 and 5.8. The county figures have been scaled up to equate with the regional responses, and the trend line for the Region follows the sum of Crucial, Influential and Minor responses as given in Figure 5.6. The county trend lines are of much the same slope as the Region and topic values largely follow the Region's values. The least five significant topics have lower totals in Dorset. Overall the Dorset totals are lower indicating respondents' choice of fewer issues from the list than respondents from Cornwall or Devon.

As for the Region, the county responses indicate that all issues are important and, although the order of significance would change slightly, there is no break-point between some issues and others.

Topical issues are returned to again in the discussion, section 5.8.2.

Figure 5.7 Issues in the coastal zone with county values - i) bar chart

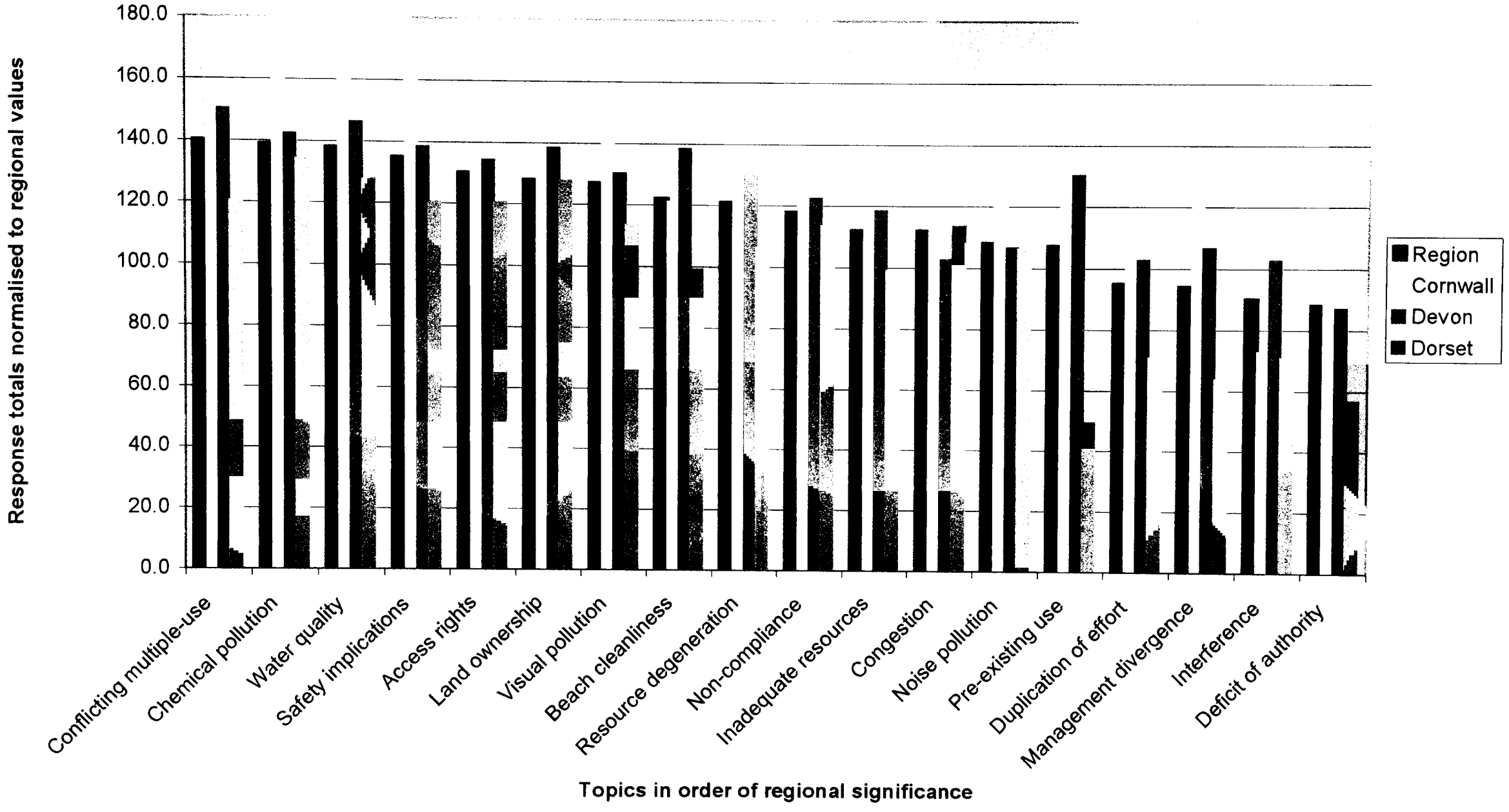
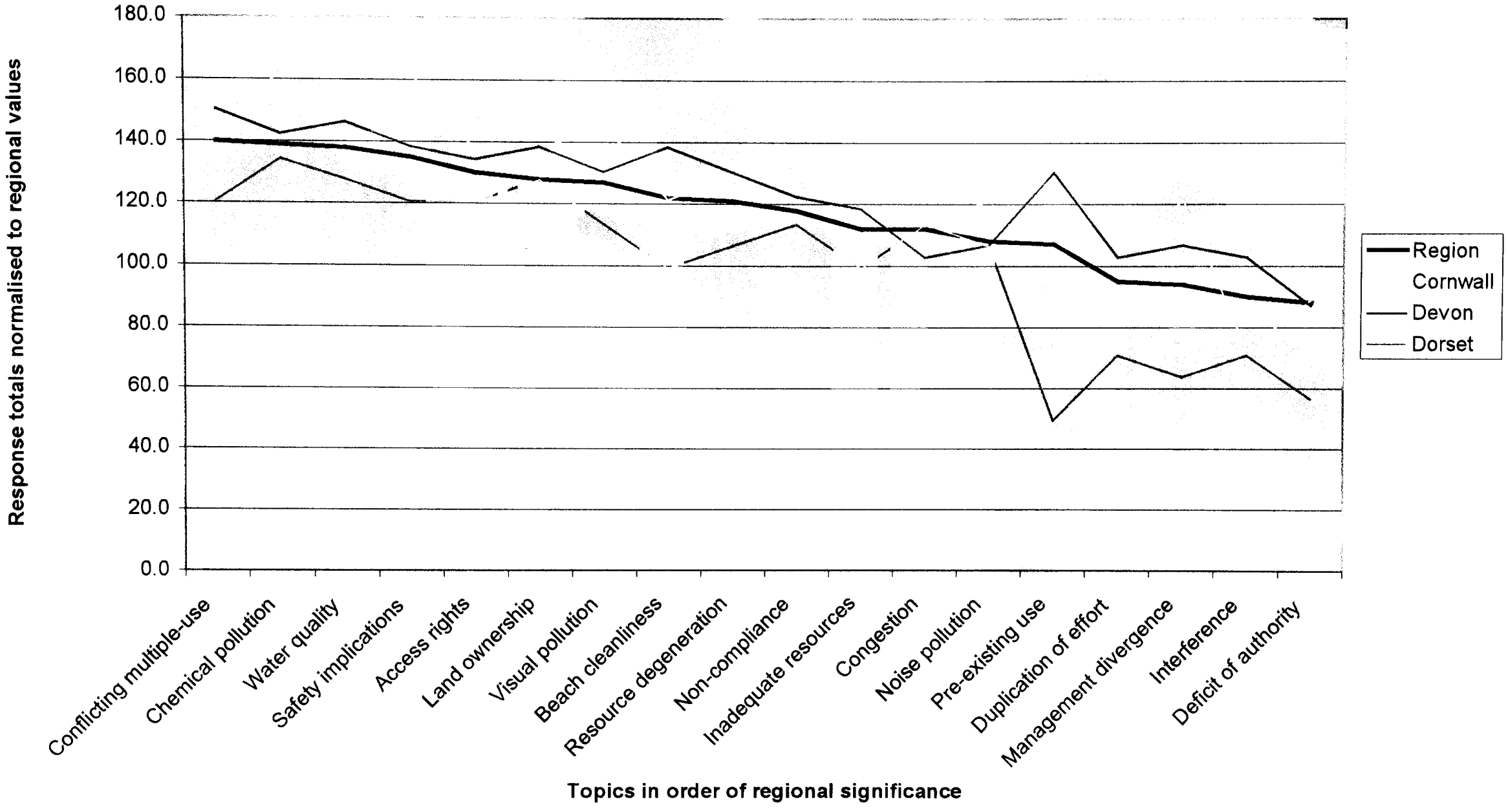


Figure 5.8 Issues in the coastal zone with county values - ii) trend lines



5.7 Datasets and data handling

The interviews had identified three main topics to be addressed under this heading – the data requirements to support integrated coastal management, respondents' ease of access to such data and the availability of appropriate hardware and software.

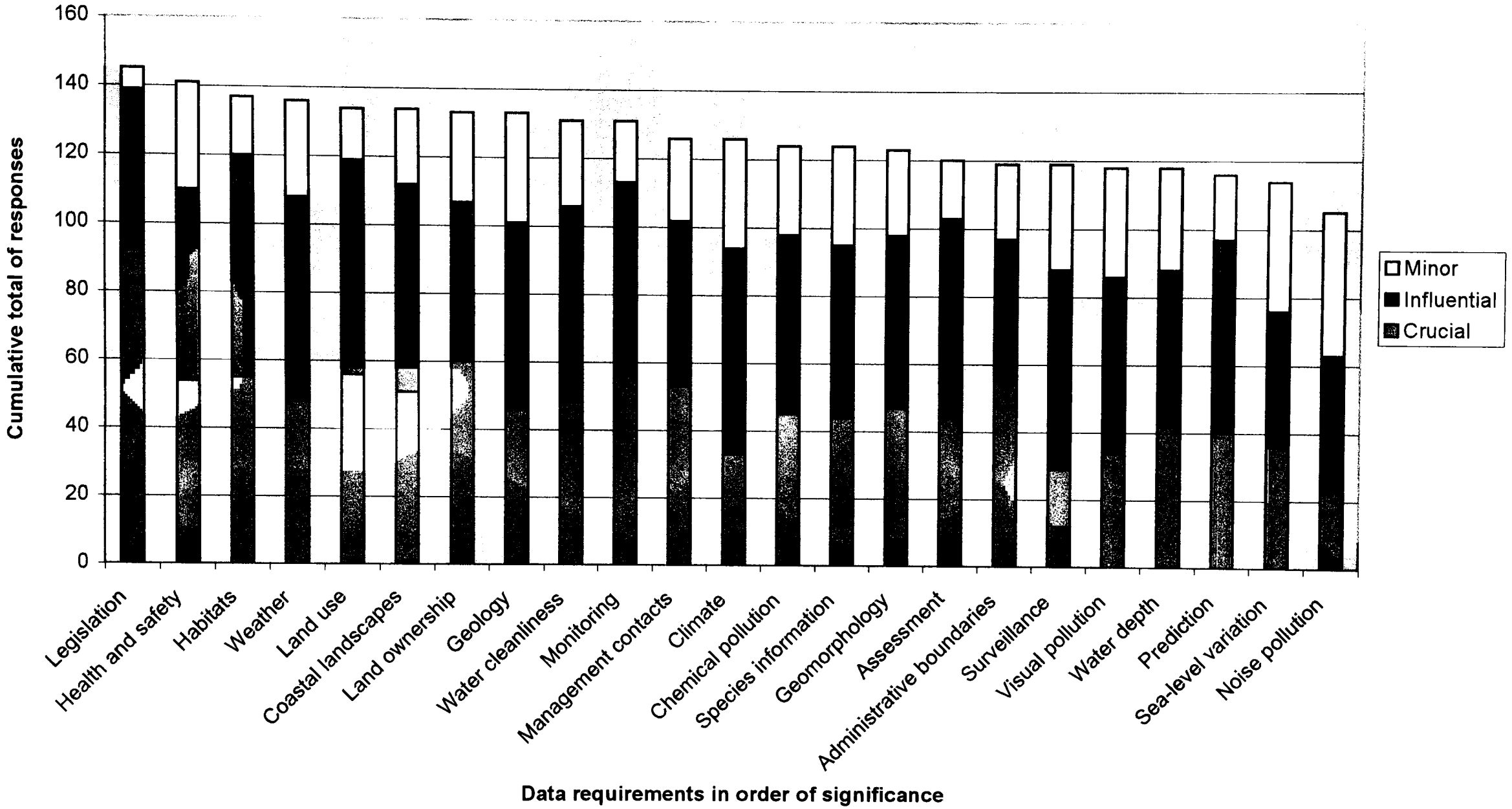
5.7.1 Data requirements

The data requirements suggested were regarded by at least some respondents as fitting the three positive categories of crucial, influential or minor. Summing across these headings, the most significant was legislation, followed by health and safety, and habitats. The less significant were noise pollution and sea-level variables. These are shown in Table 5.11 and Figure 5.9.

Order	Data requirement	Total responses
1	Legislation	145
2	Health and safety	141
3	Habitats	137
4	Weather	136
5	Land use	134
6	Coastal landscapes	134
7	Land ownership	133
8	Geology	133
9	Water cleanliness	131
10	Monitoring	131
11	Management contacts	126
12	Climate	126
13	Pollution – chemical	124
14	Species information	124
15	Geomorphology	123
16	Assessment	120
17	Administrative boundaries	119
18	Surveillance	119
19	Pollution – visual	118
20	Water depth	118
21	Prediction	116
22	Sea-level variation	114
23	Pollution – noise	105

Table 5.11 Order of importance of data requirements from summing responses (Author)

Figure 5.9 Data requirements in the coastal zone



Other nominated datasets were:

Economic information; Rainfall; Amenity; Report of illegal fishing; Wildlife; Industrial activity; Population; Archaeology; Recreation and tourism; Development

There were many fewer extra datasets nominated here than extra issues nominated earlier (section 5.6). The wider significance of these datasets could be investigated further.

There is no particular point at which one could say that some datasets are more or less significant than others. Although the totals slowly decrease, the change is gradual and continuous, and varies from 145 to 105 (albeit this ratio of nearly 3:2 signifies a considerable total change from the most required to the least). Summing only the "crucial" responses or only the "crucial" and "influential" changes the order slightly but neither produces any significant break-point, except for legislation, which received a half more crucial responses than the next dataset. It is evident that all datasets are important for a holistic system.

The county variations are shown in Figures 5.10 and 5.11. The county figures have been scaled up to equate with the regional responses, and the trend line (Figure 5.11) for the Region follows the sum of Crucial, Influential and Minor responses as given in Figure 5.9. The county trend lines are of much the same slope as the Region but there are certain variables in the counties that differ from the Region's values. Cornwall has an overall greater requirement for data and in particular, management contacts, chemical pollution, geomorphology and the last seven of the data requirements given in the Regional list (Table 5.11).

Figure 5.10 Data requirements with county values - i) bar chart

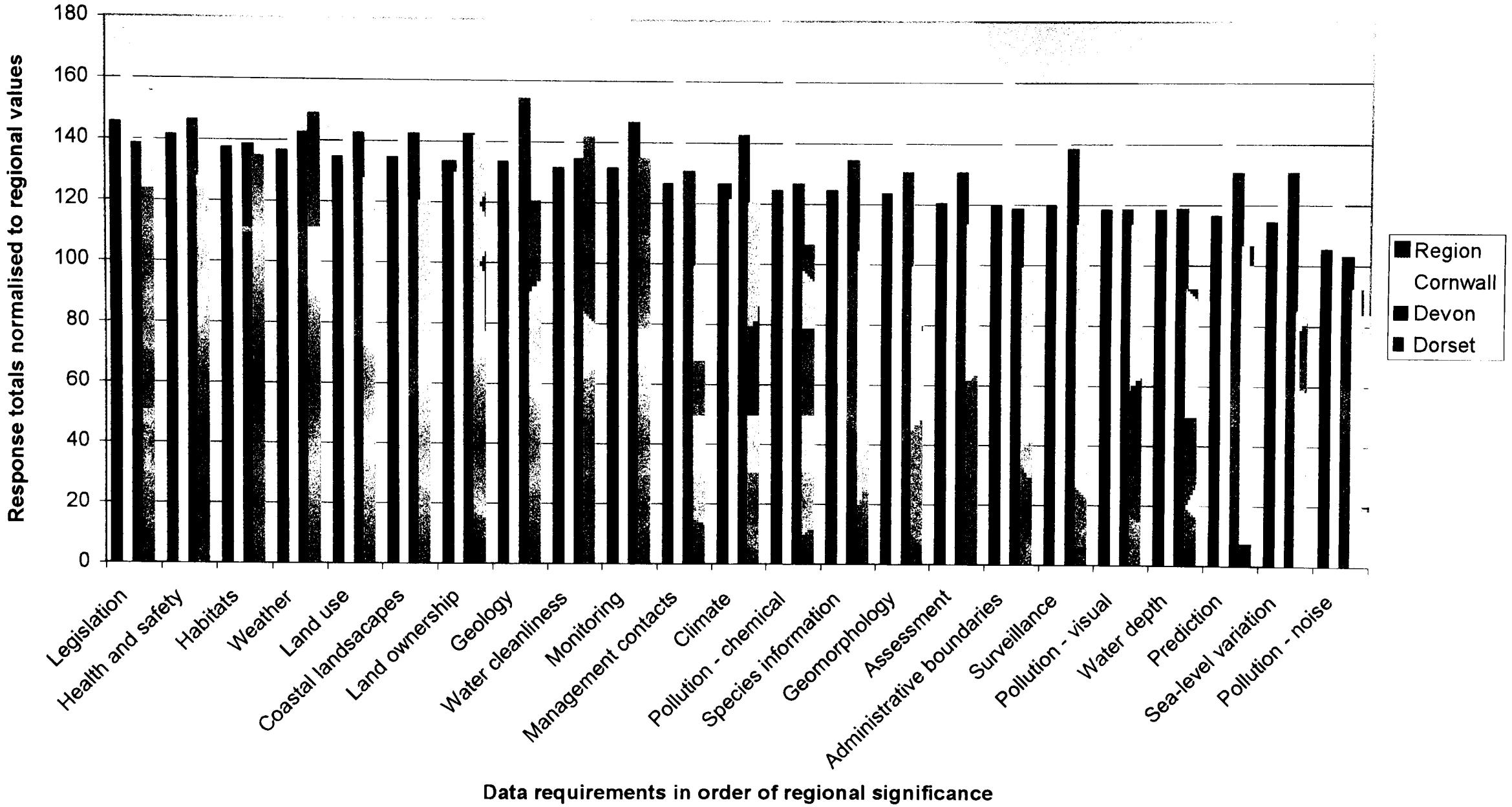
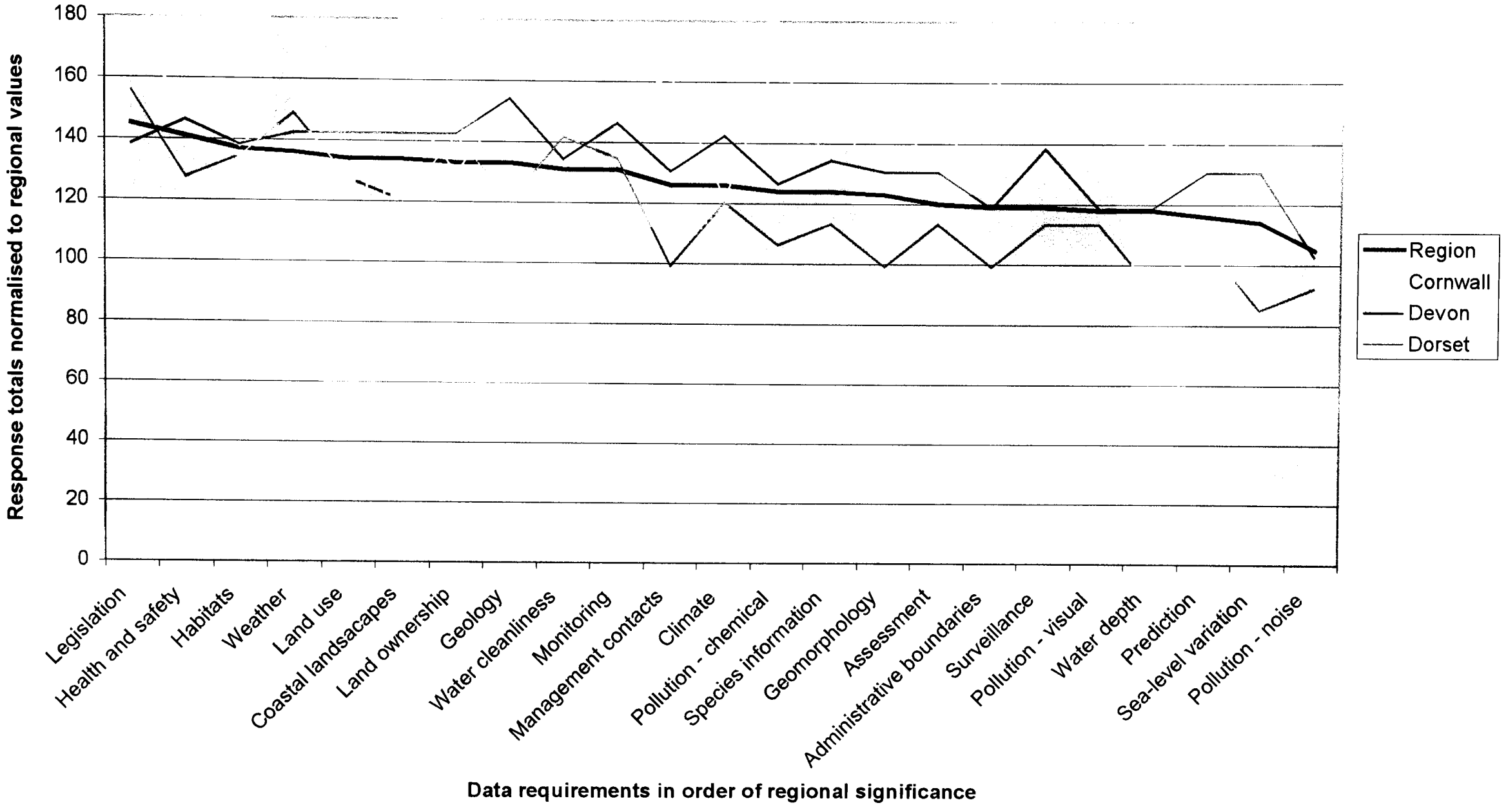


Figure 5.11 Data requirements with county values - ii) trend lines



As for the Region, the county responses indicate that all data requirements are important and, although the order of significance would change slightly, there is no break-point between some requirements and others.

5.7.2 Access to data

Eighty eight respondents found data readily available, although not, it would seem from the subsequent replies, without some difficulties. Eight wrote that they could not obtain data and 68 that they could obtain data in some way. Six expressed no view, although two of these later gave reasons for their inability to access data, with their responses included in the following list. The primary difficulties to data access were:

- The inability to find appropriate data;
- Insufficient detail in the data set;
- The age of the information;
- Cost;
- The geographical dispersion of the datasets;
- The unsuitability of the datasets to the task in hand; and
- The variety of classification systems.

All suggestions on the questionnaire (i.e. including unsuitability of paper/digital format, data protection, terminology, time for delivery and data units) were accepted as contributing to difficulties of access. In addition, gaps in the datasets, lack of data, initial knowledge of the data's existence, and the shortage of time to search for appropriate data were also cited as reasons for not being able to readily access data.

One would expect that those who state that they find data readily available would be able to obtain all datasets that they also nominate as crucial or influential to their work. All information classes given in the questionnaire (questions 221-336) were marked as relevant (together with additional suggestions for rainfall, population, development, economic information, industrial activity and recreation/tourism). Conversely, cross-referencing those stating their inability to gain access to data with crucial or influential datasets illustrates individuals' shortages. However, the cross-referencing does not highlight a trend identifying distinctive groups and their inability to access data, nor of particular datasets being difficult to access.

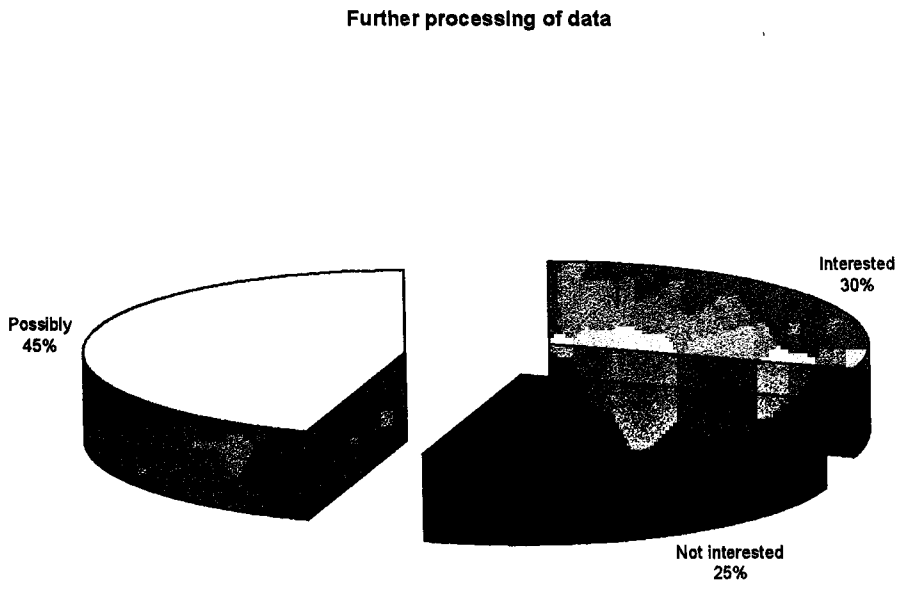
The voluntary sector is not easily identified in the questionnaire, but fifteen respondents refer to organisations such as the RNLI, voluntary organisations or amenity societies, or to issues such as school level education. Of these fifteen, only six cite cost of data as a particular issue. Not a single respondent answering solely on leisure cited cost as an impediment to data access.

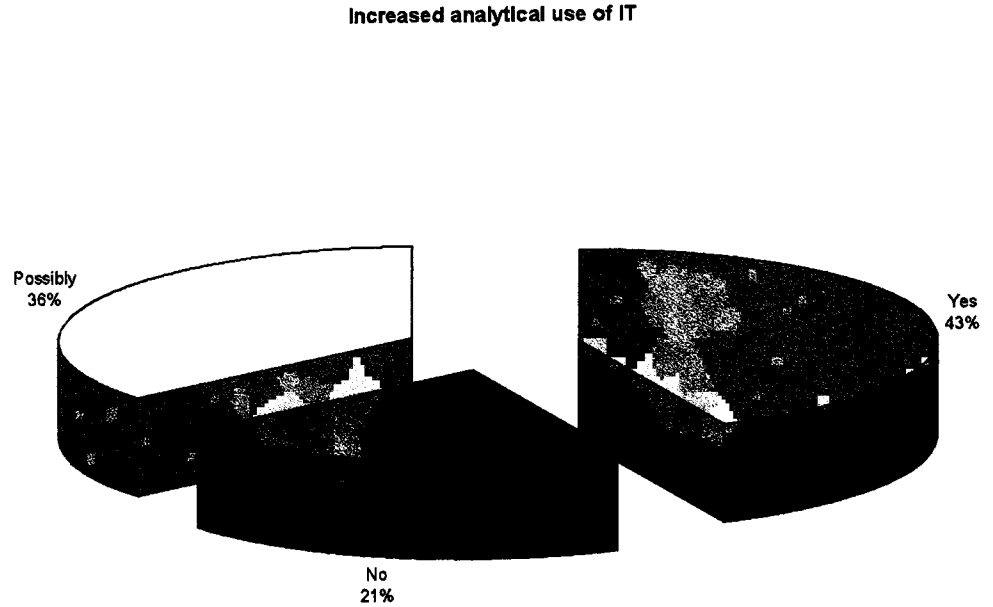
Access to data is not solely an issue for existing data from secondary sources but also of the data being available at all, and of the means of access. The latter point is addressed in the following section.

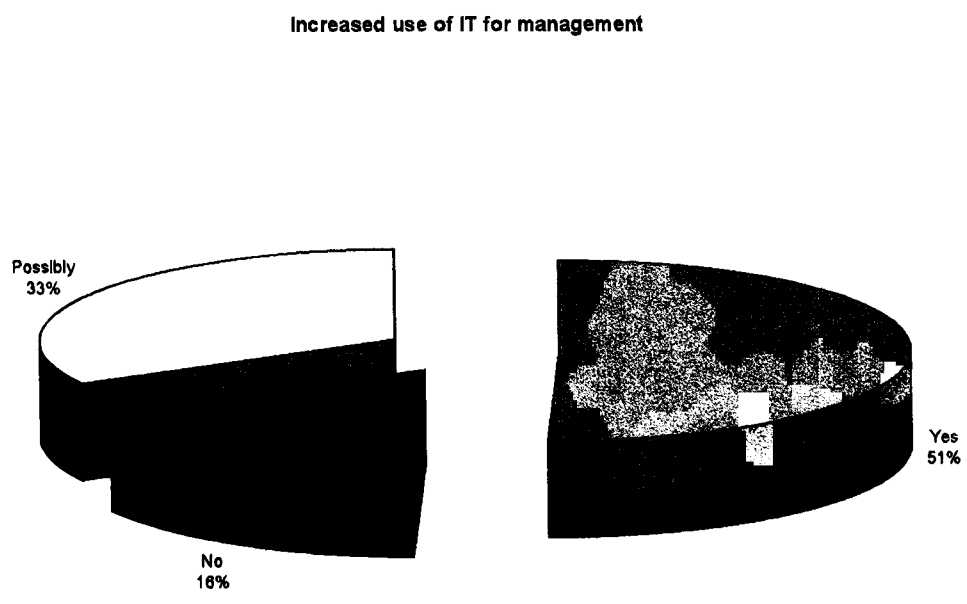
5.7.3 Availability of information technology

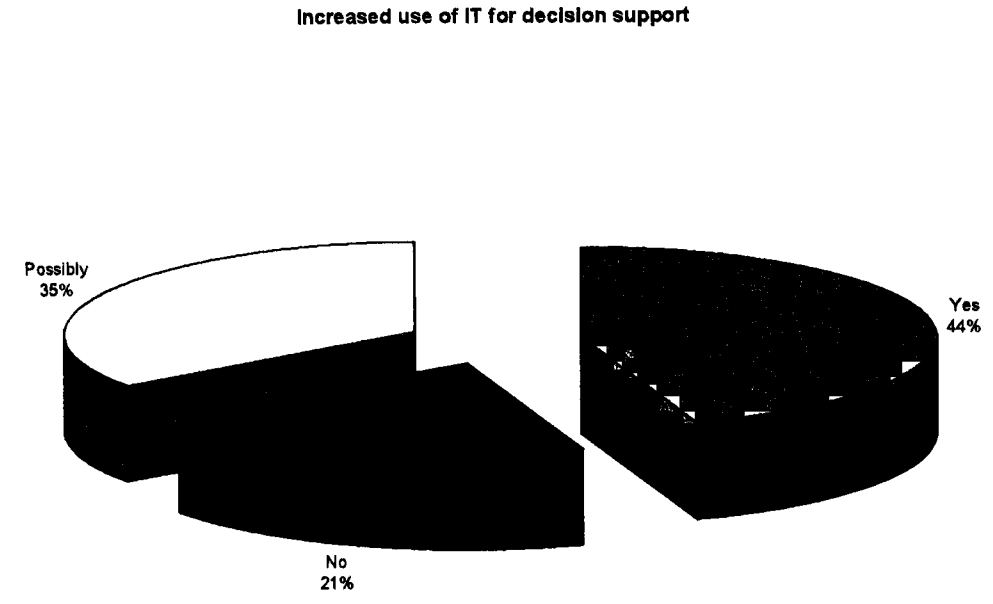
Most respondents used computers in their work (150 do; 12 do not; 8 gave no response). From a third to a half were using software capable of data transfer and analysis and the interest in upgrading to more capable software is clear from Figure 5.12, where the positive response is always greater than the negative. The undecided will in some measure increase the absolute positive response.

Figure 5.12 Illustrations of respondents' use of IT









Accessing data on paper is still commonplace. Telephonic facsimile is not used as much as post. Responses were also given for books, journals, the library and one respondent for the telephone transfer of data. The ratio of accessing data on paper to accessing it digitally is about equal. Therefore, any new system must cater for traditional means of data transfer. Only one respondent referred to an electronic transfer system by name (file transfer protocol - ftp).

Figure 5.13 illustrates the proportional use of paper transfer for data (post and facsimile) in comparison to the electronic (floppy disc, email and electronic transfer). Figure 5.14 illustrates respondents use of different formats.

Finally, 50 replies out of 147 (34%) stated that the television, radio, newspapers and/or journals were more important means of supplying data than any of the preceding methods. Nevertheless, of the 50 stating that conventional data access (TV, journals, etc.) was more important, 30 also used digital data (and all but nine used computers in their work). Some of the thirty respondents attest to the greater importance of conventional means of data supply yet are users of an Intranet, the Internet, email and so on.

Figure 5.13 Paper and digital data transfer

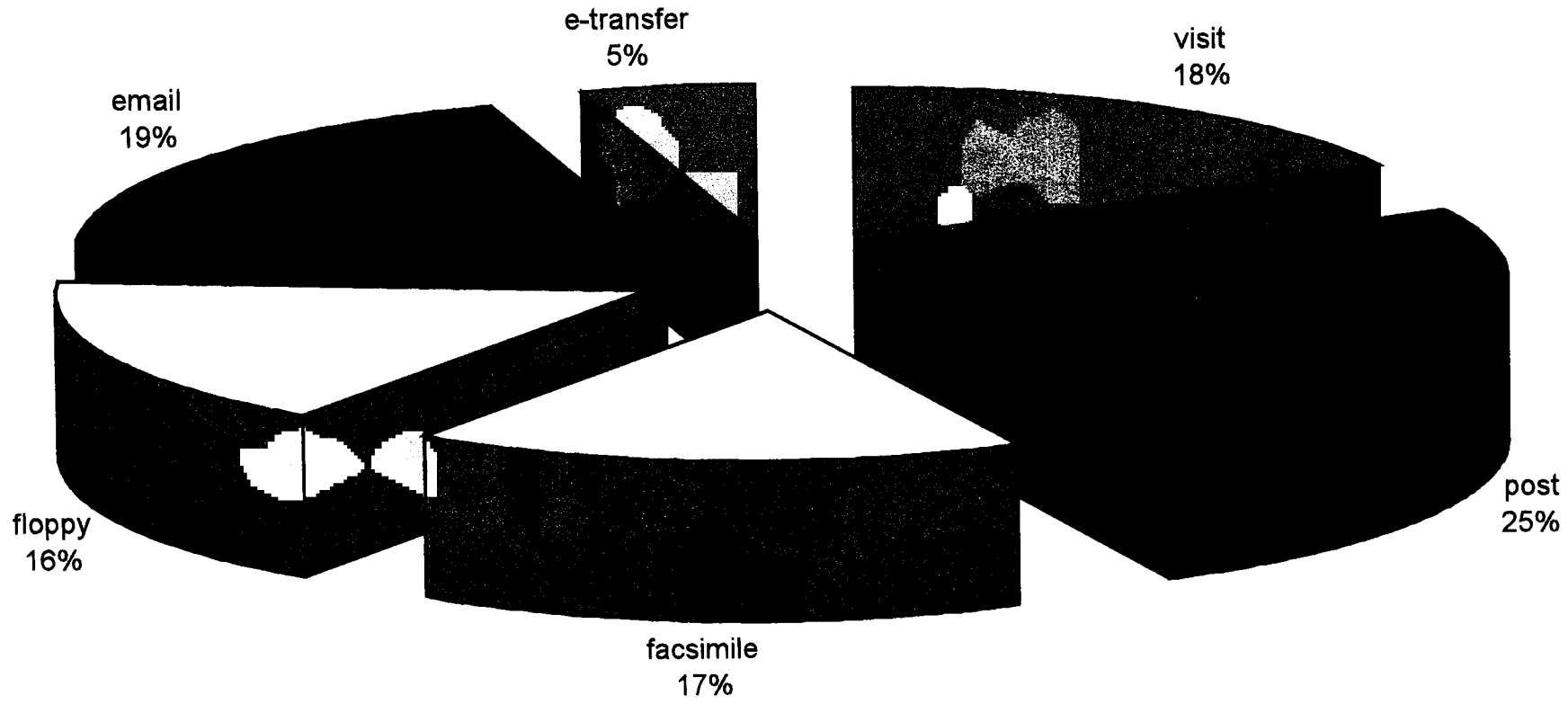
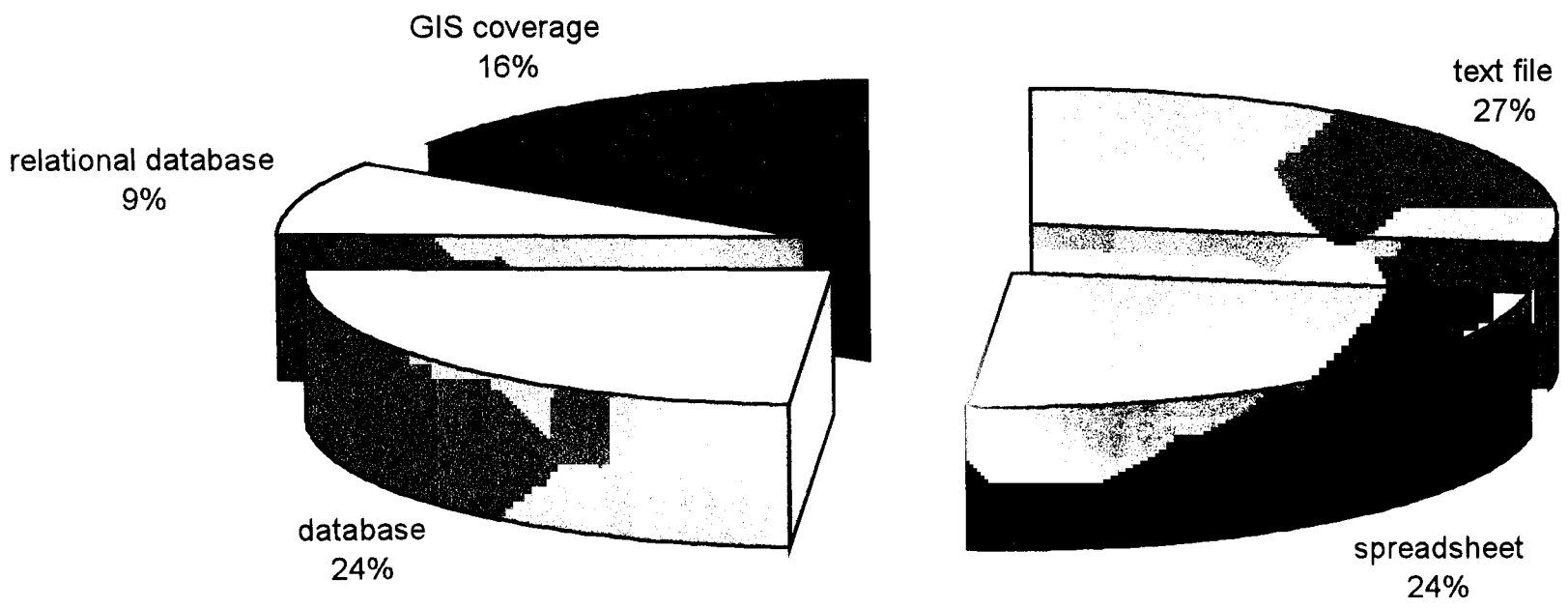


Figure 5.14 Digital data formats



5.8 Discussion

The questionnaire was developed on the foundation of the literature search and the interviews. It was intended to determine rigorous views on three topics relevant to current coastal management in this area, namely:

- a relevant region to encompass the South West;
- the issues of most concern; and
- the datasets for its proper implementation.

The following paragraphs draw the results together.

5.8.1 Boundaries

There is a difficulty in establishing a comprehensive, yet locally relevant boundary to coastal management (section 5.5). People are most concerned with their area of work or living space and wider issues may only impinge upon them in a work context that requires a wider view. Although boundaries parallel to the coast could be determined with some measure of confidence, there was no consensus for boundaries along the coast.

The compromise is to let a number of boundaries operate – the inner boundary of the maritime District Councils (with subdivisions of environmental designations, the high water mark and the limits of specific projects) out to 12 nm (with subdivisions of Chart Datum, and contours at 10 and 50 metres). The boundaries along the coast would be the standard South West Region with County, District and project subdivisions.

5.8.2 Issues

All issues proved to be of importance to at least some of the respondents and others were suggested. There was a very low level of responses for dismissing topics as irrelevant. All eighteen issues and more should be addressed if possible. If less can be addressed, then

there is a clear demonstration of eleven topics as being more important than others are. There is no clear break-point for a smaller selection of issues. The smallest collection of issues to be considered in a holistic approach to coastal management should include those given in Table 5.12.

Order	Issue
1	Conflicting multiple-use, including pre-existing use
2	Chemical pollution
3	Water quality
4	Safety implications
5	Access rights
6	Land ownership
7	Visual pollution
8	Beach cleanliness
9	Resource degeneration
10	Non-compliance
11	Congestion

Table 5.12 Minimum set of issues for holistic coastal management (Author)

As legislation is the most significant data requirement (sections 5.7.1 and 5.8.3), the issues most concerning those respondents who nominated this requirement were analysed. It was possible to identify a break point in the classification of the issues, whether the order was produced from responses to Crucial, Crucial and Influential, or Crucial, Influential and Minor. Thus, nine of the issues listed in Table 5.12 occurred in the first ten issues in this new analysis and they omitted beach cleanliness and congestion. The issue "Inadequate Resources" was present, it being absent from Table 5.12.

5.8.3 Data

The principal data requirement is legislation, in which all but twenty five users registered an interest at some level of importance, and more than most decided it was crucial to their

work. With any restriction on data supply, the order of importance of data requirements to the region and to the counties may be determined from Table 5.11.

As conflicting multiple use was the most significant issue (sections 5.6 and 5.8.2), the data requirements most concerning those respondents who nominated this issue as crucial were analysed (Table 5.13). It is significant that the order of importance of these datasets was completely different for this sub-group than for the population as a whole. The particular order was much the same whether the dataset was nominated as crucial or a total of crucial, influential and minor.

Place in original order	Data requirement	Crucial	Influential	Minor	Total
3	Habitats	81	26	5	112
10	Monitoring	84	22	4	110
11	Management contacts	83	20	6	109
5	Land use	82	24	3	109
9	Water cleanliness	74	23	6	103
2	Health and safety	72	22	7	101
6	Coastal landscapes	74	22	4	100
17	Admin boundaries	79	13	6	98
13	Chemical pollution	67	24	4	95
4	Weather	65	22	5	92
14	Species information	64	20	6	90
20	Water depth	62	19	9	90
15	Geomorphology	65	17	7	89
16	Assessment	65	19	3	87
8	Geology	62	19	4	85
21	Prediction	59	20	5	84
19	Visual pollution	53	20	6	79
22	Sea-level variables	53	17	9	79
18	Surveillance	44	22	5	71
12	Climate	45	20	3	68
1	Legislation	39	20	0	59
23	Noise pollution	34	15	9	58
7	Land ownership	27	21	5	53

Table 5.13 Data requirements in order established by those nominating multiple-use conflicts as crucial (Author)

It seems likely that the difficulty in establishing a break point in the whole population's data requirements and the variation from the whole population to this sub-group's requirements point to an eclectic demand for data.

The reasons given for difficulty of access are stated in section 5.7.2 and require the actions given in Table 5.14.

Item	**Response**
Locating appropriate data	The establishment and advertisement of indices
Having sufficient detail	The development of appropriate metadata
Ensuring currency	The inclusion of suitable time issues within the metadata
Establishing appropriate cost	Inclusion of cost within a contract
Accessing remote datasets	The provision of indices; access to remote servers
Determining suitability of datasets	The development of appropriate metadata
Establishing appropriate classification	The development of appropriate metadata

Table 5.14 Responses to difficulties in data access (Author)

Thus, the development of suitable indices and the establishment of good metadata practice will go a long way to meeting the problems over access to data. Co-operative ventures on new survey work would also address future data supply issues but they are likely to be less attainable than selling on data already produced for a specific purpose.

There is a very large showing (50 respondents) for the press and audio/visual media for data supply. Ninety-seven respondents stated that paper or electronic means were more

important than the former. Any new system must cater for the diversity of data sources and these are likely to continue to be older and less technical means than current computer developments allow. Amongst the statistically small group of leisure interests, the ratio is 7:3 for published and broadcast media over electronic means.

Despite the foregoing, there is a readiness to use and upgrade to higher level software.

A recent workshop on data access ("Maximising the use and exchange of coastal data – Developing best practice" at HR Wallingford, February 1999), open to participants from across the country, concluded that data indices were amongst the most important outstanding issues on the use of geographic information. Cost was not cited as a major issue, as in many cases it was possible to build it into the contract.

5.9 Summary

The interviews were open-ended to encourage wide responses and to allow the questionnaire to be developed with a measure of freedom from the author's bias. The interviews were structured to ensure a cross-section of users' views.

The questionnaire was developed following a framework analysis of the interviews, trialled and sent out to a large user group. This did not include tourists *per se*, although one expects all locals to utilise the area for recreation to some extent. The returns were balanced across the user groups.

The results allowed the determination of majority opinions giving orders of importance for coastal issues and data requirements. There were identifiable problems in data access and

IT use. The regional responses were in line with smaller groups that could be identified with the counties of Cornwall, Devon and Dorset.

The regional boundaries were not determined by reference to the natural influences discussed in chapter three of this thesis, but by issues relating to work. Current administrative boundaries and projects were the dominant features. The data requirements were numerous and indicate the range required for a holistic system. There were a number of difficulties in access to data and although the answer to many of these might be met by modern technology, current coastal zone users may not have the necessary equipment or skills. There is an interest in becoming skilled in the appropriate techniques.

Chapter Six

Implementation in the region

For any developments mooted in this thesis to be useful in practice, they would need to show improvements over the present "system". Thus, from the issues covered so far, they would need to:

- have regard for holistic, integrated, sustainable coastal management;
- be a requirement for work on a local level and compatible with a regional framework;
- improve the management process through relevant and available data supply.

That holistic, integrated, sustainable coastal management is seen to be "a good thing" may only put it alongside other altruistic ideas. The occasional dissenting voice (see the interviews, section 5.1.01 and Table 5.2) is perhaps allied with the questionnaire analysis indicating some individuals' preferences for their projects rather than a wider framework. Even a more sympathetic interviewee (Humphreys), utilises finite projects to raise awareness, interest and funding.

There is some anecdotal evidence of information overload (see section 5.1.13, Table 5.2 and as stated in a discussion at a conference (Anon, 7/5/99)). There are certainly conflicting requirements of i) accessing all relevant information, yet of ii) being physically and intellectually able to assimilate the pertinent issues. Communications technology may make some headway in forwarding data and enabling analysis, but the immediate effects are likely to be an increased workload on busy professionals. Some saving in time and workload would result from processing prior to the whole dataset reaching the desk of the decision-maker, but then prior processing may take from the precision or interpretation of the question being asked.

This chapter considers these issues and suggests models for the implementation of holistic, integrated coastal zone management.

6.1 Holism, a region and local interests

In one respect, two groups were identifiable from the questionnaire – those with a regional view and those concentrating on local projects. The former was evident amongst 72 respondents (42%). Those with local projects were adamantly parochial - one respondent answered "Lyme, Uplyme and Charmouth" at every opportunity. Others had their own versions of project-based interests such as an "offshore sea danger zone" and "local Jurassic cliffs". No over-riding regional area was identifiable, although a majority would be encompassed by maritime District Councils with a seaward extension to 12 nm.

Any new information system and its operation needs to take into account a wider view and people's local concerns. Although the interested parties surveyed were dispersed by the distribution of the questionnaire from Bristol south to Land's End and east to Weymouth, there is likely to be a need to access information of a similar data type if not the exact same dataset. Many datasets are likely to come from a common regional supplier. The questionnaire pointed to the similar and multiplicity of data required (Table 5.11).

6.2 Management of the coast

In order to achieve holistic coastal management there is likely to be a choice between conflicting uses. This then requires a social and political input - important enough for debate, but not the issue here. Instead, the focus is on the provision of adequate

information to enable satisfactory political or operational decision making. The outcomes will result from scientific, social and political issues using:

- a relevant and adequate data supply;
- analyses of datasets;
- an assessment of the quality of the input and output.

In a local trial ("SeeBed", at the University of Plymouth to experiment with data collation on a GIS), some of the benefits of the collection and collation process are to identify areas of data shortages, areas of partial data gathering, and areas where data exists but need to be updated. As data shortage is a common difficulty in coastal management, this alone is of significant advantage to a manager/decision maker. A further advantage, in a readily accessible library or database, is to enable reference to be made to background legislation, to similar studies and to other experts.

Spatial analyses that identify co-locational or co-temporal conflicts will best suit the requirements of conflict resolution. The "playing" of variations in pollution or accident scenarios will aid planning for conflict resolution or disaster relief. Straightforward overlay of multiple datasets will allow a broader view of the area to be managed. Specific products may integrate those datasets identified in section 5.7.1.

A schematic of information flow to develop policy for coastal management is given in Figure 6.1.

Regional Use of the Coastal Zone

Legislation

Habitats

Land use

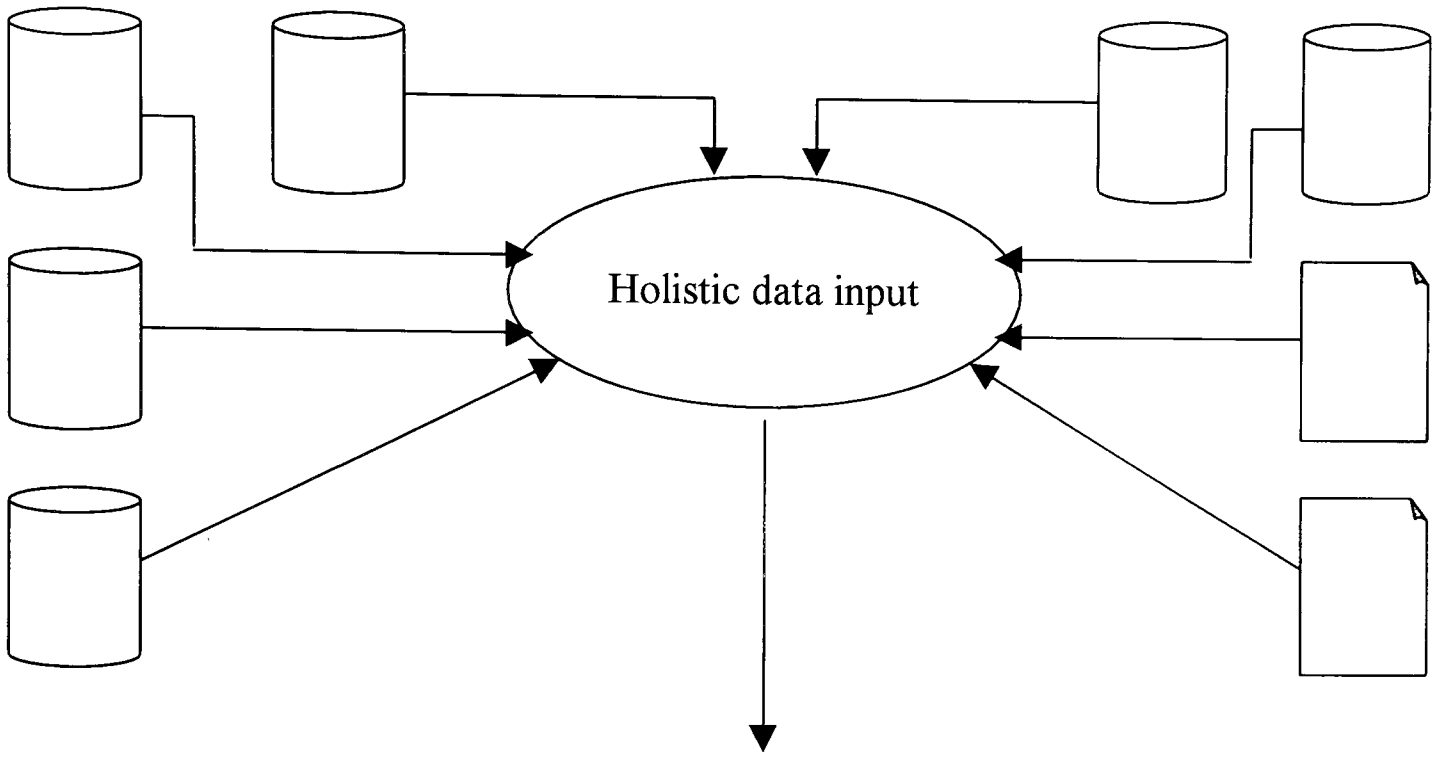
Land ownership

Health and safety

Weather

Coastal landscapes

Geology



Visual

Audible

Integration

Cross-correlation

Multiple-use

Temporal

Spatial

Management

Determine and respond to separation and sustainability scenarios

Figure 6.1 Input and use of technological and sociological coastal zone data (Author)

6.3 The supply of information

Depending how an information system is set up, it may be necessary for:

- all coastal zone users to access data from many data holders and also to have links to users without datasets; or
- a centralised unit to act as an intermediary between the user and the data holders.

However, it is not necessary to access all the data that each data owner controls.

As an example, an electricity generation or transmission company will have much data on the quality of electricity supply, their service to industry and householders, and the state of the supply network, yet these data are not crucial to coastal management. However, the visual impact of pylons and/or the local provision of supply as a facility may be crucial. Allowing access to a partial dataset decreases the problems of protecting privacy or of competition information. Access only to data on visual impact and/or local supply prevents the release of more sensitive marketing or personal information. Two interviewees (section 5.1.12 and Table 5.2) highlighted a parallel example of supplying interpreted information on habitats whilst protecting the raw information to prevent others making their own, possibly sub-standard, interpretations.

Remote access to data sets would require confidence in the currency of the data and an underlying security of the originator's data sets. The metadata would have to include comments on currency. If the need becomes evident, the new user can request updating by the data owner or decide to undertake his or her own work.

Some find data access easy (Table 5.2, "you just have to ask") and others know its there but do not know how to get hold of it (section 5.1.09 and Table 5.2). Coupled with good

indices and appropriate metadata (Table 5.14), remote access would increase the availability of regional or centralised distributed data (see sections 3.5 and 4.4).

6.4 Development of a decision-support system

In order to determine the information required for a particular task, the task must first be analysed. It is simplistic to say that in a holistic management system all data is required. Practicalities of data storage, data handling and cost militate against that approach, and a more practical route must be determined.

The Environmental Systems Research Institute (ESRI, 1993, pp.3-3, 3-4) produces the following procedure for investigations through GIS:

- determine the objectives;
- build the database;
- perform the analysis;
- present the results.

This allows information to be drawn from a wide database, but to select only the information deemed relevant to the question under investigation. Further guidelines are given at Appendix E.

Guidance notes associated with the US Clark University's, *Idrisi* (Eastman, 1995, pp.13-49 to 13-59), suggest the building of cartographic models (as, for example at Figures 3.1 and 3.2), but complete with the mathematical functions required to develop the analytical process to feed into the end product.

The development of a model to support (i.e. to inform rather than to lead) coastal management requires that the situation be simplified. The order for operations is:

- Specify;
- Simplify;
- Evaluate;
- Verify;
- Communicate.

The specification has to ensure that the topics are fully addressed and there is some tension between specification and simplification. The range of concerns identified in the foregoing chapters highlights the extent of the subjects; simplifying too far will leave few gains over present practice. A compromise must be sought between:

- Over-extension and incomprehensibility; and
- Over-simplification and little advantage.

Evaluation and verification can be tried in different combinations by altering computer-based scenarios. With adequate software, the conditions of growth or disaster scenarios can be tried and the responses evaluated.

Communication needs to address not only data supply but also reporting to managers and the public. Both interviewees and the questionnaire indicated the need for providing data and information to the public.

Thus, the operational requirements demand:

- the external setting of an appropriate social and political framework;

- the opportunity to access specific datasets;
- the performance of suitable analyses to determine appropriate information; and
- the communication of results.

Figure 6.2 illustrates the opportunity for any individual to undertake analysis given appropriate access to data. It illustrates each and every coastal manager accessing all datasets, as he or she requires. Each data owner would need to make access open to a large number of managers and there would be difficulties in restricting access to maintain elements of privacy, yet supply the conflicting demands of different practitioners.

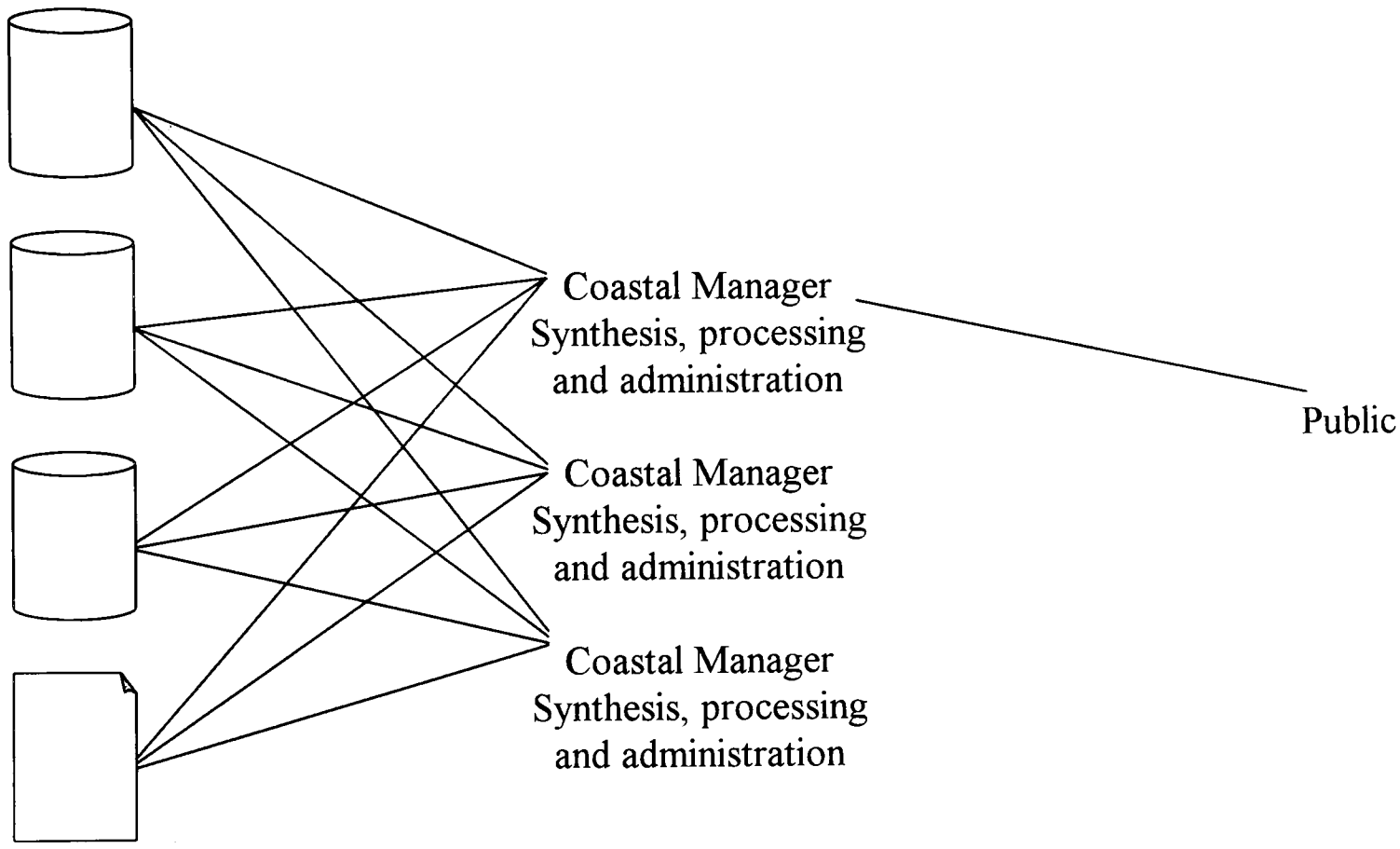


Figure 6.2 Distributed organisation model (Author)

According to section 5.7.3, it would also currently require access to and suitable training on appropriate software and current workloads would tend to go against this model. It is not yet in the operational experience of many coastal managers to undertake analytical operations and they are likely to be too busy to enter into such activities.

Conversely a central unit can undertake the analysis with the software centralised. The model is illustrated in Figure 6.3. This model would allow skilled individuals to make direct contact with a processing system but also give unskilled users an administrator to undertake analysis on their behalf. An administrator could also act as an intermediary with the public, giving both an extra public facility and relieving coastal managers of distractions.

This model will reduce the duplication on data supply made by the data holders, enable the devolution of the task of analysis, reduce the data overload on the intermediate and managerial staff, but also divorce the decision maker from direct contact with the raw data. This may have a detrimental effect; for example the administrator would have to interpret the manager's question possibly resulting in some confusion.

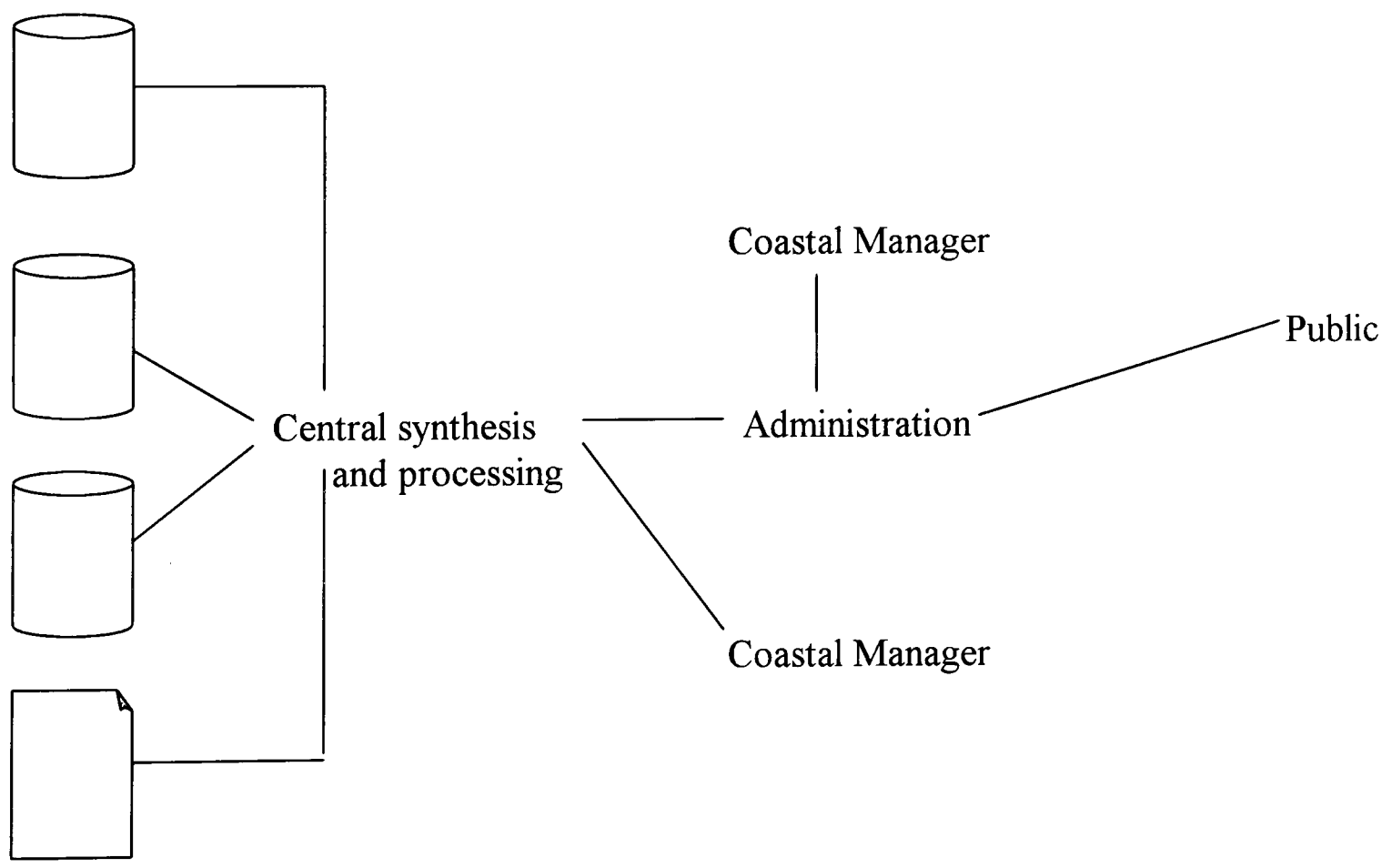


Figure 6.3 Centralised organisation model (Author)

Useful attributes of such a system are accessibility, ease of use, currency, security, cost-effectiveness and access by the uninitiated using a skilled intermediary.

6.5 Summary

High workloads, insufficient analytical skills (section 5.7.3) and the range of data required (section 5.7.1) make a centralised organisational model attractive. The results of this investigation support such a development if only due to the pressures on staff.

The discussion at section 5.8.1 concluded that the relevant administrative units would be the standard (i.e. UK) South West Region with County, District and project subdivisions. The opportunity for administrative cost savings would suggest centralisation on a South West Region. Demands for concentration on local projects could be met by coastal managers (or other relevant field workers) accessing the hub directly or indirectly as their expertise allowed. They might be best working within a District Council framework.

Chapter Seven

Conclusion

During the six years over which this thesis has been researched there has been continued development in the practical outworking of coastal management as, for example, funded by the European Union (Dorset Coast Forum, 1999; ALC, 2000) and experiences gained by applying new technologies to the topic (Johnston, 1998; Morris, 1999).

This final chapter reviews the study, summarises the results of the work and reflects upon issues through which it could have been improved. In overall terms the chapter assesses the aim of the thesis, namely:

i) the issues in setting up a regional coastal zone information system, and

ii) the potential benefits of setting up such a system.

7.1 A review of the study

This thesis has reviewed the current state of coastal management, considered the local setting, gathered local opinions and formulated a way ahead. The coastal management review took place in a time of strong development despite the sixty year history of interest in the UK coastline and the thirty year history since the enunciation of Federal US coastal management policy. UK policy development includes apparent changes in emphasis from a sectoral to an integrated approach albeit with actual limitations. Technologically, the increased use of digital data and the ability to display and transfer those data permit developments in approach that will support the changes in policy. Additionally, developments in freedom of access to government information will also support such changes. Conversely, the pressure on the individual to undertake the necessary personal development will delay the realisation of the benefits.

It has been possible to assess a number of issues related to setting up a coastal zone information system such as the usefulness of a region, the relative importance of datasets, local proficiency in turning the data into information and tentative comments upon a model for its implementation. The benefits of setting up such a system are greater effectiveness and efficiency. Current deficiencies in owning and operating analytical software are offered a possible solution through the interest of the users, but due to high workloads are more likely to be achieved by some centralised investment in providing an appropriate service structure.

Certainly, integrated coastal management is of key interest in Devon and the surrounding counties, despite a shortage of some coastal pressures, such as coasts in imminent danger of inundation by the sea or of large industrial development likely to pollute the coast. The counties from Cornwall to Dorset are more concerned with the tourism potential and current fashion of environmentalism promoting green tourism and clean beaches. These do, though, result in their own potential multiple-use conflicts.

The variety of computer-based software offer a range of benefits and the technological developments offer the opportunity to overcome the problems of storage and manipulation of paper-based data. This will happen more quickly for new records than for old. There are large quantities of historical records and there is little commercial gain in investing in their conversion to digital form. Conversely, it is more efficient to gather new records digitally and the datasets will likely be ready for storage and further manipulation in digital form. For this, relational databases offer many advantages in record keeping, digital mapping systems allow the addition of geography, but for analytical work only a GIS is suitable. Although GIS are not required by all, their analytical capabilities would be very useful in this context.

The methodology to investigate this work included an original and then on-going literature search, the holding of structured interviews together with a framework analysis, the distribution and analysis of a questionnaire and a discussion of the results. The former is fundamental to research. The questionnaire is less common in the physical sciences and has the drawback of subjectivity at its heart. This subjectivity has been overcome in part due to:

- the construction of the questionnaire on a solid foundation of
    - a relevant cross-section of interviewees, and
    - an appropriate range of questions developed from the literature search;
- the appropriateness of the sample group and the large number of returns.

It is reasonable to assume that the majority opinions that form the basis of Chapter Five are applicable across the counties.

One drawback in the questionnaire design was the attempt to identify respondents with towns - too many towns were listed from which respondents could choose an association. The consequences were:

- respondents identifying themselves with multiple places;
- a difficulty in identifying sub-regional responses;
- an overall blurring of physical geography to outcomes – only counties were abstracted as showing similar (or, if they had occurred, different) responses.

An improved choice of towns would have been to list only six – perhaps, Burnham, Appledore, Truro, Plymouth, Exeter and Weymouth. Yet even this is not straightforward – the people of the new Unitary Authority of Torbay may be unwilling to choose either Plymouth or Exeter.

Although the sample group seemed suitable, the questionnaire and the answers drew out some uncertainties. As reviewed in section 7.3, issues suggested by respondents were not fully investigated and they could influence the content and order of the results as given in Tables 7.1 and 7.2. Tourism and recreation could have been given greater emphasis.

There are further opportunities for cross-tabulation. Although that opportunity still exists, the interviews ranged from 1995 to 1998 and the questionnaire was sent out in 1998. Further analysis on this particular dataset is now less relevant than undertaking fresh work.

7.2 Outcomes

This thesis has determined the parochial nature of people's interests and set them within the maritime District Councils of the South West Region with an outer (seaward) boundary of 12 nm. It has listed the issues of concern to the majority, of which the first eleven is shown in Table 7.1.

Order	**Issue**
1	Conflicting multiple-use
2	Chemical pollution
3	Water quality
4	Safety implications
5	Access rights
6	Land ownership
7	Visual pollution
8	Beach cleanliness
9	Resource degeneration
10	Non-compliance
11	Congestion

Table 7.1 The primary eleven issues for South West regional coastal management (Author)

Further, the thesis has determined the datasets of most interest to the user group, of which the first seven are shown in Table 7.2.

Order	Data requirement
1	Legislation
2	Health and safety
3	Habitats
4	Weather
5	Land use
6	Coastal landscapes
7	Land ownership

Table 7.2 The primary seven datasets for South West regional coastal management (Author)

The work has indicated an interest in further software use for analysis. This is not hampered by its availability but is more likely hampered by work and time constraints. Thus, a recommendation for a regional, intermediary unit to support coastal management is proposed (Figure 6.3).

Particular outcomes of this work include anecdotal, rigorous and interpreted results.

Anecdotal results included:

- public apathy to coastal issues (section 5.1.08);
- the expense in data gathering and conversion (section 5.1.13);
- the statements on information overload (section 5.1.13).

More rigorous results derived from the questionnaire included:

- reasons for difficulties of accessing data (section 5.7.2);
- boundaries for a region (section 5.8.1);

- hierarchies of issues and data requirements (sections 5.8.2 and 5.8.3; Tables 7.1, 7.2).

Interpretation of the results included:

- the parochial response of individuals to coastal issues even where a regional approach is suitable (section 5.8.1);
- responses to difficulties in data access, such as through appropriate metadata (Table 5.14);
- the context for improvements in local coastal management (section 6.0);
- the advantages in digital data storage, referencing and access (section 6.2);
- the advantages in restricting access to elements of a dataset rather than its totality (section 6.3);
- the outline methodology for implementing an information system (section 6.4)

7.3 Issues for further work

As stated in section 2.3, it would be useful to investigate these developments and contrast these results against other options. Therefore it would be appropriate to establish a trial system using the ideas within the thesis, including working within the South West region. Conversely, wider research in the country may establish further commonality in issues and datasets. If so, it may be possible to further centralise the operational model (Figure 6.3).

It would be useful to investigate the more general importance of the supplementary issues garnered from the questionnaire (section 5.6). As they were nominated by respondents on the questionnaire returns no further work on them has yet been carried out, but given the opportunity, the wider community of coastal users may rate these highly.

Similarly, it would be useful to investigate the other nominated datasets, being:

Economic information; Rainfall; Amenity; Report of illegal fishing; Wildlife; Industrial activity; Population; Archaeology; Recreation and tourism; Development

Finally, the design and marketing of indices and metadata need to be developed to address the problems of locating appropriate datasets.

7.4 Summary

It is evident from the review of coastal management that:

- management will optimise coastal use for sustainable development by:
  - identifying conflict through co-spatial or co-temporal use;
  - developing alternative scenarios;
  - identifying change utilising a comprehensive database;
  - ultimately, reducing conflict;
- management will need information that results from analysing data.

It is evident from the questionnaire that:

- the issues of interest are wide ranging;
- there is interest in a holistic approach by the range of datasets nominated as important to the coast;
- data must be of sufficient relevance, quality, depth and breadth;
- data exchange and information exchange formats must be identified;
- data analysis and management techniques must be available.

Thus the aim of the thesis has been attained.

Annex

Appendix A Extracts from a contemporary discussion list, SEA-GIS

SEA-GIS discussion list (edited) occurring through the two weeks to 6 April 1998.

"Can we talk about CZM? I seem to remember a thread a few months back about the meaning of the term "integrated". From my readings, "integrated" seems usually to refer to bringing all relevant parties into the decision-making process, but it's rare to see anyone use the term in the context of bringing the various facets of CZM (law, economics, science, business, politics, etc) into the same "information map". Having been both a scientist and a resource manager I have seen some of the problems of getting the scientists and the managers on the same wavelength. I can also see problems with casting legal instruments in terms that can be handled by ecological science (e.g. what constitutes "harm" to the "environment")."
Nick Holmes

"I'm just now involved in a project preparing the grounds for an ICZM. As far as I understand the term, INTEGRATED in this context means that one doesn't manage some sectors in temporal, geographic, and institutional separation from the others. I assume that coastal management has to deal with a system of processes started, propelled, and fuelled by, and affecting both, different interests and the society at large. Thus, a holistic, i.e., whole-system (or integrated) approach would be more rational and, hence, hopefully more effective, than a piecemeal strategy.

Therefore, ICZM should institute a series of inter-related negotiation and management mechanisms, criteria for decision-making, and a set of policies and if necessary, new legislation that integrate the different demands and interests and are able to allocate accordingly coastal resources and assure equitable (or not - depending on governments' attitudes) benefits distribution."
Menakhem Ben-Yami, Fisheries Development & Management Adviser

"Cicin-Sain (Ocean and Coastal Management 1993, v21 pp.11-43) discusses the following dimensions of integration:-
* horizontal: between different sectors
* vertical: between different institutional layers (int. > local)
* of planning approaches across the land sea divide
* between nations
* among disciplines
The last dimension is obviously particularly relevant to Nick Holme's point about bringing the various facets of CZM into the same "information map", though these elements could also be considered as the various facets of science that need to be brought into CZM decision-making processes.

... we are trying to get those researchers and practitioners that are used to talking in strictly defined terms (engineers, lawyers, etc) and those that are used to talking in less strictly defined terms (ecologists, environmental sociologists, etc) to work together to address pressing CZM issues. However, the traditional divide between what positivists might refer to as "hard" and "soft" science is quite a hurdle to overcome, but one that arguably must be overcome in order to achieve integration.

The example that Nick raises is a good one, and is illustrated by the implementation of the European Commission's Habitats Directive, which requires the designation of 'Special

Areas of Conservation', including marine sites. However, the Directive has been drafted in non-defined terms such as 'favourable conservation status', 'significant change', etc. Those with economic development interests that may be restricted by SAC designations are using this lack of definition as a means of challenging SAC proposals in a classic adversarial judicial manner. It could be counter-argued that over zealous conservationists are using this lack of definition as a means of imposing over-restrictive management schemes to further preservationist aims.

However, the EC cannot define these terms in precise terms due to the diversity of habitats and species across Europe to which they apply coupled with the subsidiarity principle, whereby such decisions should be taken at as devolved a level as possible rather than being imposed by the EC. Where such issues cannot be resolved at a national level, there is recourse to the European Court of Justice, who will take scientific and legal advice and take decisions which are binding on European member state governments.

Clearly these issues need to be addressed by ecologists, lawyers, geomorphologists, economists, environmental sociologists, etc working in a collaborative manner, rather than taking an entrenched approach which is best left to the 'stakeholders'. The challenge is to get researchers out of their 'disciplinary trenches' in order to undertake transdisciplinary research to address pressing environmental issues. It is difficult to 'integrate' coastal engineering with environmental sociology, ecology with law, etc, but researchers from different disciplines should be encouraged to drop their disciplinary barriers (often based on arguments such as: " I can't work with people that talk in those terms and work in that way") in order to work towards integration. Any inter-disciplinary conflicts will fuel the fires of opposition to conservation and sustainable management policies.

Neither lawyers nor ecologists, environmental sociologists nor geomorphologists, etc, can alone address pressing CZM issues, and it is argued that they should avoid thinking, talking and working in a purely disciplinary manner and be prepared to constructively collaborate with each other ... and, as Jose so well points out, professional researchers, conservationists, and practitioners really do need to work with local communities rather than patronising them and it could well be argued that more resources should be focused on taking a 'bottom-up' approach rather than on paying scientists to go on "jollies", procrastinate in the quest for greater precision (i.e. research and consultancy funds!) and argue with each other! However, it is not an either/or situation as science will often be needed to inform strategic decision-making. It is therefore argued that a greater emphasis should be placed on translational research, which is focused on local-scale issues and on immediately supporting decision-making processes."
Dr Peter Jones, University College London

"I think that integrated CZM is a poor concept because it continues the impossible concept that humans "manage" the ecosystem. Actually, the only thing we can affect is the activities of humans. We can pave the shoreline or not. The ecosystem then does its own thing. So integrated (or comprehensive) coastal zone management should put a conceptual balloon around human society to identify all of the human activities that affects the coastal zone and then also project the affects of each human activity on all components of the coastal ecosystem. We then need to modify the human behaviors that cause harm. And the modification of the behaviors should follow the logical sequence of mitigation, i.e. first avoidance, then minimization of effects left after avoidance, then compensation for the effects left after avoidance AND minimization."
John Dohrmann, Puget Sound Water Quality Action Team

"The good old saying of removing human activity to save the ecosystems has a flaw - humans are part of the ecosystem - without this recognition of fact nothing proper can be done. Besides, a large majority of the human population lives on the coastal zone, some say 70%. Education and alternatives to the overuse of coastal systems are two good tools that proved efficient.

The term integrated is usually considered as a way to encompass the origin of the causes of a degradation. I believe it should not be seen as a complete integration of all systems and flows that could interact with the coastal zone unless a proven correlation with the origin of a stressor is found. Thus, the concept has to be flexible in its definition, because how do we define the boundary of an ecosystem."
Pascal *(surname lost)*

* ICM is a important construct, a way of thinking about problem solving that ties together relevant institutions, resources, society, and individuals at the land-water interface. The "integrated" part has several dimensions with four elements of integration (1) land-water interface, (2) institutional (vertical and horizontal), (3) sectoral, and (4) disciplinary. It's a simple, easy to use evaluation framework for understanding where you are in your efforts to integrate and where you might improve. There's a whole literature on how--the processes and tools of coastal planning, regulation, and management.
* Another very thoughtful piece on integration in resource management is Underdahl's 1980 article in Marine Policy 4(3):159-169, "Integrated Marine Policy: What? Why? How?" One of Underdahl's messages is that integration has both benefits and COSTS. Know what they are and act rationally. You can't integrate everything.
* Another assertion I often make is that U.S. CZM was/is a pretty good 1st generation effort at ICM as we now define it. Although there is ample room for improvement, it serves as a pretty good prototype. There have many improvements or attempts at improvement over the years to make it more "integrated" than it was--the notorious 6217 nonpoint pollution control program is a case in point (either point).
* Another observation: ICM does not necessarily result in sustainable development, sustainable communities, or sustainable resource management. On the other hand, to have a truly sustainable global society, we would all do well to incorporate a lot more integration into our decision making. Uh-oh, I've opened up a can of worms there.
* Finally, and I have to say this, probably the dumbest thing about ICM is that there seem to arguments over whose idea it was or who knows best how to do it. Who cares? There's enough integrated coastal problem solving out there to keep us busy for generations. What ICM looks like will be a function of the problems, local institutions and their capacity and flexibility, and local social and cultural norms. No straight jackets, please. There's too much to do."
Jim Good

Appendix B Steps to determine the requirements for a project (ESRI, 1993)

- What are the problems to be solved ?
- How is it solved now ?
- Are there alternative methods for solving the problem using the GIS ?
- What are the final products of the project - reports, working maps, presentation quality maps ?
- How frequently might these products be generated ?
- Who is the intended audience for the final products ?
- Are there, or will there be, other uses for this same data ?
- What might the specific requirements for those uses be ?

Appendix C Consultees and interviewees, west to east

Mr E Derriman, Cornwall Sea Fisheries, Penzance, 20th July 1998
*Mr C Howe, Cornwall Wildlife Trust, Allet, Truro, 14th August 1996
*Mr B Shipman, Cornwall County Council, Truro, June 1997

Captain M Sutherland, Fowey Harbour Commissioners, Fowey, 29th July 1997
Ms S Porter, Environmental consultant, as above
*Mr D James, Plymouth City Council, Plymouth, various

Anonymous, planner, 25th May 1998
Mr P Squire, farmer, Holbeton, Devon, 28th May 1998
Mr R Marriott, householder, Ivybridge, 7th June 1998

Mr R Twogood, Heritage Coast Officer, South Hams District Council, 23rd July 1997
Dr R Porter, Britannia Royal Naval College, Dartmouth, 30th July 1997
Mr R Humphreys, Dart Estuary Project Officer, Dartmouth, 2nd July 1997

Mr P Gibbons, Arch Bridge Oyster Farm, Shaldon, 11th August 1997
Mr Peter Hayden, Dawlish Warren, 10th August 1998
Mr Steve Holley, Local Nature Reserve, Dawlish Warren, 10th August 1998

*Mr A Winders, Devon County Council, August 1996
Mr I Carl, Devon Wildlife Trust, 5th October 1995
Mr M Camplin, Devon Wildlife Trust, as above

Mr C Gilbert, Kent County Council, 25th July 1997

The individuals starred (*) were consulted in the early stages of the work (see Chapter Four), but not at the more formal time of developing the basis for the questionnaire.

Appendix D Questionnaire as distributed

Coastal Management in the south west

This is a request for co-operation in a project that aims to assess the information required to support coastal management.

Coastal Management can be used to optimise the use of the coastal zone. This research uses a questionnaire to support a review of coastal management, and the information to which you have access (or would like to have access). The research aims to determine the personnel to whom this system might be useful. It examines the user requirements of the information system, and the range of data sets required.

The questionnaire looks at, and beyond, the sea meeting the land; to how the sea affects the land, and the how the land affects the sea. It might involve interests some miles offshore as well as up-river or across country.

An information system is likely to be of use to planners and decision-makers, but there are many users of the coast from use of the beach, to the work of farmers, fishermen and conservationists. Shipping companies, sports clubs, hotels, environmentalists - indeed anyone using the coast might be interested in that information system or the data that others are using.

What is the expected outcome ?
An assessment of the requirements for information provision, indicating -

- Data needs
- Data supply routes
- Suitability of data for secondary users
- Benefits of improved information provision to optimise coastal use

The questionnaire
Most questions require a cross, a number, or a few words. Please supply answers as you see fit. I would be grateful for any response you can give, though the more detailed, the better.

Thank you,

Vic Abbott

Section A

- Is your work or your leisure most affected by the coastal zone (× in the box ❑)?
  ❑[1] Work ❑[2] Leisure

Please answer the questionnaire according to this dominant activity.

Section B – Regional limits

- Does your principal work/leisure interest occur on (× in one box ❑):

❑[3] land ❑[4] the water's edge (+- 10 metres, say, either way) ❑[5] the sea

- If your work/leisure affects the land or land use what is the inner limit of your interest (e.g., a city boundary, a main road or a tidal limit) ?
  [6,7] .....

- If your work/leisure affects the sea or sea use what is the outer limit of your interest (e.g. in km from the shoreline, or other unit)? [8,9] .....

- Does your work/leisure occur nearest to (1 in the box ❑ for your primary area of interest; (2, 3, and 4 in the boxes ❑ for supplementary centres)

❑[10] Avonmouth ❑[11] Clevedon ❑[12] Weston-s-Mare ❑[13] Burnham ❑[14] Watchet
❑[15] Minehead ❑[16] Lynmouth ❑[17] Ilfracombe ❑[18] Appledore ❑[19] Bude
❑[20] Boscastle ❑[21] Padstow ❑[22] Newquay ❑[23] Redruth ❑[24] Hayle
❑[25] St Just ❑[26] Penzance ❑[27] Falmouth ❑[28] Fowey ❑[29] Looe
❑[30] Plymouth ❑[31] Salcombe ❑[32] Dartmouth ❑[33] Torquay ❑[34] Exmouth
❑[35] Lyme Regis ❑[36] Weymouth
❑[37] or, if more than 50 km from any of these, other .....

- Are the boundaries of your work/leisure affected by (× in the boxes ❑ for all applicable)

❑[38] Travel ❑[39] Economics ❑[40] Politics ❑[41] Climate
❑[42] Geology ❑[43] Ecology ❑[44] Other.....,

And if so, what are their geographic limits (e.g. Fal Estuary, Dorset, south west peninsula, English Channel)

Travel [46,47] .....
Economics [48,49] .....
Politics [50,51] .....
Climate [52,53] .....
Geology [54,55] .....
Ecology [56,57] .....
Other [58,59] .....

Section C – topical issues, datasets and co-operation

What issues are relevant to continuing or developing your work/leisure ?
(please classify under crucial, influential, minor or irrelevant; ✖ in the boxes ❑ for all applicable):

	Crucial		Influential	Minor	Irrelevant
101 ❑	Water quality		❑ 131	❑ 161	❑ 191
102 ❑	Beach cleanliness		❑ 132	❑ 162	❑ 192
103 ❑	Pre-existing use		❑ 133	❑ 163	❑ 193
104 ❑	Conflicting multiple-use		❑ 134	❑ 164	❑ 194
105 ❑	Congestion		❑ 135	❑ 165	❑ 195
106 ❑	Interference		❑ 136	❑ 166	❑ 196
107 ❑	Land ownership		❑ 137	❑ 167	❑ 197
108 ❑	Access rights		❑ 138	❑ 168	❑ 198
109 ❑	Safety implications		❑ 139	❑ 169	❑ 199
	Pollution -				
110 ❑		chemical	❑ 140	❑ 170	❑ 200
111 ❑		visual	❑ 141	❑ 171	❑ 201
112 ❑		noise	❑ 142	❑ 172	❑ 202
113 ❑	Resource degeneration		❑ 143	❑ 173	❑ 203
	Management -				
114 ❑		failure to comply with regulations	❑ 144	❑ 174	❑ 204
115 ❑		duplication of responsibility/effort	❑ 145	❑ 175	❑ 205
116 ❑		management divergence	❑ 146	❑ 176	❑ 206
117 ❑		inadequate resources	❑ 147	❑ 177	❑ 207
118 ❑		deficit of authority	❑ 148	❑ 178	❑ 208
119 ❑	Other		❑ 149	❑ 179	❑ 209
120 ❑	Other		❑ 150	❑ 180	❑ 210
121 ❑	Other		❑ 151	❑ 181	❑ 211

- What is the information you require to undertake your work/leisure ?

(please classify; ✖ in the boxes ❑ for all applicable):

	Crucial		Influential	Minor	Irrelevant
221 ❑	Legislation		❑ 251	❑ 281	❑ 311
222 ❑	Land ownership		❑ 252	❑ 282	❑ 312
223 ❑	Land use		❑ 253	❑ 283	❑ 313
224 ❑	Water cleanliness		❑ 254	❑ 284	❑ 314
225 ❑	Administrative boundaries		❑ 255	❑ 285	❑ 315
	Pollution (current or historic) –				
226 ❑		chemical	❑ 256	❑ 286	❑ 316
227 ❑		visual	❑ 257	❑ 287	❑ 317
228 ❑		noise	❑ 258	❑ 288	❑ 318
	Management -				
229 ❑		contacts	❑ 259	❑ 289	❑ 319
230 ❑		monitoring	❑ 260	❑ 290	❑ 320
231 ❑		surveillance	❑ 261	❑ 291	❑ 321
232 ❑		assessment	❑ 262	❑ 292	❑ 322
233 ❑		prediction	❑ 263	❑ 293	❑ 323
234 ❑	Geology		❑ 264	❑ 294	❑ 324

... (continued overleaf) ...

235 ❑	Geomorphology	❑265		❑295		❑325	
236 ❑	Coastal landscapes	❑266		❑296		❑326	
237 ❑	Habitats	❑267		❑297		❑327	
238 ❑	Species information	❑268		❑298		❑328	
239 ❑	Climate	❑269		❑299		❑329	
240 ❑	Weather	❑270		❑300		❑330	
241 ❑	Water depth	❑271		❑301		❑331	
242 ❑	Other sea-level variables	❑272		❑302		❑332	
243 ❑	Health and safety implications	❑273		❑303		❑333	
244 ❑	Other	❑274		❑304		❑334	
245 ❑	Other	❑275		❑305		❑335	
246 ❑	Other	❑276		❑306		❑336	

- Please indicate below (1 in the box ❑), your primary area of interest; please indicate on the same tables (2, 3, 4, etc in the boxes ❑), other areas with which you have significant contact:

European or national government -
❑[341] European Union ❑[342] Government Department/Ministry
❑[343] Government Agency ❑[344] other .....

Local government -
❑[345] County Council ❑[346] District Council ❑[347] Unitary Authority
❑[348] other .....

Transport -
❑[349] port operations ❑[350] shipping operations ❑[351] road haulage ❑[352] traffic planning ❑[353] other .....

Mineral and energy resources -
❑[354] aggregate recovery ❑[355] aggregate processing ❑[356] hydrocarbons
❑[357] wind generation ❑[358] other .....

Biological resources and fisheries -
❑[359] aquaculture ❑[360] line fishing ❑[361] fishing from vessels
❑[362] fish processing ❑[363] arable farming ❑[364] livestock farming ❑[365] other .....

Waste disposal -
❑[366] waste authority ❑[367] disposal by ships ❑[368] disposal on land ❑[369] other .....

Strategic uses -
❑[370] Port Authority ❑[371] Ministry of Defence ❑[372] other .....

Research, education and training -
❑[373] university ❑[374] college ❑[375] research institution ❑[376] MOD institution
❑[377] other .....

... (continued overleaf) ...

Recreation and tourism -

❑[378] sailing clubs ❑[379] chandlery ❑[380] hotel/guest house
❑[381] tourism management ❑[382] tourism venue ❑[383] other .....

Environmental support -

❑[384] English Nature ❑[385] Environment Agency ❑[386] research institution
❑[387] Heritage Coast ❑[388] Nature Reserve ❑[389] SAC
❑[390] Estuary management ❑[391] Shoreline management ❑[392] other .....

Section D – Data management and information technology

- Can you readily get hold of the information you require ?

❑[401] Yes ❑[402] No ❑[403] Partly

- If not, what inhibits your access to data ? (× in the boxes ❑ for all applicable)

❑[404] terminology ❑[405] variety of classification systems
❑[406] data units (e.g. imperial or older measurements)
❑[407] cost ❑[408] databases spread across the country
❑[409] inability to find appropriate data ❑[410] data protection
❑[411] age of the information ❑[412] time for delivery
❑[413] insufficient detail ❑[414] unsuitability to the task in hand
❑[415] unsuitability of paper/digital format ❑[416] other .....

- If you access any data on paper, is it by - (× in the boxes ❑ for all applicable)

❑[417] personal visit, and copying ❑[418] post ❑[419] fax ❑[420] other .....

- If you access any data digitally, is it by - (× in the boxes ❑ for all applicable)

❑[421] floppy disc ❑[422] via email ❑[423] via other electronic transfer (by which system ?)
❑[425] other ..... [424] .....

- If you access any data digitally, is the format as - (× in the boxes ❑ for all applicable)

❑[426] a text file ❑[427] a spreadsheet ❑[428] a database ❑[429] a relational database ❑[430] a GIS coverage ❑[431] other .....

- Are any of the following – TV, radio, newspapers or journals – .a more important means than the above for supplying data ? ❑[432] Yes ❑[433] No

- Do you use computers for your work ? ❑[434] Yes ❑[435] No

- Do you have adequate software to enable (× in the boxes ❑ for all applicable) :

❑[436] Compatibility/data transfer ❑[437] An integrated database
❑[438] Analysis ❑[439] Ease of use

- Does your work principally involve (× in the boxes ❑ for all applicable) :

❑[440] data processing others' work ❑[441] other manual/technical work
❑[442] management ❑[443] academic study ❑[444] other .....

Information note

The Internet, particularly via Bulletin Boards or email Discussion Lists, can provide textual information with some sorting by subject heading and the opportunity to contribute.

Digital mapping systems provide a graphical interface for visual integration of data. This can be made available by floppy disc or over the Internet. They are fairly simple to use.

Geographical Information Systems offer the supplementary ability (over digital mapping) of being able to analyse or query spatial data; of being able to interrogate multiple layers with reference to one location or across an area. Analysis complicates the process, but information can be processed centrally, in response to general or specific questions, or data can be supplied for analysis by the end user. The former option provides an answer in similar complexity to a digital map; the latter option requires skills in the particular software's analysis functions.

With reference to your work or leisure interests affecting the coastal zone –

- Would further processing of your data be of interest to you ?
  ❑[451] Yes ❑[452] No ❑[453] Possibly

- Do you plan to increase your use of Information Technology (IT) by the lines above ?
  ❑[454] Yes ❑[455] No ❑[456] Possibly

- Would you be interested in the increased use of such IT to manage data ?
  ❑[457] Yes ❑[458] No ❑[459] Possibly

- Would you be interested in the increased use of IT to support decision making ?
  ❑[460] Yes ❑[461] No ❑[462] Possibly

Section E – Odds and ends

- Could data gathered for others be made suitable for you ?, e.g.
  by modifying the data set being collected (by sample interval, or topic)
  ❑[501] Yes ❑[502] No ❑[503] Possibly
  by modifying the data collection format; ❑[504] Yes ❑[505] No ❑[506] Possibly

- Do you have a set of indicators of change ? ❑[507] Yes ❑[508] No

- Is information provision to others an important issue ? – ❑[509] Yes ❑[510] No

If yes … who wants it ? [511, 512] .....
How do they obtain it from you ? [513, 514] .....
Do they want general information, such as ? [515, 516] .....
Do they want project specific information, such as ? [517, 518] .....

- Can you access the results of local research projects ? ❑[519] Yes ❑[520] No

- Can you access the results of remote research projects ? ❑[521] Yes ❑[522] No

- Would you like stronger partnerships in this area of data and information ?
  ❑[523] Yes ❑[524] No

If there are other issues you believe of significance in the context of the coastal zone. coastal zone use, data and information provision, would you please comment here.

This questionnaire is anonymous. If you would like to identify yourself, please do in the space below (the information will remain confidential). If, in addition you would like to receive a summary sheet on completion of my work, please indicate here. ❑

Title

Name

Job title

Address

email

Please return in the reply-paid envelope.

Appendix E

(After AGI, 1996, pp.49-52)

SPECIFYING REQUIREMENTS FOR DATASETS

1. DEFINING YOUR TASK
   - 1.1 What is your task? What question or questions are you trying to answer?
   - 1.2 What region are you interested in?
   - 1.3 Is your answer time dependent?
   - 1.4 How will you know if you have the right answer?
   - 1.5 How would you like the results presented?
   - 1.6 Has someone else already got the answer to your question or would they be interested in your answer?

2. IDENTIFYING THE CONTENTS OF THE DATASET THAT YOUR TASK REQUIRES
   - 2.1 For what region do you want your data?
   - 2.2 For what instant or time period do you want your data?
   - 2.3 What objects are required of your data?
   - 2.4 What attributes of these objects will your task's answer depend on?
   - 2.5 Do you need to know about every instance of these objects or a selected sample of them?

3. SPECIFYING SPATIAL ATTRIBUTES
   - 3.1 How will you identify the location of size of the objects?
   - 3.2 Do you envisage objects as a point, line or area?
   - 3.3 Do you require cross references between one type of object and another?
   - 3.4 Is the reference system for your location important to you?
   - 3.5 To what resolution do you need to know location?
   - 3.6 Do you need to consider further the positional accuracy?
   - 3.7 Are the spatial relationships between objects important?

4. SPECIFYING TEMPORAL ATTRIBUTES
   - 4.1 In what way, if any, will time be important to the dataset?
   - 4.2 Is the resolution, or how the time and date are written, important?
   - 4.3 How do you want an interval specified?
   - 4.4 Are the temporal relationships between different objects or different attributes important?

5. SPECIFYING THEMATIC ATTRIBUTES
   - 5.1 What other attributes of these objects are important to you?
   - 5.2 For any attributes you require, can you list all the possible values?
   - 5.3 For any attribute you require, what types of values do you want?
   - 5.4 What units of measurement, language, etc. do you require?
   - 5.5 Can you detail any constraints to which you expect your attribute value to conform?

6. IDENTIFYING OTHER ISSUES
   - 6.1 Do datasets exist that meet (or partially meet) your needs?
   - 6.2 Have you considered the most important elements of the data in your specification?
   - 6.3 What assurance do you require that the data is to your specification?
   - 6.4 Do you require the data to be kept up to date, and if so how and by whom?
   - 6.5 Could anyone else use this data now or in the future?
   - 6.6 Have you considered the functionality you will require of the software package to process this data?
   - 6.7 Will resources constrain your ability to acquire and use the data?
   - 6.8 How would you like to receive the data?
   - 6.9 Are there likely to be any restrictions in the use of this data?

7. WHAT NEXT?
   - 7.1 How are you going to use your data specification?
   - 7.2 Do you need further advice?

References

The use of Internet references are classified thus:

E1: from a source (e.g. the European Union) generally accepted as being reputable without it necessarily being a refereed publication in the conventional manner;
E2: examples of Internet systems in use and electronic sources of information;
E3: an Internet source that might be of higher standing if it had originated through a published work. The only E3 is in the Bibliography.

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Talks and published papers

The introduction of GIS into a hydrographic teaching programme

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1. Introduction

This paper reviews the development of a conventional hydrographic surveying syllabus to take on the new software of Geographical Information Systems (GIS) that opens wider fields of data manipulation and management. The integration of such software is gradual, and has been undertaken in co-operation with, but not by, geographers more skilled in utilisation of the technology.

Surveyors have long been data gatherers, and sometimes data processors, although the latter often involved little beyond the final map or chart. The opportunities now being utilised include the development of information systems and decision support tools.

2. The Institute of Marine Studies

The hydrographic education programmes undertaken at the Institute of Marine Studies, University of Plymouth (UK) have developed out of the decades-old seafaring tradition and the related teaching of the pre-University maritime school. Plymouth is well known for seafaring exploits, like those of Frobisher and Drake, and of the sailings of the Mayflower and the Beagle. It is a naval port, indeed is controlled by a Queen's Harbourmaster (a naval officer), and is the home of the British naval hydrographic ships and their associated school.

The present hydrographic lecturing team at the University is integrating the well known changes in positioning and data gathering systems into the curricula. These changes are already leading to the redundancy of some terrestrial positioning systems, and indeed, if the course was to cater for five years hence, it could be argued that a hard line change should be instituted immediately, resulting in only relative (carrier phase) and differential (pseudo-ranging) GPS being taught in response to DGPS as a stand-alone positioning tool. However, our courses evolve rather than change in steps. We accept that there are many terrestrial positioning sets already owned, and will continue to be used, and we are typical amongst educational establishments, in trying to add on new material whilst not wanting to lose the traditional element.

GIS may seem to be software, or a technology, that is superfluous to mainstream surveying. Indeed, many of the applications that have been developed utilise satellite-based remote sensing, and therefore are of use at quite small scale. This is typically a geographer's or an oceanographer's approach - obtaining an overview of an extensive process. Surveyors, conversely, work at large scales - indeed it is their ability to measure precisely for which they are best known. The rationale for getting involved with GIS must therefore be clear, or much time might be wasted in pursuing a fashionable, but irrelevant path.

The GIS development continues around our skill base. At the large scale, plans are in hand for establishing a port-based facility management system. On data management, the opportunities so long promoted in places like the Royal Institution of Chartered Surveyors (RICS), can come to fruition though our holding on to the data for longer, and "adding value" before passing it to the client.

3. Staff developments

With an awareness of the affects of GIS on the world of surveying, there has been a drive to i) broadens our own education, ii) widen the experience of students and, iii) renew the syllabus. GIS were already part of the teaching in the Department of Geography, and there was an option was to bring in their expertise,

but the difference in skill base and approach to the subject (particularly as to the scale of the work) between the two departments gave sense to expanding our own knowledge, our own rationale and our own method of subject delivery.

As you might expect, when not lecturing, running fieldwork, marking, undertaking administration and organising meetings, we attend other people's meetings. Hence we have benefited from others' expertise at symposia, taking in courses at universities in Cambridge, Portsmouth and Manchester. In order to initiate our hands-on experience, we are taking the subject of coastal management as the application area, and hence we have a natural zone for combining hydrography with GIS.

There are a number of courses run by system vendors and through University short courses. Quite often they are geared to a particular type of software - the underlying techniques being taught through the system's own approach. Thus, attending a course based on ArcInfo, the jargon terms of "arc", "cover", or "join" are part of the experience, whereas through Idrisi, you are introduced to pixel, "color a", "maint". You may recognise some of these as being integral to the respective vector or raster approach, but the argument still holds.

Some generic teaching material is available from the US National Center for Geographic Information and Analysis. As a lecturer, these are extremely useful, providing ready-to-copy overheads, and explanations of many aspects of the vector and raster approaches. Similarly, the "GIS Tutor II" provides a hyper-text approach to learning. It may be little more than a book, but provides a fresh approach to textual dissemination.

One of the new "helps" is the Idrisi Resource Centre at Manchester Metropolitan University. They run a cost-effective course on the latest version of Idrisi. From nearby Manchester University, Kamie Kitmitto gives help and teach-ins on ArcInfo.

Finally, bulletin boards provide questions and answers on a range of topics associated with proprietary software. I've always felt my questions too simple to ask and have preferred to ask knowledgeable people I meet - like all computer related areas, an expert is hounded for his or her experience.

4. Student developments

One major benefit to the lecturers has been the willingness of certain students to take on the challenge of exploratory final-year projects, even though they are only at undergraduate level. They do this in order to discover for themselves the benefits of our GIS. This can be a daunting prospect - especially for the student who took on the production of educational materials to help explain ArcInfo.

Most of the projects involve a mix of applying survey experience (gathering data) with GIS data manipulation. Not all the original aims are met as they have to be adjusted to the realities of working with difficult equipment, weather conditions adversely affecting allotted survey times, or with processing not coming up with the expected answers.

Student projects in 1994 included:

gathering bathymetric data of Plymouth Sound, forming a digital terrain model, and entering the result into a GIS (as planned, but in reality, AutoCad);

gathering a differential (pseudo-range) coastline of i) Plymouth Sound and ii) the wider coastline, and entering these into an AutoCad database and to Idrisi respectively. Discussions on this work by the students involved the accuracy of the data and the scale at which it could

therefore be used. These two projects were interesting for other reasons, being based upon the manipulation of post-processed GPS as we were using Del Norte 5-channel receivers (on long term loan from Del Norte), but not using a real-time data link;

the production of notes and overheads for use in class, to enable the faster appreciation of GIS by new students.

Projects in 1995 included:

the potential for GIS in maritime archaeological projects;

conflict in the coastal zone: a question of priorities;

GIS as a compositional and analytical tool.

Projects set for 1996 include:

transfer techniques in digital data processing;

production of maritime-centred GIS tutorials ... one of the problems with many of our example data sets are their concentration on forestry as the example area for problem solving - not very convincing to the sceptical hydrographic survey student.

Some of the student projects, are complete topics in themselves; some work for the betterment of the wider student body's understanding of GIS, some are also heading to a wider input of a coastal management exercise in a regional setting.

One research topic currently being investigated is the application of GIS to coastal management - not the narrow coastal management of some civil engineers that is really a misnomer for coastal protection, but of the wide ranging coastal management as developed, for example, in the US under federal Coastal Zone Management legislation.

A number of GIS issues have to be addressed, in addition to those specific to coastal management. These include:

an assessment of the usefulness of GIS in this particular application, including determining the attempts made so far to use GIS in similar applications;

a review of the information needs in such a context, and whether GIS may be able to fulfil them;

an assessment of the effectiveness of such a system, compared with systems presently in operation, and,

the output of data (especially linked data sets) in combinations not previously seen.

Other maritime GIS projects are being pursued. Already completed is an MSc dissertation (through the Department of Geography) investigating changes in the spit of land (Dawlish Warren) at the mouth of the River Exe south of Exeter. Utilising old maps and charts, projected onto a common reference system, a workstation-based GIS (ArcInfo) was used to compare changes in the shape of the spit.

At present, another MSc student is investigating sightings of marine mammals in the Ligurian Sea, and looking for correlation with environmental data. She is using the raster-based GIS, Idrisi (on a PC). This has involved obtaining data sets of sea-surface and sub-surface temperature, current data, coastline, bathymetry and mammal sightings, reformatting them to the same geographical area and data type and performing computer overlays to attempt to determine trends. The study has done more to highlight the difficulties in obtaining sufficient and relevant data than in allowing an analysis. Since most of the surveyors' work is in obtaining data, I suppose this is not a bad result.

Finally, at present, contact has been made with the engineer of the local

port, to obtain permission to survey his port with the aim of establishing a Facilities Management information system. Plans are in their very early stages, and with a long time scale for completion. In addition, computer mapping for such systems is not new, but surveyors in our department have not yet taken up this opportunity. This really is working at large scale - perhaps large enough to show, or to link to, engineering drawings of valves, machinery or the like. Utilising a vector based GIS will bring a real-world application to this project, and highlight areas of work opportunity for the students. The improvements available in using a GIS rather than a digital mapping system have yet to be shown, but there may yet be spin-offs in directions I do not appreciate.

5. Facilities

Our hardware utilises the IBM-compatible approach to GIS, made possible through the availability of discounted educational software for that environment. Under a UK agreement with educational establishments and with the University central funds bearing most of that cost, the (US) ESRI ArcInfo is available to our hydrographic unit of the Institute of Marine Studies at little more than the cost of the hardware and a dongle. Thus, we have a powerful vector-based system.

Our second GIS software package is the (US) Clarke University's Idrisi, purchased at the educational discount and providing us with a raster-based system. Use of Idrisi has recently been supported through the establishment of the Idrisi support group at Manchester Metropolitan University. A recent course there introduced the Windows front-end for Idrisi, which makes it so much easier to use.

With these two GIS we have a mix of data handling software: comprehensive and complicated; simpler and straightforward.

These software can run on 386 computers with maths co-processors, but we have them on at least 486DX, 33MHz, 8MB RAM machines with 300MB hard disk. We attach small digitisers, a laser printer and A3 and A0 plotters.

Associated software, running on neighbouring machines in our specialist laboratory include hydrographic survey software from Fugro, Trimble and Racal, AutoCad, and a ground modelling package. Additionally, GIS training packages are becoming increasingly available, and, as mentioned above, we have some from UK and US establishments.

We do have access to workstation-based ArcInfo, although not within our own laboratory. Also, geographers are using PC-based software, with similar facilities to our own. These are laboratory based and utilised when running tutorials for larger classes.

6. Support activities

A well established way of increasing student awareness was through our support of the professional institutions and learned societies. Lecturers have been organising local technical and developmental meetings for the wider surveying community for six years, primarily through the (UK) RICS, and more recently in conjunction with the local region of the Hydrographic Society. These meetings have included:

A demonstration of the RICS GIS package shown on behalf of the RICS by members of the Land and Hydrographic Survey Division. This was regularly on show to try to spread the message to our own and to other divisions;

Sea-dredged aggregates: the role of the Crown Estate in marine aggregate dredging (including environmental impact assessment);
GIS: principles, types and components - an introductory talk on the nature of GIS.

Domesday 2000: a talk and demonstration of this major UK GIS initiative. This workstation-based, yet portable system had three very interesting display areas, ranging from urban displays in Southampton which zoomed into individual property and the services available to the area, and raster maps draped across digital terrain models to give a three dimensional effect not purely depending on the observer to interpret contours.

7. Curricula changes

The mechanics of change in the teaching programmes is to alter the syllabus slowly on a yearly basis, and more dramatically at quin-quennial reviews that can involve re-validation.

As the introduction of GIS has gone hand-in-hand with introducing the concepts of integrated, holistic coastal management, the earliest changes were in the Higher National Diploma in Marine Operations that had an environmental module. This allowed the majority of time to be spent on the principles of coastal management, with a support lecture and demonstration in data handing through GIS.

This approach fed into the undergraduate programme, whose inshore survey module contained the above approach, but has now spawned a joint GIS/ECDIS module: Digital Data in Survey and Navigation. Supported by a pre-requisite in Marine Computer Applications it will allow a technical appreciation of the subject, more deeply developed, and with greater hands-on time of readily available tutorials.

The Post-graduate Diploma has recently been revalidated, bringing a twenty year old format into the 1990s approach of modularisation and semesterisation. Whatever the arguments for or against these two approaches, the time of change was utilised to commence greater GIS teaching and a GIS workshop. Once again, off-the-shelf tutorials are used to illustrate the facilities of GIS.

The new MSc will probably not have a new module in GIS. GIS are not the be-all and end-all, and at present, the decision is to use a ready made module in Remote Sensing and GIS offered on a parallel MSc within the Institute of Marine Studies. However, the differences in approach between the output of that course (marine scientists), and ours (research in hydrography) will be highlighted.

8. Conclusion

This paper has looked at the new developments possible through the utilisation of GIS, and the way in which the syllabus is being modified to incorporate the subject. Change is continuous, and we must be careful both to keep up-to date with new technologies and work opportunities, and yet not to lose touch with the specialisms that form our unique educational programmes.

I'm sure you know that Universities could always benefit from support from the commercial community. One spur for gathering our own coastline is that data ownership then rests with us - purchasing external data can be very expensive. Additionally, we are grateful for company support through equipment and software loans ... but there is always room for more up to date investment. In

return we offer a research base to forward your interests. Finally, you have seen how we have benefited from the expertise of others' talks, and I hope this will continue.

RICS, Exeter, Wednesday 20th January 1999

PP 1

V J Abbott, Senior Lecturer in Hydrographic Surveying,
Institute of Marine Studies, University of Plymouth.

Preamble

PP 2

GIS is not just about digital data storage but about data manipulation and analysis. They are commonly computerised.

Digital data is increasingly common, but not ubiquitous, and there are particular costs associated with accessing and converting paper-based data. When the original format is digital, it can lead to very large datasets[3].

Single tasks are rarely worth undertaking within a GIS, but the investment in data input can quickly prove beneficial when it turns out that the same dataset can be used again and again[4]. However, not all tasks require the exact same dataset, and there may be problems over such issues as precision, currency, geographical limits[5], or others.

It may well be easier to manipulate digital data in simpler software than GIS. Arthur Allan, in a revision of a standard land survey text[6], refers to the use of spreadsheets for standard computations. Databases or digital maps provide particular facilities and often-greater usability than GIS (cf UKDMAP). Research by a Plymouth graduate[7], pointed to an under-use of GIS facilities, due, perhaps, to the lengthy initiation needed into a more complex system. Additionally, increasing functionality blurs the distinctions between simpler and more complex software.

Nevertheless, until there is spatially-related information with an ability to correlate datasets, then (despite manufacturers' claims) the software is not really a GIS. Once at the point of having digital data in a GIS, then the benefits can increase productivity many fold.

The scope for marine GIS

A University of Plymouth hydrographic surveying graduate[8] has recently taken up a post with ESRI (the manufacturers of the dominant GIS, ArcInfo) in California. In discussing with him the range of possibilities for product development, I suggested the following topics. Some are specific, some general, and some may be partial to a wider system:

PP 3, 4, 5

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[3] Humphreys R G, 1989, Marine Information Systems, The Hydrographic Journal, No 54, The Hydrographic Society

[4] Ontario

[5] For example, local observations quoted in latitude and longitude, referenced to the GPS satellite system WGS84 will be 100 metres from the same values referenced to the Ordnance Survey mapping system, OSGB36.

[6] Allan A L, 1997, Practical Surveying and Computations, Laxtons, p xiii

[7] Ms Rose Gillon, BSc, now undertaking an MSc at Bangor, Wales

[8] Mr Simon Evans, BSc, MSc, Manager, Applications Department, ESRI, Redlands, California

Coastal Zone Management
Natural Resource Management
Oil Spill Management
Electronic Charts (EC)/Electronic Chart Display and Information System (ECDIS)
Waste disposal
Environmental
Aggregates and offshore nodules mining
Geodesy
Construction
Aquaculture/Mariculture
Submarine Telecommunication Cables
Port Authorities
Data brokerage
Insurance

The visualisation element of GIS may underpin work on ECDIS (and the International Hydrographic Organisation's standards, S57, on their symbols, S52, on the addition of data (such as tides) to raster charts (and for a different example, see the displays to follow).

Example Applications
PP 6
The following are examples of current and prospective marine GIS
a company utilising the Admiralty *ARCS* system,
a port survey team's involvement with GIS,
tide data over wide areas,
MetOcean data supporting exploration,
ECDIS (S57) chart production using a GIS,
my own research into coastal zone management.

1. PP 7 - 8
A Norwich company's work illustrates the advances in digital mapping and the gains to be had in add-ons. They are add-ons provided by the company, and do not offer the user direct opportunities for change or analysis.

ARCS is a raster based system, and raster development has support from some hydrographic offices and the user community[9]. In particular they provide:

· Charts that are exact facsimile reproductions of existing Admiralty paper charts, are fully correctable and officially approved.
· A Notice to Mariners service that is equivalent to that provided for paper charts, and a correction process that is fast and automatic.
· A data format that is system independent, supports fast data-handling and accurate geographical referencing, and provides links to notes and diagrams on charts, and to Preliminary and Temporary Notice to Mariners.

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[9] Harris, P, Hydro 99, Raster Charts – Do they have a future, Paper 20, p 2

2. PP 9-16
The Port of London Authority[10] has gone down the digital chart route, utilising a GIS as a relational database. This has the benefit of keeping checks on updates.

The figure illustrates the wealth of data being handled, the range of separate storage devices and the transformation that takes place to out put the required product. Information handling is made much safer through use of the digital form. In particular, each object is assigned a unique identifier by the GIS which is passed through the converter. It is this which allows objects in the ENC to be identified by the respective systems for updating or correction.

For some years now the PLA Hydrographic Service has supplied the most significant navigation sounding data on small scale (1:250,000), A4 paper chartlets called "*Miniplots*". The objective has been to disseminate this most critical depth information to both the Port Control Centre and Pilots in as short a time as possible. This is normally achieved on the day of sounding and certainly within 24 hours of the survey being landed. PP 11

Changed data flows, quicker updates, and faster dissemination have resulted from this new approach. These last slides from the Authority show ...

3. PP 17 - 21
At Hydro 99, Wayne Collier[11] introduced the National Oceanic and Atmospheric Administration (NOAA)'s Tidal Zoning software. The complexities of working over large areas include a constantly changing tidal regime, and with it a constantly changing reference datum.

At sea and up rivers, a fixed reference level is rarely used. Instead, a low water level is chosen so that depths shown on the chart will be close to the minimum likely to be experienced by the navigator – it is a safe water reference level. In addition, predictions are rarely used in the original data gathering process as the actual tidal height may vary by some tenths of a metre from the predicted value.

Combining these two issues together - the need for constant monitoring of tidal values to an occasionally changing reference level (which change can occur during a survey line) meant that real time corrections were too complicated to determine, and even in post processing, the situation could be complicated.

Yet the various parameters are well known – it suited computerisation.

NOAA already used MapInfo, and were able to utilise the system for planning, on-line surveying and post-processing. In addition, checks on the tide prediction service, on

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[10] Greenland A and Pinder J, The management of hydrographic information within a major UK port, Hydro 99, Paper 22
[11] Collier, W. *et al.*, Managing Tide Information, Hydro 99, Paper 1

tide gauges themselves, and investigations into effective tide monitoring by GPS are being supported by this software.

4. PP 22 - 25
I'm not sure this falls entirely within my own definition of GIS, but there is a geographical search capability – so it may be OK.

The purpose of Seadata is to provide MetOcean data for exploration areas, and to make it available to the unskilled in such data. Although more a metadata system than a data repository, there is much to be found within the software (afterall, one man's data is another's metadata – it's often a matter of scale).

The climatology for each region makes extensive use of maps, figures and tables to describe bathymetry, winds, waves, currents, water levels and water density structure. It contains general environmental features rather than statistical criteria suitable for detailed design purposes.
Due to the commonest search tool being location, it starts with that
PP 23

5. PP 26
Like the first set of data, *ARCS*, the company involved in this work started with, indeed developed, the *ARCS* packages. They have now moved onto vector data, and are involved in producing S57, ECDIS compliant data using GIS technology.
They are using the latest in GIS programming – Object Oriented programming, which embeds attributes into the design of the features. This has the advantage of protection against mis-use. There are supposed benefits in both data capture and the modelling process of chart production.

6. PP 27
My own research is investigating the information needs for coastal management in the south west of England (if you received and returned my questionnaire – thank you very much !). Today, though, I'll mention the more general benefits you might obtain from a working system.

First to set the context, as with such a verbose topic it can mean many different things. The most powerful group, the civil engineers, tend to mean work in defence of the coastline, although it has expanded from "holding the line", to include managed retreat.

My definition, however, is to consider the holistic nature of multiple use, and to provide a framework for conflict resolution and decision support. That it enters the political sphere is not my concern – as a surveyor I am involved in data gathering and information provision. Therefore I am interested in displays such as:

[Power Point presentation as per Figure 3.1 and 3.2 in this PhD]

Information for the Coastal Zone

Abstract

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For coastal zone management (czm) to be holistic it should be able to assimilate all views, yet the practicalities of data overload preclude this. For czm to be integrated, it should be able to manage all the inputs before disseminating results.

The first step - to assess a selection of issues and their supporting data - is the main topic of this paper. The second topic, of integration, is alluded to as a by-product of the research.

Thus, the paper gives two fictitious examples of multiple dataset use to illustrate the breadth of data required to address even single issues. It then proceeds to a report of the author's research, commenting on
the determination of the relevant constituency for czm
initial interviews to establish a questionnaire
the design of the questionnaire, and
the reliability of the results.

Some initial results of the work are given, including a statement of the most significant issues as determined by a local coastal zone user group and the most significant datasets required to address such issues. A comment on the use of modern analytical software is included.

The paper ends with work to be undertaken within the research to bring it to its internal conclusion and comments on requirements for external work.