Aspects of Debris Pollution at Selected Bristol Channel Beaches

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APPENDIX II (EA/NALG PROTOCOL) HAS BEEN REDACTED IN THIS DIGITIZED VERSION DUE TO POTENTIAL COPYRIGHT ISSUES.

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ABSTRACT

Thirty-three beaches along the Bristol Channel coast were investigated for litter amounts, distribution, perception and source. 'Added value' was given to the study by an investigation of litter aspects at 12 beaches along the mid and north Wales coastline, together with litter gathered from 4 Turkish beaches and UK roadsides. Over a 5 year period litter abundance at a pocket cobble beach decreased 38%, from 1,689 to 1,040 items. After one total beach litter clearance 46% of the total amount returned within two weeks. The use of lay persons to gather data on litter pollution was verified and no statistical difference was found between inexperienced/ experienced surveyors with respect to data collection results. Amounts of litter exhumation and burial from a cobble ridge were related to weather conditions. On one occasion between spring tides, out of 209 litter items counted on the ridge, 39 items had been exhumed indicating the potential and importance of litter burial. Areas below the current strandline contained on average *circa* 1% of all beach litter. Species Curve analyses showed that >80% of beach litter could be found in a 25m width transect. A long linear beach had litter abundance ranging from 201 to 1525 items of litter/100m stretch. On these beaches several survey points are recommended. Principal component analysis of litter found on Bristol Channel beaches showed the western end as being heavily influenced by shipping/fishing sourced debris; eastern extremity beaches were subject to greater inputs from river and land sources. Turkish beach/UK roadside surveys of litter, formed a distinct land user source group when compared with the diverse litter found on Bristol Channel beaches. Questionnaire studies (2727 persons) related to public opinions of beach litter and beach management issues indicated that: sewage related debris and hazardous items were ranked as the most offensive litter items; 52% of respondents were unaware of *any* beach award; beach choice was primarily decided by the presence of clean sand and water; beaches should be graded by a 'star' system; no dogs should be allowed on a resort beach during the bathing season. Photographs of litter *perceived* to be a possible danger to health produced a high level of offensiveness, regardless of any *real* danger. Litter pollution must be viewed holistically, with debris on beaches not being the only consideration. It should be tackled with consideration for those involved in its production, and those responsible for its continuing presence.

1. INTRODUCTION

Coastal areas form an important interface between land and sea. Although they cover only 10% of the earth's land area, they are home to over 60% of the world's population (Lakshmi and Rajagopalan, 2000). Marine debris is a problem that affects these coastal areas and the sea floor at all depths, and its impact is of global significance. It has been recognised as a serious pollutant for around 30 years (Carpenter *et al.*, 1972; Scott, 1972; Cundell, 1973), but has only gained widespread recognition in the past decade. Marine debris has been defined as 'any manufactured or processed solid waste material (typically inert) that enters the marine environment from any source' (Coe and Rogers, 1997, page xxxi). Marine debris is also often termed marine or beach litter (Rees and Pond, 1995a; Uneputty and Evans, 1997).

The sources of this form of pollution may be from the land, or from the ocean itself. Once in the marine environment debris may remain for many years, particularly if it is plastic, and numerous world-wide beach based debris studies have recorded plastic as the dominant material (e.g. Gilligan *et al.*, 1992, in the USA; Garrity and Levings, 1993, in Panama; Benton, 1995, in the Pitcairn Islands; Jones, 1995, in Australia; Bowman *et al.*, 1998, in Israel; Williams and Tudor, 2001, in the UK). Indeed, plastics have been considered a threat to the marine environment whose importance will incrementally increase through the 21st century (Goldberg, 1995; 1997). It has been stated that the 'major marine contaminants in their order of importance are: nutrients from urban sewage; plastics from land and sea-disposal; synthetic organic compounds such as pesticides and industrial chemicals; and oil from routine transport and spills' (WRI, 1990, page 179). The problems created are chronic and potentially global, rather than acute and local or regional as many would contemplate. Beach litter clean up schemes, particularly those requiring public participation, have led to increased public awareness (e.g. MCS, 2000). However, this does not appear to have led to any great reduction in the amounts of debris being found on beaches world-wide.

Widespread acknowledgement now exists that coastal litter sources can be classified into two broad groups: sea-borne sources and land-based sources (Fowler, 1987; Corbin and Singh, 1993; Rees and Pond, 1995a). Sea-borne sources include offshore installations, commercial fishing vessels, cruise ships, recreational vessels and merchant and military ships (Simmons and Williams, 1994). Land-based sources include beach users, riverine inputs and direct land inputs. Most of the past concern has focused on debris discharged from sea-borne vessels. There is now (in 2001), extensive evidence that land-borne discharges are a major source of marine debris and are believed to be a greater contributor of pollutants to the marine environment than vessels (Bean, 1987; Faris and Hart, 1995). Debris can be blown, washed or discharged into water from land. For example, Nollkaemper (1994), has shown that combined sewer overflows, storm water discharges, run-off from landfills sited near rivers and in coastal areas, absence of waste services or landfills in rural areas, recreational beach users and fly tipping, all contribute to debris ending up on beaches or in the oceans. While large portions of the marine environment appear not to have been significantly affected by contamination from land based sources, coastal environments are being greatly affected on a global scale. Due to their source characteristics and travel routes, the majority of contaminants entering the marine environment from land based sources are delivered to the nearshore, within which many are trapped and cycled / recycled (Windom, 1992).

Litter in the marine environment leads to numerous problems, be they economic, health related or biologic. It is widely recognised as a serious pollutant which can be costly to clean up. For example, Gilbert (1996), showed that the County of Kent, UK, incurred direct and indirect costs of around £12 million resulting from marine and coastal pollution. The increasing costs of cleaning beaches has led those involved with coastal issues to seek out more effective and lasting measures/solutions of dealing with beach litter. Difficulties in clearing litter from beaches are often compounded by rapid re-accumulation rates (Williams and Tudor, 2001). Prevention at source is one of the most important strategies in enabling the reduction of litter pollution, but for this aim to be realised strong links between measurement and management need to be established. Indeed, 'there is an increasing understanding of the links between the original sources of aquatic litter, the complex mixture which ends up in the aquatic environment, the risks this litter poses and the alternative management options' (Earll *et al.*, 2000a, page 67; Figure 1.1).

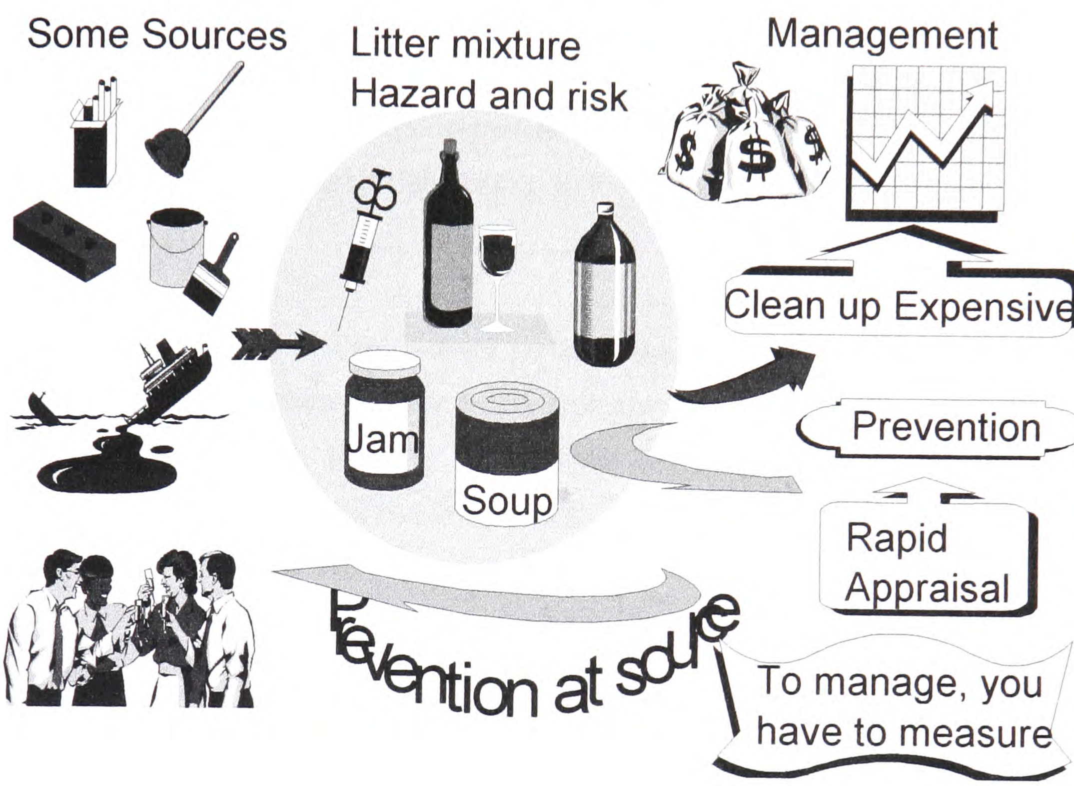

Figure 1.1 Aquatic litter linkages (adapted from Earll *et al.*, 2000a)

While there is a need to be able to monitor litter pollution in the marine environment, there has been no *widely accepted* standardised approach to enable this to be carried out. Reasons for this are possibly due to: beaches are extremely variable in size, structure and processes; location of litter on beaches is not constant and depends on many physical processes (Williams and Tudor, 2001); types, quantities and sources of litter make its composition individual; aims and objectives of litter studies differ between interest groups, individuals and organisations (Earll *et al.*, 2000a).

Litter studies conducted on beaches face problems in that the amount of debris is influenced by beach dynamics, oceanic circulation patterns, weather, debris characteristics, beach cleaning operations, offshore recreation and commercial practices (Faris and Hart, 1995). These problems do not diminish the fact that the beach survey method is the most appropriate technique in allowing estimates of amounts of litter in the marine environment. It is economical, can be conducted by inexperienced surveyors with proper instruction, carried out in almost all weather conditions and does not require large amounts of equipment. Variations on the beach survey method make it a versatile tool to be used for baseline studies and trend assessment studies to assess land-based and ocean-based litter (Rees and Pond, 1995a).

In this study, several distinct methodologies relating to litter have been utilised. It was felt that as these methodologies vary greatly, it would be more appropriate to include them in the relevant sub-sections of the Results and Discussion chapters (Chapters 4 to 6), rather than a single methodology chapter.

Thirty three beaches on the north and south shores of the Severn Estuary/Bristol Channel were studied with regard to amounts, types and distribution of beach litter. Interviews with 2067 beach users were carried out at eighteen of these beaches in order to obtain information regarding beach user perception of the litter problem. As an 'added value', twelve further beaches in Mid and North Wales were also assessed, with 660 questionnaire responses received at seven of these beaches (Figure 3.1; Table 3.1; Appendix I). In total 2727 questionnaires were completed.

A model for classifying and measuring beach litter pollution that is both standardised and generally subscribed to, is widely seen as an important management, prevention, and communication tool. The National Aquatic Litter Group (NALG) has laid the foundations of a model that may meet the demands required to produce an acceptable and usable system (EA/NALG, 2000; Appendix II). This model, commonly known as the 'ABCD model', has been heavily utilised in this work and aspects exhaustively tested.

The main aims of this study were:

- Assessment of beach litter sources along both coasts of the Bristol Channel, the hypothesis being that marine influences are apparent in litter at the western end of the region, riverine to the east.
- Testing and refinement of a standardised approach for comparing beach litter pollution, i.e. the 'ABCD model' (EA/NALG, 2000), and the usage of 'non expert' personnel to conduct litter surveys.
- Investigating public perception of litter with respect to beaches.
- To compare a variety of different beach types, e.g. resort, Whitmore Bay; semi-resort, Rest Bay; pocket, Tresilian Bay; open coastline, Freshwater West; linear, Merthyr Mawr, with respect to thresholds associated with litter. These included experimental work associated with transect size/widths analyses; short and long term litter tracer movements on a cobble beach; comparison of litter percentages below strand lines.
- To quantify the amounts of litter on certain beaches fringing the Bristol Channel. A series of in depth analyses was carried out at one pocket cobble beach to establish: medium-term (5 years) changes in litter abundance; re-colonisation rates of the beach by litter after complete clearance; and, the presence and quantification of buried litter.

In essence, aspects covered in this work have been the investigation of litter with respect to the use of lay people for data collection, time trends, movement patterns, survey site size/selection, cross/along beach distribution, sourcing, and public attitudes (opinion, recognition, perception). Figure 1.2 indicates a possible future scenario with regard to litter management; detailed field work should be analysed by researchers and managers, placed on a database and results promulgated to various organisations/public. The link between data gathering, analysis and subsequent dissemination must be established and maintained if any impact is to be made in reducing beach litter levels (Figure 1.2).

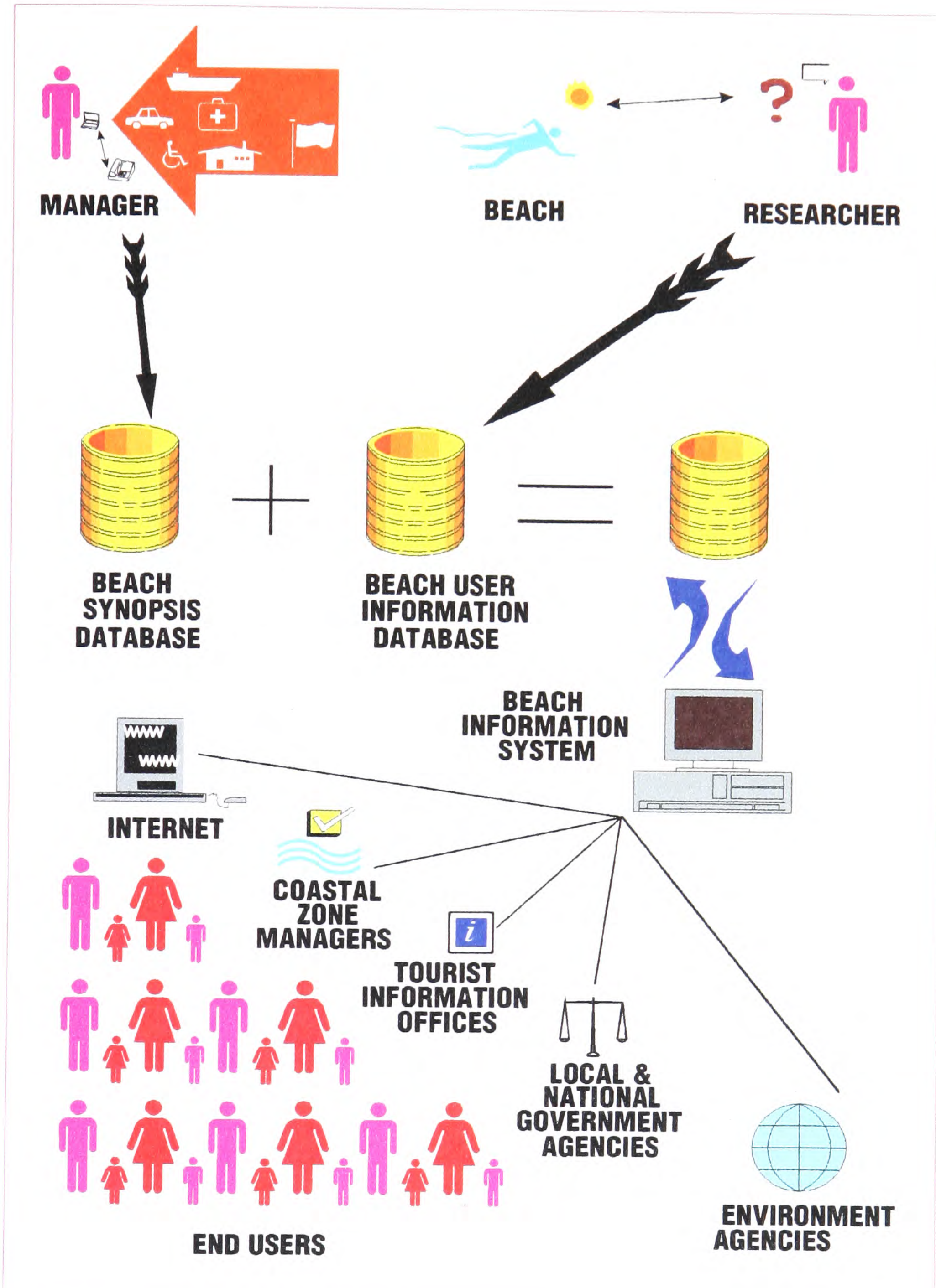

Figure 1.2 Beach litter database schematic

2. LITERATURE REVIEW

2.1 Litter Sources

Identifying from which source debris has originated is a difficult task. On occasions the source of the pollution is clear and local (Johnson, 1989; Walker *et al.*, 1997). All too often sources are not obvious and can be international either in terms of shipping (Dixon, 1995), or land based litter from other continents e.g. American litter on west coast European shores (Olin *et al.*, 1995). The movement patterns, sinks, and degradation rates of marine debris are still not completely understood, although there is recent research in this area (Williams and Simmons, 1997; Bowman *et al.*, 1998; Williams and Tudor, 2001). One cannot generalise or make assumptions about sources, and site specific measurements will almost always be required (Earll *et al.*, 2000a). At present there is no accepted methodology that enables researchers to link litter items to their source, the conceptual step taken to link litter to a source requires:

- the identity of the item is known or at least described systematically
- the function and application of the item is understood, and
- that quantities of the item are measured.

Evidence of sources can be based on very specific local knowledge. For example, Willoughby (1986), found that rubbish slicks on islands surrounding the city of Jakarta, Indonesia, contained large quantities of freshwater hyacinth, a plant which does not grow on the islands, thus linking the source of the litter to rivers of the mainland. Rivers and streams throughout Indonesia have traditionally been used as dumping grounds for every sort of waste, and a large proportion of this inevitably reaches the sea, especially around coastal cities such as Jakarta. Local villagers insisted their litter was brought from Jakarta during monsoon periods. Such local knowledge and anecdotal evidence can be extremely useful, but this is a further illustration that as yet there is no prescribed and formulated method for enabling sourcing to be carried out.

Vauk and Schrey (1987), established through the use of labels or imprints on debris items and wind directions that over 99% of items in their survey area were derived from ships. Of the 8473 items counted during their surveys, only 539 had any manufacturers imprint (6%). There are reports of direct observations of boats dumping bags of litter in to the sea (e.g. Garrity and Levings, 1993; Clunie and Hendricks, 1995). Some estimates have been made of the litter inputs made by sea faring vessels (e.g. NAS, 1975; Horsman, 1982), but no comparable estimates have been made for other potential sources of marine debris.

Nets and line used in fishing can be discarded or lost accidentally in numerous ways which can lead to various problems; for a full discussion of these see Jones (1995), and Johnson (1989). Fishing items, such as trawl web, are known to be washed back to sea after settling on beaches (Johnson and Eiler, 1999). Clean up would therefore reduce the number of these items in the system, but the vast amount of time required to clean beaches would be unnecessary if better practice and greater education was used. There are numerous occasions when litter items can come from more than one source, and determining which source is the primary polluter is extremely difficult. For example, plastic pellets discovered on beaches have been found to have more than one potential source, i.e. plastic manufacturing companies, or ships bringing in this raw material from further afield (Gregory, 1977; Shiber and Barrales-Rienda, 1991).

The importance of location where litter sources are concerned is shown in that, 'there are indications that most Mediterranean coastal litter is land-based, in contrast to the reported marine-based litter on the western European shores' (Gabrielides *et al.*, 1991, page 437). Whilst the evidence for the Mediterranean certainly points towards beach user sources (Golik and Gertner, 1992, Williams and Markos, 1995), there is contrasting evidence regarding western Europe, particularly the UK, with respect to marine origins of litter. Certainly in heavily utilised shipping lanes this is true (Gilbert, 1996), but in the Bristol Channel region the impact of marine derived litter is known to be minor in eastern extremities (Williams and Simmons, 1997).

Many remote areas of the world also experience high levels of beach litter, with the debris present on beaches in such areas unlikely to have been locally produced. This litter had probably drifted considerable distances before being deposited (Benton, 1995). Other studies have concluded that local land-based activities, such as harvested timber which often ends up in coastal waterways in North America (Perham, 1987), were the primary source of debris (Ross *et al.*, 1991; Shiber and Barrales-Rienda, 1991; Corbin and Singh, 1993; Thornton and Jackson, 1998). Additionally, proximity to large population centres and poor waste management facilities are other factors which can lead to high levels of beach litter from land based sources (Willoughby, 1986; Uneputty and Evans, 1997).

Debris can travel vast distances and remain in the marine environment for long periods. For example, surveys have found that a bottle released near Caracu, Venezueula, reached the Florida Keys four months later (Armstrong, 1994). There are other anecdotal stories, such as a message in a bottle turning up in New Zealand, forty-four years after it was thrown from a ship into the Indian Ocean (BBC Online News, 2000).

2.2 Case Studies - Extent of Problem

Comparisons of debris amounts are generally complicated by differences in methodology among studies, beach substrates and environmental factors influencing the transport of debris items. Although comparisons are difficult, certain similarities can be noticed. In a survey of debris along the Caribbean coast of Panama, Garrity and Levings (1993), found that 56% of the items were made of plastic; 89% of this plastic debris related to consumer or household goods; that the country of origin of the debris was related to distance from the survey site. This agreed with the findings of Dixon and Cooke (1977). Garrity and Levings (1993), concluded that the major sources of debris in their study were, *1.* Local household waste, *2.* Shipping, and *3.* Near shore marine activities. They found no evidence of substantial input from industrial, recreational or offshore commercial fishery sources.

Corbin and Singh (1993), in a study of Caribbean island coastlines, showed that the amount and kind of items found were associated with types of coastal activities and variations in population density. Even though the study area was a busy lane for liners and other ships passing through the Panama Canal, little evidence was found of debris from distant sources or debris discarded from cruise ships washing up on the coast. A study of marine debris at Bird Island, South Georgia, by Walker *et al.*, (1997), helps to illustrate the problem of generalising about the sources of such wastes. The findings were that the source of much of the marine debris was local fisheries, with the majority of debris being jettisoned by long-line fishing vessels.

Williams and Simmons (1997), conducted surveys on beaches fringing the Bristol Channel, UK, an estuarine area with relatively low levels of shipping. The authors stated that 'the higher number of beverage and dairy product containers tend to indicate greater contributions from land-based sources, either from beach users or riverine inputs' (Williams and Simmons, 1997, page 1161). Very low amounts of foreign material were encountered during the study, suggesting low levels of ship discards. In contrast to this, studies carried out by the Tidy Britain Group in other parts of the UK have found that the primary sources of debris within their study area originated from shipping vessel sources (Dixon, 1995). As stated earlier, comparisons between locations are difficult, any generalisation about sources, persistence and dynamics of marine litter would therefore be unwise.

Debris on beaches is a world-wide problem and there is no region that has escaped this form of pollution. From the remote Pitcairn Islands (Benton, 1995), to Europe (Phillip *et al.*, 1995; Williams and Markos, 1995; Velander and Mocogni, 1998), Australasia (Gregory 1977; Wace, 1995; Haynes, 1997), North America (Gilligan *et al.*, 1992; Ribic, 1998; Thornton and Jackson, 1998), Southern Africa (Ryan and Maloney, 1990), the Middle East (Anbar, 1996), and South America (Bourne and Clark, 1984; Goodall, 1990), litter can be found on beaches.

2.3 Effects of Marine Litter

2.3.1 Effect on Humans

Numerous studies of beach litter have commented on the potential danger to visitors, mainly from foot lacerations caused by stepping on glass or discarded ring pull tabs (Olin *et al.*, 1995; Philipp *et al.*, 1995; Williams *et al.*, 2000a). Other, more dangerous items have been encountered on beaches. For example, munitions and containers of corrosives have been found washed ashore, along with pyrotechnics and packaged hazardous goods (Dixon and Dixon, 1979). A further example occurred in 1993, off the coast of France, with an accident involving the ship '*Sherbo*' in which 60,000 bags of a pesticide similar to nerve gas were lost overboard (Olin *et al.*, 1995).

Attention has turned recently to the less obvious health risks that can feature on beaches. These are medical waste and sewage related debris (SRD). Although the risks are considered to be relatively low (Rees and Pond, 1995b, Nelson and Williams, 1997), any external contact with infected sanitary products, fluids in syringes, other medical equipment, or ingestion of any of these could cause disease. Forty needlestick accidents on bathing beaches were reported between 1988 and 1991 to the UK Public Health Laboratory Service Communicable Disease Surveillance Centre (Philipp, 1993). Medical waste has appeared on holiday beaches and in some places 'sharps' containers are now being issued to lifeguards, who are advised not to go barefoot on these beaches (Godlee and Walker, 1991). Studies carried out in Panama by Garrity and Levings (1993) also encountered significant levels of medical waste.

Beach debris provides information on debris within the oceans even though it is uncertain whether beach litter is representative of ocean litter (Jones, 1995). It is however the *only* realistic indicator of the amount and type of debris present in the ocean (Walker *et al.*, 1997). SRD on a beach would seem to suggest that the adjacent waters are contaminated with sewage, resulting in a health risk to sea users. Bathers exposed to sewage contaminated water have a high risk of skin and ear infections (McIntyre, 1990). In 1990, it was reported to the UK House of Commons that the aesthetic quality of recreational waters is becoming more important as the public becomes increasingly aware of the risks (House of Commons Environment Committee, 1990).

Attention to problems relating to the coastal zone have been based more upon public perception than on any scientific knowledge or evaluation of sources, fates and environmental effects (Windom, 1992). Associations have indeed been made between the public perceptions of items affecting the aesthetic appearance of bathing water and bathing beaches, and the gastro-intestinal symptoms experienced after bathing in sewage polluted water (University of Surrey, 1987; Nelson *et al.*, 1999a). It has been reported that 'overt filth seemed to correlate with microbial filth' (Eykyn, 1988, page 1484). Conversely, there are suggestions that the public debate on sewage in bathing water rarely makes any distinction between aesthetic impact and actual health risk (Jones *et al.*, 1991). To try and counter any ambiguities, the Government White Paper *'The Health of the Nation'* (DoH, 1992), recognised the need for research to pinpoint the association between health consequences and the quality of the environment.

2.3.2 Economic Effects

The problem of litter in the marine environment leads not only to potential health risks, but also to economic losses. Stranded debris has direct and indirect social and economic costs to shoreline communities, with the financial strains imposed by such debris not always easy to quantify, or to appreciate. Economic loss has been split into two areas; loss to fisheries, and loss to tourism.

Fisheries

The economic impact of debris on fishing has been studied over many years. Economic losses have occurred due to the fouling of trawl nets by bottom debris, blocking of water intake pipes by plastic sheeting and, propeller foulings (Jones, 1995; Lart, 1995). Damage to ships following collisions with metal drums or wooden pallets at sea have also been reported (Dixon and Dixon, 1981). Costs result mainly from the repair of damage and lost time.

'Ghost fishing' affects commercial fishing interests. This hazard occurs as a result of lost or abandoned nets and traps, which leads to the capture of target and non-target species. This will reduce reproductive potential, as immature fish that have not produced offspring are removed from the population. Large items of debris are capable of tearing nets and other fishing gear and the presence of certain debris can lead to entire catches being discarded. Data is limited of the costs incurred from these encounters with litter (MCS, 2000).

An extensive study carried out by Nash (1992), concerned the impacts of debris on a group of subsistence fishermen. The findings were similar to others relating to commercial fishing, including propeller entanglements, fouling of nets, damage to fishing gear. In addition, during the gathering of shellfish and molluscs by hand, waste such as glass can lead to foot or hand injury. An important distinction between commercial and subsistence fisherman is that even a minor decrease in yield can result in a lack of provision for the latter with respect to basic needs, such as food. This can lead to abandonment of fishing completely (Nash, 1992). The knowledge that marine debris can cause livelihoods to be lost might be a greater spur for authorities to deal with the problem than knowing of damage to wildlife.

Hall (1998), in a study in the Shetlands, UK, found that the costs associated with the time spent clearing and repairing nets was £57 - £114 per week, and the loss of contaminated fish was estimated to be worth £300 - £1,000 on each occasion. The costs associated with repairing nets damaged from snagging on debris on the seabed ranged from £2000 - £10,000+. The total cost world-wide is likely to be substantial for the commercial fishing industry. Hall (1998), also showed that there is potential for farms adjacent to the coast to become affected by marine debris; wind blown litter can collect on fences, accumulate in drainage ditches, and be ingested by or entangled around livestock.

Aesthetic quality, perception and tourism

The loss of tourism and recreational potential are very real impacts of marine debris (Nollkaemper, 1994; Nelson *et al.*, 2000a). A coastal community that relies heavily on tourism for its livelihood can have its income severely depleted by marine debris (Corbin and Singh, 1993). Indeed, Windom (1992), suggested that the greatest impact associated with marine litter is not to organisms, but to the economic loss associated with the reduction of amenities. The money that can be made, or indeed lost, from tourism and related industries is enormous; the UK maritime leisure industry is worth £8 billion a year, with £6 billion relating to seaside holidays (Maritime Technology Foresight Panel, 1996).

The aesthetic value of beaches can be reduced by the appearance of plastics, SRD, and other items of litter (Pruter, 1987; Jones, 1995). People prefer to visit clean beaches, with both land and water free of litter, rather than those containing various assortments of marine debris. The public may avoid certain beaches if they find their appearance unacceptable (Williams *et al.*, 2000a). The effect of aesthetic issues on the amenity value of marine and riverine environments has been defined by the World Health Organisation as: Loss of tourist days; resultant damage to leisure/tourism infrastructure; damage to commercial activities dependent on tourism; damage to fishery activities and fishery-dependent activities; damage to the local, national and international image of a resort (Philipp, 1993).

Many of these problems are manifest in developing regions such as the small island states of the Caribbean and South Pacific, where natural resources may be limited and economic development is largely dependent upon coastal tourism (e.g. Siung-Chang, 1997; Gregory, 1999a). Poverty is both a cause and a consequence of environmental degradation: when people are poor, they have severe short-term needs and do not have any incentive for long-term management of resources. Rising income levels allow people to satisfy their basic needs for food, shelter and clothing. This allows them to pay attention to the quality of their lives and condition of their habitat (Reilly, 1990). Particular problems lie with waste disposal and management whether it is generated on land or by visiting and passing cruise vessels (Morrison and Munro, 2000). On an atoll or small high island an ever expanding mountain of waste is difficult, if not impossible to handle (Tutangata, 1999). There are sharply conflicting interests between the sophisticated demands of most tourists and the environmental degradation inflicted upon local inhabitants who also have aspirations for a better life-style.

Cause and effect relationships have been established regarding public perception and lost revenue. Beach closures along with public perception of contaminated bathing areas in 1987 and 1988 resulted in approximately US$2 billion of lost revenue for New Jersey and New York states. The losses were ascribed to debris. Also, if any area is consistently polluted with debris then this can lead to falls in property values (Rees and Pond, 1995a).

As well as losses from tourism there are continual costs of beach clean up efforts that take time and money. Cleaning the coast costs local authorities thousands of US$ per year. Additional costs are incurred when hazardous containers are found and have to be recovered from beaches (Dixon, 1992). The cities of Santa Monica and Long Beach in California, USA, each spent more than US$1 million in 1988-9 to clean their beaches and costs continue to rise (Kauffman and Brown, 1991). Another European example is the Swedish Skagerrack coast where more than 6,000 m^3 of litter was collected in 1993. Approximately 9,000 working days over 4-5 months with a total cost of around £1 million, gave the fiscal price of clearing marine litter at £156 / m^3 (Olin *et al.*, 1995). Harbour authorities in the UK also have to pay for the costs of keeping navigational channels free from litter, Lerwick Harbour, Shetland, for example, accrues costs of £720 per annum for harbour clearance (Hall, 1998). At Studland, Dorset, UK, one million visitors per year along a 6km stretch of beach resulted in 12/13 tonnes of litter collected weekly in the summer months at a cost of £36,000 per annum (Williams *et al.*, 2000a).

2.3.3 Biologic Interactions

The impacts of marine debris on wildlife are generally divided into two main groups: entanglement and ingestion (Winston *et al.*, 1997). Entangled animals can drown, be fatally or seriously wounded, or have reduced ability to catch food, travel or avoid predators. Ingested material can block and damage digestive tracts and reduce feeding (Jones, 1995). It is estimated that over one million birds and 100,000 marine animals and sea turtles die each year from entanglement in, or ingestion of, plastics (Faris and Hart, 1995). Of the 115 species of marine mammal, 47 have been known to become entangled in and/or ingest marine debris (MCS, 2000).

Entanglement

The dangers to marine animals and birds caused by entanglement in man-made debris have been well documented (Carr, 1987; Fowler, 1987; Arnould and Croxall, 1995). In areas of particularly heavy maritime traffic or where oceanic currents naturally accumulate surface material, these problems can be particularly acute (Walker *et al.*, 1997).

A study carried out by Lucas (1992), on Canadian beaches between May 1984 and September 1986 produced data on beach litter composition and entanglement of marine animals. Results found that Harbour and Grey seals were entangled on Sable Island beaches in strapping, net, rope, and other items. Of 241 Grey seal pups handled during research, 2.5% were entangled. Further findings included, seabirds tangled in trawl net, six-pack yokes and balloon ribbons; a Sable Island horse was also found on the beach with both hind legs entangled in a bundle of plastic strapping. The discovery of the entangled horse indicates the threat posed to terrestrial animals, as well as marine species. Effects of entanglement of marine animals in debris can be broadly split into four areas:

- Large items of debris trap animals, which may result in the drowning of air-breathing species, asphyxiation of fish species that need constant movement to respire, or death by starvation or predation (MCS, 2000). Large or heavy pieces of debris are also liable to drag animals down to the sea floor.

- Smaller items of debris greatly increase drag factors. This will lead to an increased vulnerability to predators and, a decreased ability to forage, which ultimately leads to starvation (Feldkamp, 1985; Loretto, 1995).

- Smaller debris items can become snagged on the sea floor and subsequently trap animals.

- Entangled objects can tighten around the animal leading to restrictions in growth. This can lead to death or inhibit the ability to reproduce (Faris and Hart, 1995). Entanglement can also affect feeding, as the majority of entangled seals have debris wrapped around their heads and necks which can affect ingestion of food (Emery and Simmonds, 1995).

Ingestion

The problem of ingestion appears to have attracted less attention and research than the entanglement of animal species. Plastic ingestion often leads to a less acute effect than entanglement; this could be due to the gradual accumulation of plastic debris in the gut of some animals (Fry *et al.*, 1987; Faris and Hart, 1995). Some species may be able to regurgitate or excrete debris, but some plastics do not appear to pass through the intestines of certain seabirds as there is a marked absence of debris from droppings (Faris and Hart, 1995). Seabirds and turtles appear to confuse litter for food (primary ingestion), or ingest litter within other food (secondary ingestion), these items can then pass to the chicks (Loretto, 1995).

Bjorndal *et al.*, (1994), studied the digestive tracts for the presence of debris in forty three juvenile green turtles (*Chelonia mydas*) carcasses stranded in Florida. Fifty six percent had ingested marine debris. The most important conclusion drawn from the study is that even small quantities of debris can kill and it is the predictability of such an event occurring that is unclear. It can take only one transit of debris in the gut of an animal to render it incapable of feeding, resulting inevitably in death. Therefore, even in areas where low amounts of debris are recorded the threat to wildlife is still relevant.

Epibionts, encrusters, fouling and associated biota

Freely drifting plastic artifacts and other synthetic materials provide habitats for many opportunistic colonisers, and may act as attachment surrogates for natural floating substances such as logs, pumice and some surface-dwelling, free-swimming larger marine animals. Studies of beach-cast plastic debris from shores of the western North Atlantic and the South West Pacific have revealed more than 100 epibiont and associated motile taxa (Winston *et al.*, 1997). The initial colonisers following biofilm development, are filimentous algae, hydroids, ascidians and other soft fleshy organisms. These do not long survive desiccation and disintegration once exposed to the elements in harsh beach environments. As a consequence the record is biased towards resistant, hard-shelled and crustose organisms, that typically includes barnacles, bryzoans, tube worms, molluscs, foraminifera and coralline algae, as well as some more resistant sponges and hydrozoans. Of these the most common taxon is bryozoa with over 60 identified species represented. The extent of bryozoan cover and species diversity is latitudinally dependent. Species richness is greatest in low latitudes and decreases polewards in both hemispheres (Winston *et al.*, 1997; Barnes and Sanderson, 2000).

The biologic communities of pelagic plastics may find side by side associations of related species inhabit quite different environmental niches. A single item recovered from a northern New Zealand beach hosted barnacles typical of sheltered shores (*Balanus modestus*), more exposed coasts (*Balanus trigonus*), and drifting objects (*Lepas anatifera*). Another item carried a motile crab fauna represented by common algal dwellers, rocky shore taxa and a pelagic species. Some other taxa may reproduce as they are buoyed along on their floating debris island (Winston *et al.*, 1997). Larger floating objects or aggregations of debris may also attract resident schools of fish, which in turn bring birds and marine predators.

There is evidence that passively drifting islands of plastic and other debris may be a vector for local, regional and transoceanic dispersal of marine organisms and perhaps even some terrestrial ones (Gregory and Ryan, 1997). For example the common Indo-Pacific oyster *Lopha cristagalli* has been found on a southernmost

New Zealand beach attached to a tangled mass of rope, while Florida debris carried a previously unrecorded bryozoa (*Thalamoporella* sp) similar to a Brazilian species (Winston *et al.*, 1997). It has also been suggested that some terrestrial flora and fauna elements could be picked up during a stranding episode, to be later floated off and carried away by offshore winds (Gregory, 1991). While pelagic plastics may have less potential than ballast waters for the introduction of aggressive, habitat-harming alien taxa, it is not a threat that should be ignored. Gregory (1991), suggested that alien species rafted on drifting plastic could pose threats to the biota of sensitive and/or protected near-shore environments and perhaps the delicately balanced terrestrial ecosystems of small oceanic islands. These are factors that need to be taken seriously by those having stewardship responsibilities for conservation or heritage estates. An example is Codfish Island lying a short distance offshore from Stewart Island, Southern New Zealand. This is a managed refuge for a small population of a large flightless parrot, the kakapo (*Strigops* habroptilus) which is nearing extinction. The arrival of rats, mustellids or cats on the island through rafting from the mainland some 4 km away could be disastrous for the survival of this species (Gregory, 1999b).

2.4 Public Perception

The appearance of clear sea water does not necessarily mean that the water is uncontaminated, but the presence of certain items on a beach may, however, imply poor micro-biological water quality. Likewise, a beach that is free from any trace of litter does not imply that the sanitary quality of the sand is good (Williams *et al.*, 2000a). Particular litter items attain a higher degree of emotional response within the general public than others. SRD, medical, and hazardous items arouse greater levels of offence, or feelings of unpleasantness, than do more general items of litter such as beverage containers or confectionery wrappers (Nelson, 1998; Williams *et al.*, 2000a). Herring and House (1990), established that sewage derived debris had a greater social impact than any other aesthetic pollution environmental parameter, but there are suggestions that the public debate on sewage in bathing water rarely makes any distinction between aesthetic impact and actual health risk (Jones *et al.*, 1991). It has been stated that 'while the risk of infection by serious disease is small, the visible presence of faecal and other offensive materials carried by the sewerage system can mean serious loss of amenity and is therefore an unacceptable form of pollution' (House of Commons Environment Committee, 1990, page xvii).

2.5 Methodologies

Surveys can be focused on beaches, seas, or rivers where debris is used as an indicator of oceanic, riverine, estuarine or lake conditions (Williams *et al.*, 1999). Many studies monitoring marine debris have concentrated on specific items or categories: Morris (1980), and Pruter (1987), concentrated on plastics; Day and Shaw (1987), and Debrot *et al.*, (1995), focused on tar; Jones (1995), dealt with fishing debris. Other studies though have been less specific and these have assessed areas of land or water for amounts and composition of marine debris (Dixon and Cooke, 1977; Corbin and Singh, 1993; Dufault and Whitehead, 1994; Galgani *et al.*, 1995a). Beach surveys are often based on relatively small areas of study (e.g. Simmons and Williams, 1993; Frost and Cullen, 1997), with low numbers of surveyors involved in the collection of data. Larger studies often require many more people to collect data if they are to be completed at low cost within an acceptable time frame, and not all of these surveyors can be expected to have had previous experience of carrying out litter surveys. However, the use of members of the public or local interest groups in such studies has the added value of raising public awareness and indirect education (Williams *et al.*, 1999).

Surveys can be used to determine the amount and type of debris in a specified area at a certain time and to determine how types and amounts of debris change with time (Ribic, 1990). Studies may be simple enumeration surveys, assessing types and litter quantities, or they can be more detailed, indicating age and origin of items. For example, in the UK, Dixon and Dixon (1981); Simmons and Williams (1993), in Europe, Gabrielides *et al.* (1991); Golik and Gertner (1992); Bowman *et al.* (1998), North America, Gilligan *et al.* (1992); Ribic (1998), and extensively around the world, Gregory (1977); Corbin and Singh (1993); Galgani *et al.* (1995a); Jones (1995); Walker *et al.* (1997). The many different methods employed in collecting data for beach debris surveys make result comparisons very difficult. There is as yet no single accepted methodology for assessing beach litter. The aim of a study, along with other factors, often influences the technique chosen (Velander and Mocogni, 1999).

2.6 Campaigns and Initiatives to Combat Marine Litter

There are a number of campaigns and public participation schemes that aim to raise awareness and reduce the marine debris problem. Education and public awareness are key elements in the reduction of marine debris. Public involvement in beach litter management takes two forms: Direct action such as beach clean-ups and monitoring; and indirect action, such as education, award schemes and legislation. Involvement of the public in beach monitoring and clean-up programmes has a dual advantage in that it allows a large sample size to be achieved, and raises awareness among society which will then translate into effective individual action to reduce litter at source. Some of the campaigns world-wide are: The Center for Marine Conservation in the USA which is the largest network organising beach clean events (Van Maele *et al.*, 2000); Coastwatch Europe involves many thousands of volunteers each year (Dubsky, 1995); Beachwatch in the UK, run by the Marine Conservation Society (MCS, 2000); and Pitch-In-Canada. There has been some concern that where volunteers are involved in the collection of data that it can lead to spurious results. Trials by the Tidy Britain Group in the UK showed that volunteers frequently incorrectly identify litter items (Dixon, 1992). An opposing view has been presented in other research (Pond 1996; Williams *et al.*, 1999), although it has been found that particular *items* are consistently mis-identified by the public e.g. cotton bud sticks (Q tips) (Tudor and Williams, *in press* a).

2.7 Beach Cleaning

Beach cleanups provide a way of collecting data on the types and quantities of marine debris. Beach cleans cannot permanently solve the problem of marine debris as they do not reduce quantities at source (Simmons and Williams, 1993), even though there is intense pressure to clean a beach, especially by authorities wishing to promote tourism. However, clean-ups are really only applicable locally, are expensive if undertaken by mechanical means, and are labour intensive. Conversely, if volunteers are used the costs are minimal. However, clean-ups *per se* do not resolve the problem if they do not address the issues of prevention at source and it is the links to sources that represents the future challenge (Earll *et al.*, 2000a; Williams *et al.*, 2000 a; Figure 1.1).

There are, in essence, two methods of beach cleaning: Mechanical beach cleaning involves motorised equipment utilising a sieve effect which scoops up sand and retains the litter, therefore it is not selective. Most sieve machines are coarse grained allowing items such as cigarette stubs and cotton bud sticks to pass. The use of mechanical beach cleaners may threaten the stability of some beaches through the removal of organic matter which forms the 'glue' holding sand grains together (MCS, 2000). The passage of such vehicles over the beach also interferes with beach ecology (Davidson *et al.*, 1991; Acland, 1994; Llewellyn and Shackley, 1996), and this method is limited in that it cannot be used on pebble beaches. The advantages of such mechanical clean-ups are that; they are fast, can provide an apparently pristine beach for visitors, and can cover a large area. In areas with hazardous or sanitary waste, it negates the need for picking up material so reducing potential health risks to individuals (Williams *et al.*, 2000a). The alternative to mechanical methods is manual beach cleaning. These are often carried out where the expense of a mechanical device is prohibitive, or the substrate is not receptive to such machines. Manual cleans organised as community events on small areas may ensure that the beach is cleaned of small items missed by mechanical cleans (MCS, 2000).

2.8 The Offshore: (pelagic marine debris)

Heyerdahls's (1971) observations from the raft *Ra* on its drift across the equatorial Atlantic provided an initial demonstration of the extent to which surface waters were becoming contaminated by pelagic marine debris. Whether it is for shore line or high seas surveys it is convenient to separate plastic litter into four size categories (Micro litter < 1mm; meso - 1-10mm, mostly pellets or nibs of virgin resin; macro - mostly de-gradational flakes and smaller items to 10cm; mega- larger items > 10cm.). Systematic investigations to establish quantities and distribution of pelagic plastic litter have been sporadic and are based on either surface towed neuston (or pleuston) nets (e.g. Colton *et al.*, 1974), or have used sighting surveys from vessels on passage (e.g. Matsumura and Nasu, 1997). The former have focused primarily on meso-litter, mostly plastic pellets or nibs, and the latter on macro and mega-litter items identifiable with the naked eye from a vessel's deck or bridge.

There is little information available about the quantities and distribution patterns of plastic micro litter. The source lies in some propriety hand cleaners and cosmetic preparations, and air-blast cleaning media as well as from degradation and disintegration of larger debris items. There can be little doubt that micro-litter is now globally dispersed and there are suggestions that it could impact sea-surface micro-layer ecosystems and the meiofauna of inter-tidal and beach sediments (Gregory, 1996).

Plastic meso and macro-litter, mainly in the form of nibs or pellets of virgin polystyrene and polyethylene, has a universal presence in oceanic surface waters. The greatest densities have been noted in coastal and shelf waters off major urban and manufacturing centres – some quoted maximum pellet densities include >100,000/sq. km off the eastern seaboard of North America (Colton *et al.*,1974); >40,000/sq. km in waters of Cook Strait, New Zealand (Gregory, 1990); 1,500/sq. km in the Sargasso sea (Wilber,1987); and 1,500 – 3,600/sq. km in the Cape Basin Region of the South Atlantic west of South Africa (Williams *et al.*, *in press*).

Mega-litter quantities have been reported from all marine waters, but the most extensive sighting surveys have taken place across the North Pacific (e.g. Matsumura and Nasu, 1997) and the Whale sanctuary of the Indian Ocean (Grace and Frizell, 2000). There are numerous other casual or anecdotal comments since Heyerdahl (1971), brought this problem to the fore. Distribution patterns for plastic litter in all size categories across the high seas are similar. The greatest densities, whether measured by weight or item count are to be consistently found in coastal and shelf waters adjacent to and down drift from major urban and manufacturing regions. On the open ocean, distant from land-based sources it tends to concentrate along oceanic fronts and in large eddy systems or gyres. Concentrations of macro and mega litter are also present along many shipping routes particularly those of the

North Atlantic and North Pacific. They are much less across the South Pacific where shipping traffic is sparser and industrial developments are fewer and more distant.

2.9 The Seafloor: (benthic marine debris)

The sea floor, from inter-tidal and shallow sub-littoral to outer shelf slope and abyssal depths, has been identified as an important sink for marine debris (Williams *et al.*, 1993; Goldberg, 1997). An early demonstration of this came with the recognition of plastic film accumulating on the floor of the Skaggerack, by Hollström (1975). The problem is now appreciated to be global with many observations made by divers, through video footage from remote operated vehicles as well as sampling by bottom trawls. Data has been obtained from varying depths and at many widely separated places, including Antarctica (Lenihan *et al.*, 1990); the Bay of Biscay and other European waters (Galgani *et al.*, 2000); the western (Galgani *et al.*, 1995a, 1995b) and eastern Mediterranean (Bingel *et al.*, 1987; Galil *et al.*, 1995; Stefatos *et al.*, 1999); Alaska (Hess, *et al.*, 1999); California (Moore and Allen, 2000); Indonesia (Uneputty and Evans,1997); Japan (Kanehiro *et al.*, 1995); South Africa and New Zealand (Gregory and Ryan, 1997). Many of the early reports are generalised and descriptive e.g. Hollström (1975). Latterly there have been several studies presenting substantial data on types, amounts and distribution of marine debris on the seafloor, and although bottom trawl sampling is the preferred technique, methodologies vary, making comparisons difficult; e.g. 6.5 m beam trawl pulled for 25 - 90 minutes (Kanehiro *et al.*, 1995); haul of 6 hours at 3.5 knots (Stefatos *et al.*, 1999); benthic tows along a 1.85 km track (Hess *et al.*, 1999); Moore and Allen (2000), towed along isobath for 10 minutes at 0.8 - 1.2 m/s; trawl times of 5 - 30 minutes, and also estimates of densities from a submersible along tracks of 730 - 6500 m (Galgani *et al.*, 2000); furthermore, in each of these studies, the categories of marine debris identified differ.

The quantities of sunken litter being reported are high. Litter densities on the sea floor of central Tokyo Bay, Japan, have been estimated at between c25,000 and c60,000 items/sq. km (Kanehiro *et al.*, 1995). Of this, plastics comprised 80-85% with fishing related items between 2.7 and 9.0%. Quantities had not significantly changed over a four year period (1989-93) and land based sources were considered to be of most importance. In water depths of less than 10m at French Frigate Shoal, in the Hawaiian chain, Bowland (1997), estimated that netting fragments were 94 items/sq. km. Stefatos *et al.*, (1999), recognised that marine debris concentrations on floors of the enclosed Patras and Echinadhes Gulfs, western Greece, reached 240 and 89 items/sq. km respectively. They noted that these differences could be related to land-based sources for the former and shipping traffic in the latter. From studies of inshore waters around Kodiak Island, Alaska, Hess *et al.*, (1999) showed that fisheries-related and other plastic debris quantities were greatest in inlets (20-25 items/sq. km) and least in open waters outside inlets (4.5-11 items/sq. km). These differences were considered to reflect variations in fishing effort and water circulation patterns.

Moore and Allen's (2000) shelf survey of the Southern California Bight, ranked quantities of anthropogenic and natural debris into four broad categories (trace, low, moderate, high) on the basis of number and weight of items determined from standardised trawl times along isobaths between depths of 20 and 200 m. Bathymetrically, the proportion of area with anthropogenic debris increased with increasing distance along a broad offshore front, from inner to outer shelf. This suggested a source that lies in disposal practices from boating activities. The most comprehensive and thorough reports are those coming from European and western Mediterranean waters (e.g. Stefatos *et al.*, 1999; Galgani *et al.*, 2000). Densities found were highly variable between and within separate sampling areas. Near metropolitan areas they could exceed 100,000 items/sq. km but elsewhere maximum values were lower (50,000 items/sq. km in the Bay of Biscay; 600 items/sq. km in the North Sea 200 km west of Denmark). It was also noted that concentrations of debris (to densities >50,000 items/sq. km) were encountered at depths of >2000metres on floors of canyons along the Mediterranean coast of France. Variations in distribution patterns were attributed to geomorphologic factors, local anthropogenic activities and land-based river inputs (Williams *et al.*, *in press*).

Mechanisms by which the mostly neutrally buoyant plastics in marine debris reaches the deep-sea floor are poorly understood. Oshima (2000), for instance recorded a fleet of flimsy, white, supermarket shopping bags upended and suspended at depths of 2000m and drifting like an assembly of ghosts. Significant quantities of land-sourced materials on submarine canyon floors to considerable distances offshore, suggest rapid transport through near-shore zones and entrainment in bottom hugging currents. It has been argued (Ye and Andrady, 1991; Stevens,1992), that density increases, following rapid and heavy fouling, may be sufficient to permanently sink them. On the other hand, grazers may clean covered surfaces leading to 'yo-yo like' episodes of submergence and resurfacing until permanent settlement to the sea floor is effected. As well as biofilm development, plastic sheeting may also attract non-living detritus, which with photo-degradation and progressive embrittlement leads to density increases taking it to the sea floor without the need for invoking down-welling and/or entrainment (Powlik, 1995).

The epibionts of benthic plastic debris are not as well known as those of pelagic items. Accounts are limited, e.g. Hollström (1975), Harms (1990), Powlik (1995), but indicate a hard ground biota characterised typically by bryozoans, sponges and foraminifera, with barnacles, molluscs and polychaetes. At shallow, photic zone depths, there is development of crustose (coralline) red algae as well as soft brown and green algae. Bryozoa are generally the dominant epibiont of both pelagic and benthic plastics.

Plastic sheeting together with larger, more solid items and discarded fishing gear, is an undesirable addition to the deep-sea floor and potentially damaging to the environment (Williams *et al.*, 1993; Goldberg, 1997). The blanketing effects of sheeting may damage biotas of both soft sediment and rocky hard ground substrates at all depths from inter-tidal to the abyss (Williams *et al.*, *in press*). They may lead to anoxia and hypoxia induced by inhibition of gas exchange between pore water and sea water (Goldberg, 1997).

2.10 Degradation

Breakdown of plastics mainly takes place through photo-degradation which leads to surficial cracking followed by embrittlement and ultimately complete disintegration into powder. Bio-degradation is seldom important with most plastics that enter the marine realm. Physical abrasion is also a mechanism for the breakdown of plastics along shorelines – particularly high energy cliffed and rocky shores. Degradation performance is generally measured through changes in tensile strength and viscosity, although UV and laser spectroscopy are other approaches. Several studies have shown that the rates of weathering of polyethylene and other plastics are substantially reduced when floating in sea water compared to those when exposed outdoors to normal atmospheric conditions e.g. Andrady (1990). Enhanced photo-degradable polyethylene also degrades more slowly under marine conditions (Andrady *et al.*, 1993). Alternatively, expanded polystyrene foam is known to deteriorate more rapidly in sea-water than on atmospheric exposure (Andrady and Pegram, 1991). Material that has been buried for some time in beach/riverine sediments retains much of its tensile strength - *circa* 80% (Williams and Simmons, 1996), and may be exhumed during episodes of erosion (Gregory, 1999a). Plastics sinking to the deep sea floor will not be subject to photo-degradation and if resistant to bio-degradational processes will be preserved there until burial is completed.

2.11 Legislation and Conventions Concerned with the Prevention of Marine Litter

For persistent marine debris to be tackled, there needs to be a legal framework in place so that polluters become accountable for their actions. Legislation exists, both nationally and internationally, to deal with many of the sources of marine pollution, but the effectiveness of these legislative tools varies from country to country, and from convention to convention. The various legislative aspects concerned with debris on beaches and in oceans has been discussed at length in various publications (for a full appraisal of these see: Hall, 2000; MCS, 2000). A brief overview of some of the directives are stated here.

- **London Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, 1972.**

  This convention prohibits dumping of persistent plastics and other non-biodegradable materials as well as other compounds, that are not generated in the course of vessel operations, into the sea from ships or other man-made structures.

- **International Convention for the Prevention of Pollution from Ships 1973 (MARPOL 73/78).**

  MARPOL (1973/1978), has five annexes which cover various types of pollution. Annex IV relates to sewage and Annex V concerns debris. Annex V sets minimum specific distances from land inside which certain items of rubbish cannot be disposed, and restricts discharge of litter except for safety. However, 'there is no empirical evidence that the Annex V rules are having an impact on marine debris' (Kirkley and McConnell, 1997, page 184).

- **Merchant Shipping Regulations (Prevention of Pollution by Garbage) 1988.**

  The UK's interpretation of MARPOL Annex V is via these regulations MARPOL (1973/1978). The regulations forbid the disposal of plastics anywhere in UK territorial waters and prohibit the disposal of other types of pollutant within specific distances from land.

- **Convention for the Protection of the Marine Environment, North East Atlantic - OSPAR Convention**

  The Oslo and Paris commission is an inter-governmental body which collates a range of data on inputs to the marine environment, regardless of source. The Working Group on Impacts on the Marine Environment (IMPACT) includes litter pollution as part of its remit.

- **The Bathing Water Directive -76/160/EEC (CEC, 1976)**

  This provides microbial standards for bathing waters. 'Designated' bathing waters are monitored for 19 different parameters, from May to September. To comply with the directive, designated bathing waters must achieve a mandatory standard for the amounts of bacteria in sea water. These are monitored by the Environment Agency in England and Wales.

- **Environmental Protection Act - 1990 (HMSO, 1990).**

  Under this Act, it is an offence to drop litter in a public place, this includes beaches and rivers. The fixed penalty is £10, and the maximum is £2,500. The difficulty comes with enforcement; unless caught in the act or on film there is very little chance of successful prosecution. Under the Act, local authorities have a duty to regularly clean beaches. This only applies to 'amenity beaches' and between the months May and September.

- **The Dogs (Fouling of Land) Act - 1996 (HMSO, 1996).**

  This act may be adopted by local councils to require dog owners to clean up after their pets on public land (including beaches).

3. PHYSICAL BACKGROUND

3.1 The Bristol Channel / Severn Estuary

3.1.1 Introduction

The Bristol Channel is a large inlet of the Atlantic Ocean, on the south western coast of Britain situated between south Wales to the north and the English counties of Cornwall, Devon and Somerset to the south (Figure 3.1). Its chief bays are Milford Haven, Carmarthen, and Swansea (Wales), and Barnstaple and Bridgwater (England). Many cities are on or near the channel; among the largest are Bristol, Newport, Cardiff, and Swansea. Along the coast of south Wales is a great concentration of economic activity, and the western extremity of the Bristol Channel serves as a major shipping corridor. Milford Haven, a major oil-importing centre, has a harbour that can accommodate large modern tankers.

In the Severn Estuary there are several important sources of fresh water which enter via tributary estuaries, namely the rivers Severn, Wye, Avon, Usk, Rhymney, Taff, Ely and Parrett. The average water flow into the estuary is approximately 300 cubic metres per second (26,500,000 cubic metres per day), about half coming from the rivers Severn and Wye (SES, 1997; DETR, 2000). It has the largest tidal range in Europe (16.4m), and the second highest in the world. It is Britain's biggest coastal plain estuary and has the fourth largest area of inter-tidal sand and mudflats in Britain.

Table 3.1 lists all beaches studied for litter thresholds (Chapters 4 and 5), litter sourcing (Chapter 5), and litter perception by the public (Chapter 6). For a detailed description of beaches, apart from Tresilian Bay, see Appendix I. Tresilian Bay is dealt with as a case study and its physical description is given in Chapter 4.

cycle. The spring-neap tidal cycle is roughly fourteen days, i.e. it takes a fortnight to go from spring to neap to spring tide (Haslett, 2000). The term, 'highest high water strandline', as used in this research, refers to the uppermost line of material deposit (either natural or anthropogenic) existing on the beach. 'Current high water strandline' refers to the deposit of material laid down from the most recent high tide.

Near the head (eastern end) of the channel the tidal range is one of the largest in the world, and at Avonmouth can reach 16.4m (Huntley, 1980), although there is significant variation from year to year in height and range of tides. On Spring tides, there is about five hours of flood and seven hours of ebb at Avonmouth, while at Gloucester there is about two hours of flood and ten hours of ebb. Times of high water are later further up the estuary. Two factors contribute to the large tidal range. Firstly, the overall dimensions of the Bristol Channel mean that its natural period of oscillation is close to the 12.5 hour tidal period so that there is a strong resonant oscillation; secondly, and probably more importantly, the constriction in the width and depth of the channel towards its head further amplifies the tide (Prandle, 1985; DETR, 2000). The tide is almost a standing wave, i.e. high and low water currents are zero. However, because of energy dissipation within the channel, the tidal wave is not perfectly reflected at the head, so the tide is not a pure standing wave, and high water occurs 20 minutes before slack water in the eastern channel. In addition, high water at the mouth occurs 1.7 hours before that at the head (Uncles, 1981; 1984).

Tidal current speeds generally exceed 1.5 m s^{-1} at springs and 0.75 m s^{-1} at neaps, meaning that water parcels can move up to 25 km during a flood or ebb tide. Tidal currents in the Bristol Channel exhibit some asymmetry (stronger but shorter flood than ebb), which arise from effects associated with the tidal wave passing into shallow water and being distorted by the complex topography (Huntley, 1980; Uncles, 1981; 1983). Distortion of the tidal wave by such shallow water effects becomes progressively more severe up channel and, at spring tides, a tidal bore forms in the Severn Estuary upstream of Sharpness. This is typically 1m high, but may reach 2 m on occasion (DETR, 2000).

Table 3.1. List of Beaches Studied
Key: T= Threshold Study (Chapters 4 and 5); S = Sourcing Study (Chapter 5); P = Perception Study (Chapter 6)

Key to Figure 3.1	Beach	Study Area
1.	Hartland Quay	T, S
2.	Westward Ho!	T, S
3.	Croyde	S
4.	Putsborough	T, S
5.	Woolocombe	T, S
6.	Ilfracombe	S, P
7.	Combe Martin	T, S
8.	Lynmouth	T, S
9.	Minehead	T, S, P
10.	Dunster	T, S,
11.	Blue Anchor Bay	S, P
12.	Berrow	T, S, P
13.	Brean	S, P
14.	Weston-super-Mare - Main	T, S, P
15.	Sand Bay, Weston-super-Mare	T, S
16.	Whitmore Bay	P
17.	Tresilian Bay	T, S
18.	Dunraven Bay	P
19.	Ogmore-by-Sea	P
20.	Traeth-yr-Afon (Merthyr Mawr)	T, S
21.	Newton	P
22.	Sandy Bay, Porthcawl	S, P
23.	Rest Bay	P
24.	Langland Bay	P
25.	Oxwich Bay	S, P
26.	Port Eynon Bay	P
27.	Pendine Sands	S
28.	Wisemans Bridge	S
29.	Saundersfoot	P
30.	Tenby North	S, P
31.	Tenby South	S
32.	Freshwater West	T, S
33.	West Angle Bay	T, S
34.	Broadhaven	S
35.	Nolton	S
36.	Whitesands	P
37.	Poppit Sands	S
38.	Mwnt	S
39.	Aberdyfi	T, S,P
40.	Towyn	T, S, P
41.	Barmouth	T, S, P
42.	Harlech	T, S, P
43.	Pwllheli	T, S, P
44.	Llandudno	T, P
45.	Rhyl	T, P

3.1.2. Sediments

The sediments of an estuary have a major influence on its characteristics, whether they be aesthetic, biological or commercial. The high energy associated with the tides in the Severn Estuary has a large effect on the movement of sediments held in suspension and the distribution of bottom sediments. Much of the sediment in the estuary is contained within the area which could broadly be regarded as the beach, i.e. within the intertidal and shallow subtidal zones (STPG, 1989).

East of the line between Nash Point and Hurlstone Point large areas of the bed-rock are exposed - sometimes covered with a thin layer of unconsolidated sediment while there are areas of settled mud in the Newport Deep and Bridgwater Bay. Upstream of a line joining Barry and Bridgwater Bay large quantities of fine sediment are redistributed according to the tidal state and range. During the full ebb / flood of spring tides similar levels of suspended solids may be found throughout the water column - and these may be up to 10,000 milligrams per litre. High levels of particulate material are maintained in suspension and the turbulent kinetic energy generated by the tidal current is sufficient to keep the Bristol Channel vertically well-mixed throughout the year (Pingree and Griffiths, 1978).

3.1.3. Physical oceanography

Topography

The fetch is limited by the breadth of the channel, with Atlantic swell being funnelled into the shallow waters. The funnel shape produces large areas of exposed mud flats and very restricted channels at low water and almost open sea at high water. At its mouth, the Bristol Channel is roughly 120 km wide in the north-south direction along longitude 5°W. The Bristol Channel has an axial length of about 160 km from the mouth to Avonmouth, at which point it is only around 6 km wide. The bottom topography is generally shallower than 50 m, with depths less than 10 m east of 3°W. However, west of the channel the bathymetry slopes to approximately 100 m at 6°W in the Celtic Deep (DETR, 2000).

Tides

Tides are a natural phenomenon involving the alternating rise and fall in the large fluid bodies of the earth caused by the combined gravitational attraction of the sun and moon. The combination of these two variable force influences produces the complex recurrent cycle of the tides. Tides may occur in both oceans and seas, to a limited extent in large lakes, the atmosphere, and, to a very minute degree, in the earth itself. The period between succeeding tides varies as the result of many factors and force influences (Carter, 1988; OU, 1989).

At the surface of the Earth the gravitational force of the Moon is about 2.2 times greater than that of the Sun. The moon, being much nearer to the earth than the sun, is the principal cause of tides; because the sun is far from the earth, its tide-raising force is only about 46 percent that of the moon. The effect of the Sun is similar and additive to that of the Moon. Consequently, the tides of largest range or amplitude (spring tides) occur at New Moon, when the Moon and the Sun are in the same direction, and at Full Moon, when they are in opposite directions; the tides of smallest range (neap tides) occur at intermediate phases of the Moon (EBO, 2001; OU, 1989). The largest spring tides take place at the vernal (spring) equinox and autumnal equinoxes, when the sun crosses the equator (Haslett, 2000).

In addition to tides in the oceans (and in large lakes, where similar processes occur with smaller amplitudes), there are analogous gravitational effects on the atmosphere and on the interior of the Earth. Atmospheric tides are detectable meteorological phenomena but are a comparatively minor component in atmospheric motions. An Earth tide differs from oceanic and atmospheric ones in that the response to it is an elastic deformation rather than a flow. Observations of Earth tides contribute to knowledge of the internal structure of the Earth (Carter, 1988).

Tides in the Bristol Channel are predominantly semi-diurnal and dominate its dynamics. They are particularly relevant to this study of litter levels found on beaches. At high water, debris is deposited along what are commonly called 'strandlines', the position and amount of these strandlines at the time research surveys were conducted was dependant on the current state of the spring-neap tidal cycle. The spring-neap tidal cycle is roughly fourteen days, i.e. it takes a fortnight to go from spring to neap to spring tide (Haslett, 2000). The term, 'highest high water strandline', as used in this research, refers to the uppermost line of material deposit (either natural or anthropogenic) existing on the beach. 'Current high water strandline' refers to the deposit of material laid down from the most recent high tide.

Near the head (eastern end) of the channel the tidal range is one of the largest in the world, and at Avonmouth can reach 16.4m (Huntley, 1980), although there is significant variation from year to year in height and range of tides. On Spring tides, there is about five hours of flood and seven hours of ebb at Avonmouth, while at Gloucester there is about two hours of flood and ten hours of ebb. Times of high water are later further up the estuary. Two factors contribute to the large tidal range. Firstly, the overall dimensions of the Bristol Channel mean that its natural period of oscillation is close to the 12.5 hour tidal period so that there is a strong resonant oscillation; secondly, and probably more importantly, the constriction in the width and depth of the channel towards its head further amplifies the tide (Prandle, 1985; DETR, 2000). The tide is almost a standing wave, i.e. high and low water currents are zero. However, because of energy dissipation within the channel, the tidal wave is not perfectly reflected at the head, so the tide is not a pure standing wave, and high water occurs 20 minutes before slack water in the eastern channel. In addition, high water at the mouth occurs 1.7 hours before that at the head (Uncles, 1981; 1984).

Tidal current speeds generally exceed 1.5 m s^{-1} at springs and 0.75 m s^{-1} at neaps, meaning that water parcels can move up to 25 km during a flood or ebb tide. Tidal currents in the Bristol Channel exhibit some asymmetry (stronger but shorter flood than ebb), which arise from effects associated with the tidal wave passing into shallow water and being distorted by the complex topography (Huntley, 1980; Uncles, 1981; 1983). Distortion of the tidal wave by such shallow water effects becomes progressively more severe up channel and, at spring tides, a tidal bore forms in the Severn Estuary upstream of Sharpness. This is typically 1m high, but may reach 2 m on occasion (DETR, 2000).

Another feature of interest is the 'tidal excursion'. This is a term which refers to how far an object will be carried on a single tide. This is important for the study of pollution, sediments and litter which wash back and forth on the tide. From the Holm islands, maximum tidal excursions are 26km for the north side and 37km for the south side, showing that the currents are not identical on either side of the estuary (SES, 1997).

Storm surges

The low-lying coasts on the south shore of the Bristol Channel are vulnerable to flooding during storm surges. The very large tidal range in the Bristol Channel means that the timing of surge events is critical in determining whether flooding will occur. Strong westerly gales acting over the Bristol Channel during the 2-3 hours before high water push water into the Channel, thereby increasing the height of the tide (Proctor and Flather, 1989). Estimates of extreme sea level return periods for the Bristol Channel have been provided by Blackman (1985) and, for instance, the 50 year return period maximum level is 8.69 m at Avonmouth (DETR, 2000).

Surface waves

The Bristol Channel is exposed to winds and waves from the prevailing south westerly direction. The wave climate is mainly influenced by the partially enclosed nature of the Irish Sea and the influence of the westerly airflows that predominate over the British Isles. It has been shown that the 50 year predicted wave height in open water is *circa* 15m, being highest off south-west Pembrokeshire, and 8 m east of the Gower Peninsula (Jones, 1987). Storm wave energies of >40,000 j/m/s, with an average from thirty three storm events of >16,000 j/m/s, commonly occur from the south west quadrant (Jones and Williams, 1991; Gruffydd, 1993).

Residual circulation

The River Severn is the major source of fresh water to the Bristol Channel (60% of the total), with river inputs along the Welsh and English coasts contributing 30% and 10% respectively. However, there is significant seasonal variance in the river discharge, maximum in winter and minimum in summer. There is a north-south gradient of salinity within the Bristol Channel, with the lowest salinity occurring along the Welsh coast (Owen, 1980; Uncles, 1983; Stephens, 1986; DETR, 2000). The strong tides in the Bristol Channel cause intense vertical mixing, which has been estimated to take 2-7 hours for passive tracers (Uncles and Joint, 1983), and the estimated flushing time for the whole Bristol Channel is from 150-300 days (Uncles, 1984). In winter (February) the vertically mixed water temperature within the Bristol Channel typically ranges from 8°C at the mouth to 6°C in the shallower waters of the Severn Estuary, whereas, in summer (August), water temperatures are >13°C throughout the channel (Elliott *et al.*, 1991; Pingree, 1980; DETR, 2000). To the west of approximately 5°W, the near surface stratified waters exceed 17°C, whilst waters below the thermocline are below 11°C (Simpson, 1976).

3.1.4. Geography and demography

The two shores of the estuary also offer differing socio-economic and physical backgrounds. The Welsh coastline is drained by rivers emanating from an old established heavy industrial base and has a large population. The English side of the estuary is predominantly agricultural with a low population density. The coastline between Land's End and Portishead in the Severn Estuary is fairly sparsely populated while the area around Bristol, Newport and Cardiff is quite heavily populated. Avonmouth is the main centre of industrial activity with a corresponding population size in Bristol of 400,700, followed by Cardiff and Newport with population sizes of 302,700 and 137,200 respectively (ONS, 1996).

The coasts of Cornwall and Devon have comparatively low populations with Truro, Falmouth, Penzance, Newquay and Barnstaple the main residential centres. However these areas see a considerable increase in population size during peak holiday weeks. Further north-east, the population in towns and cities begins to rise, although extensive sections of the coast remain relatively unpopulated. Many towns and cities are situated away from the coast on inner tidal stretches of river, e.g. Bristol, Newport and Bridgwater. Those which are on the coast, are often large tourist centres which receive visitors during the summer months, e.g. Barry Island, Porthcawl, Tenby, Ilfracombe, Minehead and Weston-super-Mare. The area west of Swansea is also sparsely populated, with the only major residential developments being Llanelli and Milford Haven. Many towns in the region are tourist attractions and thus increase in population during the summer months but have relatively low permanent populations, i.e. usually less than 5,000 (DETR, 2000). These include Mumbles, Fishguard, and Tenby.

3.1.5. Geology

The area was formed as a result of the drowning of river valleys by rising post-glacial sea level. As the rise in sea level slowed down, the deposition of estuarine muds and peats began first at the heads of embayments and then along straighter, exposed stretches of coastline. There is evidence to show that the shoreline of the Severn Estuary is unstable and has experienced a series of horizontal movements in the form of retreats and advances over the last few thousand years, which vary locally from a few to many hundreds of metres (Allen, 1987; Allen and Rae, 1987; STPG, 1989).

The Bristol Channel is an aggressive process environment, with a macro-tidal regime, and high storm frequency from the south west. One of the dominant geomorphological features is the occurrence of extensive gravel beaches. In addition there are extensive tidal mudflat developments on both sides of the channel, especially at Bridgwater Bay and the Wentlooge Flats. Erosion is probably the prevailing condition of these systems. This characteristic is confirmed by hard and overconsolidated deposits, exposed peat beds, 'submerged' forests, inclined and truncated beds of overconsolidated layered sediments, occasional dead burrowing bivalves projecting from the surface, wide areas of polygonal cracks and furrowed topography. For example, on the Brean to Burnham stretch, although the lower flats are soft and unstable, the upper flats show overconsolidated, cracked and dessicated clay; this is the clay basement of the eroding sand beach. The coastal zone from Cardiff up-estuary to caldicot is also overconsolidated with exposed peat beds and fossil forests, surfaces which all have the characteristics of an erosional regime (STPG, 1989). Sand beaches are few and are mainly fossil due to emplacement by rising sea levels. The Outer Severn Estuary sand beaches have a history of erosion, e.g. Blue Anchor Bay. Several off shore sand banks are present (JNCC, 1996). The inner Bristol Channel, east of a line from Bridgwater to Cardiff, is flanked largely by wide estuarine flats of Holocene age underlain by softer Triassic or Jurassic strata. The Somerset Levels on the south coast and the Wentlooge Levels on the north coast are the most extensive of these flats. Rising above the levels, and locally forming the coast, are the steep sided hills forming Brean Down and the area between Portishead and Clevedon, near to Bristol.

From southern Cornwall to Minehead the coast is composed of a range of Devonian and Carboniferous rocks arranged in a structurally complex assemblage of folds. The structural 'grain' of the region, is east-west, reflected in the orientation of the major and minor folds, although the folds are cut by NW-SE faults which had a history of movement until at least the mid-Tertiary. East and north of Minehead, structurally simpler and younger Triassic and Jurassic rocks are exposed along the coast, with local outcrops of Carboniferous and older rocks seen in anticlinal cores.

The north coast of Devon from Morte Point to Porlock display steep cliffs where high, rounded inland hills meet the coast. For example, narrow linear valleys reach the coast at Coombe Martin and Lynmouth. The cliffs are formed of Devonian slates and grits with subtle variations in form related to the structure or chemistry of the rocks. The morphology of the coast changes dramatically east of Minehead, where steep cliffs of Devonian rocks are replaced by lower cliffs of Triassic and Jurassic sandstones, shales and mudstones (JNCC, 1996). The very large tidal range in the Bristol Channel and rapid erosion of the cliffs has produced a wide rocky foreshore along parts of this coast (Williams and Davies, 1989). Triassic rocks forming the southern flank of the syncline are well exposed at Blue Anchor Bay, and the Rhaetic is exposed on the foreshore near Watchet. Most of Barnstaple Bay is cut into the Carboniferous rocks, but these are not like Carboniferous rocks in any other part of England: there is little limestone, and no tract can be likened to the Mountain Limestone areas across the Bristol Channel (Edmonds *et al.*, 1969; Edwards, 1999).

Devonian rocks outcrop for 53km, only on the southern shore, consisting of felspathic and quartzitic sandstones, slates and pebble beds. They are the oldest sequence in the region. The Carboniferous series outcrop at a number of locations extending a total of 20km. Occasionally the Lower Limestone Shale succession is well exposed after storms in Clevedon Bay, though normally only the harder beds project through the sand and mud (Kellaway and Welch, 1993). The system includes dolomitic siltstones and calcitic mudstones but the dominant characteristic is the coherent massively bedded Carboniferous Limestone. The Trias extends for 59km, but is extensively fronted with mudflats especially in the eastern area (Williams and Davies, 1989).

On the northern coastline, a relatively narrow outcrop of Silurian rocks trending north-east to south-west through Llandovery disappears east of Carmarthen under the Upper Palaeozoics which form the eastern shore of St Bride's Bay. The northern limit of these Palaeozoic rocks runs through Haverfordwest almost due east to a point about two miles south of Carmarthen, and hence north-eastwards. In southern Pembrokeshire and Gower peninsula the relation between structure and coast scenery is usually very clear. Carmarthen Bay and Swansea Bay lie mainly in the Coal Measures. In eastern south Wales occurs the Trias, Rhaetic, and Lias - which form the coastline between Porthcawl and Cardiff. . The cliffs along this portion of the coast (from Penarth to Porthcawl) are never much above 30m high, and for miles at a time present a continuous front to the sea. In front of the cliffs is an extensive platform cut in the rocks by the waves, in places heaped up with debris of boulders from the destruction of the cliffs, elsewhere swept bare by every tide (Trueman, 1971). The coal basin of south Wales, together with its continuation west of Carmarthen Bay in Pembrokeshire, is primarily a great syncline, girdled by Millstone Grit, Carboniferous Limestone, and Old Red Sandstone rocks. These are much interrupted by coastal indentations on the southern side of the basin. It is to the comparatively small-scale folding of these rocks that the coasts of southern Pembrokeshire and Gower owe their beauty and variety (Steers, 1964).

Swansea Bay, lying on the southern flank of the south Wales syncline, is surrounded by poorly exposed, locally carbonaceous shales of the Coal Measures. The bulk of Gower Peninsula comprises shelly, coral-rich Carboniferous Limestone but an inlier of Old Red Sandstone conglomerates outcrops at Rhossili Bay. The bays along the south coast result from erosion of softer shales, which form synclinal cores in the Millstone Grit. Numerous faults and folds traverse the rocks of southern Gower. Glacial deposits, raised beaches and cliffs are found along this southern coast, though mantling glacial deposits are absent inland (JNCC, 1995). The whole Gower coastal area, from Mumbles Head, at the angle of Swansea Bay, to Worms Head in the extreme west, consists of Mountain Limestone cliffs which vary in form with the changing dip and structure of the rocks (Trueman, 1971). The coast of Carmarthen Bay north-west of Gower is formed largely of sand dunes backed by alluvial flats. Red Marls of Old Red Sandstone age reach the coast at the confluence of the Rivers Tywi and Taf.

Southern Pembrokeshire is composed of a wide variety of rocks ranging in age from Precambrian to Carboniferous, formed into a series of complex, tight and locally overturned folds. 'Probably nowhere else in the British Isles is there so much variety in scenery in such a comparatively small area' (Steers, 1964, page 155). The area south of Milford Haven is similar to the Gower peninsula, with continuous high cliffed sections delimiting the onshore plateau surface. with rocks being chiefly folded Mountain Limestone and Old Red Sandstone (Trueman, 1971; Duff and Smith, 1992). To the north, inliers of Ordovician volcanic, sedimentary and intrusive rocks form Skomer island, the mainland to the east and an elongate zone which reaches the coast south of Little Haven. The coast along the southern part of St Bride's Bay is formed of folded and faulted Coal Measures with numerous coal seams.

4 RESULTS AND DISCUSSION : BEACH LITTER CASE STUDY : TRESILIAN BAY

Preamble

Tresilian Bay, Vale of Glamorgan (Ordnance Survey grid reference: SS 945 679), is one of several pocket beaches situated within the Glamorgan Heritage Coast on the north shore of the Bristol Channel, Wales, UK (Figure 3.1). It is a small beach with a cobble substrate, which can only be accessed on foot via a cliff top pathway or along the shoreline at low tide; consequently there are only small numbers of visitors to the beach. It is approximately 100 metres in length measured parallel to the shore at the landward edge. Nash Point bisects the orientation of this coastline; areas to the west of the Point directly face the south west and areas of highest wave energy; areas to the east, including Tresilian Bay, are situated on a coastline that lies parallel with the prevailing wind system.

The headlands surrounding the beach are composed of Lias limestone rocks and shales that undergo some 6-10cm of erosion per year (Belov *et al.*, 1999). The cobble beach itself is 40m in width and at the landward edge rises >8m in height above the shore platform, enclosing a cobble volume of some 16,000m^3 (Williams and Tudor, 2001). Cobbles within this embayment tend to be trapped, as longshore drift for the Glamorgan Heritage Coast coastal cell in this area is eastwards. As Tresilian is a pocket beach, cobble migration around the cliff extremity is minimal; two-dimensional cross beach movement being more common than lateral. Some 10 km west of the beach is the river Ogmore which is known to bring large amounts of litter into the system (Williams and Simmons, 1997), whilst 1km to the east lies Colhuw (Llantwit Major) beach.

4.1 Temporal Trends in Litter Abundance and Distribution

4.1.1 Introduction

The aim was to establish a long-term view (5 years) of litter amounts, types, and accumulation patterns, as well as determining the rate of litter re-colonisation of a pocket beach over a two-week period. Litter pick-ups can have a public service and educational value, but it was hypothesised that in the main litter clearance is futile and it is a necessity to manage litter at its source. A further goal was to ascertain the effectiveness of sampling the beach as a whole, as opposed to a small selection of narrow transects (5m) on a 100m long pocket beach.

4.1.2 Methodology

Currently, no standard methodology exists with respect to the measurement of beach litter. For this study, the *whole* of Tresilian beach was divided into 5m wide down beach transects (Figures 4.1.1 to 4.1.7) and all litter found in each transect was recorded. Selection of several five metre transects, usually three in number, is fairly commonly utilised in beach litter surveys (e.g. Dixon and Dixon, 1981). The number of litter items were counted and attributed to the following twelve litter categories - plastic; polystyrene; metal; glass; plastic containers; polystyrene containers; metal containers; paper containers; shoes; tyres and rubber; clothing; string, rope and nets. Transects were labelled A, B, C etc., with transect A being located at the eastern edge of the beach. Therefore *all* beach litter was recorded. The survey covered a period of 5 years, 1994-1998, and after each initial survey, taken at low spring tide in May, *all litter was taken from the beach.* A second survey was initiated at the next low spring tide, *circa* 15 days later, and the litter recording in each of the transects was repeated. These surveys were termed, *'pre clean up'* (PCU) and *'after clean up'* (ACU). The amounts of litter found were graphed and subject to standard statistical analysis. All statistical analysis utilised the non-parametric Wilcoxon Signed Rank Test.

4.1.3 Results and Discussion

Beach Transects

Dixon and Dixon (1981), have argued that three random number generated transects of 5 metre width taken orthogonal to a beach, can adequately represent the litter content of that beach, and this seems to have been accepted by many researchers. The 5m width was apparently chosen arbitrarily without any justification or discussion regarding implications with respect to sample representativeness. The principle is that narrow belt transects are more easily studied, because they enable work to be completed more quickly, but wider transects probably yield more reliable data. Also why only three transects? The target population, 'is the set of N population units about which inferences will be made. The sampled population is the set of population units directly available for measurement', (Gilbert, 1987, page 7). However, Simmons (1993), showed by minimal area curve analysis, also known as species area curves derived from the Braun-Blanquet (1932), school of phytosociology, that the curve associated with litter items *does* start to tail off around this transect width. Therefore, the optimum transect width is one which provides a reliable representation of the litter present, for the minimum amount of work. Further work by Williams *et al.* (1999), found that a 5 metre transect would cover some 66% of litter categories present on the beach studied. However, it should be noted that this figure is dependant on the litter categorisation employed, as well as the beach being investigated.

The works cited above (Dixon and Dixon, 1981; Simmons, 1993), were carried out at linear beaches and riverine areas respectively, i.e. areas having a basic unidirectional flow pattern and they were not pocket beaches. Inspection of Figures 4.1.1 and 4.1.2 for 1998, showed that the selection of just three of these 5m transects on Tresilian beach would produce vastly differing results. Figure 4.1.3, showed that the litter was concentrated against the eastern edge of the beach in 1997 and the pattern was completely different from the 1998 litter distribution (Figures 4.1.1 and 4.1.2). On pocket beaches it is suggested that *all* litter should be sampled.

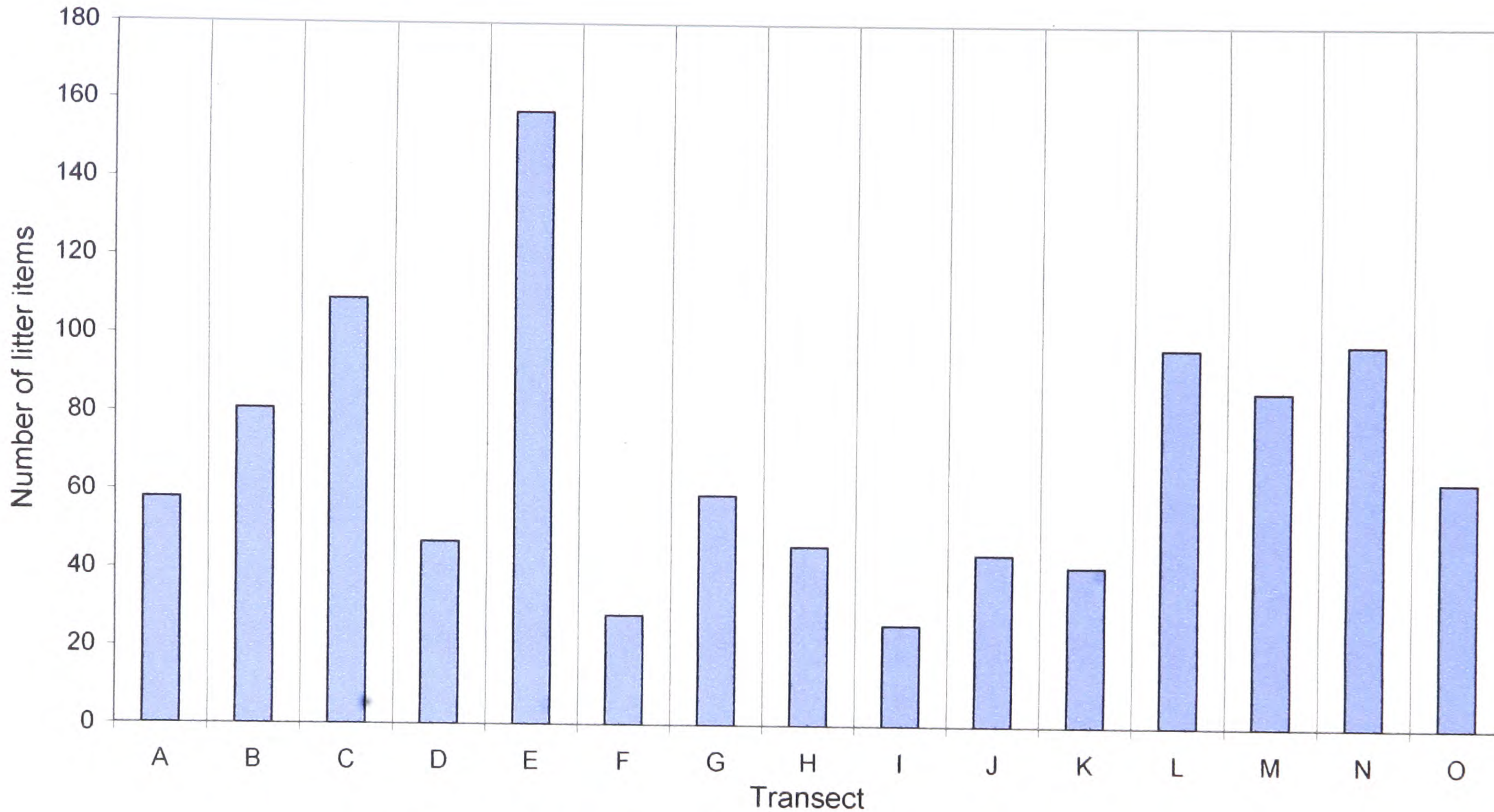

Figure 4.1.1 - Pre Clean Up Tresilian Bay 1998

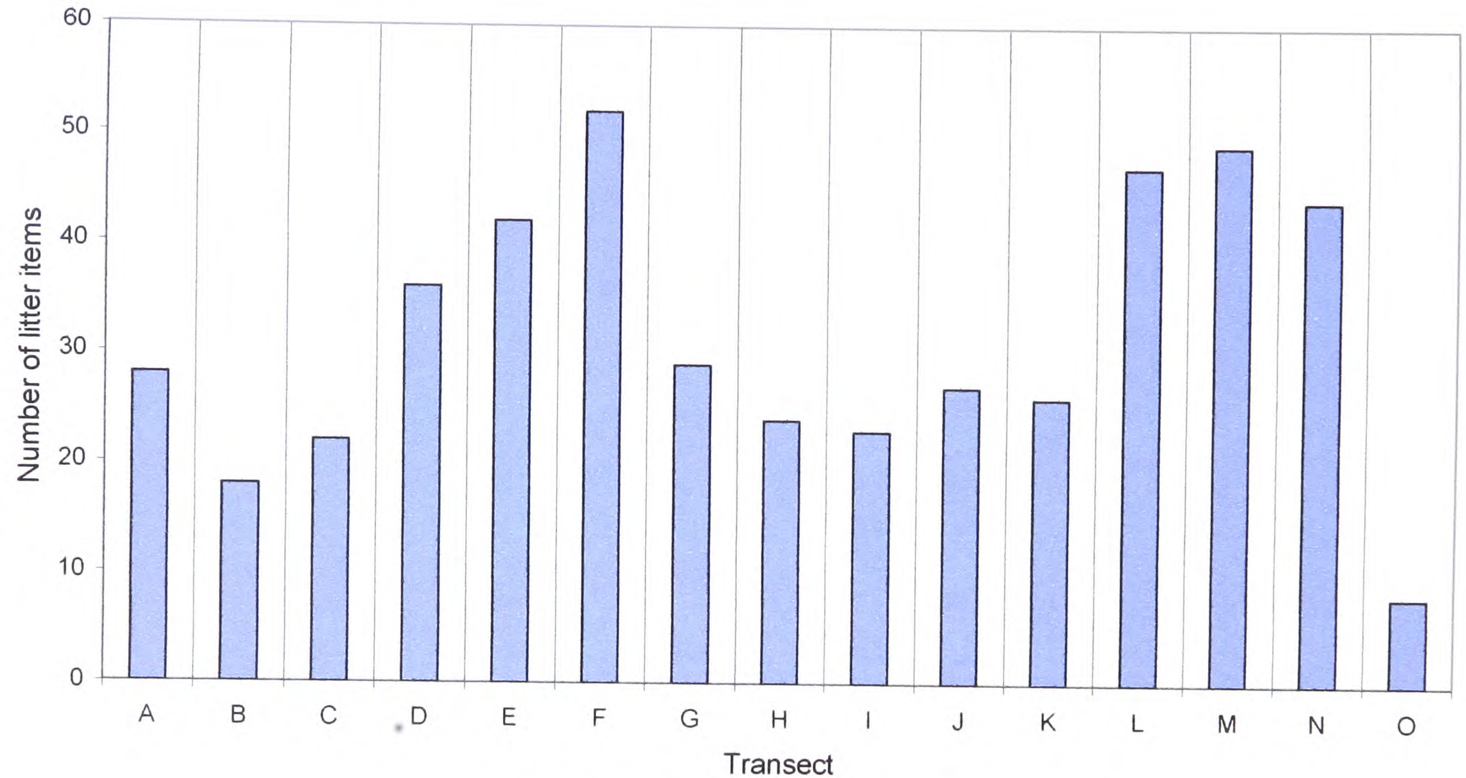

Figure 4.1.2 - After Clean Up Tresilian Bay 1998

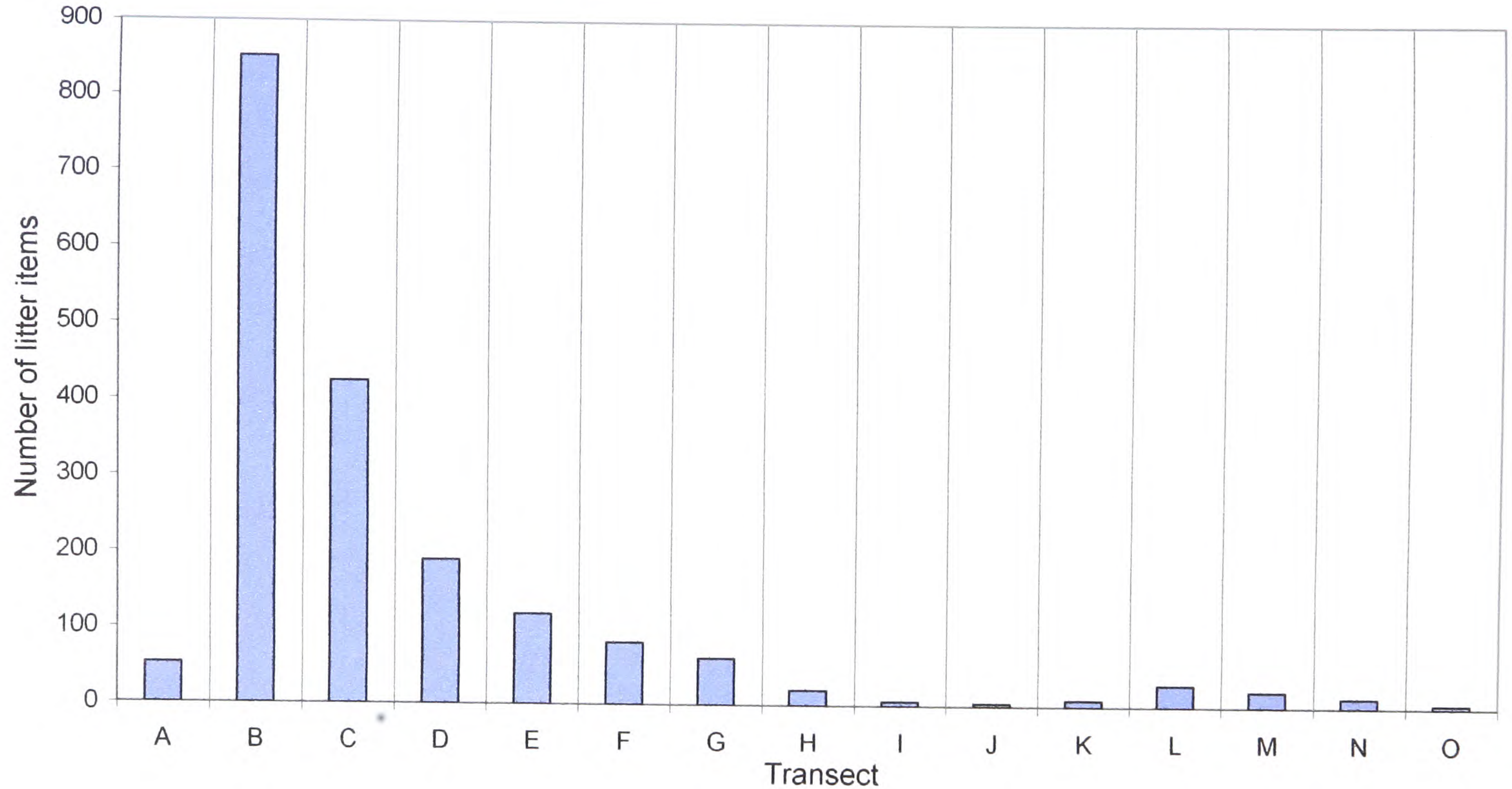

Figure 4.1.3 - Pre Clean Up Tresilian Bay 1997

Litter Amounts

i) Time trends

Figure 4.1.4 shows the total amounts of litter collected at Tresilian beach over a 5 year period both PCU and subsequently (approximately 15 days) ACU. Figure 4.1.5 shows the total amounts collected PCU along each 5m transect over the same period, and helps to illustrate the variation in litter abundance and position year on year. Values for 1996 (Figure 4.1.4), are lower than other years. This was due to a 'public beach clean exercise' about a month previous to the PCU survey. Litter data collected are illustrated in Appendix IVd.

Tables 4.1.1 and 4.1.2, display the results of statistical analysis of eleven categories of litter. The aim was to ascertain if there were any statistical differences in the amounts of litter year on year, i.e. each survey was compared with the previous years results. Glass has not been included in statistical analyses as it occurred in very small amounts (0 or 1 items) in all years except in the PCU survey of 1996. An inexorable rise in the use of plastics by society has been mirrored in the amounts of plastic litter found on a beach, but the plus side has been the decline in glass (whole or fragmented) on beaches. For the PCU period 1995/6, statistical differences can be attributed to the unusually low figures of litter abundance in 1996 due to the beach clean up previously mentioned (Table 4.1.1). Statistical differences found for the PCU 1997/8 reflect in the main variance between polystyrene and plastic containers. Plastic containers constituted a larger proportion of the litter found on the beach (32% in the 1998 PCU survey) compared to previous surveys, with polystyrene numbers being far lower in 1998 than 1997 (9% and 30% of total litter amount respectively; Appendix IVd). Other litter categories displayed similar litter proportions between 1997 and 1998. In statistical analyses of the other two surveys, no difference was found (Table 4.1.1).

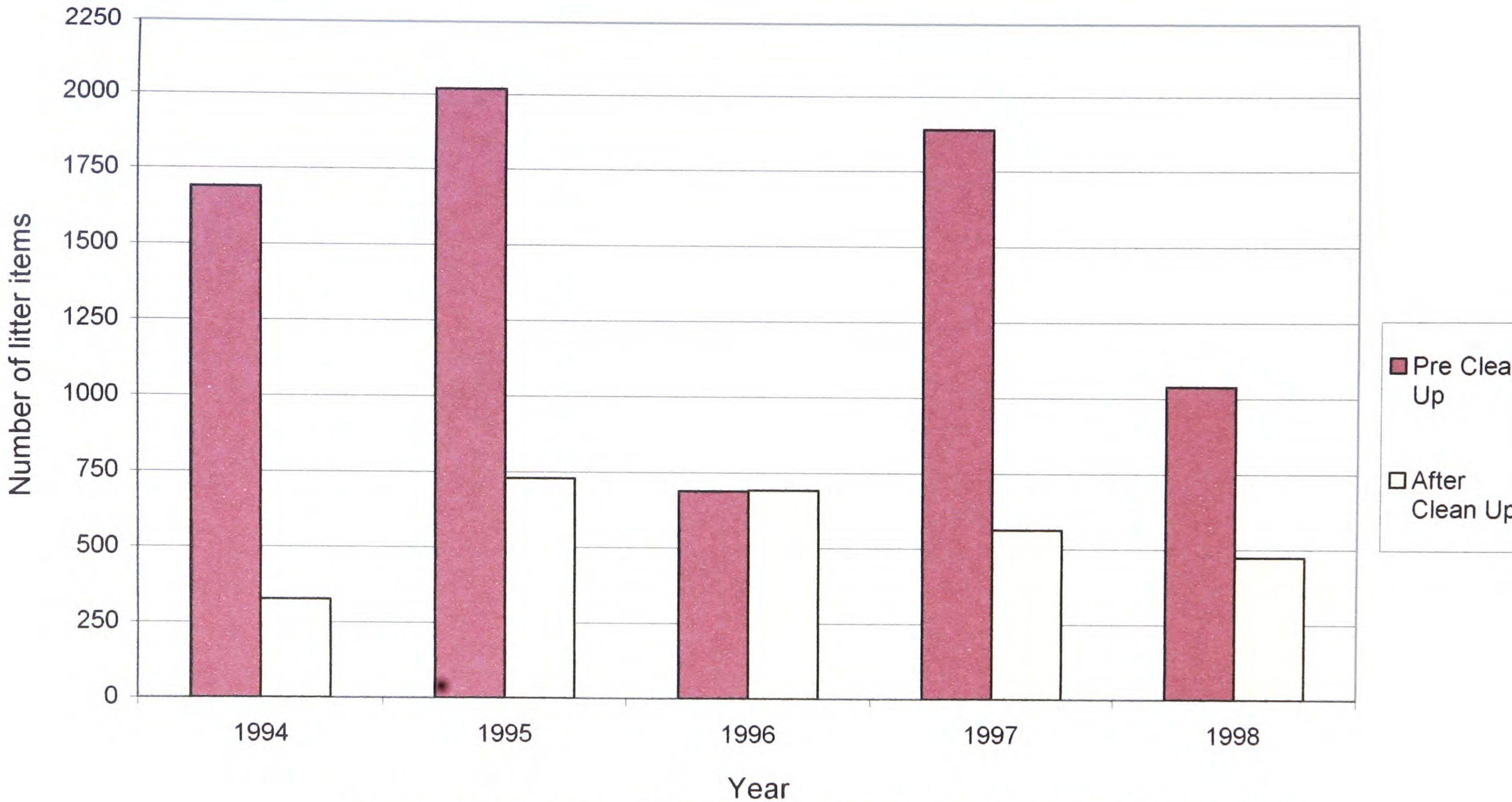

Figure 4.1.4 - Total Litter Amounts Tresilian Bay 1994-1998

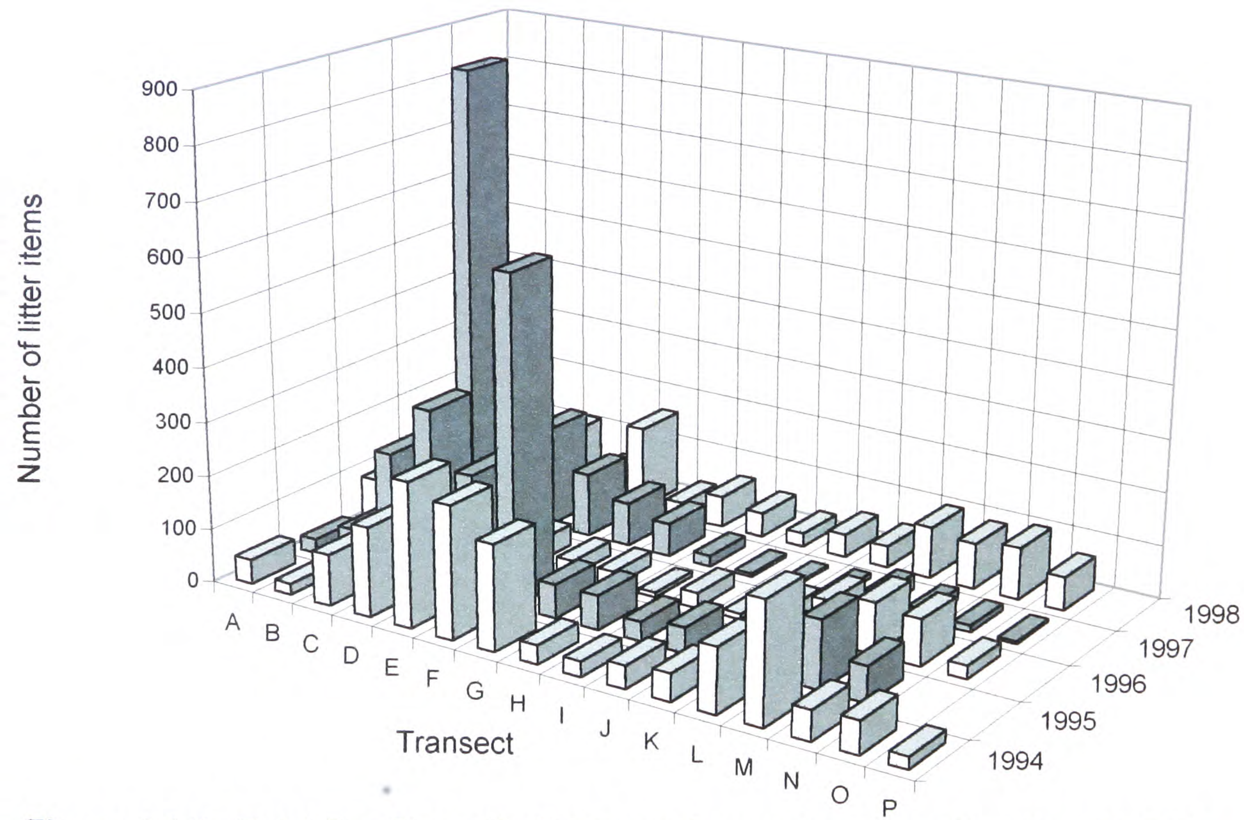

Figure 4.1.5 - Total Pre Clean Up Transect Comparison Tresilian Bay 1994-98

Table 4.1.1. Results of Wilcoxon Signed Rank Tests to determine statistical differences in litter abundance between surveys. Pre Clean Up 1994-1998

Pre Clean Up Survey Dates	P value
1994-1995	0.37
1995-1996	0.04*
1996-1997	0.08
1997-1998	0.02*

* significant at P=0.05 level

For the ACU surveys (Table 4.1.2), statistical differences were found between the 1994/5 surveys. The amount of litter showed a marked increase between surveys in these years (Figure 4.1.4). This anomaly could be due to the weather patterns experienced for some time pre measurement, as in 1995 the surveys coincided with a period of very inclement weather. Litter in the area studied is known to be essentially riverine in origin (Williams and Simmons, 1997). Therefore, material found on this beach could have originated from the river Ogmore some 10 km to the west, which would have been in a swollen state and had the ability to transport litter very rapidly to the sea (Tudor, 1997).

Table 4.1.2 Results of Wilcoxon Signed Rank Tests to determine statistical differences in litter abundance between surveys. After Clean Up 1994-1998.

After Clean Up Survey Dates	P value
1994-1995	0.02*
1995-1996	0.83
1996-1997	0.15
1997-1998	0.70

* significant at P=0.05 level

ii) Comparison of Pre Clean up and After Clean up Litter Amounts and Beach Distribution

Table 4.1.3 illustrates the litter categories utilised in this study and litter amounts obtained in the PCU and ACU, for 1997. Table 4.1.4 shows the actual counts per 5m transect for the same time period. It can be seen that plastic and polystyrene categories represent the largest amounts of materials found on the beach (Table 4.1.3; Figure 4.1.6 for 1997 and Figure 4.1.7 for 1995). Many studies throughout the world have recorded plastic as the predominant material (e.g. Corbin and Singh, 1993; Garrity and Levings, 1993; Jones, 1995; Bowman *et al.*, 1998). Plastics will be the biggest problem of the 21st Century with respect to beach litter as, 'plastic pollution has risen dramatically with an increase in production of plastic resin during the past few decades' (Robards *et al.*, 1997, page 71). Some 24% of the *total number of items* in the plastic and polystyrene categories found on the beach PCU were returned over the next two weeks (Table 4.1.3). It should be noted that these litter items are not the same objects returning, but are 'new' items arriving from the sea or being exhumed from the beach. This is indicative of the accumulation rate of litter at Tresilian beach. It would appear that the beach is merely a temporary site for litter before it is removed again by the sea.

Table 4.1.3. Pre clean up (PCU) and after clean up (ACU) material rankings and litter totals for 1997

Litter Category	PCU Litter Amounts	Litter Category	ACU Litter Amounts
Plastic	577	Plastic	158
Polystyrene	573	Polystyrene	114
Plastic containers	392	Plastic containers	94
Shoes	72	Metal containers	44
Tyres and rubber	59	Tyres and rubber	38
Clothing	51	Shoes	27
String, rope, net	48	Metal	27
Polystyrene containers	46	String, rope, net	25
Metal containers	36	Clothing	18
Metal	28	Paper container	11
Paper containers	7	Glass	9
Glass	1	Polystyrene containers	0
Total	1890	Total	565

With regard to the following discussion, the transect positions (refer to methodology, section 4.1.2) are consistent with the layout shown in Figure 4.1.1, i.e. transect 'A' is at the eastern edge of the beach. All data can be found in Appendix IVd.

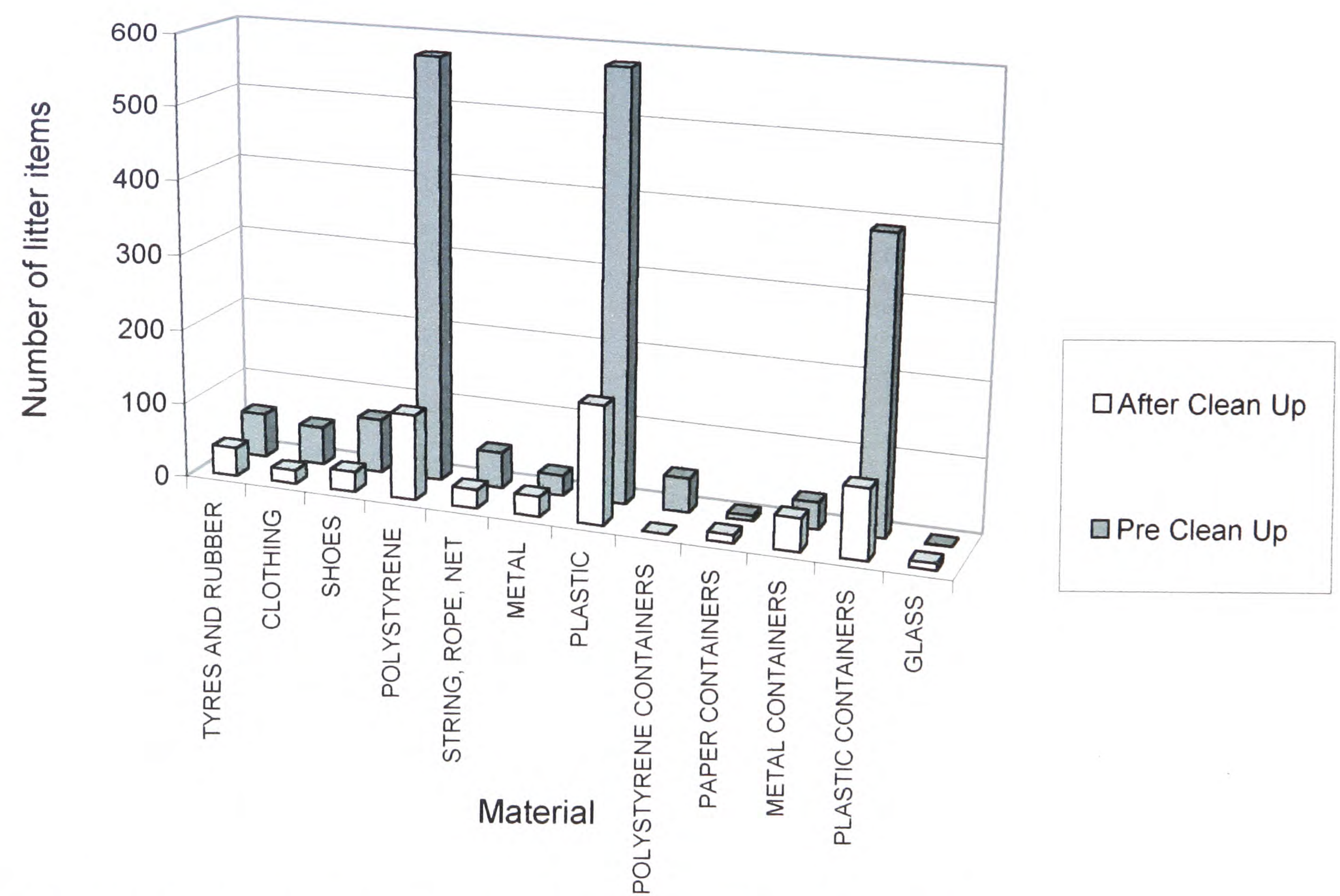

Figure 4.1.6 - Material Comparison Tresilian Bay 1997

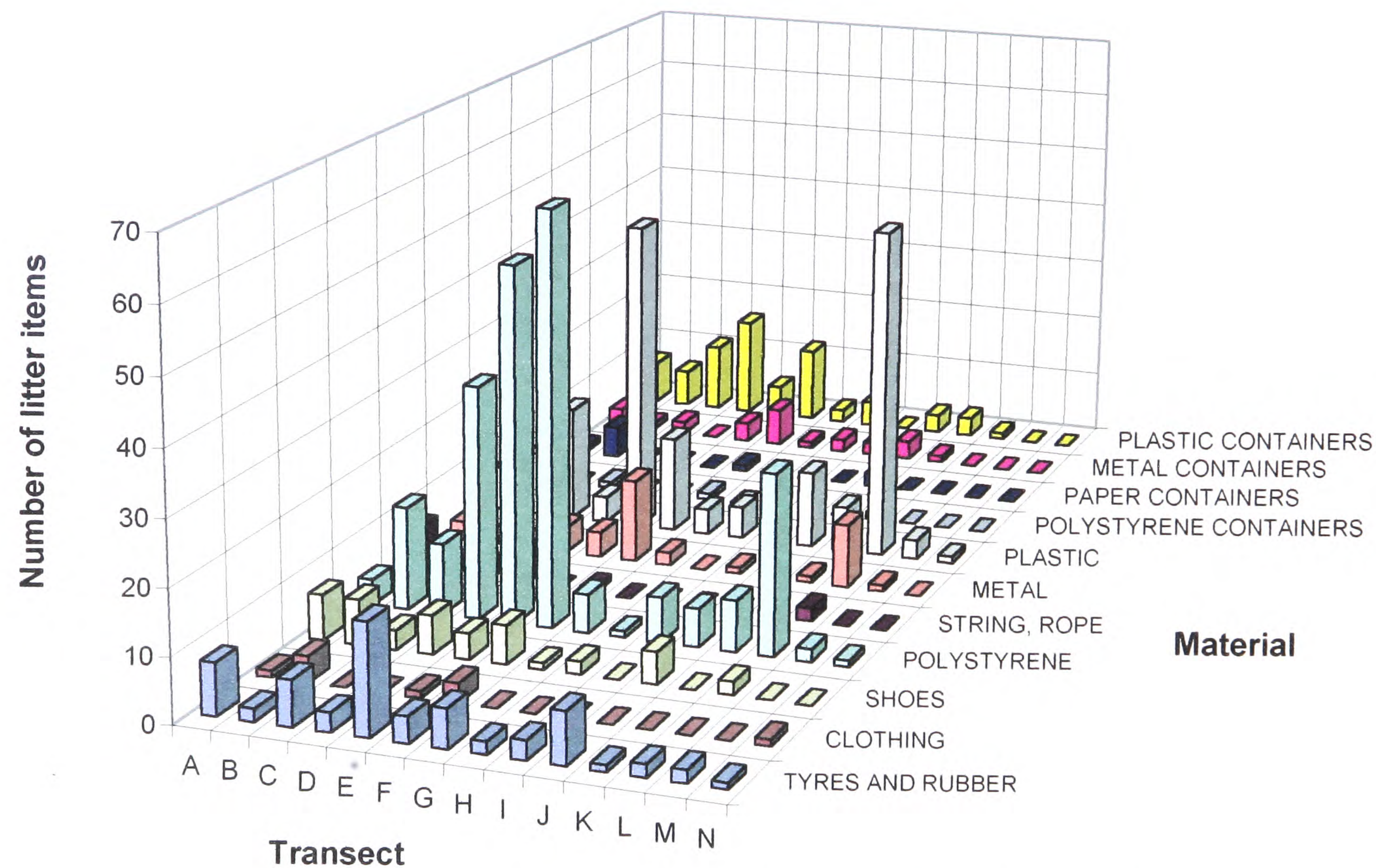

Figure 4.1.7 - After Clean Up Tresilian Bay 1995

Table 4.1.4. Transect litter counts 1997

Transect	PCU Litter Abundance	ACU Litter Abundance
A	53	27
B	852	33
C	425	35
D	190	68
E	119	67
F	82	42
G	62	25
H	20	43
I	6	18
J	4	20
K	9	37
L	29	28
M	21	53
N	13	37
O	5	32
Total	**1890**	**565**

a) 1994 Survey Results. The greatest abundance of PCU litter items was in transect E (i.e. 20-25m from the eastern edge of the beach), with other large amounts in transects F and M. A very similar pattern was seen in the ACU survey, with E again showing the greatest abundance, and large amounts being found in transects D and M. The total amount of litter fell by some 81% from the first to second survey (Figure 4.1.4). This was the biggest fall recorded, which was not surprising as the beach had not been cleaned for several years by the local authorities. The category with the largest number of litter items was plastic, followed by polystyrene and plastic containers in the PCU survey. Polystyrene was the most abundant item in the ACU survey, followed very closely by plastic (Appendix IVd). Although the enumeration of polystyrene can be misleading, it is still very important that its impact is not ignored as such small litter items are especially hazardous to bird life (Moser and Lee, 1992).

b) 1995 Survey Results. In the PCU survey, transect F had the highest number of litter items, with transect D ranking second. The ACU survey had transect E as the highest ranked transect with transect F close behind, transect L also had high numbers. The total number of litter items fell by 71% between surveys. The most abundant litter category was polystyrene (31% of the total), followed by non-container plastics and there were also high numbers (23%) of plastic containers (Appendix IVd). The same pattern was seen in the ACU survey. Both surveys produced the largest amounts of litter respectively over the five year study period (Figure 4.1.4).

c) 1996 Survey Results. This year was an unusual one regarding results obtained. The total amount of litter for the PCU survey was far lower than any other year, and yet the ACU survey had the second highest amount of litter compared to other ACU surveys (Figure 4.1.4). It was actually higher than the initial survey carried out in 1996. There was a 1% increase in litter between survey periods, i.e. more litter had arrived at the beach than was taken away. The low levels of litter for the PCU survey are probably due to the public beach clean which occurred about a month previous to the survey.

In the PCU survey, M was the transect with the greatest litter abundance, with transects A, L, N and D all having slightly less litter amounts. All five transects had similar amounts of litter, and a large accumulation of litter was found at the west end of the beach (transects L, M and N). This bears out the point that random number generated transects on pocket beaches can give skewed results and all litter on such beaches should be recorded. In the ACU survey, transect F had the greatest litter abundance. In fact there was more litter in this transect than encountered in transect M in the PCU survey. In the PCU survey, plastic was the most abundant litter category (26%) followed by polystyrene and then plastic containers. In the ACU survey plastic was again the most abundant category, this time making up some 43% of the total amount of litter (Appendix IVd).

d) 1997 Survey Results. Transect B had the greatest abundance of litter, followed by transect C (C had half as much litter as B; Figure 4.1.3). Unlike most other years there was no peak at the western end of the beach. Transect B made up 45% of the total amount of litter on the beach, transects B and C combined made up 68% of the total. In the ACU survey, transects D and E had almost identical amounts of litter (68 and 67 items respectively). There was a 70% drop in the total amount of litter between surveys (Figure 4.1.4). In the PCU survey, plastics and polystyrene were almost equal with plastic containers ranked third. These three litter types made up 82% of the total amount of litter. The ACU survey was similar, but this time the litter types made up 65% of the litter amount.

e) 1998 Survey Results. In the PCU survey, transect E had the greatest amount of litter, followed by transects C, N and L (Figure 4.1.1). In the ACU survey, transect F had the highest amount followed by transect M (Figure 4.1.2). There was a 54% decrease in litter between surveys. The most abundant material in the PCU survey was non-container plastic, with plastic containers a close second. Polystyrene made up a much smaller proportion of total litter amounts than in previous years (9%). Non-container plastic and plastic containers made up 65% of the total amount of litter. In the ACU survey, plastic containers were the most abundant item for the first time in all 10 surveys (37%). These together with general plastics made up 62% of the total litter amount (Appendix IVd).

iii) Management

Litter is one of several main issues associated with most coastal management plans (Figure 1.1). Results from this study have shown that beach clean operations are only a temporary management measure. All surveys were conducted approximately two weeks apart and initially involved the removal of all debris from the beach which resulted in less litter being found on the beach during the second survey. Nevertheless, the speed at which even the smaller amount of litter returned to the beach shows that the problem cannot be solved by simple beach clean ups and these are often a waste of time, money and effort. In a resort beach, management has to clean the beach; in rural beaches it is an option, but clean ups do not *solve* the problem. The problem clearly needs to be tackled at source and this is an area of research that has hardly been investigated (see chapter 5). In this respect it should be reiterated that even in the lowest return period (1994), some 19% of the original litter amount had accumulated within a two week time span.

4.1.4 Summary

A pocket beach in South Wales (Tresilian), UK, was studied over a five year period (1994-1998) to assess amounts, types and accumulation of litter. At low spring tide, the beach was sub-divided into 5m transects and all litter recorded prior to removal. At the subsequent low spring tide, roughly 15 days after the initial survey, the beach was revisited and the litter recording repeated. The study established that at least 19% of the total amount of PCU beach litter, returned within two weeks; in one year this figure was as high as 46%. Trends in the amounts and composition of the litter were also apparent. The litter standing stock fell by almost 50% between 1995 and 1998, with plastics being the dominant litter material. Plastic containers increased in proportion over the survey period, making up some 30% of the litter in 1998 compared with 12% in 1996. Litter was distributed across the beach at varying levels, with the largest accumulations occurring at the eastern end of the beach, this was especially so in 1997. Litter distribution across this pocket beach brings into question the validity of using selected small transects to give a true assessment of the amounts of litter present.

4.2 The Robustness of Litter Transect Data - Collection by Different Survey Groups

4.2.1 Introduction

Marine debris studies are generally focused on three main areas; either the biological effects of debris, quantification (chapters 4 and 5), or public perception (chapter 6). This section is concerned with the importance of replication of results in beach litter data collection. Very little work appears to have been carried out in establishing the replicability of beach litter surveying techniques. Replication of results across individual groups is important if volunteers and lay persons are to be reliably used in assessing and quantifying the extent of litter on beaches. Coastwatch UK undertook a quality control assessment of around 10% of the 0.5km blocks utilised in their annual analyses of the British coastline (Rees and Pond, 1994). Two separate volunteer groups were recruited to survey the same block of coastline independently of each other and results compared using appropriate statistical analysis. For example, in 1994 this comprised 42 groups. The difference in reporting rates was generally not significant, but where differences were recorded, they were related to specific categories of litter such as 'potentially hazardous containers' where different interpretations of the definition of 'hazardous' were adopted by different groups. This highlights the importance of accurately defining the specific categories of litter used in beach surveys as perception can influence results.

Beach surveys are often based on relatively small areas of study (Dixon and Cooke, 1977; Simmons and Williams, 1993; Frost and Cullen, 1997), with low numbers of surveyors involved in the collection of data. Those concerned with the accumulation of data for these studies usually had an interest or prior knowledge of the locality and the issue of marine debris. Studies on a larger scale require many more people to collect data if they are to be completed at low cost within an acceptable time frame, not all of these surveyors can be expected to have had previous experience of carrying out beach litter surveys. However, there is little technique required to identify certain litter items and the use of 'non-experts' with no prior motives for data collection has the advantage of ensuring that the data collected is completely unbiased. In addition, the use of members of the public or local interest groups in such studies has the added value of raising public awareness and indirect education.

4.2.2 Methodology

The beach was divided into one metre wide transects running from above the high tide position towards the sea, these continuing parallel to one another for thirty metres westwards along the beach width. From thirty to one hundred metres of beach length transects were increased in width to five metres. Forty final year undergraduate students from Bath Spa University College, UK were split into pairs to aid the recording process. They had a minimal background in litter analysis and studied as many transects as time would allow, describing and quantifying *all litter* within each transect surveyed (Figures 4.2.1 and 4.2.2).

Figure 4.2.1 View of Tresilian Bay.

Figure 4.2.2 Recording litter from transects at Tresilian Bay

As far as possible it was ensured that at least two groups of students scrutinised each surveyed transect independently of each other. Additionally, two surveyors with experience of debris surveys conducted analysis on several of the transects to allow a comparison of results between those with no experience. Raw data obtained was arranged into broad litter categories to allow analysis to take place. The Null Hypothesis was that there would be no significant difference between recorded litter categories for any paired grouping. It should be noted that the litter categories were established from visits to numerous beaches in the area and created to be pertinent to these beaches. These categories are site specific and may therefore not be relevant or applicable to other beaches in different locations. The Mann Whitney Rank Sum test was used to analyse data and a sample of the results shown in Table 4.2.1.

Broad litter categories utilised were:

- Food related items (sweet wrappers, fast food containers etc.)
- SRD (including cotton bud sticks)
- Drink related items (plastic bottles, glass bottles, cans, tamper proof rings, straws etc.)

- Fishing related items (twine, rope)
- Motor vehicle related items (tyres, car parts etc.)
- Unidentifiable fragments (metal, plastic)
- Road building (traffic cones, mesh fencing, etc.)
- Building materials and tools (bricks, paint cans, buckets etc.)
- Harmful litter (medical waste, glass sharps etc.)
- Clothing (shoes, cloths, textiles)
- Household related items (detergent containers, toothbrush, shampoo bottles, flower pot etc.)
- Packaging (packing straps, polystyrene, plastic bags, foams etc.)
- Other large items (beer barrel, fire extinguisher, shopping trolley etc.)
- Miscellaneous items (balloon, gun cartridge, balls etc.)
- Manufactured Wood

4.2.3 Results and discussion

Statistical analysis showed that there was *no significant difference* between results obtained from different surveyors (Table 4.2.1), the one exception being the 70 to 75 metres transect. Table 4.2.2 shows the probability values of the analysis for the four groups (labelled 1-4) that surveyed the 70 to 75m transect. Significant differences in data were identified where group 1 was involved at the P=0.05 level (Table 4.2.2). This anomaly can most likely be attributed to either poor recording of the litter found by members of group 1, or possibly the incorrect noting of the transect location on the beach by this group. Apart from this anomaly, results shown in Table 4.2.1 suggest that transect size did not have any affect; both one and five metre wide transects gave findings showing no statistical significant difference in litter quantities recorded. However, it should be noted that the experienced surveyors did record a potentially hazardous container at transect 65-70m that was not recorded as such by the students, but logged simply as a container. Results presented in Table 4.2.3 showed no significant statistical difference between student results and those of the experienced surveyors.

Table 4.2.1 Statistical probabilities obtained for group analyses of different transect widths.

Transect (metres)	Probability (P value)	Transect (metres)	Probability (P value)
0-1	0.560	14-40	*
1-2	0.739	40-45	0.229
2-3	0.770	45-50	*
3-4	0.145	50-55	0.803
4-5	0.835	55-60	0.663
5-6	0.632	60-65	0.934
6-7	0.546	65-70	0.983
7-8	0.819	70-75	**
8-9	0.211	75-80	0.663
9-10	0.119	80-85	0.084
10-11	0.724	85-90	0.818
11-12	0.755	90-95	0.518
12-13	0.506	95-100	0.402
13-14	0.349		

* Only one group recorded data so no comparison was possible; ** See Table 4.2.2.

Table 4.2.2. Statistical probabilities obtained for group analyses of the *same transect,* 70-75m

Groups	P Value
1 and 2	0.019*
1 and 3	0.018*
1 and 4	0.010*
2 and 3	0.604
2 and 4	0.648
3 and 4	0.983
1 and experienced surveyors	0.018*

*significant at 0.05% level

Table 4.2.3 Statistical probabilities obtained for group analyses (Experienced vs. inexperienced surveyors)

Transect studied (m)	P Value
60-65	0.934
65-70	0.361
70-75	0.983
75-80	0.158
80-85	0.601
85-90	0.491
90-95	0.983
95-100	0.391

4.2.4 Summary

The study attempted to establish if distinctions could be made between findings of disparate groups of people undertaking beach based marine debris surveys. Final year University undergraduates collected and analysed litter. Tresilian pocket beach was subdivided into 1 metre strips for 30 m and then every 5m. Undergraduates were divided into groups and recorded all litter found in the transects. In all cases - except for one undergraduate group, *no* statistical difference was obtained between groups recording litter from the same profile, therefore verifying the Null Hypothesis. The exception in the undergraduate group was due to recorder error. In both student groups, potentially hazardous containers were wrongly identified. The study indicates that litter counts by volunteer groups can be carried out at a sound level of confidence.

4.3 Litter Burial and Exhumation - Spatial and Temporal Distribution

4.3.1 Introduction

Few studies have endeavoured to quantify short term movement patterns of beach debris as the dynamic environment of many beaches leads to frequent potential changes in litter composition and amounts. This study attempted to assess not just, for example, how much litter appeared on a beach over consecutive time intervals, but whether specific individual litter items were transported along, remained stationary, or were removed from the beach. Repeated observations indicated that litter could apparently 'disappear' from a beach and emerge some time later as a seemingly 'fresh' / 'new' input. Litter can be inputted and removed from beaches at intervals, but how much of the 'fresh' litter is just buried litter that has re-emerged at the surface? The use of marked colour coded litter items effectively established whether litter encountered on the beach was a fresh input, or had been on the beach at a previous survey date. This is extremely important and has huge implications with respect to practical measurements of litter inputs. For example, marking litter on a beach and seeing unmarked litter appear by the time of the next survey, has usually been tacitly assumed by researchers as being a fresh input of litter from the sea.

Litter can be easily and quickly buried on beaches, whether they are of a sand, pebble or cobble substrate. Virtually no work has been conducted on the potential for litter to be buried, together with its subsequent exhumation within a cobble ridge. Litter, similarly to sediments, are generally considered to have a source, pathway and sink. What happens during the course of the pathway with regard to sites of temporary burial seems not to have been considered.

4.3.2 Methodology

On 4/12/98 - spring tide, Tresilian beach was cleared of all surface debris. Approximately two weeks later (20/12/98), the next spring tide, the beach was re-visited and a record taken of all litter, this litter being marked with waterproof permanent paint. Surveys were then conducted at regular 2 week intervals associated with the spring tidal cycle. Each survey involved the marking of 'fresh', or 'new', litter with a different colour, and recording litter previously present according to its marked colour. This continued for 3 months (20/12/98 to 8/3/99), and resulted in six surveys (i.e. six different colours). The colours representing each new spring tidal cycle were red (initial survey), blue, green, yellow, black, and white respectively. Only items of debris that were visible on the beach surface were included in these surveys. After the three month study was concluded, three 2 x 2 x 1m pits were dug in the cobble ridge (22/3/99) and all litter found within these pits was recorded.

There is a potential for litter to degrade or disintegrate and time spans for this varies from litter item to item. Polystyrene can break up very quickly, but containers (plastic, metal) do not generally disintegrate over the time period in question. For results given in this study, the probability of double counting as a result of litter disintegration would be minimal.

The pattern of litter dispersal on beaches is often irregular, it can collect at one end or in patches across the beach (Williams and Tudor, 2001). Some cobble beaches often have very undefined strand lines, with some litter distributed away from these areas due to re-emergence from beneath the surface, as a result of being trapped between surficial cobbles or as wind blown accumulations. It is for this reason the whole of this cobble beach was surveyed, rather than simply concentrating on a strandline or randomly selected transects.

4.3.3 Results and Discussion

After complete clearance of litter from the beach, two weeks later, 137 individual items of litter were recorded at the first survey (20/12/98), rising to 667 items by the final survey (8/3/99). This is a prime example of the capacity of debris to re-colonise a pristine beach within a relatively short period. Figure 4.3.1 illustrates the accumulation of litter on the beach over the study period. New litter found after each survey was tabulated in Table 4.3.1. Litter was classified by function rather than material, as this is far more informative and assists in sourcing, and therefore possible prevention. Sourcing was not the priority of this study, but the debris composition leaned toward a river/land input. There was very little shipping or fishing related debris. Items found included a number of tyres (without ropes to signify their non-use as ship fenders), many plastic drink bottles, some DIY items, hub caps, children's toys etc. (Table 4.3.1).

Plastic drinks bottles (e.g. soft drinks, mineral water) were the primary component of the beach litter, these items made up over 50% of all accumulated debris on the beach (Figure 4.3.1). This high proportion of plastic beverage containers is a common occurrence at beaches fringing the Bristol Channel (Williams and Simmons, 1997). Even though at almost all surveys, plastic bottles made up approximately half of the accumulated litter on the beach (Figure 4.3.1), they did not account for a similar proportion of the new or 'fresh' inputs on as many occasions (Figure 4.3.2). One can postulate from this that plastic bottles more readily accumulate on the surface of this cobble beach than other litter items. It is therefore important to establish what items do disappear from the beach surface, and whether these are removed by tidal currents/waves, or buried.

Figure 4.3.3 portrays the 'fresh' litter input at each survey point. It can be seen that the amounts of previously unseen and unmarked litter items varied between 297 at survey 2 (blue) and 40 at survey 5 (black). The average was 165 'new' items between every spring tidal cycle. This figure is in contrast to other studies carried out on the same beach in the month of May over a 5 year period where the average figure for fresh litter input over a spring tidal cycle period was approximately 558 items (see section 4.1; Williams and Tudor, 2001). This discrepancy illustrates the great variability in litter amounts and distribution at different times of the year.

Table 4.3.1 List of amounts of new litter found at each survey

Litter Item	Survey 1 20/12/98	Survey 2 1/4/99	Survey 3 17/1/99	Survey 4 3/2/99	Survey 5 21/2/99	Survey 6 8/3/99
sweet wrapper	0	0	0	0	0	12
small plastic drinks bottle (<500 ml)	19	46	27	22	7	16
food container	2	1	1	3	0	2
large plastic drinks bottle (≥500 ml)	20	99	61	44	3	45
metal drinks can	3	3	2	1	0	6
fishing debris (net, line etc.)	1	1	3	1	1	1
tyre	8	5	4	1	0	9
unidentifiable plastic fragment	21	25	22	25	23	34
shoe	14	9	8	8	1	14
cloth pieces	4	4	4	4	2	5
unidentifiable metal fragment	1	2	0	2	1	7
polystyrene pieces	8	27	7	4	0	16
polyurethane pieces	2	6	0	4	0	0
rusty aerosol can	0	6	1	0	0	3
milk container	0	3	0	0	0	0
detergents	3	6	0	0	0	1
rope	0	0	0	0	0	1
rubber fragments	5	12	3	11	1	15
hub cap	1	1	2	2	0	3
silicone gun container	1	0	0	0	0	0
oil container	1	0	0	0	0	0
drinking straw	1	0	0	0	0	2
rubber boot	1	1	0	0	0	5
milk crate	0	1	0	0	0	0
piece of piping	0	7	4	1	0	0
buoy	0	2	0	0	0	2
wooden pallet	0	1	0	1	0	0
rubber glove	0	0	1	0	0	0
children's toys	2	2	5	3	1	6
DIY/maintenance items	1	5	0	2	0	1
traffic cone	0	0	1	0	0	2
secondary use container	0	0	0	1	0	1
car tow hitch	0	0	0	0	0	1
car bumper	0	0	0	0	0	1
miscellaneous items	18	22	1	2	0	11
TOTAL	137	297	157	142	40	222

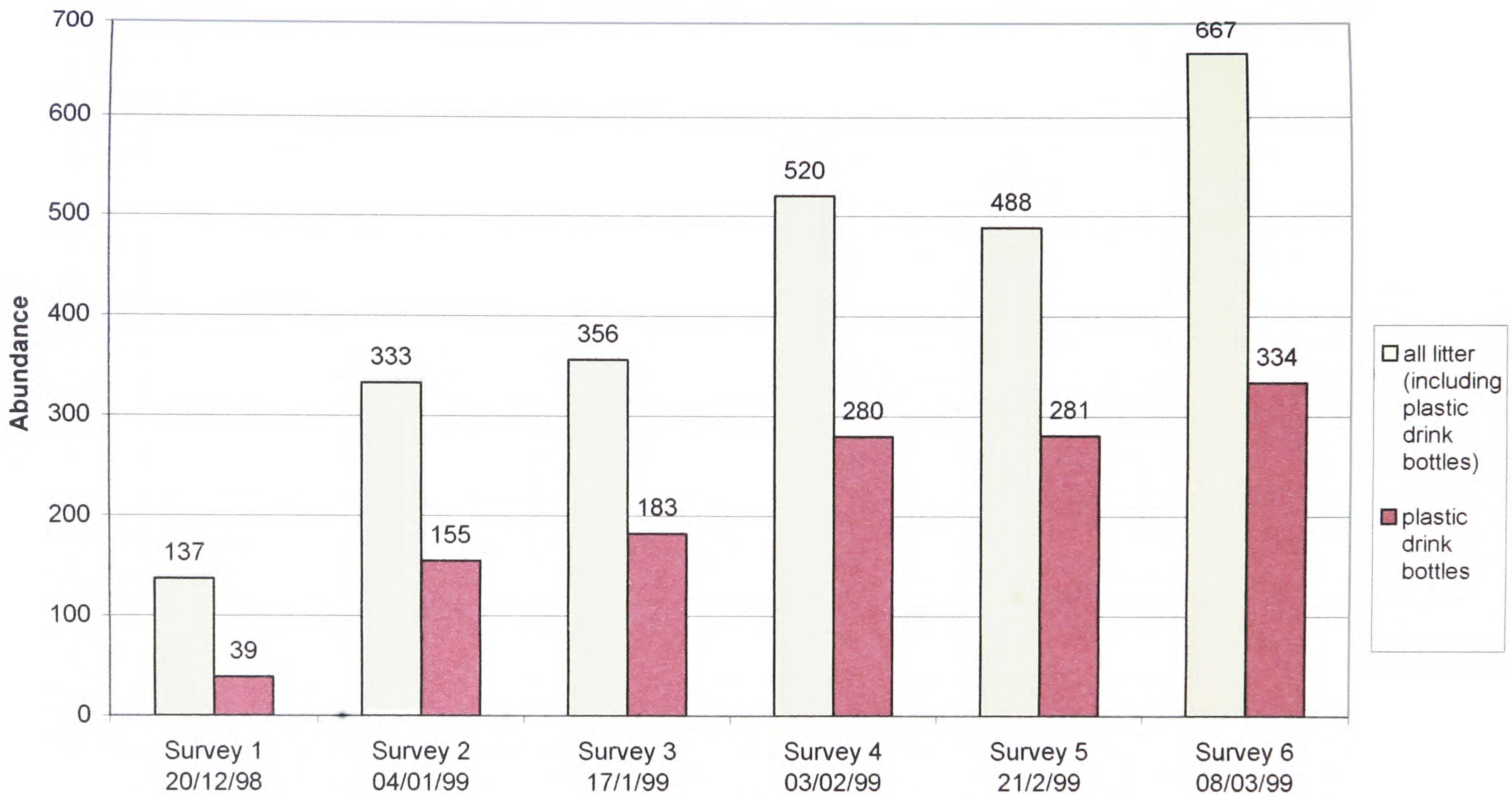

Figure 4.3.1 Accumulating Litter and Plastic Drink Bottles

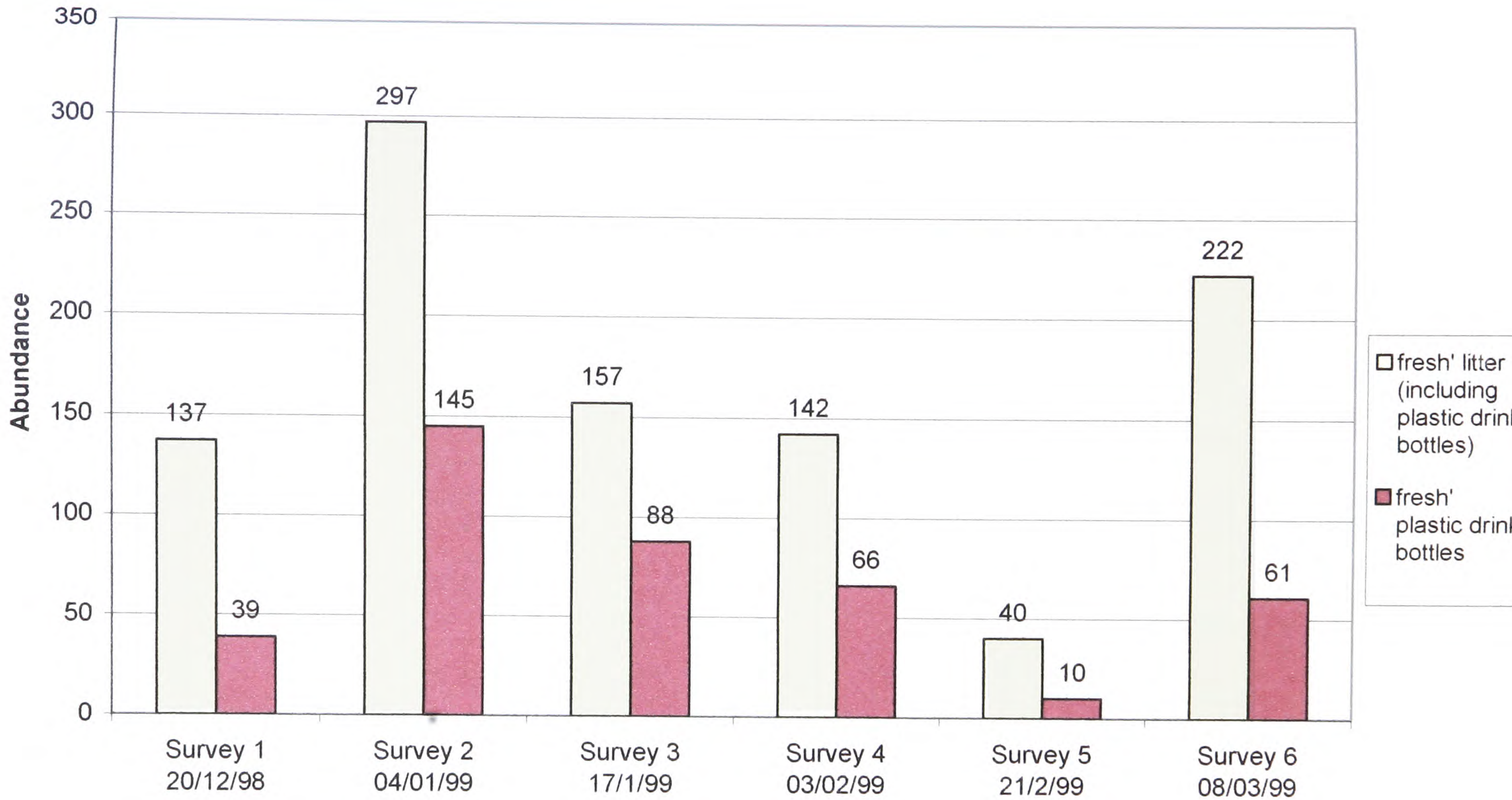

Figure 4.3.2 'Fresh' Litter and Plastic Drink Bottle Inputs

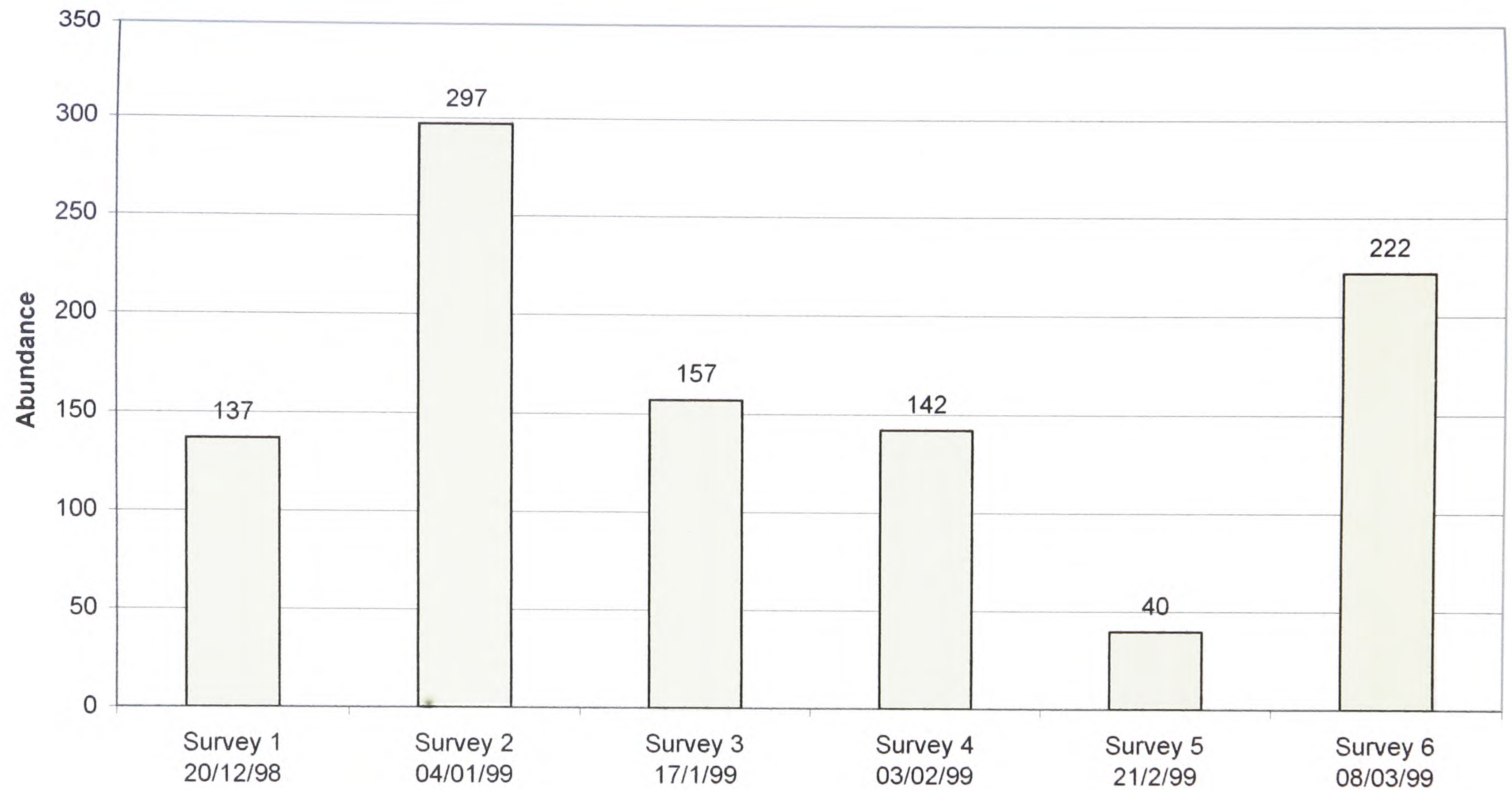

Figure 4.3.3 'Fresh' Litter Inputs

Comparing Figure 4.3.3 ('fresh' litter inputs) to Figure 4.3.4 (average wind speeds between surveys) revealed a high level of similarity in the pattern of the two histograms. The periods of highest average wind speed, preceded survey points that attained the highest 'fresh' litter amounts. This can either be attributed to litter being brought into the beach from the sea, or by exhumation of previously buried litter. This re-emergence was a result of movement in the cobble ridge caused by higher wind speeds, which resulted in larger energy levels in the waves. Wind gust peaks of 25, 27 and 26 knots per hour respectively were recorded between surveys 1 and 2, 2-3 and 5-6. Peak gusts of 20 knots per hour were recorded for the intervals between the other surveys. The prevailing wind direction throughout the three month study period was from the south west quadrant. Weather data was gathered from records kept at the Cardiff Meteorological Office Weather Centre.

The fall in the amount of 'red', 'blue' and 'green' litter present on the beach over the study period is depicted in Figures 4.3.5a, b and c, and Table 4.3.2. The big percentage fall (74%) in the 'red' debris amount present between surveys 1 and 2, was a result of a large proportion of this litter either being removed from the beach by the sea, or being buried in the ridge (Figure 4.3.5a). Unlike other surveys there was little or no re-emergence of buried 'red' litter and it is highly possible that it had been removed (Figure 4.3.5a); alternatively it could have been buried deeper than 1m. Following the initial 'red' marking there followed a period of relatively higher wind speed and wave energies (Figure 4.3.4), which helped to explain the large drop in 'red' litter found on the beach after survey 1. By survey period 6, only 18% of the litter marked 'red' remained visible on the beach (Figure 4.3.5a).

Table 4.3.2 Total amounts of litter remaining of 'red', 'green' and 'blue' surveys.

Survey	20/12/98	01/04/99	17/1/99	02/03/99	21/2/99	03/08/99
	Survey 1 Red	Survey 2 Blue	Survey 3 Green	Survey 4 Yellow	Survey 5 Black	Survey 6 White
'Red'	137	36	29	32	27	25
'Blue'	-	297	170	209	183	171
'Green'	-	-	157	137	138	120

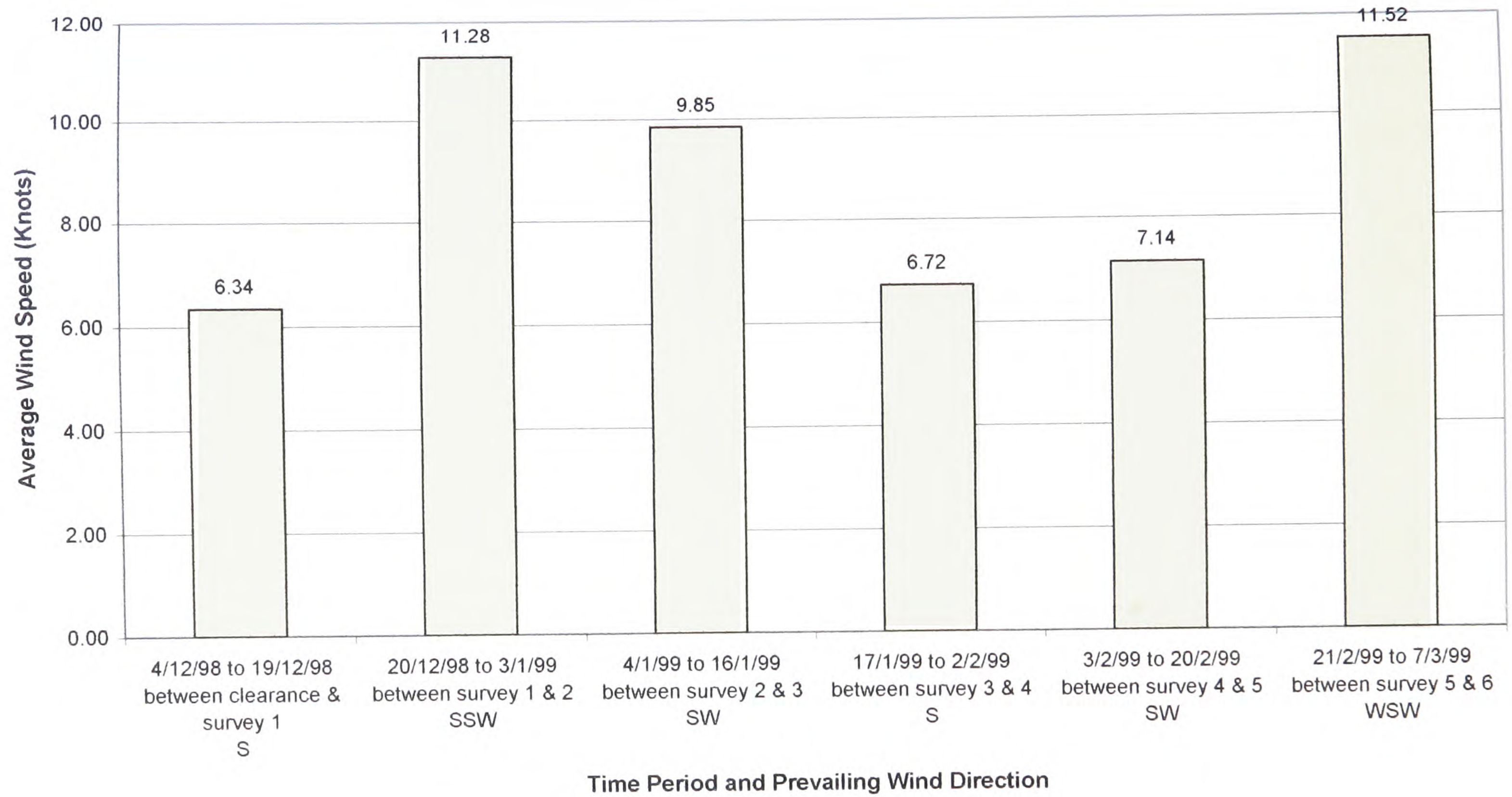

Figure 4.3.4 Average Wind Speeds Between Surveys

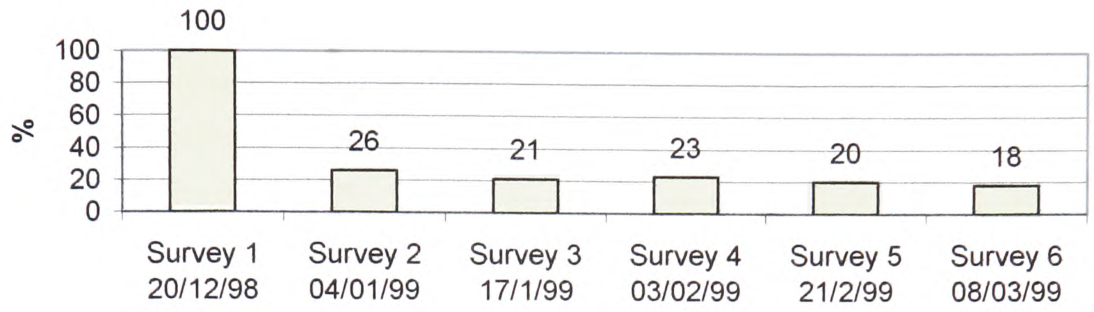

Figure 4.3.5 a - Percentage of 'Red' Litter Remaining

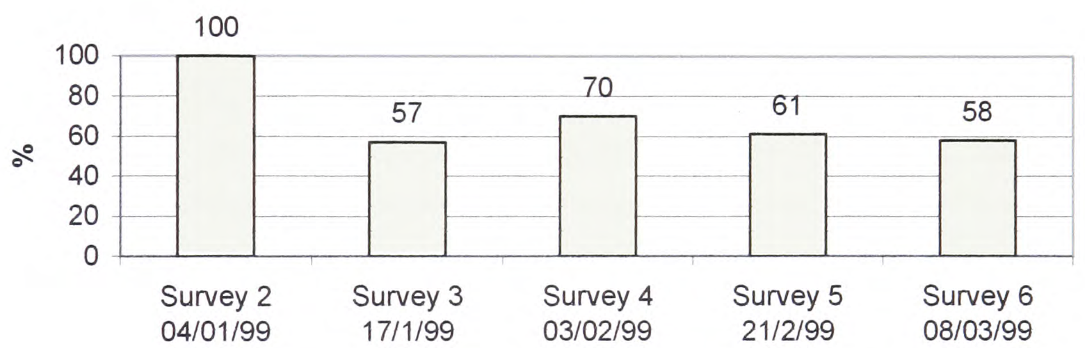

Figure 4.3.5 b - Percentage of 'Blue' Litter Remaining

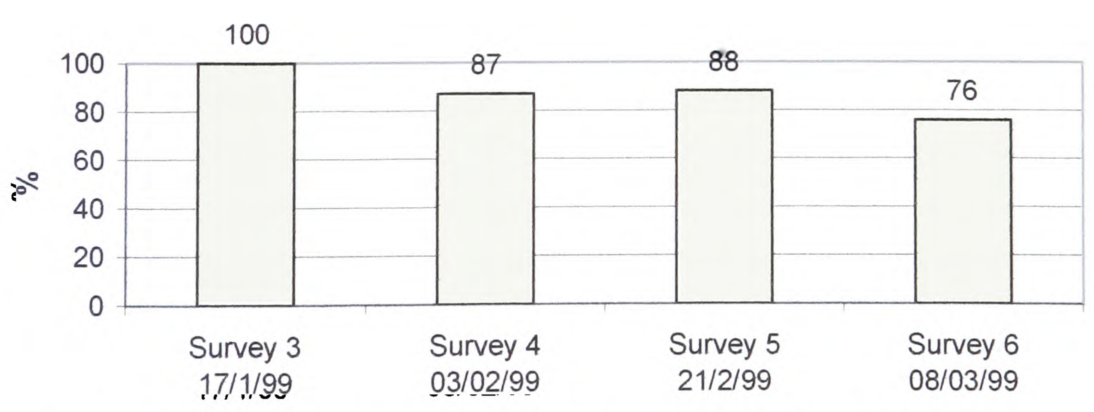

Figure 4.3.5 c - Percentage of 'Green' Litter Remaining

Figure 4.3.5b represents the changing amounts of 'blue' litter present. It can be seen that after a large fall in the amount of debris (43% drop from 297 to 170 litter items), between surveys 2 and 3 (Table 4.3.2), there was a small rise in the debris amount between surveys 3 and 4 (from 170 to 209 items, Table 4.3.2) as a result of litter re-emergence from the cobble ridge. An almost identical picture appears when examining the pattern of plastic bottle abundance for these 'blue' items (Figure 4.3.6). A 40% fall in the number of plastic drink bottles was experienced between surveys 2 and 3, and a rise occurred between surveys 3 and 4. The contrast between the overall litter re-emergence and that of the bottles, was that a greater proportion of the bottles re-appeared at the surface.

There was a small drop in the amount of 'green' items present, with only a 24% loss in the initial total amount still visible after all surveys were completed (Figure 4.3.5c; Table 4.3.2). The litter that did disappear consisted of various small fragments of plastic and metal which can easily be lost from the surface between voids in the cobbles. The final three surveys (yellow 3/2/99, black 21/2/99, white 3/8/99) showed very little fall in their litter abundance (10%, 7%, N/A, respectively), probably due to relatively lower wind speeds, and little change in the cobble ridge over this period.

Figure 4.3.7 illustrates the accumulation of plastic drink bottles on the beach over the full survey period, compared to the amount of 'new' plastic drink bottles appearing on the beach at each survey point. Over 80% of the bottles that were considered as a 'fresh' input remained on the beach at the end of the three month study period (Figure 4.3.7; see 'Total' column). In contrast to this, when plastic drink bottles were excluded from the analysis, only 57%,of 'new' or 'fresh' input litter items remained on the beach surface at the final survey point (Figure 4.3.8; see 'Total' column). Of the plastic drinks bottles encountered on the beach, 66% were classified as large, i.e. ≥500ml. Approximately 93% of these remained on the beach surface at the end of the three months, whereas only 60% of the smaller plastic drink bottles (<500ml; *circa* <20cm in length) remained visible. It would appear that smaller bottles are more readily buried in the cobble ridge, or removed from the beach, than larger plastic drink bottles. Figures 4.3.9 and 4.3.10 show some examples of litter that were colour coded during the experiments.

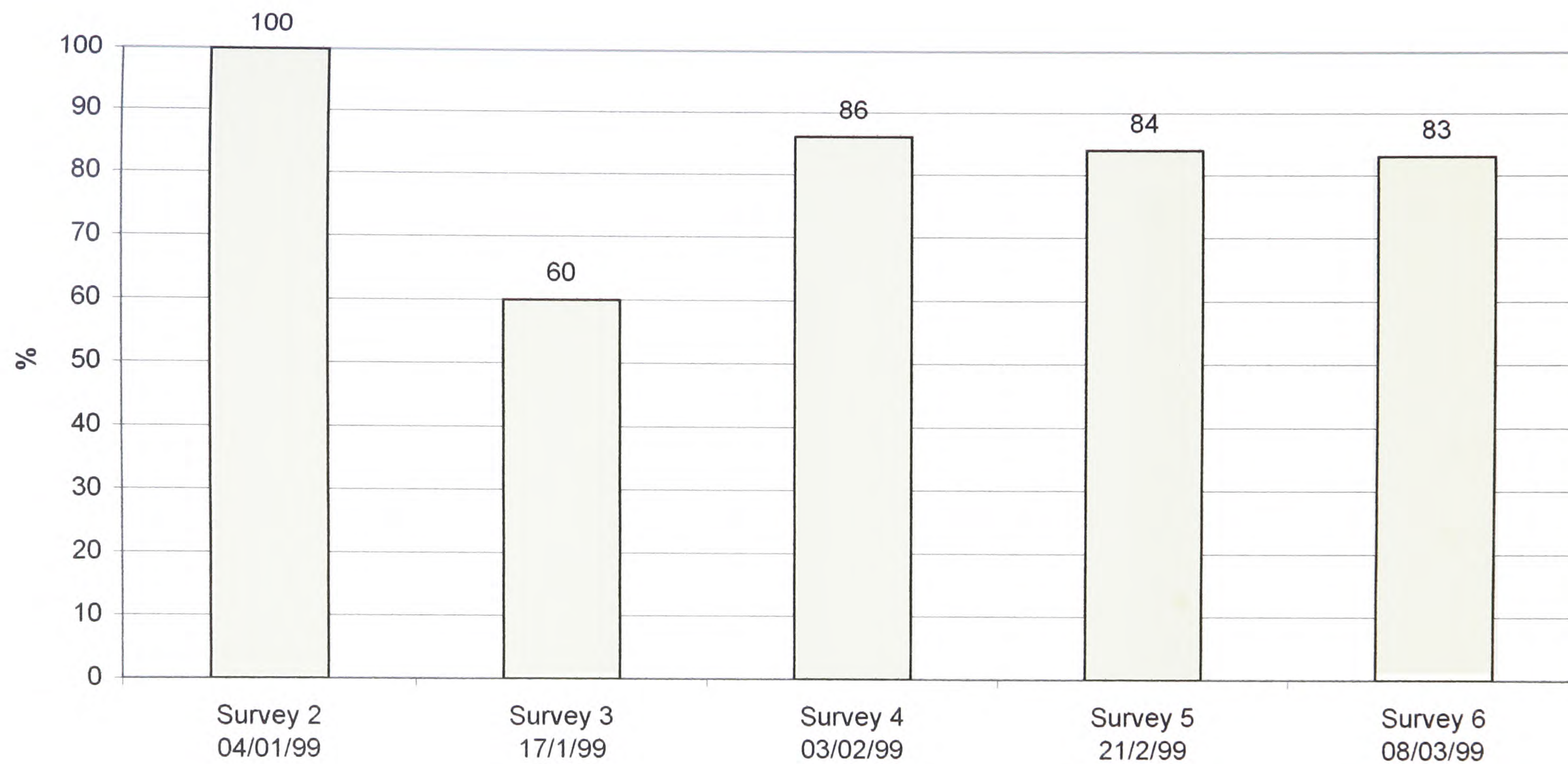

Figure 4.3.6 Percentage of Plastic Drink Bottles Remaining - 'Blue' Surveys

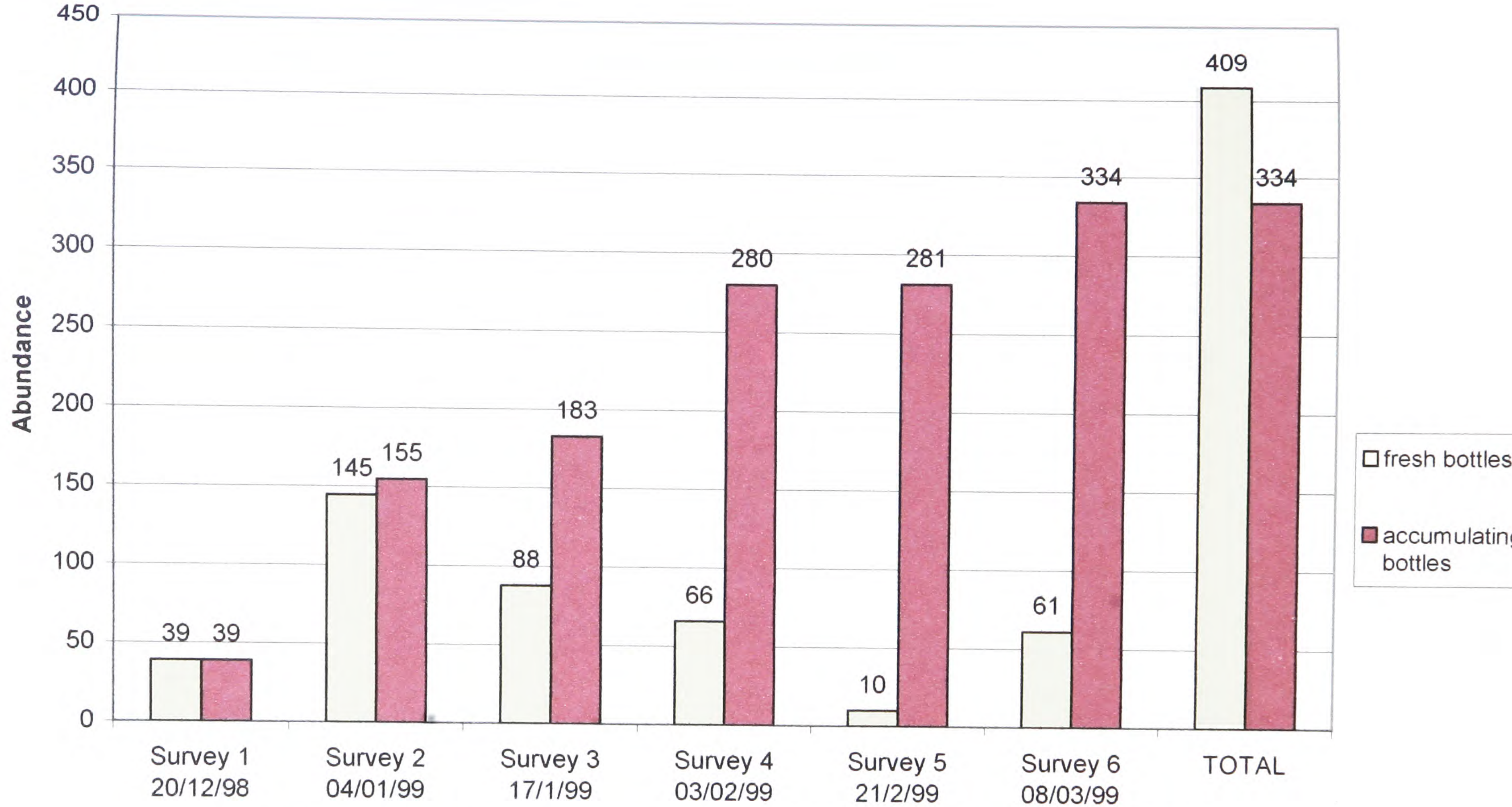

Figure 4.3.7 'Fresh' and accumulating Plastic Drink Bottles

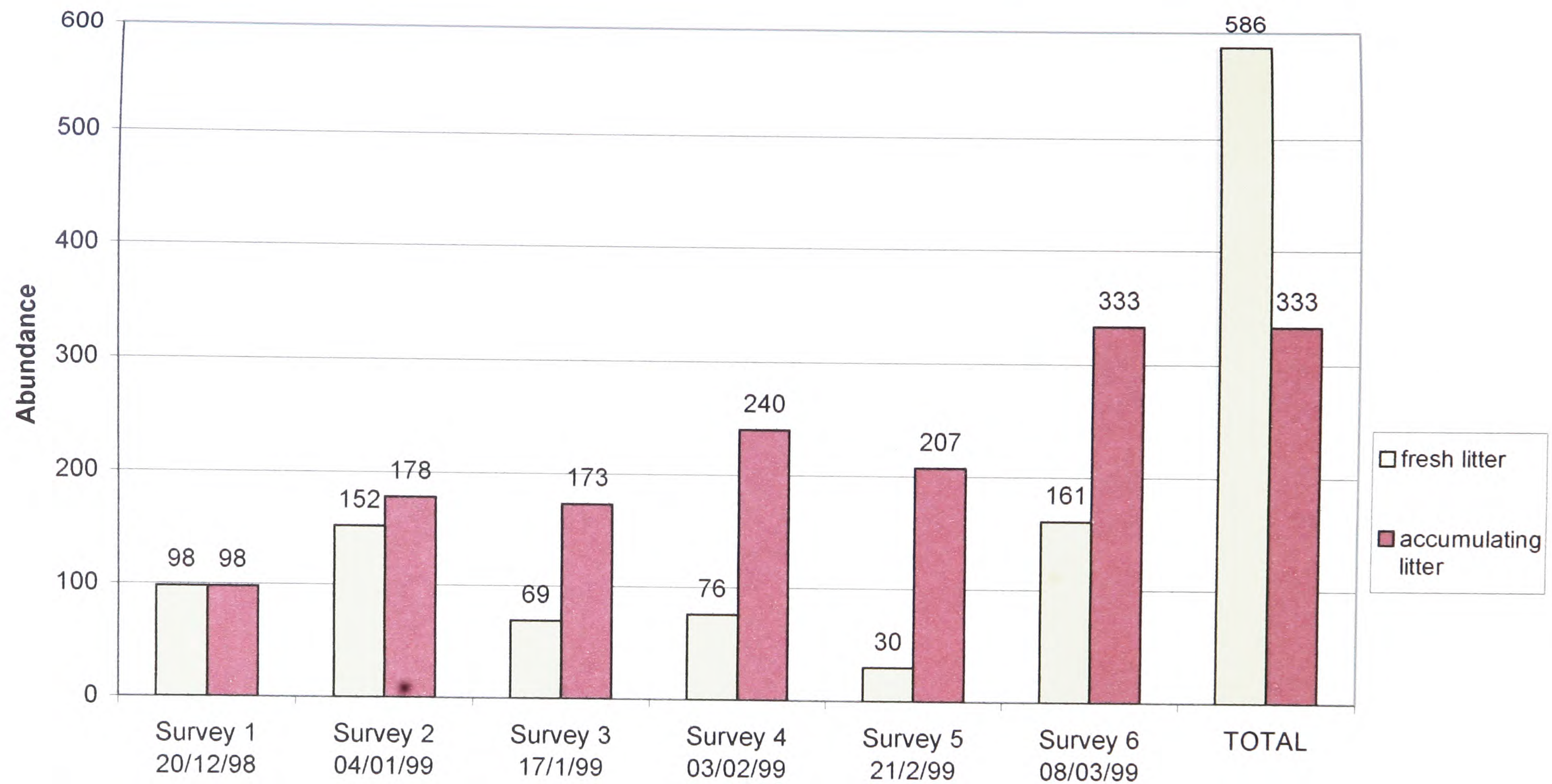

Figure 4.3.8 'Fresh' and Accumulating Litter (Excluding Plastic Drink Bottles)

Figure 4.3.9 Examples of marked litter items

Figure 4.3.10 An example of marked litter item

If as much as 93% of large plastic drink bottles remained on the beach, what items were removed or buried? Items such as tyres, oil containers, and various food containers (e.g. sauce bottles), all generally over 20-25cm in one dimension, remained on the beach. Items which readily disappeared were small plastic fragments/shards, metal drink cans, various small pieces of cloth or rubber and polystyrene pieces. It would appear that the smaller items slipped more easily between cobbles and were therefore not counted.

Litter has a source, pathway and sink similar to that of the a,b,c model in sedimentology (Tanner, 1962). Sallenger (1979), has given an excellent account of grading and hydraulic equivalence showing that grain dispersive stress controls hydraulic equivalence of grain flow deposits. Inverse grading of sediments can be produced by grain flow (shear sorting) during depositional processes (Bagnold, 1968). Similarly, Middleton (1970), explained this type of sorting by a 'kinetic sieve' mechanism whereby small grains fall to the bottom displacing larger particles upward during sedimentation. Both theories are based upon sorting occurring during the flow responsible for the original deposition of material rather than any *in situ* mechanism. It is likely that the buried litter at Tresilian followed a similar pattern.

Several pits were dug into the ridge top and items found in 3 typical pits (shown in Table 4.3.3) seem to confirm this point. As can be seen, the litter comprised *small* items, mainly plastic in origin and all items were representative of litter found on the beach surface. No large items appear to have been buried; small plastic bottles comprised *circa* a third of the litter buried. This confirms findings stated earlier that a greater proportion of the small (<500ml) plastic drink bottles were not visible by the final survey, whereas the larger drinks bottles remained on the beach surface. A significant proportion of the smaller plastic drinks bottles were most likely buried within the cobble ridge and not removed from the beach. Following the Middleton (1970) and Bagnold (1968) theories, larger bottles that were seen to disappear in some instances and be initially buried, were later displaced upward to re-appear at the surface. All litter items found in the dug pits were smaller than the surrounding cobbles and it is unlikely that they could have penetrated some 1m into the cobble ridge without a very large, sudden, depositional phase of wave activity, although this can happen on occasions in high energy environments (Caldwell and Williams, 1985).

Much of the litter at Tresilian Bay will apparently stay for long periods if it remains on top of the cobble ridge near the back of the beach. It is only likely to be moved if a period of high wave energy reaches the top of the beach and removes it, or if it is buried after a similar period of high energy wave activity. Indeed, in January 2001, over two years after the initial survey, a dozen sprayed items still remained visible on the beach. Half of these items were plastic beverage containers. Many more litter items were almost certainly buried. It is possible that the small number of new items encountered at survey 5 was a result of a period of weather/waves that was not strong enough to push the debris to the cobble ridge top (Figure 4.3.2). Therefore the litter was continually inputted and then removed, as little burial occurs at the lower end of the beach. High litter retention levels experienced in the latter surveys (from survey 3 to 6) can also be attributed to minor changes in the cobble ridge, which led to only small amounts of litter being buried.

Table 4.3.3 Contents of 3 typical 2x2x1 m pits dug into the cobble ridge top.

Litter Item	Abundance in Pit 1	Abundance in Pit 2	Abundance in Pit 3
small plastic drink bottle (<500 ml)	9	8	12
unidentifiable plastic fragments	4	5	6
metal drinks can (parts)	2	2	0
metal drinks can (whole)	1	0	0
tyre (fragments)	2	1	1
shoe (uppers)	0	1	1
shoe (soles)	2	0	1
crisp packet	1	1	1
large plastic drink bottle (≥500 ml)	1	0	0
cloth	1	2	3
polyurethane	1	1	2
plastic sheeting	1	3	4
rubber fragments	1	0	0
ball (piece)	1	0	0
rubber piping	1	0	0
lid/cap	1	2	0
fishing twine	1	2	0
cigarette lighter	0	0	1
cigarette ends	0	2	0
sweet wrapper	0	2	2
Total	30	32	34

4.3.4 Summary

After total beach litter clearance, six surveys were conducted at consecutive spring tides, over a three month winter period, which involved marking of previously unrecorded litter. The beach was soon inundated with debris, predominantly plastic beverage containers. Some marked litter was found to disappear from the beach surface, re-emerging weeks later which suggests that the potential for litter burial has been underestimated in litter research. Higher wave energies between surveys coincided with higher levels of previously unseen litter. These new inputs consisted of sea borne and exhumed litter. Items larger than the surrounding cobbles were found to work their way back to the surface of the beach after burial, smaller items remained buried. Pits dug into the cobble ridge confirmed the burial of mainly small items.

5 RESULTS AND DISCUSSION : BEACH LITTER THRESHOLDS

5.1 Levels in Beach Litter Measurement

5.1.1 Introduction

Examination of the literature regarding this subject presents an eclectic mix of aims and objectives. In any scientific study, these will have major influences on the methodology employed and this is certainly the case with marine litter surveys. As a result, a broad diversity of techniques exist to describe and measure litter which are not directly comparable. For example, litter can be categorised according to size (Ribic, 1990), weight (YRLMP, 1991), number of black bin-bags collected (Dunn, *personal communication*), or composition (Dixon and Hawksley, 1980). There is as yet no single accepted methodology for assessing beach litter.

Several techniques are currently utilised as any trawl of the literature will show:

1. Transects. These may be used of varying width. The optimum transect width is one that provides a reliable sample of the litter present on a beach (Earll *et al*, 2000a).
2. The whole beach is surveyed from splash zone to waters edge (Dubsky, 1995).
3. Transect line quadrats or randomly dispersed quadrats (Dixon and Hawksley, 1980).
4. Strand line counts (Williams and Simmons, 1997).
5. Sampling of the offshore water column (Williams *et al.*, 1993).

This study set out to clarify specific aspects of litter survey methodologies - especially point 1 above, and to assess their effectiveness. The basis for the study was the Environment Agency (EA) / National Aquatic Litter Group (NALG) 'monitoring protocol and classification scheme for the assessment of aesthetic quality of coastal and bathing beaches' (EA/NALG, 2000; Appendix II). This methodology and grading scheme was developed over a number of years in order to facilitate a standardised approach that the organisations and individuals of NALG could implement. In essence, beach litter over a 100m stretch is counted and placed into seven distinct categories. The beach is graded from A (the best) to D (the worst), according to strict criteria regarding the number of items found (EA/NALG, 2000). The final overall grade defaults to whichever is the worst category found, i.e. A, B, C or D (Table 5.1.1).

Where on-going monitoring regimes are in place, there is a need for consistency, and therefore identical methodologies are required year on year. This can be carried out successfully as demonstrated in section 4.1. The many different methods employed in collecting data for beach debris surveys make comparisons of results very difficult. Studies such as cobble beaches described in chapter 4, show that due to the uneven pattern of distribution of debris on beaches, the whole of the beach needs to be studied if a skewed picture is to be avoided. With the majority of beaches within the study area, there was a need to establish what amount of litter existed at different areas of the beach. It was unclear if the exclusion of certain areas or strand lines of the beach would give rise to misleading results.

Table 5.1.1 EA/NALG (2000) categories for grading a beach. (Numbers refer to abundance of items.)

Category		Sub-Category	Grade			
			A	**B**	**C**	**D**
1	Sewage Related Debris	General	0	1-5	6-14	15+
		Cotton Buds (Q tips)	0-9	10-49	50-99	100+
2	Gross Litter		0	1-5	6-14	15+
3	General Litter		0-49	50-499	500-999	1000+
4	Potentially Harmful Litter	Broken Glass	0	1-5	6-24	25+
		Other	0	1-4	5-9	10+
5	Accumulations	Number	0	1-4	5-9	10+
		Continuous Strip	-	-	-	Grade D
6	Oil		Absent	Trace	Nuisance	Objectionable
7	Faeces		0	1-5	6-24	25+

Many of the beach grading systems in operation, such as the EA/NALG (2000) scheme, assign a classification to a beach after sampling only a small area of that beach. The reason for this is clear; logistical, time and financial constraints mean that whole beaches can rarely be studied. The inherent problem with a small sample area is that the true reflection of beach condition is not produced. Examples of this can be seen on large linear beaches where one end may be pristine, while another is a sink for debris (e.g. Newton-Merthyr Mawr beach; see section 5.1.3c).

The three methodological aspects considered for this portion of the study were, firstly, to determine the optimum width of transect survey area so that a significant proportion (>66%) of the litter categories are covered. Secondly, to map the location of litter within the transect area. Thirdly, select sites on a long beach (in this study, the Newton-Merthyr Mawr beach area) and investigate site gradings. The *total* survey covered 22 beaches, i.e. all beaches in Tables 5.1.5 and 5.1.6 plus, Merthyr Mawr (Figure 3.1).

5.1.2 Methodology

a) Transect widths / Species Area Curves

Classic minimal area analyses (also known as a species area curves) originated in the Braun-Blanquet (1932), school of phytosociology, and was developed for determining optimum quadrat sizes for ecological studies. The optimum transect width is one which provides a reliable representation of litter present, for the minimum amount of work (see Gilbert, 1987; section 4.1.3). To determine this optimum width, a 100m wide beach study area was split into 1m wide transects for the first 30m, and then 5m wide sections for the remainder. All litter in *each* belt transect was recorded and placed into broad category groupings (Table 5.1.2), with information regarding item function and type being noted. Broad category groupings (or Genus) were chosen to reflect the function of litter items. The counting procedure was repeated for a full 100m stretch of beach. Beaches selected for study were, Aberdyfi; Towyn; Barmouth; and Pwllheli in north Wales. At Newton - Merthyr Mawr beach, Porthcawl, the 3km beach was sub-divided into 6 sectors spaced some 0.5km apart and the same procedure - enumerated above, was carried out at all 6 sections.

Table 5.1.2. Categories used (Genus), and some examples, in species curve analysis

Broad Category Name (Genus Category)	Some Examples of Items Within Category
Sewage Related Debris	Cotton bud stick (Q tip), sanitary towel
Shipping/Fishing Related Debris	Netting
Unidentifiable Fragments	-
Drink Related Debris	Bottle (plastic/glass)
Food Related Debris	'Fast food' container
Domestic/Household Related Debris	Detergent bottle
DIY/Maintenance Related Debris	WD-40
Packaging Items	Plastic packing strap
Miscellaneous Items	Plastic toy.
Gross Litter	Supermarket trolley
Harmful	Broken Glass
Faeces	Dog faeces

b) Litter location within beach transects

A 100m stretch of beach was surveyed in accordance with the EA/NALG (2000), protocol (Appendix II). The particular 100m stretch selected was determined by proximity to access points and it was necessary where possible to identify a portion of the beach where strandlines were clearly identifiable. Litter within each 100m stretch was then mapped according to its beach location (Figure 5.1.1).

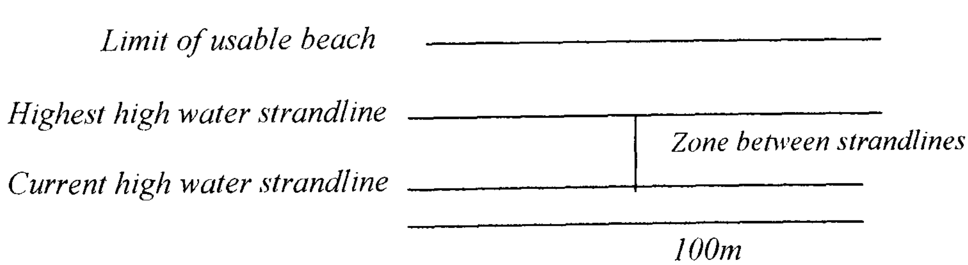

Figure 5.1.1 Sampling strategy locations

Location parameters chosen were :

- above the highest high water strandline;
- along the highest high water strandline;
- the zone between the highest high water strandline, and the current high water strandline;
- along the current high water strandline;
- the area below the current high water strandline.

All litter items were enumerated and placed in their respective groupings according to the schematic outline above. The one exception was extensive tangles or accumulations of litter where individual items could not be distinguished. This procedure was carried out on 21 beaches (Tables 5.1.5 and 5.1.6) around the coastline of Wales and the southern segment of the Inner Bristol Channel (Figure 3.1).

c) Beach Grading

The EA/NALG (2000) protocol methods were utilised in this part of the study. This involved marking off a 100m stretch of beach and counting all litter items encountered within this stretch in accordance with Figure 5.1.1, and summarising the results as shown in Table 5.1.1. This was carried out at six separate sections on a 3km stretch of beach between Newton and Merthyr Mawr, Porthcawl.

5.1.3 Results and Discussion

a) Transect widths / Species Area Curves

Litter species curves were used in an attempt to establish at what point, with regards to transect size, the survey encountered a large enough percentage of litter items to be representative of litter at that site (Earll *et al.*, 2000a). The broad category groupings help establish which item types were found, but they are not useful for debris sourcing. For example, drink related items include both soft drink bottles and milk containers, and even though these are both beverage containers the potential sources are likely to be different. The list (Table 5.1.2) can be further split in order to aid sourcing, or can be aimed at specific sources, e.g. shipping (Earll *et* *al.*, 2000b). There is a level of subjectivity in where to place a litter item within each category and these broad categories could be split into more detailed categories. Species curves depend on the genus types used, so consistency is essential.

i) Newton-Merthyr Mawr stretch of beach

Litter found on a 100m beach stretch, was placed into twelve broad categories (Table 5.1.2). Between 45 and 100% of all litter types were encountered within a 5m transect; between 70% and 100% for a 10m interval; 82% and 100% for a 25m interval; 90% and 100% for a 50m interval (Figure 5.1.2). Litter data that was categorised with far greater detail (40 items), gave a maximum of 53% of total litter types being found within a 5m transect, falling to a low of 28% (Table 5.1.3). Even using the very detailed genus categories, at least 75% of the litter categories encountered for each section were experienced at 50 metres (Table 5.1.3).

Table 5.1.3 Detailed litter species categories used at Newton-Merthyr Mawr beach. Percentage of total litter present in different sized transects

Survey Area	Percentage of total litter present in different sized transects			
	5 metre transect	15 m transect	25 m transect	50 m transect
Section 1, Newton	29	61	65	84
Section 2	28	62	75	81
Section 3	28	51	62	80
Section 4	53	65	74	82
Section 5	33	61	66	75
Section 6, Merthyr Mawr	46	76	82	92

Table 5.1.4 gives an example of items found on the six sites investigated at Newton-Merthyr Mawr. The greater the attention to detail that is employed in recording and later categorising, then the potential for missing important information and thus the link to source - which is what litter analyses should be about - is diminished. Certain items are particularly rare on beaches and these are also often large items. Such unusual items may not be seen in small study areas and may require a larger survey zone, but these decisions can only be made when the aims of a survey have been established.

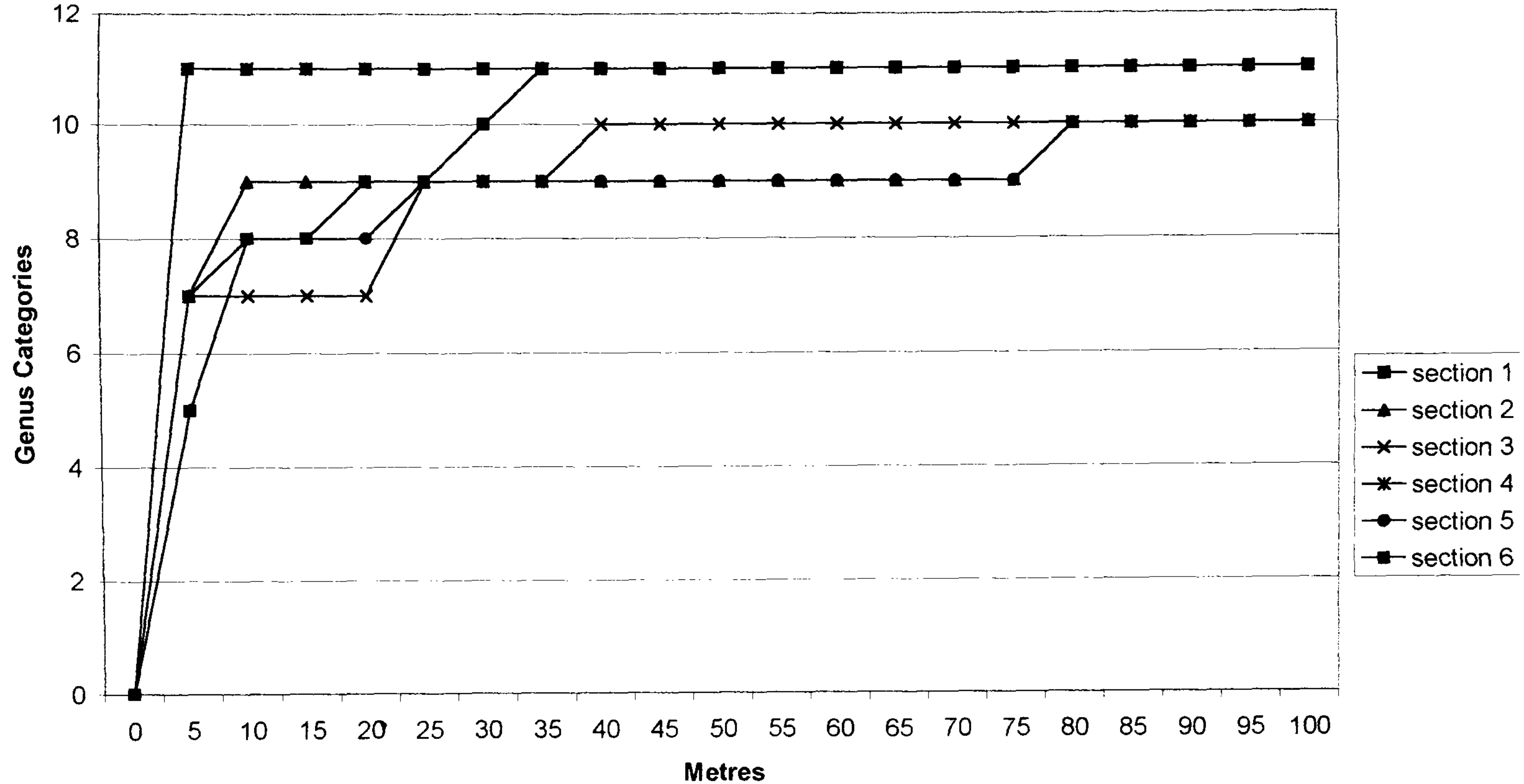

Figure 5.1.2 Species Area Curves - Newton / Merthyr Mawr

ii) Aberdyfi, Towyn, Barmouth and Pwllheli

These are tourist beaches located in mid and north Wales, which during summer months are cleaned by local authorities (Figure 3.1). Results for August 2000, showed that they were much cleaner than Newton-Merthyr Mawr beach, which is only cleaned whenever voluntary organisations set up a beach clean operation. For Pwllheli and Barmouth, 100% of the genus categories for the 100m stretch of beach were attained within 5m of beach transect. At Aberdyfi, 20% of litter was encountered within a 5m transect; 80% within 25m. For Towyn, 42% of litter was encountered within a 5m transect; 86% within 25m (Figure 5.1.3). Very little litter was present on these beaches as a result of the beach cleaning regimes. Perhaps litter analyses such as these should only be carried out during winter months. Depending on the aim of a particular project, conceivably studying a 100m stretch of beach is unnecessary as this necessitates an extended time factor in beach recordings.

Table 5.1.4 Examples of litter items found on Newton-Merthyr Mawr beach (3km).

Plastic fragment	Skateboard	sweet wrapper
Food wrapper/container	milk crate	glass sharps
Sewage related debris	traffic cone	drinking straw
Cotton bud stick (Q tip)	motor vehicle part	plastic bag
Paper	beer barrel	plastic bottle top
Plastic sheet	fire extinguisher	flower pot
Fishing twine	Shopping trolley	clothing/textile
Cigarette end	detergent container	Shoe
Small plastic drinks bottle <500ml	Foil	Cardboard
Large plastic drinks bottle	rubber glove	Polystyrene
Cigarette lighter	cable wheel	Polyurethane
Metal drinks can	gun cartridge	Tyre
Unidentifiable plastic container	gas cylinder	plastic drinks cup
Cigarette pack	Chair	toiletry container e.g. Shampoo
Packing strap	Foam	milk carton
Metal fragment	metal drum	Batteries
Tamper proof ring	Rubber	Balloon
Ball	Pen	building material and tools
Leather	Comb	Toothbrush
sun tan lotion bottle	medical waste	motor oil container
glass bottle	plastic toy	

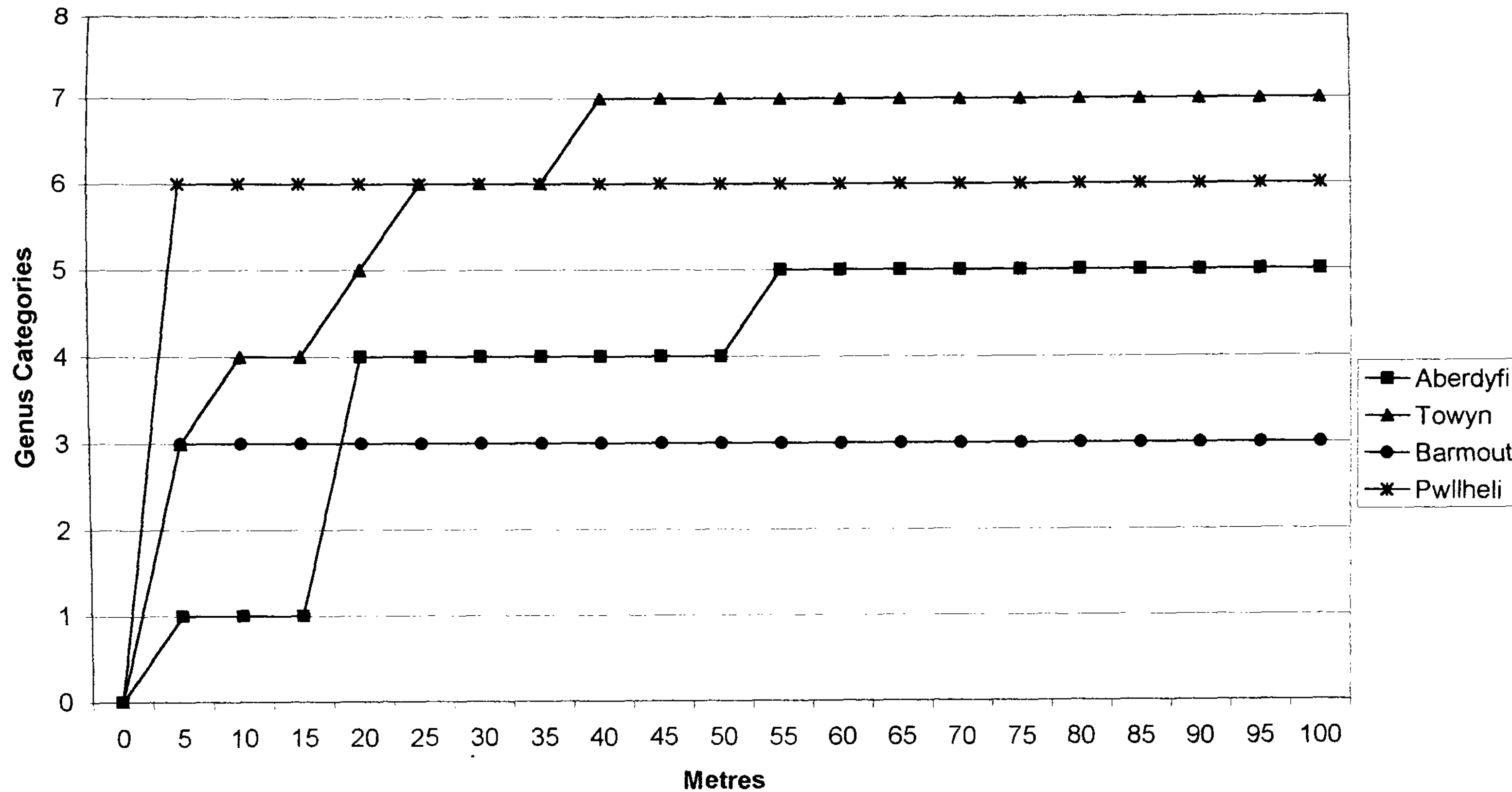

Figure 5.1.3 Species Area Curves - Mid/North Wales Beaches

b) Litter location within beach transects

Tables 5.1.5 and 5.1.6, illustrate the variable distribution of beach litter. The vast majority of beach litter was found in the zone from the highest high-water strandline to the current high-water strandline (Figure 5.1.1), with most litter being concentrated along the actual strandlines themselves. It is suggested that this is the area where litter surveys need to be concentrated, obviously depending on the aim of a survey. Tables 5.1.5 and 5.1.6 confirm the EA/NALG (2000), protocol view that areas below the current high water strandline do not merit inclusion within any study area. The average figure for the amount of litter found below the current high water strandline was just over 1% of the total for the beach. Litter analysis below this point is not really necessary. It can help the logistics regarding litter monitoring by cutting down field work time (Tudor and Williams, *in press* b), but it also highlights the fact that misleading results can accrue if researchers measure litter right down to the 'waters edge' and produce figures quoting litter abundance as a per metre value (Dixon, 1995). In high tidal range areas, the 'waters edge' can vary enormously.

Litter present above the highest high water strandline consists mainly of litter accumulations. These can be built up over a considerable length of time, and are not a true reflection of the new litter coming into the beach on a regular basis. Areas above the highest high water strandlines should not be ignored, but it must be noted that these areas consist mainly of wind blown and accumulated litter. There is extensive information that can be gained from these areas, but if the quantification of recent and new inputs is required then it is the strandline zone that is important.

Beaches that had high levels of litter above the highest high water strandline tended to be of a pebble substrate. Hartland Quay and Tresilian Bay are cobble beaches where litter was found often trapped between cobbles, or was protected from removal from the beach by the cobble ridge. Both these beaches, and also Lynmouth, had very indistinguishable strandlines. At Lynmouth much litter consisted of plastic drink bottles trapped between rocks. Putsborough had a small pebble ridge behind the sandy area where litter was trapped. Whether litter was mainly found on the highest high-water strandline or the current high-water strandline is dependant on the state of the tides, wind direction as well as beach aspect and beach substrate. In tideless areas e.g. the Mediterranean, the strand line is the key element in litter assessment.

Many of these beaches were subject to some form of cleaning regime, whether it was the whole beach or just certain strandlines. The relevant point is not on which strandline the litter occurs, but whether it occurs either above or below the strandline zone. Accumulation of litter above the strandlines is greatly influenced by substrate, topography, vegetation, weather etc., and results in this region must be carefully considered. Litter in this area provides useful information, especially with regard to long term inputs, but is obviously not indicative of daily or new inputs. The area below the strandline on these beaches had been shown to be almost completely free of litter and any time consuming surveys carried out below this line are futile (Tables 5.1.5 and 5.1.6). A contrary view was presented by Thornton and Jackson (1998), who found glass accumulating on the lower foreshore of a beach in New Jersey, USA, however, this would appear to be a very location specific example.

c) Beach Grading (see Table 5.1.1 for grading scheme)

The Newton-Merthyr Mawr beach stretch was selected for an in depth study as it is long (3km) and not subject to a cleaning regime (Figures 5.1.4 and 5.1.5). The variations in amounts and types of litter across this beach was found to be enormous, and ranged from 201 items in section 3, to 1525 items of litter/100m stretch in section 6 (Table 5.1.7). As shown in Table 5.1.7, the beach grade ranged from C, C, B, D, D, D on a west-east trawl. It is worth noting the number of SRD items found in sections 4 and 6, especially as only 15+ such items are required to constitute a 'D' grade according to the EA/NALG (2000), protocol (Tables 5.1.1 and 5.1.7). It cannot be expected that such a large beach would produce perfectly consistent results across its entire length, but this does call into question a single point selection as being representative of the whole beach.

Table 5.1.5. Percentage of debris at various areas of selected beaches on the south shore of the Bristol Channel
(N = total amount of litter found)

Area of beach	Beach Studied										
	Minehead N = 42	Sand Bay N = 167	Dunster N = 34	Putsborough N = 66	Woolocombe N = 63	Westward Ho! N = 320	Lynmouth N = 79	Weston Main N = 576	Berrow N = 1603	Hartland Quay N = 138	Combe Martin N = 412
ABOVE HIGHEST STRAND LINE	0	0	3	52	0	0	0	0	<1	63	0
HIGHEST STRANDLINE	0	88	0	6	1	86	0	12	65	26	56
ZONE BETWEEN STRANDLINES	0	0	0	0	1	13.5	0	19	5	0	0
CURRENT STRANDLINE	100	11	97	42	98	0.5	100	69	28	8	43
BELOW CURRENT STRANDLINE	0	<1	0	0	0	0	0	0	2	3	1

Table 5.1.6 Percentage of debris at various areas of selected beaches on the Wales coastline
(N = total amount of litter found)

Area of beach	Beach Studied									
	Aberdyfi N = 17	Towyn N = 63	Barmouth N = 44	Harlech N = 40	Pwllheli N = 36	Llandudno N = 68	Rhyl N = 54	Freshwater West N = 480	Angle N = 258	Tresilian Bay N = 215
ABOVE HIGHEST STRAND LINE	5	4	0	0	3	1	8	2	11	35
HIGHEST STRANDLINE	18	14	3	65	50	85	19	35	56	40
ZONE BETWEEN STRANDLINES	1	5	13	5	8	0	4	14	10	16
CURRENT STRANDLINE	75	75	82	30	34	13	67	25	20	8
BELOW CURRENT STRANDLINE	1	2	2	0	5	1	2	4	3	1

Table 5.1.7 Number of litter items found at Newton beach. Graded via the Environment Agency/National Aquatic Litter Group (2000), protocol categories.

Litter Category	Section 1 (Newton End- west) - Grade C		Section 2 - Grade C		Section 3 - Grade B	
	Total number of litter items	Grade	Total number of litter items	Grade	Total number of litter items	Grade
SRD -GENERAL	11	C	2	B	5	B
SRD - Cotton Bud Sticks	46	B	14	B	9	A
Harmful litter	6	C	6	C	2	B
Oil	0	A	0	A	0	A
Faeces	0	A	0	A	0	A
Accumulations	0	A	0	A	0	A
Gross litter	0	A	0	A	0	A
General litter	275	B	212	B	185	B
Column Total	**338**		**234**		**201**	

Litter Category	Section 4 - Grade D		Section 5 - Grade D		Section 6 (Merthyr Mawr end - east). - Grade D.	
	Total number of litter items	Grade	Total number of litter items	Grade	Total number of litter items	Grade
SRD -GENERAL	133	D	22	D	96	D
SRD - Cotton Bud Sticks	54	C	12	B	34	B
Harmful litter	11	C	0	A	14	C
Oil	0	A	0	A	0	A
Faeces	0	A	0	A	0	A
Accumulations	0	A	0	A	2	B
Gross litter	3	B	4	B	9	C
General litter	565	C	287	B	1370	D
Column Total	**766**		**325**		**1525**	

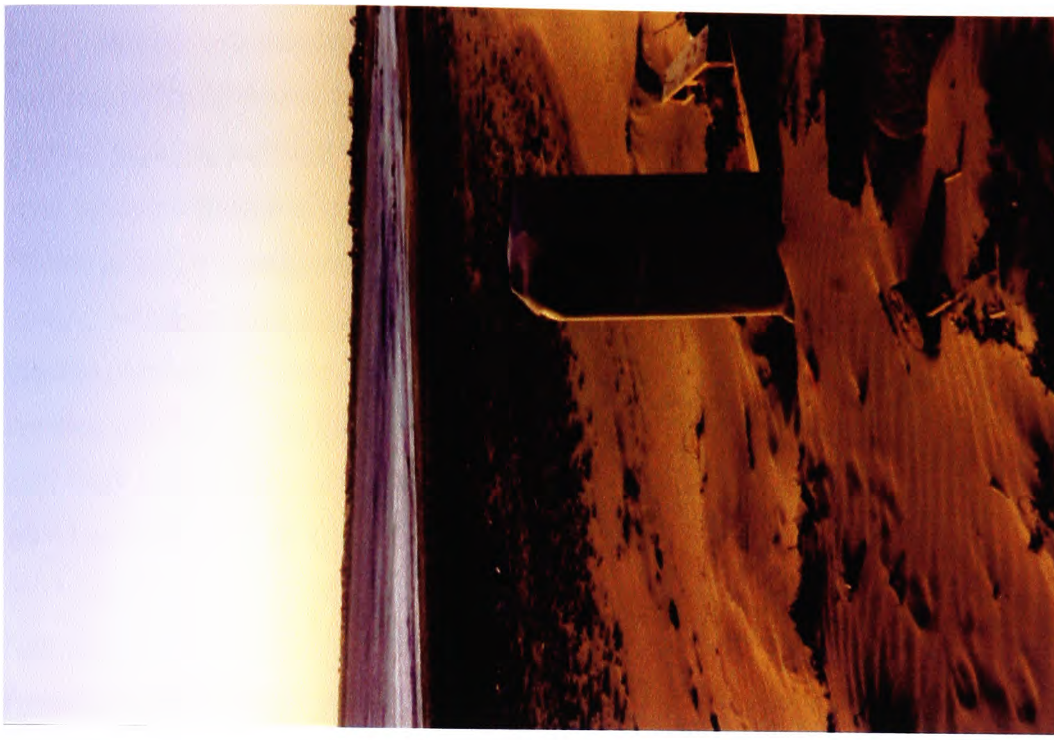

Figure 5.1.4 Example of litter at Merthyr Mawr beach

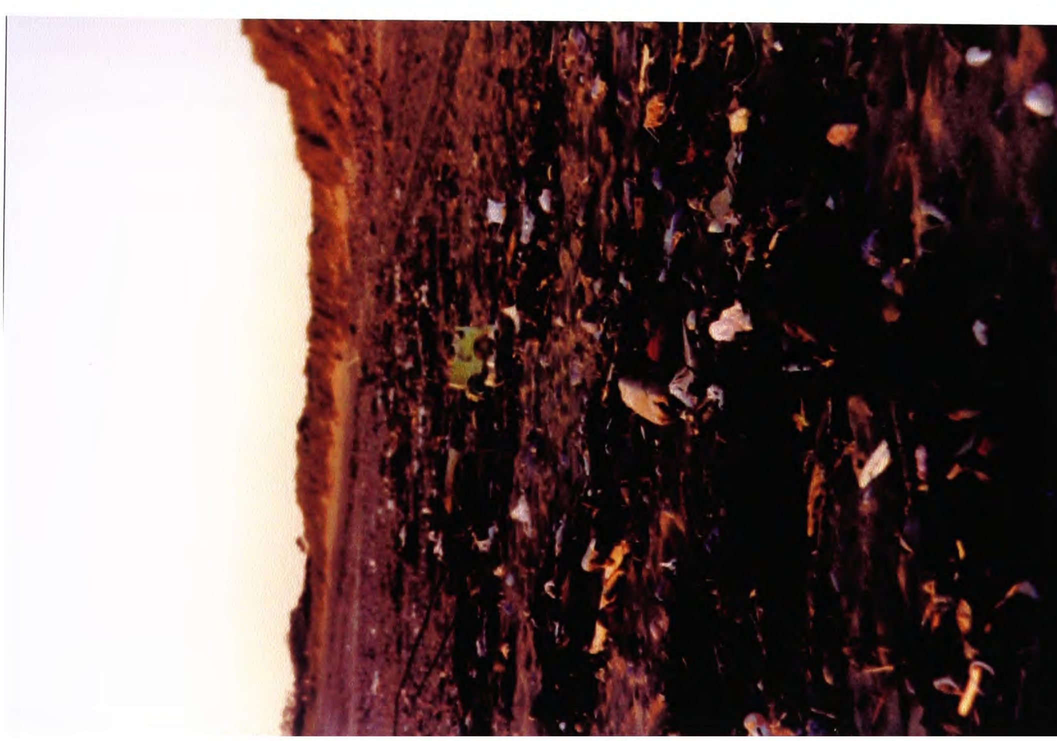

Figure 5.1.5 Litter at Merthyr Mawr beach

5.1.4 Summary

Twenty two beaches along the southern coastline of the Bristol Channel and the Principality of Wales, UK, were studied for abundance/position of litter. For five of these beaches, minimal area (species) curves were produced to establish at what level the curve flattened, as an aid in determining how much of a beach needs to be studied to find a significant proportion of the 'genus' categories. The importance of 'genus' selection and consistency of these categories is essential. For the four beaches (Aberdyfi, Towyn, Barmouth, Pwllheli) which were cleaned during summer months, within a 25m transect width, 80 - 100% of the genus categories for beach litter were found. For a non- cleaned beach the range was 80 - 90%. Analysis as to what level litter existed at different areas of the beach established that an average of only *circa* 1% of litter encountered on these beaches was found below the current high water strandline. The most recent litter inputs are concentrated along the current and highest high water strandlines and in the zone between. It is suggested that this is the area where litter surveys and management actions need to be concentrated. Areas above the highest high water strandlines should not be ignored as these areas consist mainly of wind blown and accumulated litter, potentially collecting over long time spans. Extensive information can be gained from these areas, but if quantification of recent and new inputs is required then it is the strandline zone that is important. Large variations in assessing the grade of a long linear beach (six sections at Newton-Merthyr Mawr) were found, bringing into question, the view of grading a long beach at one point. At this beach, total litter items ranged from 201 to 1,525 items /100m stretch.

5.2 SOURCING BEACH LITTER

5.2.1 Introduction

Determining the source of litter found on beaches is often proclaimed as the absolute aim of many monitoring and survey programmes. However, the effectiveness of such schemes to accurately attribute litter to a source is in some doubt. At present there is no explicit or widely used methodology that facilitates the sourcing of beach litter. Other research studies, e.g. Gabrielides *et al.*, (1991); Thornton and Jackson (1998), have assigned sources of beach litter for a particular location, but often these are based on assumptions or educated estimations through local knowledge. Whilst locality knowledge is very important in order to assist sourcing, the methods used in the attribution process are often unclear and do not seem to be systematic or theory based. There appears to be a theoretical vacuum with respect to litter sourcing. To have any realistic hope of preventing, or at least abating, the beach litter problem it is essential to ascertain its source and to establish a robust methodology to facilitate this (see Figure 1.1).

Most litter surveys conducted on beaches simply enumerate and categorise litter according to material composition, i.e. plastic, metal, glass etc. (e.g. Corbin and Singh, 1993; Frost and Cullen, 1997). This material breakdown *is* useful in establishing the effectiveness of legislation such as MARPOL Annex V (1973/1978). However, the shortcomings of this method of litter survey is that no information is gleaned regarding potential sources. Although it is a very difficult and often imprecise task, sourcing, along with education, is perhaps the prime weapon in the fight against this type of pollution. If a source can be established, then those perpetrating the pollution can be targeted and hopefully measures taken to address and subsequently prevent the problem. Beach managers and port/harbour authorities can use information gained regarding the sources of beach litter to formulate plans and actions with regard to prevention measures. This is perhaps an idealistic aim, in that there are certain beach locations that possess such a mix of litter with several potential sources that any attribution to a specific one would be extremely difficult.

Beach litter can be categorised into two broad source groups (see section 2.1), which can be further split to enable a more useful and accurate attribution. Sea-based sources of litter includes all types of sea-going vessel as well as offshore installations (Earll *et al.*, 1999). Land-based sources incorporate litter left by beach users (Golik and Gertner, 1992), litter entering the sea via rivers or municipal drainage systems (Williams *et al.*, 2000b), and litter directly deposited at or near the beach (Nash, 1992). A third broad category can also be considered, namely *truly pelagic litter*. This litter will have spent lengthy periods afloat with distant sources, whether these were land or sea based (Gregory, 1998). The problem with considering this final category is that the litter would be difficult to distinguish from litter emanating from the other two prime sources, especially as originally such items would have derived from one or other of these.

Linking Items to Source

Occasionally, litter can be very directly linked to a specific source, on other occasions the sources can be numerous, with little indication or information available on litter items to allow easy attribution. Items such as water or soft drink bottles rarely contain any labelling when they are found on a beach, these items are used by beach visitors, those at sea, and can also arrive at a beach via rivers. There are sometimes clues to source on the surface of debris items, for example, marine growths or oiling could point towards a sea input. Although items that have been at sea a long time, but originated from a land source, could also be tainted with these. Indeed, colonisation can be very quick and plastic substrates need not have drifted very far before they become heavily coated with bryozoans and barnacles (Gregory, M. *personal communication*).

Containers carry a wealth of information on their surface or on labels. Any labelling present, fully intact containers, and recent sell by dates imprinted on the container will help identify beach user discards. However a caveat must be recognised, burial or some time spent at sea may mask the original source of these items, and may lead some to consider these as being from a sea borne source. Other labelling, such as milk containers with specific local markings, help to pinpoint sources, plastic shopping bags may also have local addresses which aid the attribution process. Foreign items are widely accepted as indicating a shipping source (Figure 5.2.1). This is because items either come from foreign vessels, or UK vessels which have purchased foreign goods abroad. A number of foreign containers (e.g. milk, detergents) have been found on Pembrokeshire beaches, illustrating the use of the area by Spanish fishing vessels.

Figure 5.2.1 Example of foreign litter item

Attribution Process

Attributing a source to litter found on beaches is very complex. Trying to establish a source from an amalgam of debris is not an easy task and it is important to consider several factors and often to make informed assumptions.

- **Identification**

This is probably the most crucial factor. Without correct and robust identification of a litter item no link to source can be made. There is evidence of people mis-identifying items of litter, particularly those that are potentially hazardous or of a sewage derived origin (Williams *et al.*, 1999; Tudor and Williams, *in press* a). Aids to help identify items of debris have been developed both in the US and UK (CMC, 1993; Earll *et al.*, 2000 b). These guides consist either of photographs or sketches of individual pieces of litter, with descriptions of their attributes and function. The use of such visual aids is an important step forward in the process of sourcing, and the pooling of information into a photographic resource can help both lay-man and 'experts' alike.

- **Function**

Once an item has been identified it is essential to know its use. For example, containers on beaches are often found to have been deliberately cut or split in half. These containers have been used for a secondary purpose, i.e. they are being used as bailers in boats, or as a receptacle for oil changes or to hold paint. Similarly, containers or tyres will often be found with rope attached, indicating a secondary use (Figure 5.2.2). The function of the item will therefore link back to the source, in this example to a shipping / sea based source. It is simply not enough to record such an item as a 'container'. The data gathering process is vital where the source of litter is the ultimate aim of any monitoring programme.

Figure 5.2.2 Example of secondary usage of litter

- **Quantity**

Some items are particularly rare (e.g. syringes), and the presence of a solitary item is not sufficient to point to a particular source dominating the litter on a beach. Items found in large quantities (e.g. cotton bud sticks, pieces of fishing net) will point either to deliberate dumping, an accidental spill, or a regular input. The quantity of litter items found on a beach must be taken into consideration where sourcing is concerned.

Attribution to a Specific Source

These three factors - identity, function and quantity - contribute to the attribution process. Even with this information, ascribing a precise source can still be perplexing. Some attempts have been made to apportion litter to specific types of shipping vessels (e.g. Whiting, 1998; Earll *et al.*, 1999), but this is an imprecise process that is open to large errors. There are though some distinctions that can be made between shipping vessels, for example merchant shipping may have larger quantities or sizes of household and food goods on board than those of smaller fishing vessels. They may also carry duty free spirits and packaging items from more distant parts of the world (Dixon, 1995). Ferry and cruise liners often carry products on board that bear their logo, which will obviously aid sourcing if such items are found on beaches. With regard to the study area of the Bristol Channel, more information regarding the types of fishing and shipping vessels using the area would be needed, as well as traffic volumes, before any attempt to attribute litter to specific vessel types is attempted. To further cloud the issue, the Bristol Channel is also influenced by offshore activities taking place in the Atlantic Ocean and the Irish / Celtic Seas.

An example to illustrate the dangers of making generalisations about certain litter items and linking them to a specific source exists with 25 litre plastic drums. During the study period these were commonly found on beaches at the western end of the Bristol Channel (e.g. Freshwater West, Hartland Quay), but they were also been found on beaches at the eastern end (e.g. Tresilian Bay). The important distinction between items found at these sites is the markings embossed on the drum itself. The overwhelming majority of those found in west Wales were oil containers, mainly used in the shipping industry. Those found on beaches near the Severn Estuary were predominantly from an agricultural land based source, markings on the container illustrated that the contents were used in dairy farm hygiene (e.g. 'Deosan' Hypochlorite; Figure 5.2.3). This situation could well occur in reverse, with agricultural products appearing on west Wales beaches (especially as this is a very agricultural area of the country), but the important point to note is the abundance of the oil containers and the mix of the litter. The incidence of 25 litre containers found in west Wales is comparatively high and consists principally of oil containers, in association with fishing debris. The abundance of 25 litre containers is lower at the eastern end of the channel and consists of a mix of shipping and agricultural related uses. Land use around the beach will certainly play a part in the source of debris encountered, but beaches are so variable in their attributes that any generalisation regarding sources is unwise.

Figure 5.2.3 Agricultural containers found at Tresilian Bay, Vale of Glamorgan

Associations

There are certain items that are 'indicators' of a particular source. Such items include cotton bud sticks as an indicator of sewage / river source, or fragments of netting as an indication of a sea / fishing source. Other items, such as plastic drink bottles, can have numerous sources. It is the association of items that is important, for example, if these bottles are found in conjunction with many items of fishing debris or shipping waste, it can be assumed that a proportion of these beverage containers are from a shipping source. On the other hand, if these same type of bottles are on a beach with no fishing or shipping debris, but with large amounts of sewage and domestic containers, then this would point to debris being of a predominantly land-based nature (Earll *et. al.*, 1999). However, trying to establish what proportion of litter has come from each source is a more difficult proposition. There is often huge diversity of litter items at beaches, and there is also an enormous diversity within litter item groupings. For example, beverage and food containers can vary enormously in their size, shape, and colour. This large range of diversity within item groups may help point to a particular source.

Often sourcing attribution is based heavily on assumptions (Shiber and Barrales-Rienda, 1991). Much of the attribution process is simply common sense applied to the items encountered. If there are large amounts of broken lobster pots or floats for lines, then a significant source of litter will be fishing vessels. The difficulty arises in trying to apportion litter to *specific* sources, it is the mix of litter together with associations between items that is important.

5.2.2 Methodology

Method for Recording Beach Litter

Litter items encountered on beaches covered in this study were recorded with as much detail as possible, making a note of all printed and additional information. The size of survey site followed the EA/NALG (2000), methodology (Appendix II). Site selection was based on a uniform geographic spread of beaches along the Bristol Channel coast, and not because they were known to be heavily polluted, or in an area recognised for suffering from specific types of pollution e.g. open coasts or areas near shipping lanes. In addition, beaches from other parts of Wales were included in order to give 'added value' and comparisons to the analysis (Figure 3.1).

Methodologies used in Sourcing Beach Litter

There are a number of methodologies that attempt to attribute litter items to a specific source. The procedures used and the merits of each method have been considered along with some proposals for improvements. Each method is considered in the light of the aims of this study and survey area.

Method 1: Percentage Allocation (e.g. Earll et al., 1999)

One method of making an attribution to source would be to consider a percentage allocation rule, where several input sources make a possible contribution to beach litter, and are apportioned an appropriate allocation. In these cases a percentage allocation would have to be split between potential sources.

The sources considered by Earll *et al.* (1999), were:

- Tourism (beach users)
- Sewage related debris
- Fly tipping – land
- Land (urban/rural) run off
- Shipping
- Offshore installations
- Fishing related debris

(descriptions of these sources can be found in Appendix III).

The sources outlined above are applicable to beaches of the study area, i.e. the Bristol Channel, although distinctions made between potential sea borne sources (i.e. shipping, offshore installations, and fishing) are perhaps too intricate. There are certain items, such as netting or lobster pots that are obviously from fishing sources, but there are a number of items that alight on beaches that are in common usage on all shipping vessels, including fishing boats, and are also used on offshore installations (Figures 5.2.4 and 5.2.5). Attempting to distinguish between vessel types is a further step which can be attempted once a general sea based source is established.

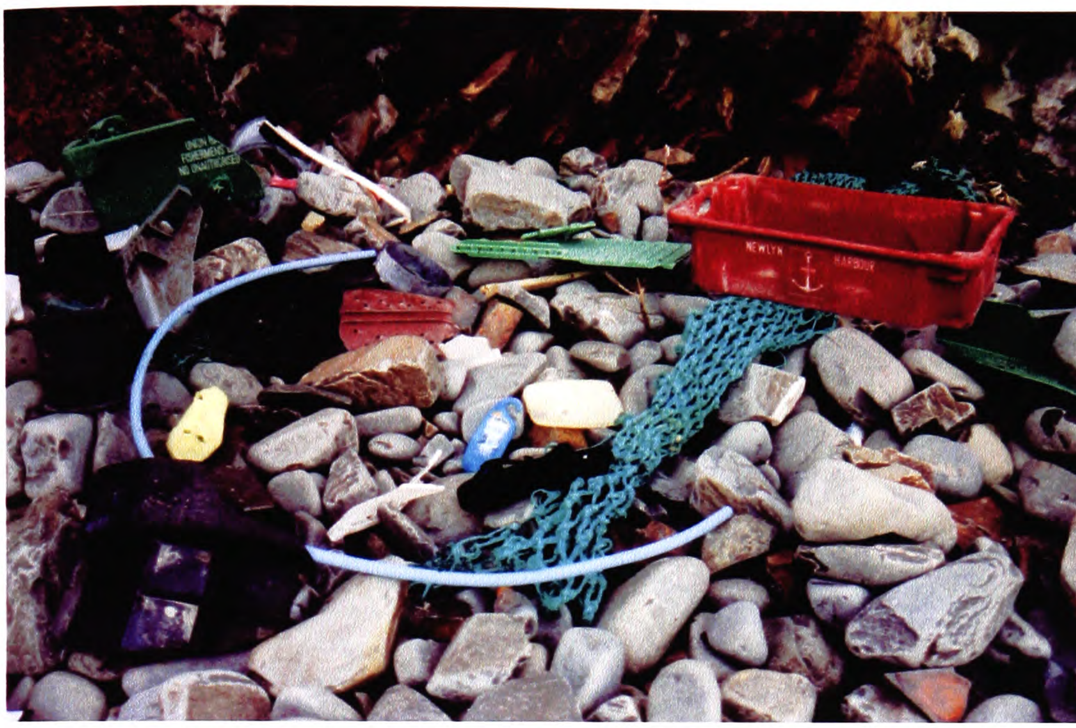

Figure 5.2.4 Example of fishing / shipping debris items found at Hartland Quay, Devon

Figure 5.2.5 Example of fishing / shipping debris items, along with large tangles found at Hartland Quay, Devon

- Once a list of litter items from a beach is established the next step is to place them in an elimination list. An example of part of an elimination list is detailed in Table 5.2.1.

- Before any percentage allocation is attempted, a rationale and step by step process must be initiated. An elimination criteria is used for each item of beach litter in an attempt to assess the likelihood of it originating from each source. Each item of litter is considered individually and an assessment is made of the likelihood of it originating from each of the broad source categories. Another consideration is the quantity of items found, i.e. does a large amount of a certain litter type mean that it is more likely to come from one source than another (Table 5.2.1).

- This elimination process helps to set out the reasoning behind the subsequent allocation to a specific source. In the recent past most studies involved with beach litter sourcing failed to set out the reasoning behind their attribution to source, simply mentioning it almost in passing e.g. Corbin and Singh (1993); Gabrielides (1995).

Table 5.2.1 Elimination List - Litter items linkage to various sources

Indications of Source / Litter Item	Sea Source	River Source	Beach User Source	Is Quantity Found Applicable?
tyre	If rope attached for use as fender	no rope	no	not generally - other information is more useful
oil drum	if marked for ship- specific grade of oil for ship.	if marked car /lorry/tractor	no	large amount of either would mean dumping or ship wreck
cigarette lighter	yes- thrown overboard	yes- tossed in river or even flushed	yes	Very large amounts could mean wreck or spill
milk containers	yes - especially UHT / long life	only if wind blown into river - fly tipping is unlikely	not likely- especially not large containers (>2 pints)	Large amounts would point to systematic input from ships
light bulb	yes - possibly if still intact	possibly - but unlikely	no	large amount could mean wreck or spill
pallets	yes	some possibly	no	no

The elimination list (Table 5.2.1), shows that, for example, the milk container (especially large sizes) can be almost completely ruled out as coming from a river or beach user source, whereas, the source of the tyre will be dependant on the presence of any attachments which help give a pointer towards a source. From the list above (Table 5.2.1), items can be given an allocation using a probability phraseology (Table 5.2.2).

Table 5.2.2 Litter Items and the Likelihood of Source.

Key to probability phraseology : Extremely unlikely (EU); Unlikely (U); Possible (P); Likely (L); Extremely likely (EL).

	Tourism (Beach Users)	SRD	Fly tipping - land	Land (run off)	Shipping	Offshore Installations	Fishing related debris
SWEET WRAPPER	EL	EU	EU	U	EU	EU	EU
FOOD CONTAINER	L	EU	EU	U	U	EU	EU
PLASTIC DRINKS BOTTLE <500ML	EL	EU	EU	U	U	EU	EU
TAKE AWAY FOOD CONTAINER	EL	EU	EU	U	EU	EU	EU
LOLLIPOP STICK	EL	EU	EU	U	EU	EU	EU
STRAW	EL	EU	EU	U	EU	EU	EU
FISHING LINE	EU	EU	EU	EU	EU	EU	EL
UNIDENTIFIABLE PLASTIC FRAGMENT	P	EU	EU	U	P	EU	P
POLYSTYRENE PIECE	P	EU	EU	U	P	EU	P
CIGARETTE STUBS	EL	EU	EU	U	EU	EU	EU
CIGARETTE BOX	EL	EU	EU	EU	EU	EU	EU
CHILDRENS TOY	EL	EU	EU	EU	EU	EU	EU

Following this stage a percentage allocation can be attempted following the scheme outlined in Earll *et al.*, (1999), (Table 5.2.3).

Table 5.2.3 Scheme of probability and percentage allocation of an item originating from a source

Probability phraseology	A probability score	Percentage Allocation
Extremely unlikely (EU)	0.001%	0%
Unlikely (U)	0.001-10%	0 to 10%
Possible (P)	50 – 50%	between 10-90%
Likely (L)	>90%	over 90%
Extremely likely (EL)	100%	100%

One potential difficulty with this method is that it would be difficult to allocate a certain percentage to a particular source, due to many potential sources. This is where the percentage allocation process can become arbitrary and subjective. Table 5.2.4 is an example of this point, in that it is difficult to determine what percentage allocation to attribute to each of the sources, due to the number of 'possible' sources.

Table 5.2.4 The difficulty of allocating a percentage probability to a litter item

Litter Item: Plastic drink bottle	
Elimination Criteria / Source	**Probability Phraseology**
Tourism (beach users)	Very likely
Sewage related debris	Extremely unlikely
Fly tipping – land	Possible
Land (urban/rural) run off	Possible
Shipping	Possible
Offshore installations	Possible
Fishing related debris	Possible

Items cannot be considered in isolation, location is important as well as the litter mix. A prime example of the importance of these factors is illustrated in Table 5.2.5. Attribution to a source is dependant on many factors, e.g. are there any river inputs near the survey site, if so the influence of shipping sources may be dismissed (Table 5.2.5).

Table 5.2.5 Importance of location and litter mix in attributing a source to a litter item

Litter Item: Engine oil/lubricant	
Elimination Criteria / Source	**Probability Phraseology**
Tourism (beach users)	Extremely unlikely
Sewage related debris	Extremely unlikely
Fly tipping – land	Possible
Land (urban/rural) run off	Possible
Shipping	Very likely – grade of oil a key issue
Offshore installations	Very likely – grade of oil a key issue
Fishing related debris	Very likely – grade of oil a key issue

It may be difficult to differentiate between an item being 'Unlikely', or 'Extremely unlikely' of originating from a source. For example, it could easily be argued that the probability for the tourism source should be 'Extremely unlikely', and equally that the SRD source could be 'Unlikely' (Table 5.2.6). This problem of where to place an item in the probability criteria is common for many litter items, and is a limitation of this method.

Table 5.2.6 The difficulty in apportioning a likelihood of an item originating from a particular source

Litter Item: Containers for disinfectants/ surface cleansers / metal polish	
Elimination Criteria / Source	**Probability Phraseology**
Tourism (beach users)	Unlikely
Sewage related debris	Extremely unlikely
Fly tipping – land	Possible
Land (urban/rural) run off	Possible
Shipping	Possible
Offshore installations	Possible
Fishing related debris	Possible

The ideas and methods set out above by Earll *et al.* (1999), have been further developed by Earll *et al.*, (2000b) in formulating a methodology for the identification of shipping derived litter.

Method 2: Attribution by Litter Type (e.g. Marine Conservation Society - Beachwatch Reports - MCS, 2000)

The method employed by the Marine Conservation Society (MCS) *Beachwatch* study is to assign each litter item to a specific source. The main weakness of the *Beachwatch* approach is the attribution process. It is carried out away from the beach and from the items themselves simply by attributing all records (from a form) of a particular item, as recorded by the volunteer, to the particular source (Earll *et al.*, 1999). The use of volunteers, which are lay-people, has been shown to be a valid and reliable means of collecting large amounts of data (see section 4.2), particularly if trained as is the case with *Beachwatch* surveys (MCS, 2000).

There is also a large category of non-sourced litter, this consists of items which do not easily fall into specific sourcing categories, e.g. plastic bags, caps/lids. These items have come from one source or another but there is no means of apportioning these to a specific source. This method of attributing litter certainly has merits and the use of lists of items linked to sources serves as a useful database of information, however, the prescriptive and rigid nature of this method is perhaps not ideal for the purposes of this study.

Method 3: Sourcing with the use of container information (e.g. Tidy Britain Group (TBG) - Dixon, 1995)

This method is based on a national **ocean focused vessel-source** litter assessment study which seeks to identify any major differences in the composition and quantities of beach litter from paired observations, approximately 10 years apart, at 185 sampling units situated around the UK coastline (Dixon, 1995; Earll *et al.*, 1999). It was specifically designed to assess whether MARPOL Annex V (1973/1978) was working, and the method does meet this criteria.

Sources were primarily established from 'the identified contents and geographical origins of the containers located on sampling units' (Dixon, 1995, page 61). This information was then cross referenced with products taken aboard ships following discussions with trade and fishing bodies and packaging manufacturers. The information on containers, and the types of containers used onboard ships, from these studies is very useful and can be applied in other methodologies regarding litter sourcing. The TBG method has focused almost exclusively on containers for the sourcing of litter. It was felt that the great diversity of items found on Bristol Channel beaches meant that a more holistic sourcing method was necessary, with *all* litter items included in sourcing attempts.

Method 4: Use of Indicator Items (e.g. Ribic, 1998)

This method is similar to that employed by *Beachwatch* (MCS, 2000) in that lists of items are considered for each source, the difference being that only specific indicators are considered and only these are recorded at each beach survey. This scheme was developed to give an indication of changing litter amounts over time, rather than establishing sources. However, the lists of litter items arranged into source groups could be utilised for sourcing purposes (Table 5.2.7).

Table 5.2.7 Indicator items and source groupings (Ribic, 1998)

Ocean Based Litter Items	Land Based Litter Items	General Litter Items
All gloves	Syringes	Plastic bags with seams
Plastic sheets ≥1m	Condoms	Straps
Light bulbs/tubes	Metal beverage cans	Plastic bottles
Oil/gas containers ≥ 1 quart	1 quart motor oil containers	
Pipe-thread protectors	Mylar or rubber balloons	
Nets, traps/pots, fish baskets	Six-pack rings	
Fishing line	Straws	
Floats/buoys	Tampon applicators	
Rope ≥ 1 m	Cotton swabs	
Salt bags		
Cruiseline logo items		

Method 5: Matrix Scoring Method (e.g. Whiting, 1998)

This method attempts to proportion a percentage allocation of each debris item to each source to produce an overall percentage allocation figure. Each litter item encountered was assigned a probability, and subsequent score, of the item originating from a particular source. Litter items were cross-tabulated with potential sources. The scores above were based on several factors, namely; markings and labelling of items, type of debris, distance to each source, amount of activity of each source within the region, seasonal wind and current patterns (Whiting, 1998). This method proposes the following likelihood scoring system for source attribution:

Likelihood of litter alighting from Source	Score
Highly probable	3
Probable	2
Possible	1
Unlikely	0

Although background knowledge and an understanding of the vagaries of marine debris is needed before utilising this system, a certain amount of subjectivity is used in apportioning a likelihood score to each item of litter. A matrix was developed that enabled a figure to be derived that gave the percentage allocation of each source. The method was applied to one area in Northern Australia (Whiting, 1998), and the sources chosen for attribution were:

- Recreational boaters
- Domestic merchant vessels
- Commercial fishing vessels
- Urban / land based
- Camping
- Foreign vessels
- Foreign shores

The sources chosen for use highlight the influence of site / regional specificity where litter is concerned. Whether the attribution to specific sea going vessels is robust enough is open to question.

Method 6: Multivariate Analysis

Multivariate analysis has the following aims:

- Searching for possible causal relationships between distribution and environmental factors.
- Searching for pattern or structure in a set of data
- Describing or summarising the data efficiently to reduce the data matrix to a more manageable form (Gauch, 1982; Randerson, 1993).

The first two aims neatly describe the use of this form of analyses for the study of litter sourcing. Multivariate analysis uses an inductive, non-experimental approach to generate rather than test hypotheses. In relation to litter sources it was hoped that relationships between certain litter groups would be realised, along with associations between beach location and the types and abundance of litter found. Multivariate analysis methods follow one of two strategies, either Ordination (e.g. principal component analysis, factor analysis, discriminant analysis), or Clustering (e.g. cluster analysis) or hybrids of these. Two methods of multivariate analysis were utilised in an effort to ascertain patterns amongst beach litter items and survey sites, namely principal component analysis and cluster analysis.

Principal Component Analysis (PCA)

This is a method of ordination widely used in many fields, in which axes or components are successively extracted from a matrix of similarities. In PCA all individuals contribute equally to the components, avoiding dominance by outliers. Another advantage is that simultaneous ordinations for both individuals and attributes, such as beach sites and litter types, can be obtained by a single analysis. Ordination allows each individual, either a site or litter type, to be placed on one or more constructed axes so that its geometrical position relative to its fellows reflects its similarity to them (Randerson, 1993). The rationale for using this powerful pattern recognition tool was to identify factors that accounted for variations within the data set. Plots are produced which enable a visual interpretation to take place.

Cluster Analysis

Cluster analysis is a multivariate analysis technique and not as much a typical statistical test as it is a collection of different algorithms that put objects into clusters. The clusters formed with this family of methods should be highly internally homogenous (members are similar to one another) and highly externally heterogeneous (members are *not* like members of other clusters). Unlike many other statistical procedures, cluster analysis methods are mostly used when there is no prior hypotheses, but where research is still in an exploratory phase (Backer, 1994). In essence, cluster analysis finds the most significant solution possible. Group members will share certain properties in common and it is hoped that the resultant classification will provide some insight into the data. Following analysis a dendrogram is produced, this 'tree-like' diagram summarises the process of clustering. Similar cases are joined by links whose position in the diagram is determined by the level of similarity between the cases (Aldenderfer and Blashfield, 1984).

5.2.3 Results and Discussion

Appraisal of Suitability of Methods

Careful consideration of the merits of all the above methods were made, especially with regard to the appropriateness of implementation on beaches in the study area of the Bristol Channel. All have their strengths and weaknesses, but some were either not easily applicable or are not pertinent for the area of study.

Method 1 (Earll *et al.*, 1999). The percentage allocation method was considered to be a very robust, thorough and applicable methodology. However, the focus being on shipping vessels led to its omission from implementation within this study. This method has been broadly adopted by the OSPAR IMPACT group (see section 2.11). The elimination criteria used to exclude certain items of arising from a particular source was felt to be a useful procedure, and one which could be partially used for litter attribution on beaches within this study of the Bristol Channel (Tables 5.2.1 - 5.2.3).

Method 2 (MCS, 2000). The MCS sourcing method was based solely on *all* litter items of a certain *type* being classified from a particular source. The appropriateness of this method for use in *Beachwatch* is not in doubt, but its lack of flexibility and prescribed nature meant that implementation for this study was deemed inappropriate.

Method 3 (Dixon, 1995). The TBG technique was not felt to be transparent enough, the attribution process could not easily be followed, and a large data bank of previous material and information was also required. There is an enormous amount of knowledge regarding products and packaging used in TBG studies. Assumptions about the proportion of *non-container* garbage originating from sea-going vessels was based on information found *on containers* at the survey sites. This is an inherent weakness of this sourcing method, as containers with no markings and all other 'non-containers' are not included in any attempt to source litter. Containers do carry a wealth of information, but excluding non-containers from the analysis risks missing vital signs to the source of beach litter.

Method 4 Ribic (1998). This procedure, was developed as an indication of time trends of litter abundance, rather than sources. The inclusion of all litter encountered on beaches, rather than selecting indicator items, was deemed more appropriate.

Methods 5 (Whiting, 1998), **and 6** (Multivariate Analysis). These two techniques were considered to be appropriate for application with data gathered on beaches of the Bristol Channel.

Application of the Matrix Scoring Method for Bristol Channel Beaches

The technique employed by Whiting (1998) was considered to be a very valid tool and could be applied to beaches of the Bristol Channel. Several sources were examined for each item, not simply shipping sources as some other procedures. Although 'this method is an estimate only, it does examine in detail all debris items and major litter categories' (Whiting, 1998, page 905). An amalgamation of the methods used by Whiting (1998), and Earll *et al.*, (1999), was considered to be a robust process of identifying sources. The attribution process was based on the Earll *et al.* (1999), method of elimination of potential sources and then attempting to allocate a proportional figure to each source. The proportion figure (i.e. scores) that was decided came from consideration of the identification, function, and quantity of each litter item. The items were not considered independently of other litter found in conjunction, therefore a rigid consideration of litter item 'type' was not the defining characteristic of source. It is '*totally pointless* to discuss whether an individual item or item type, taken in isolation come from shipping or not. It is the association of items types that is the key to making the link to an input source from shipping.' (Earll *et al.*, 2000b, page 21). This statement can apply to all litter and all sources, not just to shipping. The method was applied to data gathered at beaches along the Bristol Channel, with Minehead beach used as an illustrative example below (Tables 5.2.8 - 5.2.13). Several attempts at refinement of the methodology were made, with various sources and scoring systems employed. The Whiting (1998), expressions and scores have been changed in Tables 5.2.8a to 5.12a to follow the phraseology used by Earll *et al.* (1999).

Table 5.2.8a. Scoring System A (via linear progression)

Likelihood of litter item originating from a particular source - probability phraseology	**Score**
Extremely likely	4
Likely	3
Possible	2
Unlikely	1
Extremely unlikely	0

Tables 5.2.8 b and c, show a cross tabulation of scores that are used to estimate the percentage of debris items that may be attributed to possible sources. Scores are based on the probability of each source contributing to each category of debris. *Values in parentheses represent the possible percentage allocation of each source to each category of debris.*

More detailed information is needed about the highlighted items in Table 5.2.8b to allow for more accurate attribution of source. Information on markings, any labelling, and size need to be recorded so that a source can be accurately identified and applied to the item. The large numbers of unidentifiable plastic fragments cannot reliably be included in any sourcing study. Fragmentation of plastic containers occur due to the processes of sunlight and sea-water, as well as abrasion with beach substrates. Williams and Simmons (1996), showed that after 9 months in the beach environment, plastics lose only some 20% of their intact strengths. Many of these fragments are un-identifiable because of lost markings or their small size.

Table 5.2.8 b Application of Scoring System A

Litter Item	Possible Litter Sources				
	Percentage Contribution to Total Amount of Litter on Beach	Sea Source	River Source	Beach User Source	Total Scores
Sweet wrapper	14.3	0	0	4 (14.3)	4
Food container	2.4	1 (0.6)	0	3 (1.8)	4
Plastic drinks bottle <500ml	2.4	1 (0.5)	0	4 (1.9)	5
Take away food container	7.1	0	0	4 (7.1)	4
Lollipop stick	7.1	0	0	4 (7.1)	4
Straw	4.8	0	0	4 (4.8)	4
Fishing line	7.1	4 (7.1)	0	0	4
Unidentifiable plastic fragment	9.6	2 (4.8)	0	2 (4.8)	4
Polystyrene piece	2.4	2 (1.2)	0	2 (1.2)	4
Cigarette stubs	38.0	0	0	4 (38.0)	4
Cigarette box	2.4	0	0	4 (2.4)	4
Childrens toy	2.4	0	0	4 (2.4)	4
Percentage Totals	TOTAL (100%)	(14.2%)	(0%)	(85.8%)	

Values in parentheses represent the possible percentage allocation of each source to each debris category. Shaded areas represent litter items with uncertain sources.

Alternative source categories were applied using the same scoring scheme (Table 5.2.8 c). The results in Tables 5.2.8 b and c are very similar in a broad sense, but Table 5.2.8 c illustrates that a greater number of potential sources can give a more informative picture.

Table 5.2.8c Application of Scoring System A (Table 5.2.8a), with Alternative Sources

Litter Item	Possible Litter Sources								
	Percentage Contribution to Total Amount of Litter on Beach	Tourism (Beach Users)	SRD	Fly tipping - land	Land (run off)	Shipping	Offshore Installation	Fishing related debris	Total Scores
Sweet wrapper	14.3	4 (11.4)	0	0	1 (2.9)	0	0	0	5
Food container	2.4	3 (1.4)	0	0	1 (0.5)	1 (0.5)	0	0	5
Plastic drinks bottle <500ml	2.4	4 (1.6)	0	0	1 (0.4)	1 (0.4)	0	0	6
Take away food container	7.1	4 (5.7)	0	0	1 (1.4)	0	0	0	5
Lollipop stick	7.1	4 (5.7)	0	0	1 (1.4)	0	0	0	5
Straw	4.8	4 (3.8)	0	0	1 (1.0)	0	0	0	5
Fishing line	7.1	0	0	0	0	0	0	4 (7.1)	4
Unidentifiable plastic fragment	9.6	2 (2.7)	0	0	1 (1.4)	2 (2.7)	0	2 (2.7)	7
Polystyrene piece	2.4	2 (0.7)	0	0	1 (0.3)	2 (0.7)	0	2 (0.7)	7
Cigarette stubs	38.0	4 (30.5)	0	0	1 (7.6)	0	0	0	5
Cigarette box	2.4	4 (2.4)	0	0	0	0	0	0	4
Childrens toy	2.4	4 (2.4)	0	0	0	0	0	0	4
Percentage Totals	TOTAL (100%)	(68.30)	0	0	(16 9)	(4.3)	0	(10.5)	

Values in parentheses represent the possible percentage allocation of each source to each debris category.

A case can be made for each source making at least a very small contribution to beach litter. It was therefore decided to apply a new scoring scheme without a zero value (5.2.9a). As a result, every source would make some kind of contribution to the litter found.

Table 5.2.9a. Scoring System B

Likelihood of litter item originating from a particular source - probability phraseology	Score
Extremely likely	9
Likely	7
Possible	5
Unlikely	3
Extremely unlikely	1

Table 5.2.9b Application of Scoring System B

Litter Item	Possible Litter Sources								
	Percentage Contribution to Total Amount of Litter on Beach	Tourism (Beach Users)	SRD	Fly tipping - land	Land (run off)	Shipping	Offshore Installation	Fishing related debris	Total Scores
Sweet wrapper	14.3	9 (7.6)	1 (0.8)	1 (0.8)	3 (2.5)	1(0.8)	1(0.8)	1(0.8)	17
Food container	2.4	7 (1.0)	1 (0.1)	1 (0.1)	3 (0.4)	3 (0.4)	1(0.1)	1(0.1)	17
Plastic drinks bottle <500ml	2.4	9 (1.1)	1 (0.1)	1 (0.1)	3 (0.4)	3 (0.4)	1(0.1)	1(0.1)	19
Take away food container	7.1	9 (3.8)	1 (0.4)	1 (0.4)	3 (1.3)	1(0.4)	1(0.4)	1(0.4)	17
Lollipop stick	7.1	9 (3.8)	1(0.4)	1(0.4)	3 (1.3)	1(0.4)	1(0.4)	1(0.4)	17
Straw	4.8	9 (2.5)	1 (0.3)	1 (0.3)	3 (0.8)	1(0.3)	1(0.3)	1(0.3)	17
Fishing line	7.1	1 (0.5)	1(0.5)	1(0.5)	1(0.5)	1(0.5)	1(0.5)	9 (4.3)	15
Unidentifiable plastic fragment	9.6	5 (2.5)	1 (0.5)	1 (0.5)	3 (1.5)	5 (2.5)	1(0.50)	3 (1.5)	19
Polystyrene piece	2.4	5 (0.6)	1 (0.1)	1 (0.1)	3 (0.3)	5 (0.6)	1 (0.1)	5 (0.6)	21
Cigarette stubs	38.0	9 (20.2)	1 (2.2)	1 (2.2)	3 (6.7)	1(2.2)	1(2.24	1(2.2)	17
Cigarette box	2.4	9 (1.4)	1 (0.2)	1 (0.2)	1(0.2)	1(0.2)	1(0.2)	1(0.2)	15
Childrens toy	2.4	9 (1.4)	1(0.2)	1(0.2)	1(0.2)	1(0.2)	1(0.2)	1(0.2)	15
Percentage Totals	TOTAL (100%)	46.3	5.9	5.9	16.0	8.9	5.9	11.1	

Values in parentheses represent the possible percentage allocation of each source to each category of debris.

Another scoring system was applied, in this instance via a geometric progression scale. This scheme enabled those items that were extremely likely to come from a specific source to make a larger contribution to the overall picture of the litter source (Tables 5.2.10a and 5.2.10b). Therefore, items that were considered as being extremely unlikely to come from a certain source would not constitute a larger weighting than was appropriate.

Table 5.2.10a. Scoring System C (via geometric progression)

Likelihood of litter item originating from a particular source - probability phraseology	**Score**
Extremely likely	16
Likely	8
Possible	4
Unlikely	2
Extremely unlikely	1

Table 5.2.10b Application of Scoring System C

Litter Item	**Possible Litter Sources**								
	Percentage Contribution to Total Amount of Litter on Beach	Tourism (Beach Users)	SRD	Fly tipping - land	Land (run off)	Shipping	Offshore Installation	Fishing related debris	Total Scores
Sweet wrapper	14.3	16 (9.9)	1 (0.6)	1(0.6)	2 (1.2)	1(0.6)	1(0.6)	1(0.6)	23
Food container	2.4	8 (1.2)	1 (0.2)	1(0.2)	2 (0.3)	2 (0.3)	1(0.2)	1(0.2)	16
Plastic drinks bottle <500ml	2.4	16 (1.6)	1 (0.1)	1(0.1)	2 (0.2)	2 (0.2)	1(0.1)	1(0.1)	24
Take away food container	7.1	16 (5.0)	1 (0.3)	1(0.3)	2 (0.6)	1(0.3)	1(0.3)	1(0.3)	23
Lollipop stick	7.1	16 (5.0)	1 (0.3)	1(0.3)	2 (0.6)	1(0.3)	1(0.3)	1(0.3)	23
Straw	4.8	16 (3.3)	1 (0.2)	1(0.2)	2 (0.4)	1(0.2)	1(0.2)	1(0.2)	23
Fishing line	7.1	1 (0.3)	1 (0.3)	1 (0.3)	1 (0.3)	1 (0.3)	1 (0.3)	16 (5.2)	22
Unidentifiable plastic fragment	9.6	4 (2.5)	1 (0.6)	1(0.6)	2 (1.3)	4 (2.5)	1(0.6)	2 (1.3)	15
Polystyrene piece	2.4	4 (0.5)	1 (0.1)	1 (0.1)	2 (0.3)	4 (0.5)	1 (0.1)	4 (0.5)	18
Cigarette stubs	38.0	16 (26.5)	1 (1.7)	1(1.7)	2 (3.3)	1(1.7)	1(1.7)	1(1.7)	23
Cigarette box	2.4	16 (1.7)	1 (0.1)	1(0.1)	1(0.1)	1(0.1)	1(0.1)	1(0.1)	22
Childrens toy	2.4	16 (1.7)	1 (0.1)	1(0.1)	1(0.1)	1(0.1)	1(0.1)	1(0.1)	22
Percentage Totals	TOTAL (100%)	59.3	4.7	4.7	8.8	7.2	4.7	10.6	

Values in parentheses represent the possible percentage allocation of each source to each category of debris.

System D was altered to give even less weighting to those items considered as 'extremely unlikely' to derive from a named source (Table 5.2.11a and 5.2.11b).

Table 5.2.11a. Scoring System D

Likelihood of litter item originating from a particular source - probability phraseology	**Score**
Extremely likely	16
Likely	4
Possible	2
Unlikely	1
Extremely unlikely	0.25

Table 5.2.11b Application of Scoring System D

Litter Item	Percentage Contribution to Total Amount of Litter on Beach	Possible Litter Sources: Tourism (Beach Users)	SRD	Fly tipping - land	Land (run off)	Shipping	Offshore Installation	Fishing related debris	Total Scores
Sweet wrapper	14.3	16 (12.5)	0.25 (0.20)	0.25 (0.20)	1 (0.8)	0.25(0.2)	0.25 (0.20)	0.25(0.2)	18.25
Food container	2.4	4 (1.4)	0.25 (0.1)	0.25 (0.1)	1 (0.3)	1 (0.3)	0.25 (0.1)	0.25(0.1)	7
Plastic drinks bottle <500ml	2.4	16 (2.0)	0.25 (0.1)	0.25 (0.1)	1 (0.1)	1 (0.1)	0.25 (0.1)	0.25(0.1)	19
Take away food container	7.1	16 (6.3)	0.25 (0.1)	0.25 (0.1)	1 (0.4)	0.25(0.1)	0.25 (0.1)	0.25(0.1)	18.25
Lollipop stick	7.1	16 (6.3)	0.25 (0.1)	0.25 (0.1)	1 (0.4)	0.25(0.1)	0.25 (0.1)	0.25(0.1)	18.25
Straw	4.8	16 (4.2)	0.25 (0.1)	0.25 (0.1)	1 (0.3)	0.25(0.1)	0.25 (0.1)	0.25(0.1)	18.25
Fishing line	7.1	0.25 (0.1)	0.25 (0.1)	0.25 (0.1)	0.25 (0.1)	0.25 (0.1)	0.25 (0.1)	16 (6.5)	17.5
Unidentifiable plastic fragment	9.6	2 (2.8)	0.25 (0.4)	0.25 (0.4)	1 (1.4)	2 (2.8)	0.25 (0.4)	1 (1.4)	6.75
Polystyrene piece	2.4	2 (0.6)	0.25 (0.1)	0.25 (0.1)	1 (0.3)	2 (0.6)	0.25 (0.1)	2 (0.6)	7.75
Cigarette stubs	38.0	16 (33.4)	0.25 (0.5)	0.25 (0.5)	1 (2.1)	0.25(0.5)	0.25 (0.5)	0.25(0.5)	18.25
Cigarette box	2.4	16 (2.2)	0.25 (0.1)	0.25 (0.1)	0.25(0.1)	0.25(0.1)	0.25 (0.1)	0.25(0.1)	17.5
Childrens toy	2.4	16 (2.2)	0.25 (0.1)	0.25 (0.1)	0.25(0.1)	0.25(0.1)	0.25 (0.1)	0.25(0.1)	17.5
Percentage Totals	TOTAL (100%)	73.9	1.7	1.7	6.3	5.1	1.7	10.0	

Values in parentheses represent the possible percentage allocation of each source to each category of debris.

It was felt that some items were so unlikely, or impossible, to originate from a particular source that the zero value was re-introduced in System E (Table 5.2.12a). As a result, for example, in areas where there were no rivers, this source could be completely ruled out, and would not make any contribution to the sourcing profile. The scheme now had 6 parameters, and was felt to be the most appropriate scoring system of all those implemented, although time consuming to carry out on each beach (Table 5.2.12a).

Table 5.2.12a. Scoring System E

Likelihood of litter item originating from a particular source - probability phraseology	Score
Extremely likely	16
Likely	4
Possible	2
Unlikely	1
Extremely unlikely	0.25
Not considered	0

Table 5.2.12b. Application of Scoring System E

Litter Item	Possible Litter Sources								
	Percentage Contribution to Total Amount of Litter on Beach	Tourism (Beach Users)	SRD	Fly tipping - land	Land (run off)	Shipping	Offshore Installation	Fishing related debris	Total Scores
Sweet wrapper	14.3	16 (12.5)	0.25 (0.20)	0.25(0.2)	1 (0.8)	0.25(0.2)	0.25(0.2)	0.25(0.2)	18.25
Food container	2.4	4 (1.4)	0.25 (0.09)	0.25(0.1)	1 (0.3)	1 (0.3)	0.25(0.1)	0.25(0.1)	7
Plastic drinks bottle <500ml	2.4	16 (2.0)	0.25 (0.03)	0.25(0.1)	1 (0.1)	1 (0.1)	0.25(0.1)	0.25(0.1)	19
Take away food container	7.1	16 (6.3)	0.25 (0.10)	0.25(0.1)	1 (0.4)	0.25(0.1)	0.25(0.1)	0.25(0.1)	18.25
Lollipop stick	7.1	16 (6.3)	0.25 (0.10)	0.25(0.1)	1 (0.4)	0.25(0.1)	0.25(0.1)	0.25(0.1)	18.25
Straw	4.8	16 (4.2)	0.25 (0.07)	0.25(0.1)	1 (0.3)	0.25(0.1)	0.25(0.1)	0.25(0.1)	18.25
Fishing line	7.1	0	0	0	0	0.25 (0.1)	0.25 (0.1)	16 (6.9)	16.5
Unidentifiable plastic fragment	9.6	2 (2.8)	0.25 (0.35)	0.25(0.4)	1 (1.4)	2 (2.8)	0.25(0.4)	1 (1.4)	6.75
Polystyrene piece	2.4	2 (0.6)	0.25 (0.08)	0.25 (0.1)	1 (0.3)	2 (0.6)	0.25 (0.1)	2 (0.6)	7.75
Cigarette stubs	38.0	16 (33.4)	0.25 (0.52)	0.25(0.5)	1 (2.1)	0.25(0.5)	0.25(0.5)	0.25(0.5)	18.25
Cigarette box	2.4	16 (2.2)	0.25 (0.03)	0.25(0.1)	0.25(0.1)	0.25(0.1)	0.25(0.1)	0.25(0.1)	17.5
Childrens toy	2.4	16 (2.2)	0.25 (0.03)	0.25(0.1)	0.25(0.1)	0.25(0.1)	0.25(0.1)	0.25(0.1)	17.5
Percentage Totals	TOTAL (100%)	73.8	1.60	1.6	6.2	5.1	1.8	10.2	

Values in parentheses represent the possible percentage allocation of each source to each category of debris.

Scoring used in system 'A' did not produce results that were felt to be representative of the litter found on the beach (Table 5.2.13). System B over-emphasised minor source categories. Systems C, D and E give a greater weighting to the most likely source categories (Table 5.2.13). Systems D and E are very similar, the only difference between them is the addition of a 'not considered' parameter. Scoring system E can be considered as a useful scheme to facilitate beach litter sourcing. This cross-tabulated matrix system of sourcing beach litter can produce a useful insight into the contribution of different source groups to the litter on the beach, although it is still essentially an estimate. There is some level of subjectivity when apportioning scores to each item, but a knowledge of beach litter characteristics will aid reliable attribution.

Table 5.2.13 Summary of Scoring Systems

Scoring Systems	Possible Litter Sources						
	Tourism (Beach Users)	SRD	Fly tipping - land	Land (run off)	Shipping	Offshore Installations	Fishing related debris
Scoring System A	68	0	0	16	4	0	10
Scoring System B	46	5	5	16	8	5	11
Scoring System C	59	4	4	8	7	4	10
Scoring System D	73	1	1	6	5	1	9
Scoring System E	73	1	1	6	5	1	10

Application of Multivariate Analysis

Principal Component Analysis is a novel and statistically robust method of attempting to establish sources of debris on Bristol Channel beaches. This method has been attempted on litter studies of rivers (Simmons and Williams, 1997), but *no* such wide scale *beach litter* sourcing study has been attempted. The use of PCA avoids any subjectivity in attributing litter items to a source. The placing of litter into functional groupings or classes was a very important task before analysis could begin. The litter was classed in groups where *functionality* was common. For example, the domestic/household debris category consisted of items that included toiletries, detergents, cigarette lighters, etc. Similarly, drink related debris included items such as beverage containers, straws, milk containers, bottle tops. The first pilot trial was conducted using the classifications shown in Table 5.2.14, from data obtained at 22 beach surveys (Table 5.2.15).

Table 5.2.14. Broad litter classifications utilised in Initial Pilot Testing of Principal Component Analysis (and acronyms used in Figures 5.2.6 and 5.2.7)

Broad Litter Classifications used in Pilot Study
Sewage Related Debris (SRD)
Shipping/Fishing Related Debris (FRD)
Unidentifiable Fragments (UPF)
Drink Related Debris (DRD)
Food Related Debris (FOOD)
Domestic/Household Related Debris (HOUS)
DIY/Maintenance Related Debris (DIY)
Packaging Items (PACK)
Miscellaneous Items (MISC)
Gross Litter (GROS)
Potentially Harmful (HARM)
Animal Faeces (FAE)

Table 5.2.15. Beaches Surveyed in Initial Pilot Testing of Principal Component Analysis (along with Codes used within Figures 5.2.8 and 5.2.9)

PCA Beach Code	Beach Surveyed
C1	Sand Bay 22/3/00
C2	Sand Bay 20/7/00
C3	Aberdyfi
C4	Towyn
C5	Barmouth
C6	Harlech
C7	Pwllheli
C8	Minehead
C9	Dunster
C10	Putsborough
C11	Woolocombe
C12	Westward Ho!
C13	Lynmouth
C14	Brean
C15	Weston Main
C16	Berrow
C17	Hartland Quay
C18	Combe Martin
C19	Freshwater West
C20	West Angle Bay
C21	Blue Anchor Bay
C22	Ilfracombe

Analysis was carried out in two ways, using either the covariances or correlations as measures of similarity between the categories of litter recorded. The covariance measure (non-standardised) permits differences in variance between litter categories to remain, therefore allowing those which occur in large abundance to place a large weighting on the beach survey sites where they occur. Alternatively, using the correlation coefficient standardises the variances of all litter categories such that all are given equal weightings, hence the analysis is not unduly influenced by items which occur simply with large numerical abundance. For the initial pilot study both standardised and non-standardised similarity measures were utilised. For each run of the analysis two pairs of plots are produced, one concerned with litter item categories (Figures 5.2.6 and 5.2.7), the other with beach survey sites (Figures 5.2.8 and 5.2.9). Cluster analysis also involves calculating a measure of similarity between data items which may or may not have been standardised with respect to the variances of litter categories.

Mathematically, PCA involves eigen analysis of a symmetric matrix of similarities to produce a series of eigen values and their corresponding eigen vectors (Marshall and Elliott, 1998). There are as many eigen values as there are rows (or columns) in the matrix and conceptually they can be considered to measure the strength (relative length) of an axis. Each eigen value has an associated eigen vector. An eigen value gives the length of an axis, the eigen vector determines its orientation in space. Eigen analysis of beach litter data can be found in Appendix IVa.

It was apparent from the first analysis (covariance similarities, i.e. non-standardised data), that SRD, shipping/fishing debris (FRD), and unidentifiable plastic fragments (UPF) are given heavy weightings on one or more of principal components 1, 2 and 3 (Figures 5.2.6 and 5.2.7), reflecting their relatively large abundance and distinctive distributions. No conclusions can be drawn regarding the sources of unidentifiable fragments of litter. In contrast, the majority of litter categories are clustered around the zero point, indicating their low overall occurrence or uniform distribution (Figures 5.2.6 and 5.2.7). One clear problem with this PCA analyses is the grouping of most of the beaches around the zero point. Very little information is gained from these sites, either because of small litter abundance figures (e.g. Aberdyfi), or the presence of only items which are not unusual or distinctive at these beaches (e.g. sweet wrappers, plastic fragments).

When survey sites were examined (Figures 5.2.8 and 5.2.9), Berrow (C16) was separated from other beaches on component 1, indicating a strong influence of SRD, and Freshwater West (C19) was separated on both components 2 and 3, reflecting an abundance of FRD. With non-standardised data, Berrow (C16) appears as an outlier on principal component 1 (Figure 5.2.8), whereas the group of survey sites C12, C18, C19 and C20, are found to be distinct on principal component 2 (Figure 5.2.9). Non-standardised cluster analysis displays a similar pattern, with site 16 (Berrow) separated from other clusters, and sites 12, 18, 19 and 20 grouped together (Figure 5.2.10). Standardised cluster analysis show both Berrow (16) and Hartland Quay (17) to be distinct from other survey sites (Figure 5.2.11).

PCA with standardised data (correlation similarities) produced contrasting results to non-standardised data with regard to litter categories (Figures 5.2.12 and 5.2.13). Fewer litter categories clustered around the zero point than non-standardised data (Figures 5.2.6 and 5.2.7), whereas 'household' and 'gross' litter categories were both strongly weighted on component 2 (Figures 5.2.12 and 5.2.13). 'Fishing related debris' and 'DIY' categories were separated from other groups. Survey sites displayed a similar pattern to non-standardised data, with three beach sites clear outliers (Figures 5.2.14 and 5.2.15). On component 1 Berrow (C16) is separated from other beaches, as is Hartland Quay (C17) on component 2 (Figure 5.2.14). Examination of principal components 2 and 3 for beach survey sites again show Hartland Quay (C17) separated, with Freshwater West (C19) also removed from the main cluster (Figure 5.2.15). These results suggest a very different profile of litter at these beaches (Berrow, Hartland Quay, Freshwater West) compared to other survey sites. Both Hartland Quay and Freshwater West are at the extremity of the study area and lie on the outer Bristol Channel, and litter at these two beaches comprised many fishing and shipping items. Berrow had enormous amounts of cotton bud sticks present (n=711) in a 100m stretch of beach (Appendix IVb).

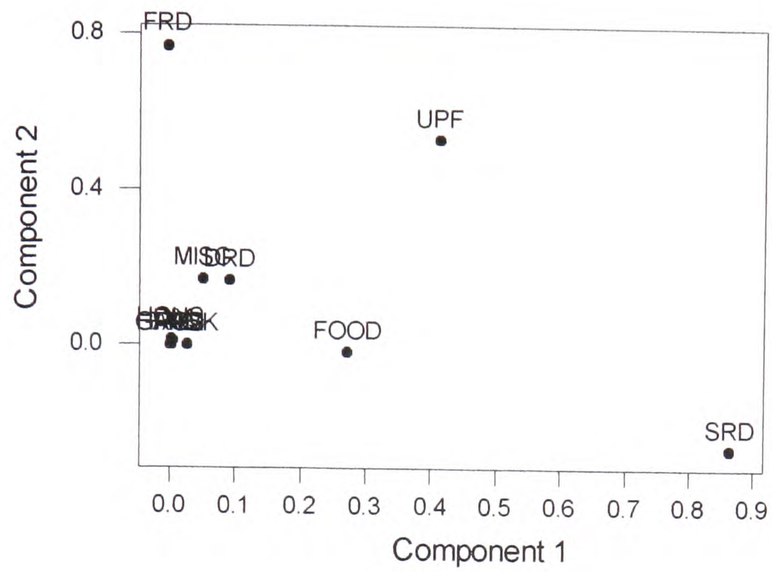

Figure 5.2.6. - Principal Component Analysis of Litter Items using Broad Litter Item Classification - Principal Components 1 and 2 (non-standardised data). *See Table 5.2.14 for key.*

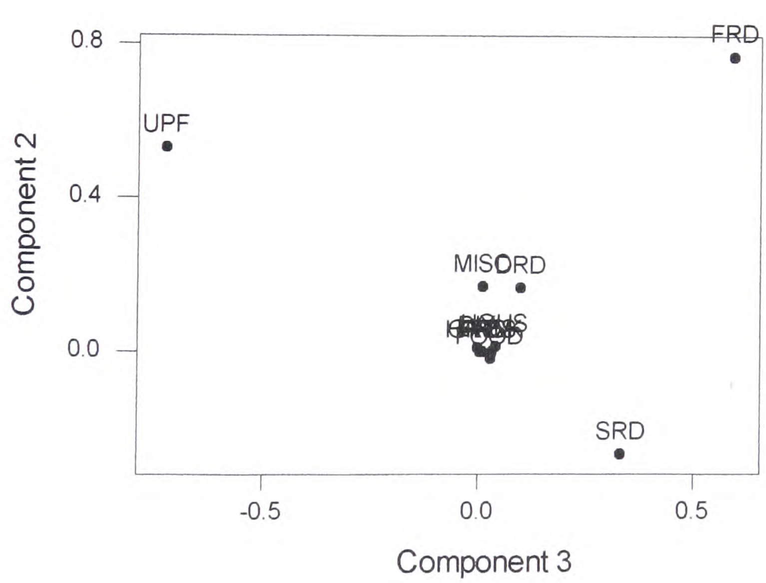

Figure 5.2.7. - Principal Component Analysis of Litter Items using Broad Litter Item Classification - Principal Components 2 and 3 (non-standardised data). *See Table 5.2.14 for key.*

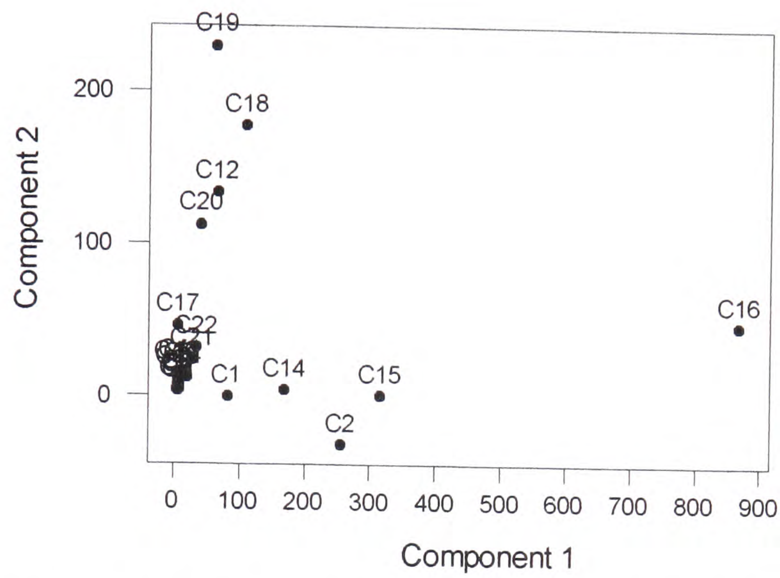

Figure 5.2.8. Principal Component Analysis of Beach Survey Sites using Broad Litter Item Classification - Principal Components 1 and 2 (non-standardised data). *See Table 5.2.15 for key.*

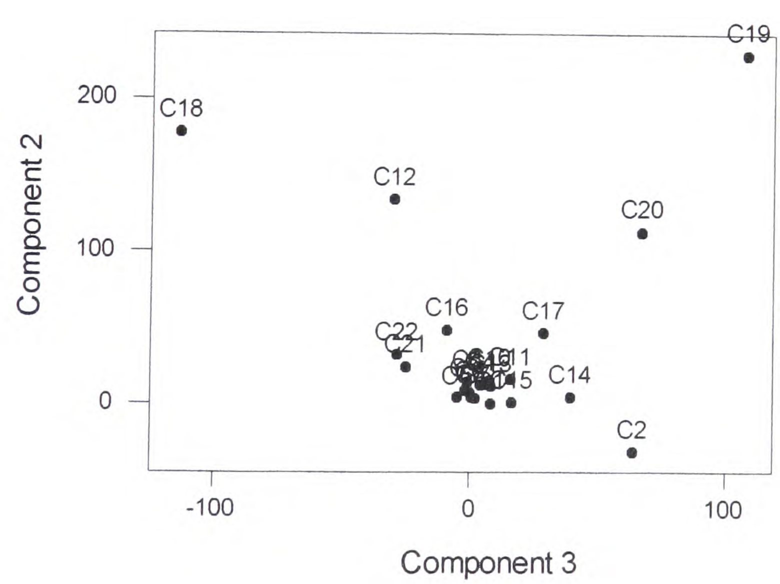

Figure 5.2.9. Principal Component Analysis of Beach Survey Sites using Broad Litter Item Classification - Principal Components 2 and 3 (non-standardised data) *See Table 5.2.15 for key.*

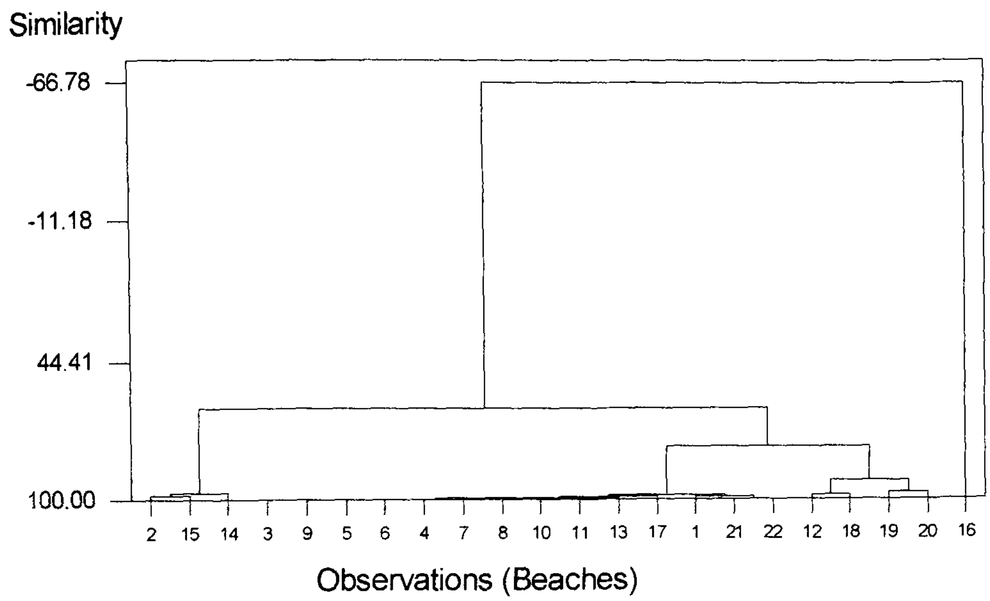

Figure 5.2.10. Cluster Analysis - Broad classification categories (Non standardised variables). For key to beach sites see Table 5.2.17

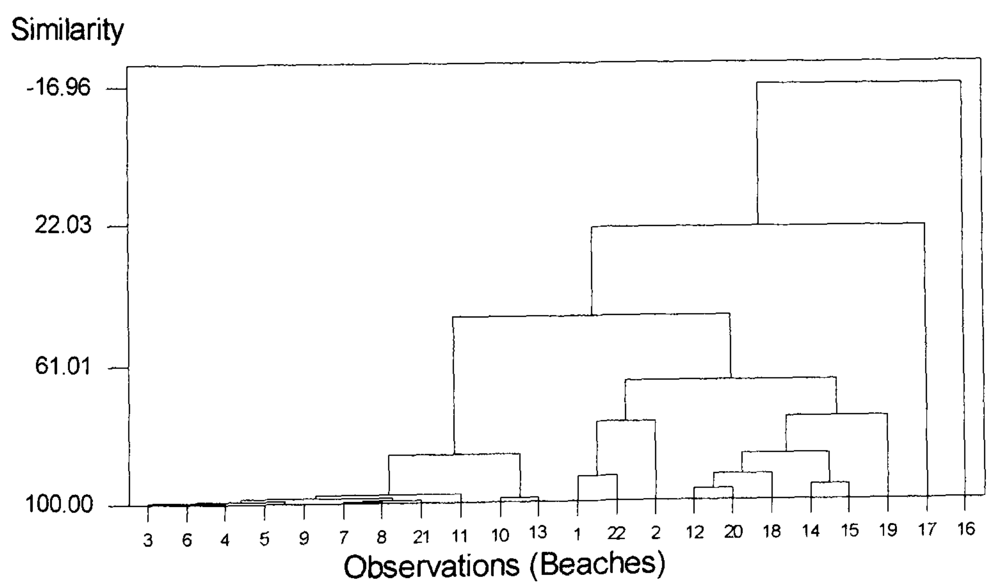

Figure 5.2.11. Cluster Analysis - Broad classification categories (standardised variables). For key to beach sites see Table 5.2.17

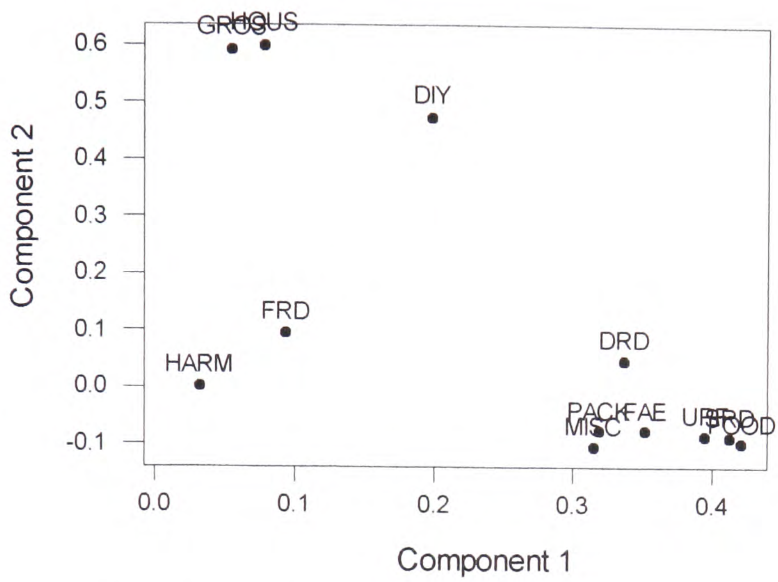

Figure 5.2.12. - Principal Component Analysis of Litter Items using Broad Litter Item Classification - Principal Components 1 and 2 (standardised data). *See Table 5.2.14 for key.*

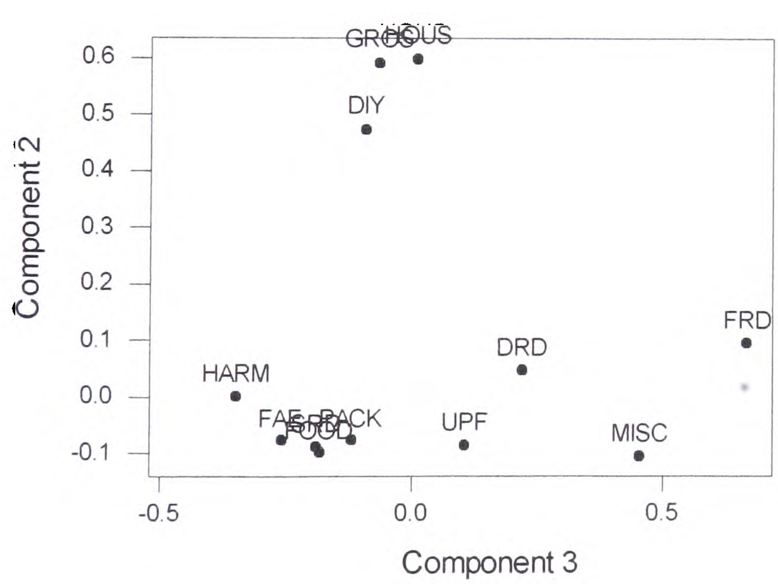

Figure 5.2.13. - Principal Component Analysis of Litter Items using Broad Litter Item Classification - Principal Components 2 and 3 (standardised data). *See Table 5.2.14 for key.*

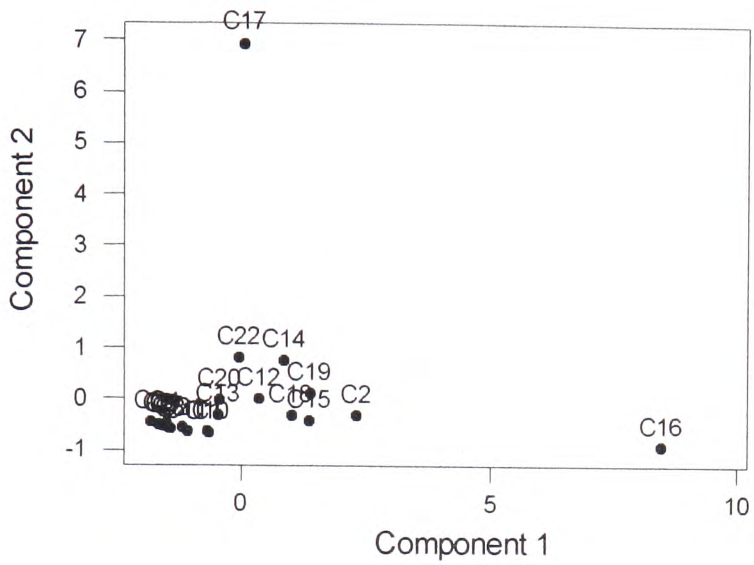

Figure 5.2.14. Principal Component Analysis of Beach Survey Sites using Broad Litter Item Classification - Principal Components 1 and 2 (standardised data). *See Table 5.2.15 for key.*

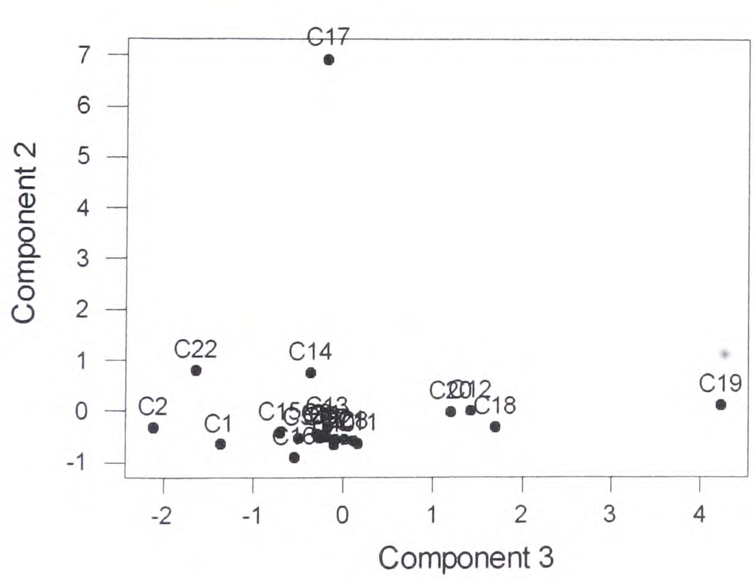

Figure 5.2.15. Principal Component Analysis of Beach Survey Sites using Broad Litter Item Classification - Principal Components 2 and 3 (standardised data) *See Table 5.2.15 for key.*

An inherent problem with these initial attempts at litter sourcing using multivariate analysis was the broad categories of items used. For example, drink related debris covered litter such as plastic drink bottles, drinking straws, milk containers, etc. Whilst all these items can reasonably be categorised as 'drink related', the potential sources could be vastly different. For example, it was logically hypothesised that drinking straws would most likely have originated from a beach user source, whereas milk containers probably derived from a sea borne source. Gathering items together from potentially differing sources was not thought to be helpful in linking, grouping, or separating items on principal component axes. As a result, data on litter from surveys conducted, which covered 45 surveys, was re-classified into more distinct and less prescriptive categories (Table 5.2.16). It was felt that a more specific 'species' classification might give a clearer picture of their source. Broad groups were split into very specific litter items or minor groups (Table 5.2.16), and a full analysis of *all* beaches studied was included (Table 5.2.17). Certain beaches were included in more than one instance (e.g. Tresilian Bay and Merthyr Mawr; Table 5.2.17), in such cases surveys were carried out on different days at the same beach.

Table 5.2.16. Key to litter items in subsequent figures

Principal Component Analysis Litter Code	Litter Item
T1	Soft drink bottle container
T2	Aluminium can - beer or soft drink
T3	Milk container
T4	Toiletry container. e.g. toothpaste, toothbrush, shampoo, deodorant
T5	Food containers- e.g. margarine, mayonnaise
T6	Take away food container/plastic cups/wooden forks-plastic spoon
T7	Detergent container
T8	Cotton Bud Stick
T9	Sewage Related Debris
T10	Netting/line
T11	Other fishing items(e.g. lobster pot, fish box, etc)
T12	Shipping general (e.g. tyre with rope, fender, buoy)
T13	Unidentifiable fragments
T14	Sweet wrappers, drinking straw, lollipop sticks, soft drink cartons
T15	Packing strap

T16	Polystyrene
T17	Cigarette lighter
T18	Cigarette stubs
T19	Beverage bottle top, tamper proof ring
T20	Plastic bag
T21	Secondary use container
T22	Land based items: e.g. Hub cap, traffic cone, car products, shopping trolley, road works
T23	Shotgun cartridge
T24	Cloth, shoe
T25	Party popper
T26	Pen
T27	Syringe
T28	Balloon
T29	Children's toys
T30	Tangles of netting
T31	4 pack holder
T32	Polyurethane
T33	DIY/Maintenance containers (e.g. diesel injector cleaner, bucket)
T34	Toilet freshener
T35	Flower pot
T36	Wood
T37	Balloon
T38	Piping/ducting
T39	25l oil drum
T40	5/10 l oil containers
T41	bait bag
T42	plastic sheet
T43	glass bottle
T44	paper
T45	light bulb

Table 5.2.17. Key to litter survey sites in subsequent figures·

Principal Component Analysis Beach Code	Beach Surveyed
S1	Sand Bay 20/7/00
S2	Sand Bay 22/3/00
S3	Aberdyfi 23/8/00
S4	Towyn 23/8/00
S5	Barmouth 23/8/00
S6	Harlech 24/8/00
S7	Pwllheli 24/8/00
S8	Broadhaven 6/11/00
S9	Tenby North 6/11/00

S10	Tenby South 6/11/00
S11	Nolton 6/11/00
S12	Mwnt 6/11/00
S13	Poppit Sands 6/11/00
S14	Wisemans Bridge 6/11/00
S15	Pendine Sands 6/11/00
S16	Croyde 10/9/00
S17	Putsborough 10/9/00
S18	Putsborough 22/3/00
S19	Woolocombe 10/9/00
S20	Woolocombe 22/3/00
S21	Lynmouth 20/9/00
S22	Lynmouth 21/3/00
S23	Blue Anchor 20/9/00
S24	Blue Anchor 21/3/00
S25	Dunster Beach 21/3/00
S26	Minehead 21/3/00
S27	Westward Ho! 21/3/00
S28	Brean 21/3/00
S29	Weston 21/3/00
S30	Berrow 21/3/00
S31	Hartland Quay 22/3/00
S32	Combe Martin 22/3/00
S33	Freshwater West 12/9/99
S34	Angle 12/9/99
S35	Blue Anchor 6/8/00
S36	Ilfracombe 8/8/00
S37	Merthyr Mawr 26/1/98
S38	Tresilian 20/12/98
S39	Tresilian 4/1/99
S40	Tresilian 17/1/99
S41	Tresilian 3/2/99
S42	Tresilian 21/2/99
S43	Tresilian 8/3/99.
S44	Merthyr Mawr 1/4/98
S45	River Ogmore 1/4/98

PCA results for these expanded litter categories and survey sites are shown in Figures 5.2.16 and 5.2.17. As a consequence of large amounts of debris experienced at certain beaches, it was decided to use the correlation coefficient (standardised data) for all subsequent analysis, this would prevent litter items or beach sites which occurred in high abundance influencing results unduly. As in the pilot study (Figures 5.2.14 and 5.2.15), three beaches were found to be clear outliers.

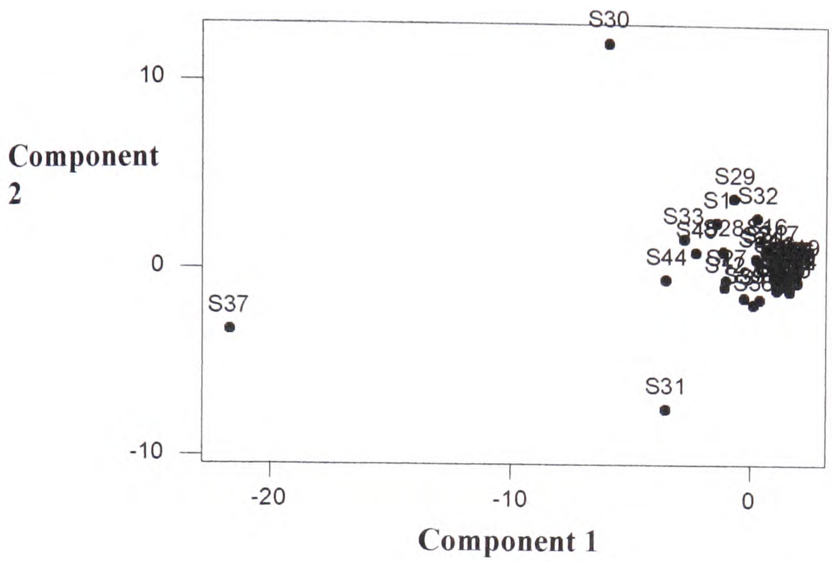

Figure 5.2.16. Principal Component Analysis of Beach Survey Sites using Specific Litter Item Classification - Principal Components 1 and 2 (standardised data). For key to beach sites see Table 5.2.17.

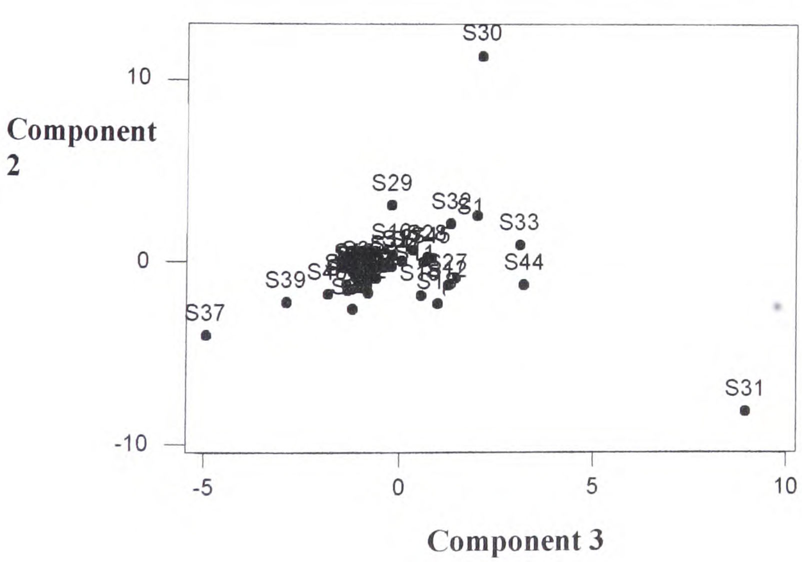

Figure 5.2.17. Principal Component Analysis of Beach Survey Sites using Specific Litter Item Classification - Principal Components 2 and 3 (standardised data). For key to beach sites see Table 5.2.17.

Both Berrow (S30), and Hartland Quay (S31), were again separated, but in this second more detailed analysis Freshwater West (S33) was replaced by a Merthyr Mawr beach survey (S37; Figures 5.2.16 and 5.2.17). Large abundance of certain litter items were seen to be causing a dominant effect on the analysis despite standardising the variables (e.g. 711 cotton bud sticks found at Berrow; 96 SRD items at Merthyr Mawr; Appendix IVb). Excluding these beaches from subsequent analysis would enable greater discrimination of differences between beaches in the main cluster and could elucidate relationships between litter sources.

When the three beaches were excluded, source groupings became more clearly defined. As previously stated PCA helps pick out patterns (relationships) in the variables. Fishing debris, shipping debris, SRD and to some extent river debris are separate groups (Figure 5.2.18). Beach user sources are separate (land/dry waste; e.g. t14 and t18, Figure 5.2.18) from other litter types, but it is not a coherent group and other potential beach user sources were not so clearly represented – perhaps highlighting the problem of distinguishing these items (sweet wrappers, plastic drink bottles) from riverine or ocean based sources. The transport mechanism of the litter types may be a factor; small SRD items do not group with the other 'land' based items such as cones or trolleys. SRD could also come from direct outfall inputs to the sea.

Figure 5.2.18 produces a number of distinct groups of litter sources. The upper left segment has a conglomeration of what can be defined as river derived items. The riverine classification is difficult to delineate, with certain items (such as traffic cones, shopping trolleys, hub caps) having an almost certain land/river source, but others such as DIY/maintenance containers or plästic bags being less definite. This riverine grouping does correlate with the survey sites (Figure 5.2.19), with S45 being a site on the river Ogmore, and S44 being Merthyr Mawr beach (both shown in Figure 5.2.19) – situated at the mouth of the Ogmore which is known to be a beach heavily influenced by riverine debris (Simmons and Williams, 1997; Figures 5.1.4 and 5.1.5).

Items of shipping waste are also clearly separated (Figure 5.2.18). Items grouped together were rope, fenders buoys, milk containers, food containers (margarine tubs etc., and not 'take away' containers), and secondary use containers (e.g. bailers, oil change containers). Items of fishing debris were also grouped together (Figure 5.2.18), with netting/line found in conjunction with lobster pots, fish boxes, packing straps, plastic sheeting, and manufactured wood. The shipping and fishing groups are separated by items of SRD. Within this group are items of general SRD (i.e. sanitary towels, tampon applicator etc.) as well as CBS and 'toilet cleansers'.

The beach user source category is less well defined. Items that were considered as originating from this source did not group together (Figure 5.2.18). Sweet wrappers were close to the SRD group, others were dispersed. Cigarette stubs were found to be separate from the other litter items, showing a positive score on component 1 axis (t18; Figure 5.2.18). This item is almost certainly from beach users. However, it possibly has different movement patterns to the other items of litter commonly left by beach users such as children's toys or take away food wrappers/packaging. The material composition means that it tends to stay where it was laid down. Other 'beach user' items have the potential that they could have come down rivers (sweet wrappers) or from the sea (drink containers), it is perhaps for this reason that these items are not grouped together. Fishing, shipping and SRD all have items within their classifications that are almost 100% certain to come from a particular source, items of a beach user, and to some extent river origin, do not have that clear or near definite attribute.

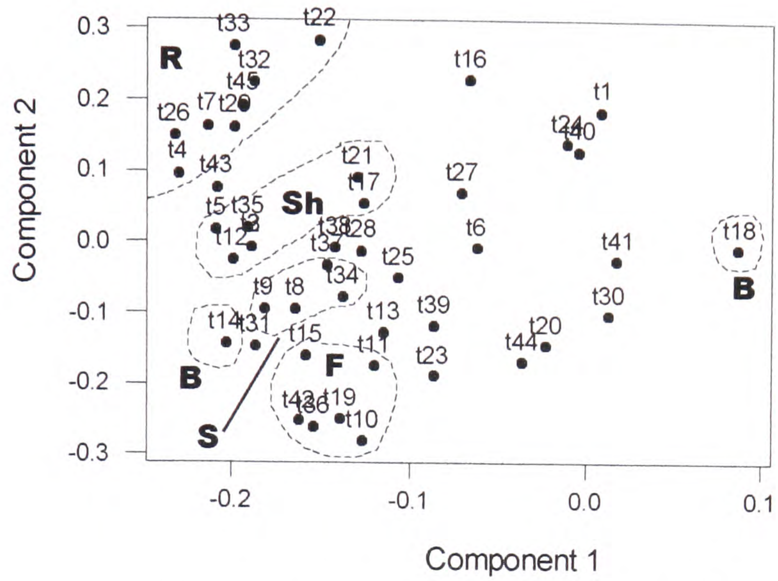

Figure 5.2.18. - Principal Component Analysis of Litter Items (excluding three outliers) using Specific Litter Item Classification - Principal Components 1 and 2 (standardised data). Key: R= River source; Sh= Shipping source; F= Fishing source; B= Beach user source; S= Sewage related debris source

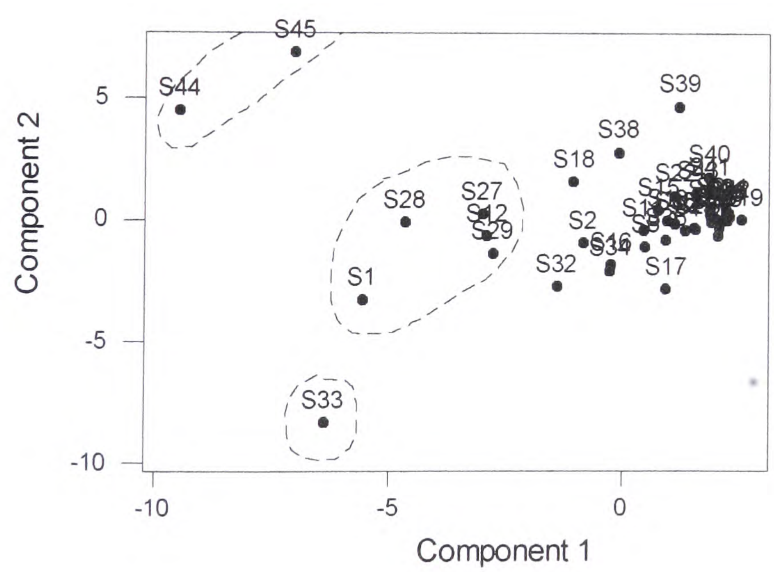

Figure 5.2.19. Principal Component Analysis of Beach Survey Sites (excluding three outliers) using Specific Litter Item Classification - Principal Components 1 and 2 (standardised data). For key to beach sites see Table 5.2.17.

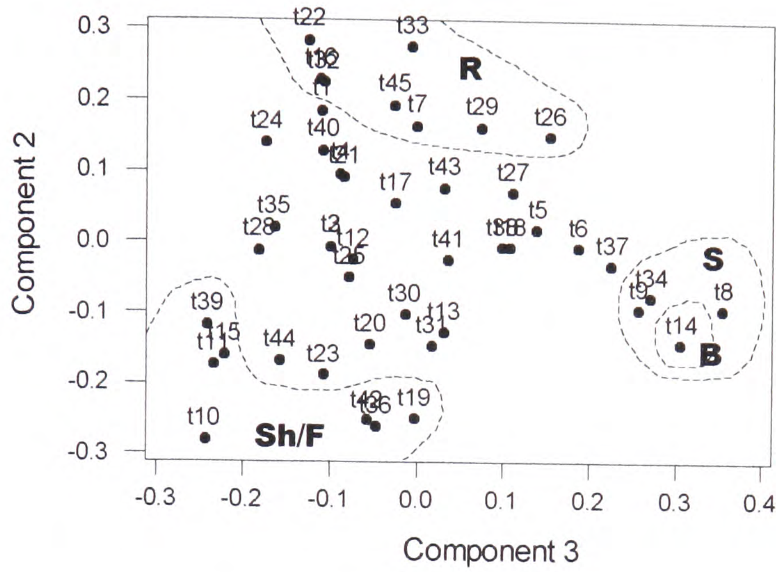

Figure 5.2.20. - Principal Component Analysis of Litter Items (excluding three outliers) using Specific Litter Item Classification - Principal Components 1 and 2 (standardised data). Key: R= River source; Sh= Shipping source; F= Fishing source; B= Beach user source; S= Sewage related debris source.

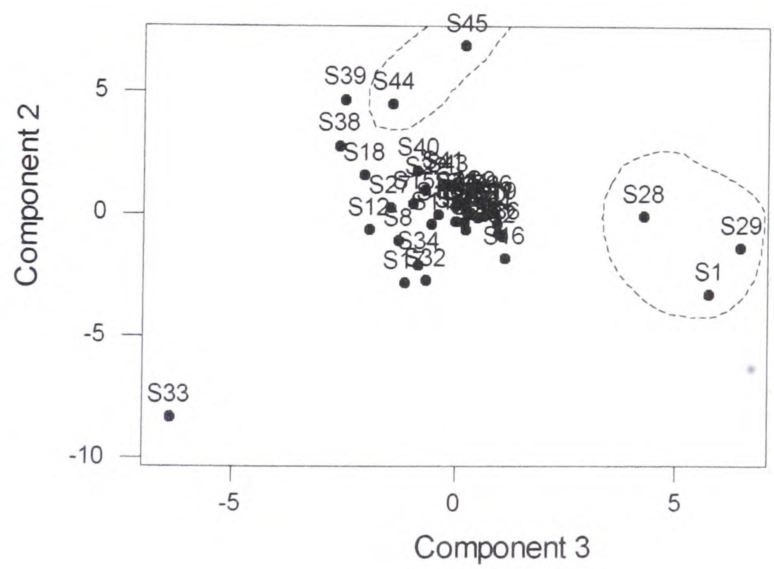

Figure 5.2.21. Principal Component Analysis of Beach Survey Sites (excluding three outliers) using Specific Litter Item Classification - Principal Components 1 and 2 (standardised data).

Freshwater West (S33; Figure 5.2.19) is separate from the main cluster of beach sites and its orientation is correlated with the fishing source group from Figure 5.2.18. Similarly, the beaches S1 and S28 (Sand Bay and Brean respectively; Figure 5.2.19) are at a similar oriented position to the SRD grouping in Figure 5.2.18. It would therefore appear from examining principal components 1 and 2 (Figure 5.2.18) that many items from source groupings cluster together, with certain beaches indicating that they either have large numbers of items from a certain source (e.g. SRD at Sand Bay and Brean), or have only litter from one category and very little from any other (e.g. Shipping/Fishing debris at Freshwater West).

Examining principal components 2 and 3 helps to draw out other variables that were not apparent on components 1 and 2. There is a separation of the SRD grouping from the fishing and shipping categories that were closely grouped on components 1 and 2 (Figure 5.2.20). Surprisingly, sweet wrappers are again grouped with SRD. Items such as large oil containers are now found grouped with the shipping debris (t39; Figure 5.2.20). River sourced items are not so clearly grouped as Figure 5.2.18. Items such as detergents or toiletry containers often end up on beaches with shipping inputs (Hartland Quay, Freshwater West) as well as on beaches with river sources (Merthyr Mawr), this multi-source item is difficult to pin down to a source; it is perhaps better to concentrate on the mix of other items where this item is found or concentrate on the amount or diversity that exists of this item.

Figure 5.2.21 shows that Freshwater West (S33), is located away from the main clusters, which also groups together sites S1 (Sand Bay), S28 (Brean), and S29 (Weston-Super-Mare). These latter three beaches are geographically very close. They obviously show differences in their litter composition when compared to other beaches which have a relatively homogenous litter distribution. In essence, each of these three beaches (S1, Sand Bay; S28, Brean; S29, Weston-Super-Mare), had large amounts of SRD, probably from inputs from the River Parrett. Freshwater West also has a different litter profile to many of the other beaches. Similarly, litter from Merthyr Mawr S44 and the River Ogmore S45, are grouped together on both principal components 1 and 2 (Figures 5.2.19 and 5.2.21).

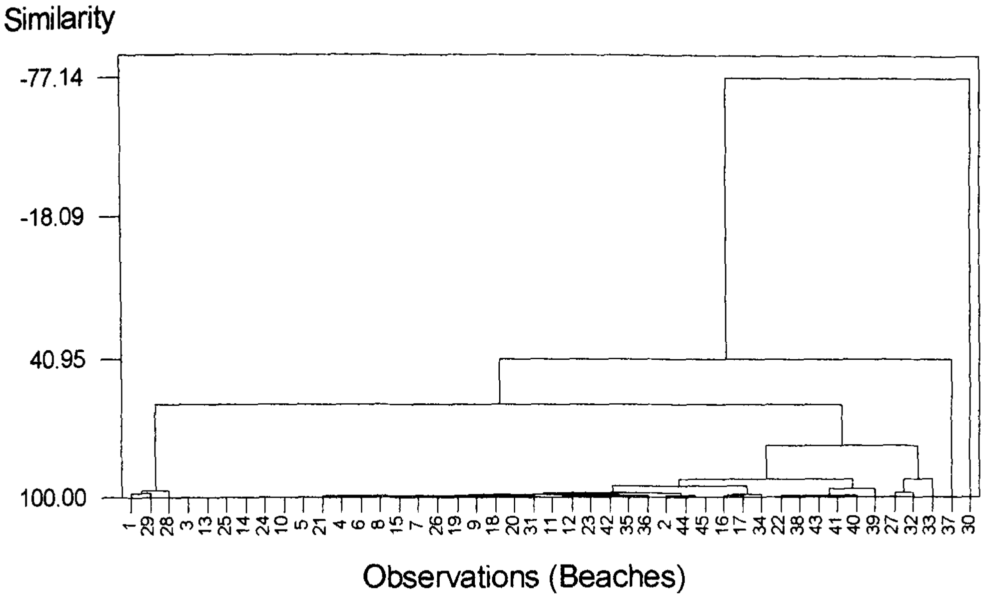

Figure 5.2.22. Cluster Analysis - Specific Litter classification categories (non-standardised variables). For key to beach sites see Table 5.2.17.

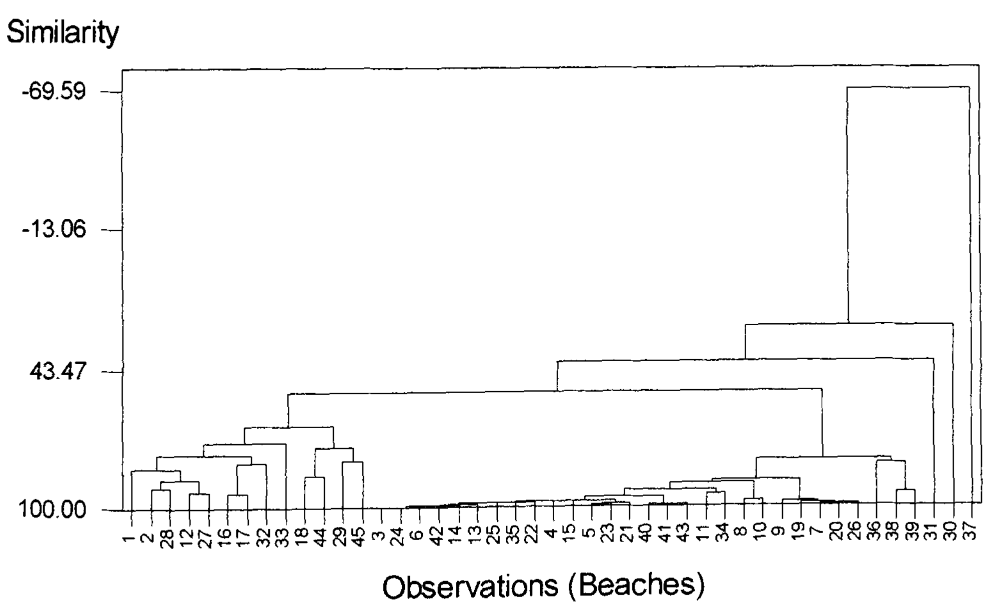

Figure 5.2.23. Cluster Analysis - Specific Litter classification categories (standardised variables). For key to beach sites see Table 5.2.17

Cluster analysis of the data (Figures 5.2.22 and 5.2.23), show a major assemblage of beaches with a few distinct sites (e.g. S30, and S37). Unlike PCA, no beaches were excluded from cluster analysis as no site is able to exert undue influence when using this method of multivariate analysis. The non-standardised method (Figure 5.2.22), illustrates a sub-cluster of sites, namely 1, 28, 29 (Sand Bay, Brean, Weston) as in PCA analysis (Figure 5.2.21). With standardised data (Figure 5.2.23), a larger sub-group appears comprising beaches on the southern shore of the Bristol Channel, indicating a difference in litter pattern profiles between these beaches and those of the northern shore as well as the inner Channel. No differences were found between beaches of the northern and southern shores of the inner Bristol Channel.

'Added value' : Addition of Turkish beaches and Roadside litter surveys to the analysis.

In order to facilitate a better understanding of litter sourcing an 'added value' aspect was included. Litter data was collected from roadsides in Gloucestershire and from twelve surveys at four popular tourist beaches in Turkey (Konyaalti, Side, Kemer and Çirali; Table 5.2.18). The roadside litter survey was conducted in rural lanes and was introduced to the analysis to represent truly 'land-based' litter. The Turkish beaches are in an area with no riverine inputs and are located in a virtually tideless sea (the maximum tidal range is 60cm.).

Table 5.2.18. Key to 'added value' litter survey sites in Figures 5.2.24 to 5.2.27

Principal Component Analysis Beach/Survey Site Code	Location Surveyed
S46	Gloucestershire roadside
S47	Kemer survey site1
S48	Kemer survey site 2
S49	Kemer survey site 3
S50	Çirali survey site 1
S51	Çirali survey site 2
S52	Çirali survey site 3
S53	Side survey site 1
S54	Side survey site 2
S55	Konyaalti survey site 1
S56	Konyaalti survey site 2
S57	Konyaalti survey site 3
S58	Konyaalti survey site 4

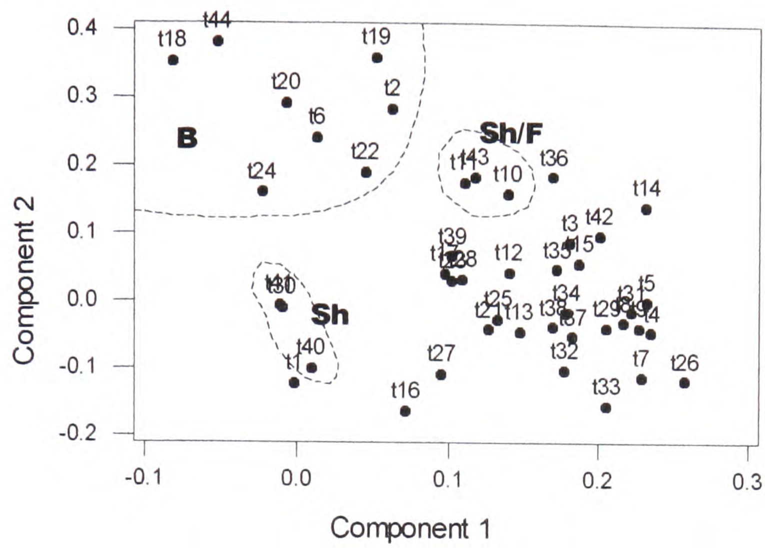

Figure 5.2.24. - Principal Component Analysis of Litter Items (excluding three outliers) using Specific Litter Item Classification. Turkish beaches and rural England roadside survey added - Principal Components 1 and 2 (standardised data). Key: R= River source; Sh= Shipping source; F= Fishing source; B= Beach user source; S= Sewage related debris source.

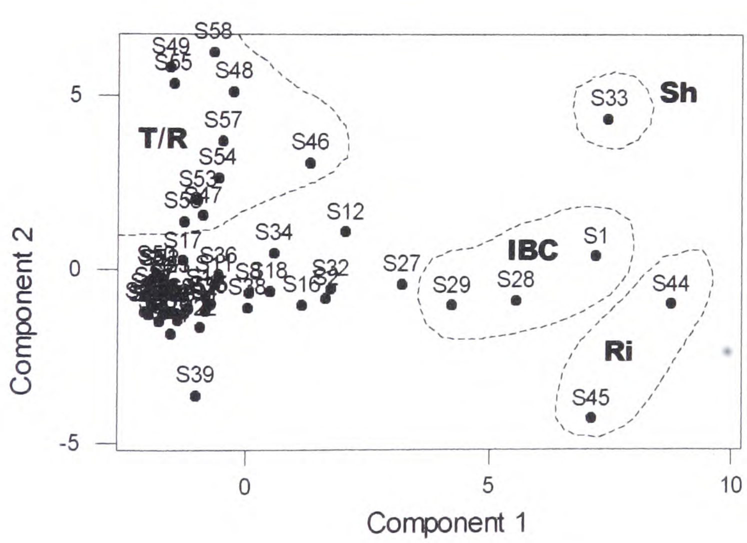

Figure 5.2.25. - Principal Component Analysis of Beach Survey Sites (excluding three outliers) using Specific Litter Item Classification. Turkish beaches and rural England roadside survey added - Principal Components 1 and 2 (standardised data). Key: T/R= Turkish/roadside survey; IBC= Inner Bristol Channel; Ri= River source litter; Sh= Shipping source.

Turkish beach litter comprised large amounts of what can be considered 'beach user' items, namely: cigarette ends; 'take-away' / convenience food wrappers and containers; confectionery wrappers, etc. In total only 10 sewage derived items were recorded on these four beaches out of a litter total of 2601 items (Appendix IVb). Reference to Figures 5.2.24 and 5.2.25 indicates that certain litter items (labelled 'B' in Figure 5.2.24; e.g. cigarette ends, take away containers) have a similar orientation to the Turkish beaches investigated (S47-S58, Figure 5.2.25) as well as the roadside litter survey (S46, Figure 5.2.25). Similar groupings occurred when PCA plots involving component 3 were introduced (Figures 5.2.26 and 5.2.27).

The addition of litter from Turkish beaches and roadside surveys did not change the orientation of outlying sites such as S33, S44, and S45 (Figures 5.2.25 and 5.2.27), and the grouping of sites S1, S28, S29 (Figure 5.2.25). This is borne out by comparison of these figures with those produced before Turkish/roadside sites were added (Figure 5.2.19 and Figure 5.2.21). What has changed is the distancing of site S44 from S45. Site S44 has been 'pulled' toward the Turkish beaches and roadside site (Figures 5.2.25 and 5.2.27 compared to Figure 5.2.19 and Figure 5.2.21). This indicates that whilst site S44 still has major similarities with S45 it contains elements that are akin with Turkish/roadside sites, i.e. land based sources of litter. Therefore, similarities occur in the litter source at these sites. Few beaches in the Inner Bristol Channel/Wales are 'pulled' toward the Turkish beaches/roadside surveys. This indicates that these Turkish beaches/roadside surveys differ significantly in composition and abundance of certain items (e.g. cigarette ends) to the beaches studied, particularly the Bristol channel. The Turkish sub set of data has added a new 'dimension' to the analysis that was not previously found (Figures 5.2.24 to 5.2.27).

Principal component analyses showed that Turkish beaches and the rural England roadside litter surveys cluster together on component 2 (Figures 5.2.25 and 5.2.27). It is interesting to note the proximity of results from litter roadside surveys to Turkish beach litter, reinforcing the land based nature/source of litter on Turkish beaches. What was unexpected was the distinction between the river Ogmore site (S45), the Merthyr Mawr beach site (S44), and the Turkish/roadside surveys (S46-

58; Figures 5.2.25 and 5.2.27). It could be conjectured that the Turkish/roadside litter surveys should cluster with the river Ogmore/ Merthyr Mawr sites. They did not. This difference could possibly result because roadside survey/Turkish beaches were not subject to any SRD inputs. The influence of large amounts of SRD at Merthyr Mawr has seemingly made this site distinctive from other litter land based surveys (i.e. roadside/Turkey surveys); and also dissimilar to sites subject to large amounts of shipping/fishing litter (e.g. Freshwater West, S33; Figures 5.2.25 and 5.2.27). The enormous accumulations and diverse nature of litter (and consequently inputs) at Merthyr Mawr beach also make it distinctive from other sites which contain large amounts of SRD but little else, for example, Berrow, Sand bay (Appendix IVb).

The use of source group 'markers'

An additional analysis was undertaken for this expanded data set which involved the use of a series of 'markers'. Three 'markers' were introduced which comprised source groupings: 'beach users'; 'vessels' (both fishing and other sea going vessels); and, sewage debris (Table 5.2.19). Abundance figures used in these 'marker' groups were extrapolated from data obtained at real survey sites. It was hypothesised that beach sites that comprised significant numbers of litter items from each of these source 'marker' groups would cluster together and help to illustrate the major litter sources acting on them.

Figure 5.2.28 illustrates the data set with 'markers' added for principal components 1 and 2. Clearly the 'vessels' marker is far removed from any beach survey sites, with 'beach users' and 'sewage debris' nestling in an amorphous conglomeration of indistinguishable sites. What information is available from Figure 5.2.28 is the clear difference between the 'beach user' marker and sites S44, S45 and S33, indicating the litter profile at these beaches contains very little 'beach user' debris. The 'Sewage debris' marker is less informative. Reasons for this are unclear, but is perhaps due to the small number (3) of items making up this group compared to the 'beach users' source group, comprising 5 items, and 6 items for the 'vessels' group (Table 5.2.19).

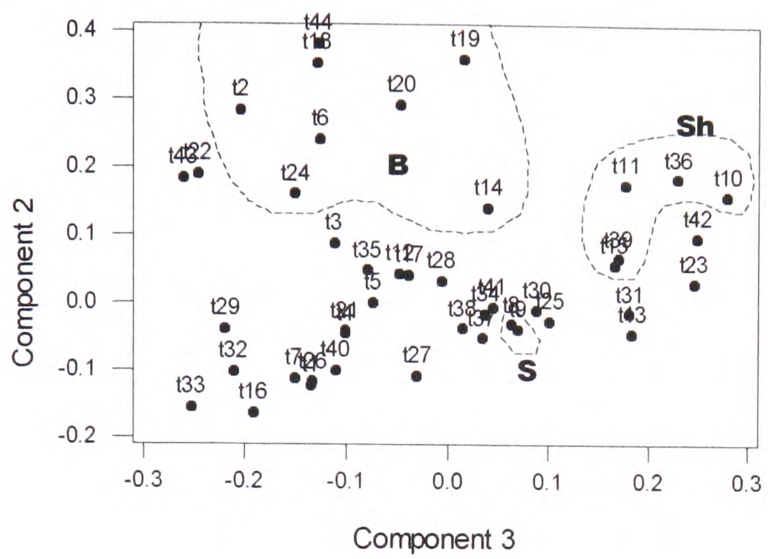

Figure 5.2.26. - Principal Component Analysis of Litter Items (excluding three outliers) using Specific Litter Item Classification. Turkish beaches and rural England roadside survey added - Principal Components 2 and 3 (standardised data). Key: R= River source; Sh= Shipping source; F= Fishing source; B= Beach user source; S= Sewage related debris source.

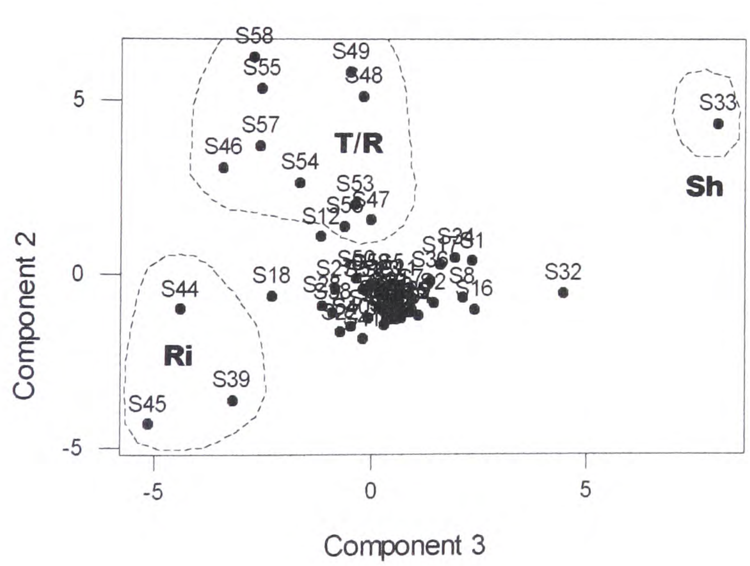

Figure 5.2.27. - Principal Component Analysis of Beach Survey Sites (excluding three outliers) using Specific Litter Item Classification. Turkish beaches and rural England roadside survey added - Principal Components 2 and 3 (standardised data). Key: T/R= Turkish/roadside survey; Ri= River source litter; Sh= Shipping source.

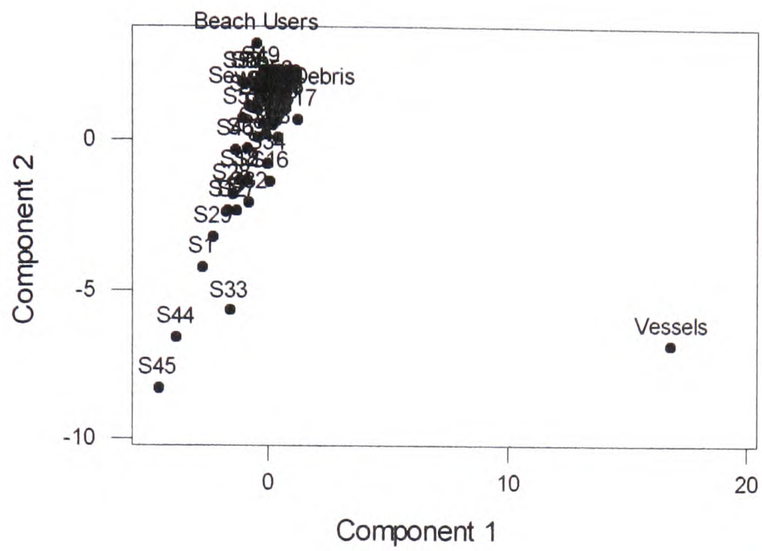

Figure 5.2.28. - Principal Component Analysis of Beach Survey Sites (excluding three outliers) using Specific Litter Item Classification. Turkish beaches and rural England roadside survey added with Source group 'markers' - Principal Components 1 and 2 (standardised data).

Table 5.2.19 Composition of beach litter source 'markers'

'Vessel' source group	'Beach user' source group	'Sewage related debris' source group
Milk container	'Take-away' food container	Cotton bud sticks
Netting / line	Sweet wrappers	General sewage related debris
Other fishing components (e.g. lobster pot, fish box etc.)	Cigarette ends	Toilet cleanser
Shipping items (e.g. buoys, fenders etc.)	Plastic bags with specific markings	
Secondary use container	Children's toys	
25 litre ship grade oil drum		

Markers are subjective in that items included are determined by the analysis producer. However, as long as this form of attribution is robust and based on knowledge and only those items which are *highly probable* of coming from a pre determined source are used, then their use can be defended. For example, there is no possibility that a wooden pallet can be sourced to a sewage system; they invariably can be attributed to a shipping source. In addition, the numbers chosen to be placed into each marker are arbitrary. Further work is needed in this area to establish the merits of using litter source group 'markers'.

Qualitative comparisons : Some Similarity Indices

A number of indices have been developed which compare joint species presence or absences between two samples or communities. However, Hellawell (1978), disputed the use of coefficients which employ joint *absences* in arriving at an index of affinity where extensive surveys had been undertaken. Therefore, coefficients of *similarity* were utilised in this study, in an attempt to establish if associations existed among litter types between various beach sites. Coefficients of similarity are widely used in ecological studies, for example, assessment and comparisons of the effect of pollutants on biological communities within rivers (Kothe, 1962; Davies, L *pers comm.*). 'Litter item', or 'litter species', data replaced ecological data in this study. This approach has been documented in papers by, for example, Simmons and Williams (1997), Earll *et al.* (2000a).

Three coefficients for comparing community species lists are commonly used, namely Jaccard (1912), Kulezynski (1928), and Sørenson (1948), (Hellawell, 1978; Magurran, 1988). These indices each have a scale which ranges from 0, no association, to 1, maximum association.

The indices are:

1) Jaccard (1912): $J = c/a + b - c$

2) Kulezynski (1928): $K = c/2\ (1/a + 1/b)$

3) Sørenson (1948): $S = 2c/a + b$

where: a = number of species in community 'A'

b = number of species in community 'B'

c = number of species common to both communities

A selection of beaches were used in trials of these qualitative measures of comparison. Beaches that illustrated high (Berrow and Brean) and low (Freshwater West and Merthyr Mawr) levels of similarity (clustering / grouping), as well as beaches that showed no clear orientation or pattern (Ilfracombe and Minehead) using principal component analyses, were compared.

Results using qualitative indices confirmed findings from PCA, with stronger similarities found between beaches exhibiting clear associations using PCA (e.g. Berrow / Brean; J=0.61; Table 5.2.20) than those displaying little or no strong association (e.g. Lynmouth / Blue Anchor Bay; J=0.27; Table 5.2.20). Freshwater West and Merthyr Mawr illustrate high levels of similarity where qualitative indices are used (Table 5.2.20), but very little association when PCA was employed (Figures 5.2.19 and 5.2.21). Both these beaches had a large diversity of items, but no correlation was found when abundance of these items is taken into consideration, i.e. the use of PCA. This is an inherent weakness of qualitative methods when compared to methods such as PCA which takes both qualitative and quantitative aspects of the data into account.

Table 5.2.20. Examples of qualitative similarity comparison methods

Beaches Compared	**Similarity Indices**		
	Jaccard	Kulezynski	Sørenson
Sand Bay / Berrow	0.42	0.63	0.59
Berrow / Brean	0.61	0.76	0.75
Freshwater West / Hartland Quay	0.39	0.58	0.56
Lynmouth / Blue Anchor Bay	0.27	0.45	0.42
Ilfracombe / Minehead	0.29	0.47	0.45
Freshwater West / Merthyr Mawr	0.58	0.74	0.74

Some Quantitative comparisons

Qualitative coefficients of similarity take no account of the relative abundance of species at each site and therefore tend to overestimate the importance of rare litter 'species' and underestimate the importance of common litter 'species'. This can be avoided by using coefficients which compare both 'species' lists and relative contribution made by each 'species', i.e. quantitative coefficients. Two such coefficients are Raabe (1952), and Czekanowski (1913). An example of the techniques are given for Freshwater West and Merthyr Mawr. These sites were chosen, as qualitative analysis indicated that they were similar with respect to presence/absence of litter composition (Table 5.2.20), but PCA analysis showed no correlation (Figures 5.2.19 and 5.2.21). Therefore it was felt that results needed to be tested further using quantitative methods.

a). The Raabe coefficient is :

$R = \Sigma \min (a, b, c, \ldots\ldots\ldots\ldots n)$

Where: a = species a; b = species b; c = species c; etc.

Raabe's coefficient is derived from the sum of the minimum percentage representation of the species common to both sites. Any two sites may differ in total numbers but the data must be reduced to percentage proportions before calculation can proceed. A value of 100% would indicate maximum similarity, with 0% indicating no similarity. Calculations of comparisons between Freshwater West and Merthyr Mawr for both Raabe and Czekanowski coefficients are shown in Appendix IVc.

The comparison of Freshwater West and Merthyr Mawr using Raabe's coefficient results in an R value of 43%, indicating that litter from these two sites have some similarity but show no strong association.

b) The Czekanowski coefficient is:

$C_z = 2W/A+B$

Where:

W = the sum of the lesser measures of abundance of each species common to both communities

A= the sum of measures of abundance at site A

B = the sum of measures of abundance at site B

This coefficient is similar in principle to that of Raabe but it is not necessary to calculate the percentage contribution of each species; any comparable measure of abundance may be used. A value of 1 would indicate maximum similarity, and 0 would point to no similarity between the sites.

A comparison of Freshwater West and Merthyr Mawr using Czekanowski's coefficient, gave a C value of 0.32, indicating that litter from these two sites have little similarity.

Results from both quantitative indices (Raabe and Czekanowski) differed from those obtained using qualitative indices (Jaccard, Kulezynski, and Sørenson). Qualitative indices confirmed PCA analysis that Freshwater West and Merthyr Mawr contain some similarities in litter composition and abundance, but are not strongly similar as qualitative indices had suggested. The quantitative coefficients employed are useful in illustrating similarities between beach sites, but because only those litter items that are common between both sites are considered in analysis, there is potential for losing important information. PCA analysis includes all data from each site in analysis, not only those litter 'species' that are common at sites, and uses qualitative and quantitative measures of similarity. Therefore, whilst the use of coefficient indices may be of use in certain situations, multivariate analysis (i.e. PCA and cluster analysis) proved to be a more robust and useful technique in transforming a large data set into visual patterns of association and subsequent interpretation.

5.2.4 Summary

Various methodologies have been examined with regard to sourcing of beach litter. With respect to the Bristol Channel it was felt that two methodologies in particular were appropriate, i.e. a data matrix scoring method as outlined by Whiting (1998), and multivariate analysis (i.e. PCA and Cluster analysis). The Whiting method (1998), is logistically a very time consuming exercise, although it has certain merits which could possibly be investigated further. It was particularly valid for highlighting beach user sources. PCA analysis is a well documented statistical technique that distinguished riverine, SRD, fishing, and shipping items, but was not really satisfactory with respect to beach user items. This could possibly be due to differences in transport mechanisms of this type of litter. Cluster analysis gave a very good grouping for southern outer Bristol Channel beaches, but no difference could be found between beaches on both sides of the inner Bristol Channel. The 'added value' beaches of mid and north Wales could not be differentiated from the central group of beaches around the zero mark of all three components, probably due to the small amounts of litter found. Hartland Quay and Freshwater West, before their exclusion from the analysis, had very different litter profiles to other Bristol Channel beaches. The western segment of the Channel is influenced more by shipping/fishing inputs than the eastern.

Introduction of four Turkish beaches to PCA illustrated the difference in litter profiles between these and Bristol Channel beaches. Litter at Turkish beaches surveyed was considered to be from a 'beach user' source, e.g. cigarette ends, 'take-away' / convenience food wrappers and containers. The land-based nature of litter found was confirmed by PCA; the UK roadside litter survey forming a close cluster with the Turkish beaches. Beaches of the Bristol Channel and Wales coast did not cluster with Turkish beaches or the roadside survey, therefore illustrating more diverse litter inputs to the UK beaches. Litter source 'markers' in PCA proved to be an interesting addition to the study, but the arbitrary nature of parameters chosen for each 'marker' mean that their use requires further testing in future research. Qualitative and quantitative similarity coefficients proved less informative than PCA. The selected indices only considered litter items that sites had in common, whereas PCA included all items as well as considering both qualitative and quantitative aspects of the data set.

6 RESULTS AND DISCUSSION: BEACH USER ATTITUDES, PERCEPTIONS, PREFERENCES AND OPINIONS

6.1 Introduction

The aim of this study was to determine attitudes, perceptions, preferences and opinions of those members of the public that use beaches. When measuring attitudinal and perceptual phenomena, researchers face the decision of selecting appropriate data collection instruments (Menezes and Elbert, 1979). 'This involves utilising suitable research methods, scaling techniques, and response formats' (Driscoll *et al.*, 1994, page 499). Logistically, the most appropriate and efficient technique to extract information from beach users was determined to be the self administered questionnaire.

Several researchers have found links between beach water quality perception and visual pollution. For example, Dinius (1981), found that laymen considered that visually polluted sites had lower water quality. Morgan (1996), established that a beach that was perceived to have the greatest litter amount within his study area (Welsh coastline), was also perceived to have the poorest water quality. Dinius (1981), also argued that if efforts to improve water quality ignored the importance of keeping recreational sites clean, then the public may not appreciate or perceive the benefits from this exertion.

Public attention to problems relating to the coastal zone have been based more upon perceptions than on any scientific knowledge or evaluation of sources, fates and environmental effects (Windom, 1992). Associations have indeed been made between the public perceptions of items affecting the aesthetic appearance of bathing water and bathing beaches and the gastro-intestinal symptoms experienced after bathing in sewage polluted water (University of Surrey, 1987). It has been reported that 'overt filth seemed to correlate with microbial filth' (Eykyn, 1988, page 1484). To try and counter any ambiguities, DOH (1992), recognised the need for research to pinpoint associations between health consequences and quality of the environment.

The initial perception of the general public to coastal environmental quality is frequently based exclusively upon the aesthetic appearance of the water and its surroundings (House and Sangster, 1991). Attributes such as water colour, surface foam / scum, oil, unusual smell and the presence of litter and other solid waste have been shown to be important factors in the perception of water quality and its fitness for use, but may bear little or no relationship to actual physio-chemical or biological water quality (House, 1996; see section 2.4).

Aesthetics is usually a subjective and intangible concept. It is a branch of philosophy concerned with the essence and perception of beauty and ugliness. Aesthetics also deals with the question of whether such qualities are objectively present in the things they appear to qualify or whether they exist only in the mind of the individual; hence, whether objects are perceived by a particular mode, the aesthetic mode, or whether instead the objects have, in themselves, special qualities - aesthetic qualities. Logbook entries by visitors to a remote beach from southernmost New Zealand, highlighted the visual and emotive impact wrought by fouling marine debris. For example, 'Most dirty, man polluted beach I've seen in New Zealand – what a shame...we did our best to clean it up but only scratched the surface', Gregory (1999b, page 207), is a revealing expression of the aesthetic values of an eco-tourist (see also section 2.3.2).

6.2 Beach User Questionnaire Surveys

6.2.1 Common methodologies relating to all questionnaires

In an environmental monitoring and knowledge gathering context, questionnaires are a useful approach. Repeated application of such a procedure with its continual analysis and refinement of data can be easily incorporated into the '**W**' model of problem solving (Figure 6.1). The latter has its roots in Zen Buddhist philosophy with a belief that insights can be achieved by concentration on simple facts. The '**W**' model is an iterative process which involves successive phases of conceptual thinking, and field testing, evaluation and modification to achieve a final verified approach - steps A to H in Figure 6.1. The name is derived from the visual pattern (**W**) associated with this sequence of problem solving. The procedure is shown in Figure 6.1. and is a useful methodology for systematising information and problem solving, which sprang from the KJ method for structuring anthropological field data (Open University, 1994).

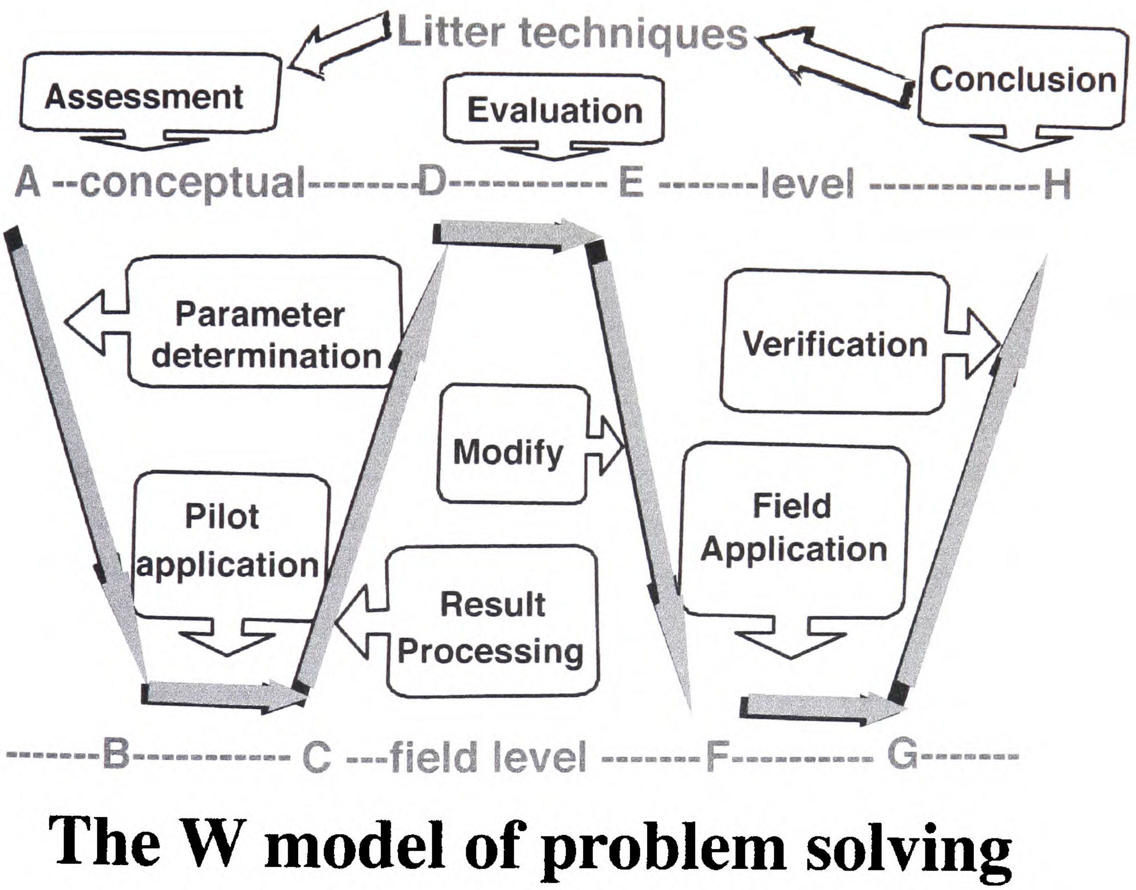

Figure 6.1 'W' Model of Problem solving

A pilot study was conducted at several beaches (i.e. Whitmore Bay, Rest Bay and Oxwich Bay; n=124), in order to establish the length of time taken by respondents to complete a questionnaire, and to further refine the posed questions. These were conceptualised and designed after first establishing the aim of the study, and then examining the literature to obtain salient points and best practice methodologies (e.g. Nelson, 1998). Terminology was developed from these pilot studies, literature searches and suggestions made by the public after field trials. For example, the Standard Occupational Classification groupings (SOC, 2000) was deemed to be important and added to the questionnaire (Table 6.1). These results were evaluated, questions modified and full scale field trials commenced in 1998. Many of the questions could have been answered away from the beach, and by people who rarely or never visit beaches. David (1971), recognised that non-users also have a stake in natural resources and surveyed representative samples rather than just users at a site, however, this point is dependant on the aims of a study. In this case it was felt that the best way to capture the most appropriate viewpoints was to go directly to those people who use beaches.

Beach selection was influenced by a number of important factors. The beach needed to be populated with significant numbers of people to enable a large enough sample to be gathered (>100 where possible). For this reason, remote rural beaches (e.g. Mwnt) were excluded from consideration. A geographical spread of beaches along the Bristol Channel coast was deemed desirable and from this a mixture of resort and semi resorts were selected. Numbers investigated were a function of logistics, as time allowed for one beach per day per interviewer. Weather played a part in the final number of people interviewed and beaches covered. The weather was predominantly sunny during these surveys but the unpredictable nature of the British climate meant that many of the less developed beaches, e.g. Dunraven Bay (Table 6.2a), did not have significant numbers of people on them if the weather was not hot and dry, and was likely to remain so.

Interviewees were approached in a courteous manner and the purpose of the survey was explained to them together with the affiliation of the surveyors. They were then asked if they would mind completing the survey form: An interviewer was on hand to assist in any queries that arose and each questionnaire took *circa* five to ten minutes to complete. Every other person / group on the beach was approached either on a horizontal or profile line until 100 questionnaires had been completed. If a refusal occurred, the next person/group was approached.

The Jandel Scientific (1995), Sigma Statistical pack was utilised to test for significant/not significant differences in perception results. It should be noted that for all tables shown in this chapter, n equals the number of people who answered that *particular* question, and does *not* refer to the total number of people involved.

Surveys were conducted over three years at eighteen beaches on the north and south coasts of the Bristol Channel, and the coast of mid and north Wales, involving a total of 2727 people. All surveys were conducted during school summer holidays. The 1998 questionnaire surveys were carried out at eight beaches along the south Wales (north shore of Bristol Channel) coast. The eight beaches were: Rest Bay, Porthcawl; Whitmore Bay, Barry Island, Vale of Glamorgan; Dunraven Bay, Southerndown, Bridgend; Tenby North, Pembrokeshire; Oxwich Bay, Gower, Swansea; Langland Bay, Gower, Swansea; Whitesands, St. David's, Pembrokeshire; and, Saundersfoot, Pembrokeshire (Figure 3.1; Table 6.2a). Surveys were carried out between 10/8/98 and 3/9/98. The total number of beach users interviewed was 883, using the '1998 Beach User Questionnaire' (Appendix V).

The 1999 questionnaire survey took place at seven beaches along the south Wales (north shore of Bristol Channel) coast. The seven beaches were: Ogmore-by-Sea, Bridgend; Sandy Bay, Porthcawl; Port Eynon, Gower, Swansea; Whitesands, St. David's, Pembrokeshire; Whitmore Bay, Barry Island, Vale of Glamorgan; Rest Bay, Porthcawl; and, Newton Beach, Porthcawl (Figure 3.1; Table 6.2b). Surveys were conducted between 25/7/99 and 23/8/99. There were 763 respondents, using the '1999 Beach User Questionnaire' (Appendix V).

Questionnaire surveys conducted in 2000 were carried out at six beaches along south shore of the Bristol Channel. The six beaches were: Berrow, Somerset; Minehead, Somerset; Weston-super-Mare, Somerset; Brean, Somerset; Blue Anchor Bay, Somerset; and, Ilfracombe, Devon (Figure 3.1; Table 6.2c). Surveys were conducted between 23/8/00 and 25/8/00, with 421 beach users interviewed. The '2000 Beach User Questionnaire' was utilised (Appendix V).

As an additional 'added value' aspect, beaches in mid/north Wales were also studied to provide a comparison between those of the Bristol Channel. Seven beaches were investigated, namely: Aberdyfi, Gwynedd; Towyn, Gwynedd; Barmouth, Gwynedd; Harlech, Gwynedd; Pwllheli, Gwynedd; Llandudno, Conwy;

and, Rhyl, Denbighshire (Figure 3.1; Table 6.2d). Surveys were carried out between 23/8/00 and 25/8/00. The total number of beach users interviewed was 660, using the '2000 Beach User Questionnaire' (Appendix V). The questionnaire was identical to the survey carried out on the southern shore of the Bristol Channel in 2000.

For specific methodologies relating to each question and questionnaire, see Appendix V.

Standard Occupational Classification (SOC, 2000)

Beach user occupations were classified according to the Standard Occupational Classification scheme (SOC, 2000), developed by the Government 'Occupational Information Unit' at the Office for National Statistics. This resource consists of two volumes: *Volume 1* describes the classification and lists the structure and gives descriptions of major groups. *Volume 2* is the coding index; an alphabetical list of over 26,000 job titles each one linked to group of both the 1990 and 2000 editions of the classification. The Standard Occupational Classification (SOC) consists of nine major groups (Table 6.1). To assist in the coding process, groups 10, 11, 12 and 13 were added as descriptions of those not employed, such as students, housewives, retired and the unemployed, were not included in the classification. The recently updated occupational classification structure (SOC, 2000) supersedes the previous five group classification (OPCS, 1991). The correct procedure for determining socio-economic groups is to firstly code the information given by beach users regarding their occupation by using the Standard Occupational Classification. This code can then be aligned with the appropriate category within the Socio-economic classification. Unfortunately, whilst .the new Standard Occupational Classification has been published, the new Socio-economic Classification is not due for release until mid-late 2001. It was therefore necessary to simply classify the respondents according to occupational classification, rather than specific socio-economic group. Nevertheless it was felt that such a classification still has validity when used for comparing responses between interviewees. Indeed, other researchers have used occupational grouping as a valid means of distinguishing groups, for example, Morgan *et al.*, (1993).

Table 6.1 Standard Occupational Classifications and Code Numbers (1-9) (SOC, 2000), with additions (10-13).

Code Number	Standard Occupational Classification Major Groupings
1	Managers and Senior Officials
2	Professional Occupations
3	Associate Professional and Technical Occupations
4	Administrative and Secretarial Occupations
5	Skilled Trades Occupations
6	Personal Service Occupations
7	Sales and Customer Service Occupations
8	Process, Plant and Machine Operatives
9	Elementary Occupations
10	Student *
11	Housewife *
12	Retired *
13	Unemployed *

* Groups added to standard classification

With respect to the actual questionnaires shown in Appendix V, the following points are pertinent. The process of placing interviewees into appropriate occupational classifications was limited by the information given at the contact point. The question regarding employment title was left open-ended so that the respondent could give as much detail as was needed. A selection of 'tick boxes' could have been used with a variety of choices, for example, student; housewife; retired; employed, but it was felt that this would not garner enough information. However, the open-ended question used brought other problems, in that some people gave either insufficient information or, it was felt, listed a job title that elevated or gave a false picture of their true occupational position. This is common to all such questionnaire research.

6.2.2 Results and Discussion

Questionnaire Response

The dates and number of questionnaires completed at each survey are given in Tables 6.2.a to 6.2.d. Dunraven Bay exemplifies the comment made earlier regarding weather conditions (section 6.2.1; Table 6.2.a). Four visits were made to this beach on different days and the total numbers interviewed came to only 22 people, due to inclement or overcast conditions.

Table 6.2.a. Location, date, and number of questionnaires completed at each survey – South Wales Coast (1998)

Beach	Rest Bay	Whitmore Bay	Dunraven Bay	Tenby North
Date	10/8/98	18/08/98	22/08/98	27/08/98
Questionnaires Completed	133	124	22	163
Beach	**Oxwich Bay**	**Langland Bay**	**Whitesands**	**Saundersfoot**
Date	28/08/98	28/08/98	01/09/98	03/09/98
Questionnaires Completed	181	73	84	103

Table 6.2.b. Location, date, and number of questionnaires completed at each survey – South Wales Coast (1999)

Beach	Ogmore-by-Sea	Sandy Bay	Port Eynon	Whitesands
Date	25/7/99	27/07/99	30/07/99	16/08/99
Questionnaires completed	112	105	127	104
Beach	**Whitmore Bay**	**Rest Bay**	**Newton**	
Date	20/08/99	21/08/99	23/08/99	
Questionnaires completed	136	76	103	

Table 6.2.c. Location, date, and number of questionnaires completed at each survey – South Shore of Bristol Channel (2000)

Beach	Berrow	Minehead	Weston-super-Mare
Date	22/7/00	21/7/00	20/7/00
Questionnaires completed	102	90	48
Beach	**Brean**	**Blue Anchor Bay**	**Ilfracombe**
Date	20/07/00	6/8/00	08/08/00
Questionnaires completed	32	55	94

Table 6.2.d. Location, date, and number of questionnaires completed at each survey – Mid/North Wales Coast (2000)

Beach	Aberdyfi	Towyn	Barmouth	Harlech
Date	23/08/00	23/08/00	23/08/00	24/08/00
Questionnaires completed	89	88	107	104
Beach	**Pwllheli**	**Llandudno**	**Rhyl**	
Date	24/08/00	25/08/00	25/08/00	
Questionnaires completed	97	95	80	

Age Distribution of Respondents

The predominant age group was 30 to 39 at all beaches (1998 survey), with Whitmore Bay having an equal number of 40-49 year olds (Table 6.3.a). *Tabulated figures in **bold** represent modal group numbers, all subsequent tables follow this procedure.* Where **'Blank'** is mentioned in a table this equates to **no answer given by respondent**. The 30-39 year old group made up approximately 32% of all respondents (n=284), with the 40-49 year old group representing around 23% (n=201) of the total (Table 6.3.a). Only approximately 10% of those interviewed were over 60 years of age (n=85). Other beach user age groupings were considered, such as <18, 18-24,25-35,35-45, 45-55, 55-65, 65+, but a decision was made to split into decade intervals for data analysis purposes. Kruskal-Wallis One Way Analysis of Variance on Ranks showed that the differences in the median values among the treatment groups were greater than would be expected by chance; there was a statistically significant difference (P = <0.05) in the age distribution between beaches. On examination of Table 6.3.a it would seem that age distribution at Whitmore Bay is unlike other beaches studied. There is a greater spread of age groups at this beach, the more 'family oriented' composition of respondents is confirmed to some degree by the large number of 'housewives' present (Table 6.6.a). Langland Bay and Whitesands display a narrower age range of respondents compared to other survey sites, both these beaches are well known for water sport activities and are therefore less appealing to the 'older' generations.

Table 6.3.a. Age distribution of respondents - decade intervals – South Wales Coast Survey (1998). Figures represent number of responses.

Age Category	Beach Studied: All Beaches	Rest Bay	Whitmore Bay	Dunraven Bay	Tenby North
Under 10	3 (<1%)	0	2	0	1
10 to 19	111 (13%)	25	19	5	21
20 to 29	114 (13%)	33	14	6	16
30 to 39	**284 (32%)**	**39**	**23**	6	**61**
40 to 49	201 (23%)	22	**23**	4	40
50 to 59	78 (9%)	5	18	0	15
60 to 69	55 (6%)	6	13	0	4
70 to 79	26 (3%)	0	9	0	3
80 +	4 (<1%)	0	2	0	1
BLANK	7 (<1%)	3	1	1	1
Total	883	133	124	22	163

Age Category	Beach Studied: Oxwich Bay	Langland Bay	Whitesands	Saundersfoot
Under 10	0	0	0	0
10 to 19	20	5	9	7
20 to 29	21	4	8	12
30 to 39	**55**	**27**	**35**	**38**
40 to 49	43	22	22	25
50 to 59	17	5	7	11
60 to 69	19	5	2	6
70 to 79	5	5	1	3
80 +	0	0	0	1
BLANK	1	0	0	0
Total	181	73	84	103

Table 6.3.b illustrates the age pattern of those interviewed during the 1999 survey. The predominant age group was 30 to 39 at all beaches, with Newton Beach having an almost equal number of 40-49 year olds. The 30-39 year old group made up approximately 36% of all respondents, with the 40-49 year old group representing around 22% of the total. The under 30 age groups made up almost 25% of the total. Only around 7% of those interviewed were over 60 years of age. Kruskal-Wallis One Way Analysis of Variance on Ranks showed that the differences in the median values among the treatment groups are greater than would be expected by chance; there was a statistically significant difference ($P = <0.05$) in the age distribution between beaches. Further analysis using Dunn's method of All

Pairwise Multiple Comparison Procedures illustrated that Whitmore Bay showed significant differences in age distribution between all other beaches except Whitesands and Rest Bay; this was possibly due to a larger proportion of respondents over 50 years of age at Whitmore Bay than many other beaches (Table 6.3.b). Also, the age distribution at Whitmore Bay displays a different pattern to those at other beaches, i.e. there are fewer young people at this beach.

Table 6.3.b. Age distribution of respondents - decade intervals – South Wales Coast Survey (1999). Figures represent number of responses.

Age category	**Beach Studied**			
	All Beaches	Ogmore-by-Sea	Sandy Bay	Port Eynon
Under 10	2 (<1%)	1	1	0
10 to 19	68 (9%)	10	18	7
20 to 29	118 (16%)	26	22	28
30 to 39	**275 (36%)**	**43**	**31**	**44**
40 to 49	171 (22%)	19	20	29
50 to 59	63 (8%)	6	9	11
60 to 69	43 (6%)	3	3	6
70 to 79	10 (1%)	1	0	0
80 +	3 (<1%)	0	0	0
BLANK	10 (1%)	3	1	2
Total	763	112	105	127
Age category	**Beach Studied**			
	Whitesands	Whitmore Bay	Rest Bay	Newton
Under 10	0	0	0	0
10 to 19	9	4	3	17
20 to 29	5	14	8	15
30 to 39	**49**	**49**	**35**	24
40 to 49	35	25	18	**25**
50 to 59	4	16	7	10
60 to 69	2	16	5	8
70 to 79	0	7	0	2
80 +	0	2	0	1
BLANK	0	3	0	1
Total	104	136	76	103

The 30 to 39 years age group was again the largest (n=127; 30%), with 22% (n=93) of respondents aged 40 to 49, an identical number were aged under 30, for studies conducted on the south shore of the Channel (Table 6.3.c). Analysis of Variance showed that the differences in the median values are not great enough to exclude the possibility that the difference is due to random sampling variability; there was not a statistically significant difference between beaches at the P=0.05 level.

Table 6.3.c. Age distribution of respondents - decade intervals – South Shore of the Bristol Channel (2000). Figures represent number of responses.

Age category	Beach Studied			
	All Beaches	Berrow	Minehead	Weston-super-Mare
Under 10	1 (<1%)	0	0	0
10 to 19	35 (8%)	4	7	5
20 to 29	57 (14%)	12	22	11
30 to 39	**127 (30%)**	**35**	**26**	**15**
40 to 49	93 (22%)	22	16	10
50 to 59	62 (15%)	21	9	4
60 to 69	31 (7%)	4	10	3
70 to 79	13 (3%)	3	0	0
80 +	2 (<1%)	1	0	0
BLANK	0	0	0	0
Total	421	102	90	48
Age category	**Beach Studied**			
	Brean	Blue Anchor Bay	Ilfracombe	
Under 10	0	1	0	
10 to 19	0	7	12	
20 to 29	4	2	6	
30 to 39	**10**	14	**27**	
40 to 49	8	**18**	19	
50 to 59	7	6	15	
60 to 69	3	5	6	
70 to 79	0	2	8	
80 +	0	0	1	
BLANK	0	0	0	
Total	32	55	94	

Age distribution of interviewees questioned at beaches in mid and north Wales is displayed in Table 6.3.d. As was recorded at all other.surveys respondents aged 30 to 39 constituted the largest group (n=216; 33%), with 40 to 49 year olds composing the next largest (n=136; 21%). Approximately 21% were under 30, and 14% were 60 plus. At Llandudno 33% of interviewees were over the age of 60, the largest amount of this group at any of the beaches studied which reflected the type of tourist resort. These differences in age distribution was confirmed via statistical analysis: Kruskal-Wallis Analysis of Variance showed differences in the median values of sample populations to be greater than would be expected by chance, indicating they were statistically significantly different at the P=0.05 level. Dunn's method of pairwise multiple comparison confirmed that Llandudno differed from other beaches, and was responsible for the large variation in data distribution. Llandudno had greater proportions of respondents over 60 years of age than other beaches (Table 6.3.d), this is confirmed in Table 6.6.g which illustrates the larger proportion of 'retired' interviewees at this site.

Table 6.3.d. Age distribution of respondents – decade intervals- Mid/North Wales Coast (2000). Figures represent number of responses.

Age category	**Beach Studied**			
	All Beaches	Aberdyfi	Towyn	Barmouth
Under 10	0 (0%)	0	0	0
10 to 19	63 (10%)	5	6	19
20 to 29	77 (11%)	8	12	12
30 to 39	**216 (33%)**	**33**	**28**	**40**
40 to 49	136 (21%)	15	19	22
50 to 59	63 (10%)	11	7	9
60 to 69	69 (10%)	14	9	0
70 to 79	19 (3%)	2	4	2
80 +	7 (1%)	1	2	0
BLANK	10 (1%)	0	1	3
Total	660	89	88	107
Age category	**Beach Studied**			
	Harlech	Pwllheli	Llandudno	Rhyl
Under 10	0	0	0	0
10 to 19	12	9	2	10
20 to 29	5	14	8	18
30 to 39	**38**	**26**	**27**	**24**
40 to 49	25	**26**	15	14
50 to 59	13	10	9	4
60 to 69	8	10	21	7
70 to 79	1	2	6	2
80 +	0	0	4	0
BLANK	2	0	3	1
Total	104	97	95	80

Gender Distribution of Respondents

Table 6.4 indicated that approximately two thirds of all respondents were female (n=1747; 64%), and the pattern is almost identical when each beach is looked at independently (Tables 6.5.a to 6.5.d). This perhaps highlights the number of mothers with children on the beach during the school holiday period. These figures concur with other research of a similar nature (Nelson, 1998).

Table 6.4 Gender Pattern For *All* Beach Questionnaire Surveys (1998-2000).

Sex	Total of *All* Surveys (1998-2000)	% of Respondents
Male	959	35
Female	1747	64
BLANK	21	<1
TOTAL	2727	100

Table 6.5.a Gender Pattern – South Wales Coast Survey (1998). Figures represent number of responses. Figures represent number of responses.

Sex	Beach Studied				
	All Beaches	Rest Bay	Whitmore Bay	Dunraven Bay	Tenby North
Male	313	53	34	9	63
Female	**567**	**79**	**90**	**13**	**98**
BLANK	3	1	0	0	2
Total	883	133	124	22	163
Sex	**Beach Studied**				
	Oxwich Bay	Langland Bay	Whitesands	Saundersfoot	
Male	53	23	36	42	
Female	**128**	**50**	**48**	**61**	
BLANK	0	0	0	0	
Total	181	73	84	103	

Table 6.5.b Gender Pattern – South Wales Coast Survey (1999). Figures represent number of responses.

Sex	Beach Studied			
	All Beaches	Ogmore-by-Sea	Sandy Bay	Port Eynon
Male	243	37	31	46
Female	**509**	**74**	**71**	**79**
BLANK	11	1	3	2
Total	763	112	105	127
Sex	**Beach Studied**			
	Whitesands	Whitmore Bay	Rest Bay	Newton
Male	33	36	27	33
Female	**71**	**99**	**47**	**68**
BLANK	0	1	2	2
Total	104	136	76	103

Table 6.5.c Gender Pattern – South Shore of Bristol Channel Survey (2000). Figures represent number of responses.

Sex	Beach Studied			
	All Beaches	Berrow	Minehead	Weston-super-Mare
Male	163	43	34	11
Female	**257**	**59**	**55**	**37**
BLANK	1	0	1	0
Total	421	102	90	48
Sex	**Beach Studied**			
	Brean	Blue Anchor Bay	Ilfracombe	
Male	14	25	36	
Female	**18**	**30**	**58**	
BLANK	0	0	0	
Total	32	55	94	

Table 6.5.d Gender Pattern – Mid/North Wales Coast Survey (2000). Figures represent number of responses.

Sex	Beach Studied			
	All Beaches	Aberdyfi	Towyn	Barmouth
Male	240	37	30	42
Female	**414**	**52**	**58**	**64**
BLANK	6	0	0	1
Total	660	89	88	107
Sex	**Beach Studied**			
	Harlech	Pwllheli	Llandudno	Rhyl
Male	46	34	25	26
Female	**56**	**62**	**68**	**54**
BLANK	2	1	2	0
Total	104	97	95	80

Socio-economic / Occupational Classifications

The majority of those participating in the 1998 beach user questionnaire study were employed, but the largest *class* group was the housewife classification (n=132; Table 6.6.a). The pattern was not consistent across all beaches where significant numbers of people in SOC classification groups 2, 3 and 4 were present (Table 6.6a). Analysis of Variance showed differences in the median values of sample populations to be greater than would be expected by chance, indicating they were statistically significantly different at the P=0.05 level. Dunn's method showed that there were significant statistical differences between Whitmore Bay, and Whitesands and Tenby North. The modal socio-economic group at Whitmore Bay was SOC Class 11 (housewife), this contrasts with both Tenby North and Whitesands which had large numbers of respondents from SOC Class groups 2 and

3 (Table 6.6.a). The SOC class groups are named in Table 6.1. The percentage breakdown of the broader categories is illustrated in Table 6.6.b, where again it can seen that employed people made up the majority of beach users (58%). The pattern is broadly similar across all beaches (Tables 6.6c to 6.6h).

Table 6.6a. Socio-economic status – South Wales Coast (1998). Figures represent number of responses. Key-SOC Class groups:Table 6.1.

Standard Occupational Classification –Class Group	**Beach Studied**				
	All Beaches	Rest Bay	Whitmore Bay	Dunraven Bay	Tenby North
1	44	4	3	2	11
2	114	12	7	**5**	26
3	125	22	13	2	**28**
4	95	17	4	3	17
5	47	7	7	0	8
6	18	3	4	0	1
7	24	4	6	2	3
8	17	1	3	0	4
9	27	5	8	1	4
10	107	**29**	19	3	19
11	**132**	14	**26**	2	21
12	76	8	14	0	8
13	4	2	1	0	1
BLANK	53	5	9	2	12
Total	883	133	124	22	163
Standard Occupational Classification – Class Group	**Beach Studied**				
	Oxwich Bay	Langland Bay	Whitesands	Saundersfoot	
1	12	2	4	6	
2	30	13	**14**	7	
3	18	10	**14**	**18**	
4	21	**14**	8	11	
5	7	4	8	6	
6	3	1	2	4	
7	2	1	2	4	
8	3	0	2	4	
9	5	0	0	4	
10	18	4	9	6	
11	**35**	**14**	7	13	
12	17	8	7	14	
13	0	0	0	0	
BLANK	10	2	7	6	
Total	181	73	84	103	

Table 6.6.b. Employment status broad (collapsed) category groupings - All beaches totalled – South Wales Coast Survey 1998.

Socio-economic status	Frequency	Percentage
Employed	**511**	**58**
Housewife	132	15
Student	107	12
Retired	76	9
BLANK	53	6
Unemployed	4	<1
TOTAL	883	100

Kruskal-Wallis One Way Analysis of Variance on Ranks showed that the differences in the median values among the treatment groups were greater than would be expected by chance; there was a statistically significant difference ($P = <0.05$) between responses for socio-economic status obtained during the 1999 survey (Table 6.6.c). Dunn's method confirmed differences in socio-economic distributions between Whitmore Bay and all other sites, and between Newton and all other beach sites. Both of these beaches had modal groups in the 'housewife' category, with Whitmore Bay displaying higher numbers of retired people than any other beach in the 1999 survey. Newton beach had large numbers of students and employed respondents in class group 8 ('Process, Plant and Machine Operatives'; Table 6.6.c).

Table 6.6.c Socio-economic status – South Wales Coast Survey (1999). Figures represent number of responses. Key to SOC Class groups: see Table 6.1.

Standard Occupational Classification – Class Group	Beach Studied							
	All Beaches	Ogmore-by-Sea	Sandy Bay	Port Eynon	Whitesands	Whitmore Bay	Rest Bay	Newton
1	44	8	3	9	5	5	10	3
2	**110**	**19**	11	**21**	**28**	14	9	8
3	96	17	7	20	15	16	**12**	8
4	61	11	10	10	11	7	8	4
5	41	4	10	7	1	2	6	4
6	33	5	2	8	8	9	4	4
7	36	6	3	8	5	8	1	6
8	24	4	4	2	1	2	1	10
9	16	6	1	3	1	5	0	0
10	58	6	14	9	11	3	3	12
11	106	7	**21**	5	10	**30**	8	**26**
12	58	6	5	10	2	22	6	7
13	9	2	2	2	0	0	0	3
BLANK	71	11	12	13	6	13	8	8
Total	763	112	105	127	104	136	76	103

Table 6.6.d. Employment status broad (collapsed) category groupings - All beaches totalled – South Wales Coast Survey (1999)

Socio-economic status	Frequency	Percentage
Employed	**461**	**60**
Housewife	106	14
Student	58	8
Retired	58	8
BLANK	71	9
Unemployed	9	1
TOTAL	763	100

Using Kruskal-Wallis One Way Analysis of Variance on Ranks determined that differences in the median values among the treatment groups were not great enough to exclude the possibility that the differences were due to random sampling variability; there was not a statistically significant difference (P = 0.411) in socio-economic groups (Table 6.6.e) amongst beaches of the south shore of the Bristol Channel.

Table 6.6.e. Socio-economic status - South Shore of Bristol Channel Survey (2000). Figures represent number of responses. Key to SOC Class groups: see Table 6.1.

Standard Occupational Classification - Class Group	Beach Studied						
	All Beaches	Berrow	Minehead	Weston-super-Mare	Brean	Blue Anchor Bay	Ilfracombe
1	24	5	6	2	3	3	5
2	39	8	7	4	5	6	9
3	61	9	**17**	8	3	**13**	11
4	38	11	10	4	2	4	7
5	24	8	4	3	2	2	5
6	5	1	1	2	0	1	0
7	33	14	6	4	2	0	7
8	16	4	0	1	3	6	2
9	15	4	5	1	0	1	4
10	32	1	10	2	0	8	11
11	**69**	**18**	12	**11**	**6**	3	**18**
12	33	8	4	3	4	5	9
13	5	2	0	0	0	1	2
BLANK	27	9	8	3	2	2	3
Total	421	102	90	48	32	55	94

Table 6.6.f. Employment status broad (collapsed) category groupings - All beaches totalled – South Shore of Bristol Channel Survey (2000)

Socio-economic status	Frequency	Percentage
Employed	**255**	**61**
Housewife	69	16
Student	32	8
Retired	33	8
BLANK	27	6
Unemployed	5	1
TOTAL	421	100

Kruskal-Wallis One Way Analysis of Variance on Ranks showed that the differences in the median values among the treatment groups were greater than would be expected by chance; there was a statistically significant difference ($P = <0.05$) between responses for socio-economic status obtained during the mid/north Wales coast survey. Dunn's method confirmed differences in socio-economic distributions between Llandudno and all other beach sites, this is due to the large numbers of retired people frequenting this beach (Table 6.6.g).

Table 6.6.g Socio-economic status – Mid/North Wales Coast Survey (2000). Figures represent number of responses. Key to SOC Class groups: see Table 6.1.

Standard Occupational Classification - Class Group	Beach Studied							
	All Beaches	Aberdyfi	Towyn	Barmouth	Harlech	Pwllheli	Llandudno	Rhyl
1	38	8	6	7	1	8	6	2
2	63	13	5	9	**21**	5	7	3
3	76	12	5	**18**	14	13	7	7
4	55	8	7	7	5	11	9	8
5	47	2	10	7	10	7	4	7
6	10	0	6	2	1	1	0	0
7	39	7	6	4	6	8	5	3
8	18	5	3	3	3	0	1	3
9	21	1	4	3	3	4	2	4
10	66	6	5	**18**	15	7	5	10
11	**93**	6	**14**	16	7	**17**	14	**19**
12	84	**17**	10	3	12	10	**28**	4
13	5	0	1	0	0	1	0	3
BLANK	45	4	6	10	6	5	7	7
Total	660	89	88	107	104	97	95	80

Table 6.6.h Employment status broad (collapsed) category groupings - All beaches totalled – Mid/North Wales Coast Survey (2000)

Socio-economic status	Frequency	Percentage
Employed	**367**	**56**
Housewife	93	14
Student	66	10
Retired	84	13
BLANK	45	7
Unemployed	5	<1
TOTAL	660	100

Geographical Origins

Table 6.7.a gives an insight into the geographical origins of the beach users, again figures in bold refer to largest groupings. The beaches furthest east in this study (1998), i.e. Rest Bay and Whitmore Bay, were made up of mainly locals and

day trippers travelling over 10 miles to the beach. Beaches to the west of Swansea (Figure 3.1), were predominantly composed of holiday makers from further afield (i.e. not staying in their own homes). Langland Bay was the exception, with the beach made up of people in almost equal proportions from local areas, day trippers from > 10 miles away and holiday makers. Overall, 51% of those interviewed were on holiday (n=452), 33% were just visiting for the day (n=292), and 15% were locals (n=136; Table 6.7.a).

Table 6.7.a. Geographical origin of interviewees – South Wales Coast Survey (1998). Figures represent number of responses.

Origin of beach user	Beach Studied								
	All Beaches	Rest Bay	Whitmore Bay	Dunraven Bay	Tenby North	Oxwich Bay	Langland Bay	Whitesands	Saundersfoot
Holiday	**452**	10	11	2	**126**	**109**	20	**75**	**99**
Just for Day – Travel >10 m	292	**80**	**94**	5	30	53	26	0	4
Live Locally	136	43	18	**14**	7	19	**27**	8	0
BLANK	3	0	1	1	0	0	0	1	0
Total	883	133	124	22	163	181	73	84	103

The geographical origin of people on the beach is illustrated in Table 6.7.b (South Wales Coast Survey - 1999). There is an east / west divide in the origin of visitors, predominantly the beaches to the west (Tenby, Whitesands) are composed of holiday makers, whereas those in the east of Wales are made up of many day trippers. The exception is Newton beach, Porthcawl, which is situated at one of the entrances to Trecco Bay caravan park. This point is confirmed by the number of people on Newton beach who were staying in a caravan (Table 6.8.b). Overall 37% were on holiday (n=282), 47% were day trippers (n=362), and 14% lived locally (n=109; Table 6.7.b).

Table 6.7.b. Geographical origin of interviewees – South Wales Coast Survey (1999). Figures represent number of responses.

Origin of beach user	Beach Studied							
	All Beaches	Ogmore-by-Sea	Sandy Bay	Port Eynon	Whitesands	Whitmore Bay	Rest Bay	Newton
Holiday	282	7	12	**60**	**102**	28	13	**60**
Just for Day – Travel >10 m	**362**	**83**	**73**	50	0	**81**	**47**	28
Live Locally	109	21	18	16	2	26	13	13
BLANK	10	1	2	1	0	1	1	2
Total	763	112	105	127	104	136	76	103

The majority of beach users on the south shore of Bristol Channel were on holiday, the one exception was Weston-super-Mare where surprisingly the modal group lived locally (Table 6.7.c).

Table 6.7.c. Geographical origin of interviewees – South Shore of Bristol Channel Survey (2000). Figures represent number of responses.

Origin of beach user	Beach Studied						
	All beaches	Berrow	Minehead	Weston-super-Mare	Brean	Blue Anchor Bay	Ilfracombe
Holiday	**234**	**50**	**66**	10	**17**	**23**	**68**
Just for Day - Travelled >10m	114	34	12	17	15	18	18
Live Locally	72	18	11	**21**	0	14	8
BLANK	1	0	1	0	0	0	0
Total	421	102	90	48	32	55	94

The majority of interviewees questioned for the mid/north Wales coast survey were on holiday (n=402, 61%; Table 6.7.d), with almost all beaches having the majority of respondents coming from this group (Table 6.7.d). This illustrates the different resorts and beach usage along this stretch of coast compared to the south east Wales coastline, where many of the beach users were day trippers (Table 6.7.b). Around 30% of those interviewed were visiting the beach for the day (n=178), with approximately 12% being locals (n=76; Table 6.7.d).

Table 6.7.d. Geographical origin of interviewees – Mid/North Wales Coast Survey (2000). Figures represent number of responses.

Origin of beach user	Beach Studied							
	All Beaches	Aberdyfi	Towyn	Barmouth	Harlech	Pwllheli	Llandudno	Rhyl
Holiday	**402**	**61**	**59**	38	**70**	**51**	**60**	38
Just for Day – Travelled >10 m	178	21	14	46	13	5	20	40
Live Locally	76	5	14	5	6	32	9	2
BLANK	4	2	1	0	0	1	0	0
Total	660	89	88	107	104	97	95	80

Type of Accommodation Used

Table 6.8.a contains large numbers in the 'Blank' row, which is a result of non holiday makers not needing to fill out this question. The largest parameters

selected were self catering (n=161), and caravan accommodation (n=134), reflecting the nature of tourist resorts chosen (Table 6.8.a). Of those on holiday, only around 10% were staying at hotels or bed and breakfast establishments with the highest numbers being recorded at Tenby North, Oxwich Bay and Langland Bay.

Table 6.8.a. Accommodation used – South Wales Coast Survey (1998). Figures represent number of responses.

Accommodation Utilised	Beach Studied				
	All Beaches	Rest Bay	Whitmore Bay	Dunraven Bay	Tenby North
Hotel/B&B	47	1	0	0	11
Camping	45	0	0	0	13
Caravan	134	4	1	0	37
Self catering	**161**	0	1	0	**52**
Friends/Relatives	89	**11**	**19**	**2**	14
BLANK	407	117	103	20	36
Total	883	133	124	22	163
Accommodation Utilised	**Beach Studied**				
	Oxwich Bay	Langland Bay	Whitesands	Saundersfoot	
Hotel/B&B	17	7	5	6	
Camping	13	0	13	6	
Caravan	**29**	**6**	24	33	
Self catering	26	3	**27**	**52**	
Friends/Relatives	28	**6**	6	3	
BLANK	68	51	9	3	
Total	181	73	84	103	

The high numbers of beach users at Newton staying in caravans is a function of its proximity to 'Trecco Bay' caravan park, a large, well established landmark on this stretch of south Wales coast (Table 6.8.b).

Table 6.8.b Accommodation used – South Wales Coast Survey (1999). Figures represent number of responses.

Accommodation Utilised	Beach Studied							
	All Beaches	Ogmore-by-Sea	Sandy Bay	Port Eynon	Whitesands	Whitmore Bay	Rest Bay	Newton
Hotel	10	0	1	0	4	5	0	0
B & B	4	0	0	2	2	0	0	0
Camping	47	1	1	22	17	0	1	5
Caravan	**119**	0	4	**28**	28	9	4	**46**
Self catering	59	**4**	0	8	**42**	4	0	1
Friends/Relatives	61	**4**	**10**	5	8	**14**	**8**	12
Youth Hostel	3	0	0	1	1	0	1	0
BLANK	460	103	89	61	2	104	62	39
Total	763	112	105	127	104	136	76	103

A number of the beaches along the south shore of Bristol Channel are surrounded by caravan parks (e.g. Berrow, Brean, Blue Anchor Bay), which explains this accommodation type receiving the greatest response (Table 6.8.c).

Table 6.8.c Accommodation used – South Shore of Bristol Channel Coast Survey (2000). Figures represent number of responses.

Accommodation Utilised	Beach Studied						
	All Beaches	Berrow	Minehead	Weston-super-Mare	Brean	Blue Anchor Bay	Ilfracombe
Hotel	36	0	**15**	0	0	2	19
B & B	18	0	7	0	1	4	6
Caravan	**97**	**38**	11	**4**	**17**	4	**23**
Camping	24	6	5	0	0	2	11
Self catering	47	8	17	3	0	**9**	10
Friends/Relatives	27	2	11	3	1	6	4
Youth Hostel	1	0	0	0	0	0	1
BLANK	171	48	24	38	13	28	20
Total	421	102	90	48	32	55	94

Accommodation usage at resorts along the mid/north Wales coast was in keeping with surveys at other locations (Table 6.8.d). The largest group of those on holiday stayed in caravans, except for beach users at Harlech and Llandudno.

Table 6.8.d Accommodation used – Mid/North Wales Coast Survey (2000). Figures represent number of responses.

Accommodation Utilised	Beach Studied							
	All Beaches	Aberdyfi	Towyn	Barmouth	Harlech	Pwllheli	Llandudno	Rhyl
Hotel	48	5	1	3	1	0	**35**	3
B & B	45	11	1	5	8	0	17	3
Caravan	**149**	**27**	**41**	**11**	17	**29**	8	**16**
Camping	36	3	1	7	8	7	2	8
Self catering	85	19	7	7	**26**	18	3	5
Friends/Relatives	33	5	8	4	4	5	4	3
Youth Hostel	3	0	0	0	3	0	0	0
BLANK	261	18	29	70	37	38	26	42
Total	660	88	88	107	104	97	95	80

Ranking of offensive forms of pollution

Table 6.9.a depicts public opinion of the most offensive forms of pollution. Respondents were required to place in order what they considered to be the most offensive forms of beach / sea pollution from eight pre-defined criteria. The categories used (Tables 6.9.a and 6.9.b) were broader and less specific than the photographs used later in the questionnaire, but give an insight into what were considered by beach users to be the offensive *types* of pollution, without concentrating on specific items of debris. At every SRD was rated as the most

offensive pollution type (Table 6.9.a). This result is perhaps not surprising when one considers the stigma and association of the word 'sewage'. The ranking of this type of pollution is in line with other studies of a similar vein (e.g. House, 1996). A consistent view was experienced with the second ranked parameter, 'oil on the beach', which was placed second by respondents at all beaches. The *Sea Empress* oil spill occurred in 1996, only two years previous to the questionnaire survey, and had affected many of the westerly beaches covered in the present study. Whether this was a factor in influencing respondents is unclear. In light of this, the need to replicate this question over a number of years was considered to be important. It is necessary to establish that responses to pollution are not just of temporary concern, and not the reaction to an event preceding the interview (David, 1971).

'Oil in the sea' was ranked third in seven out of eight beaches, only Rest Bay respondents placing 'floating debris' above this factor (Table 6.9.a). The distinction between 'oil on the beach', and 'oil in the sea', was made as a result of the presumption that some beach users rarely entered the sea and may therefore be unconcerned by oil if it was only in the water. Obviously most oil in the sea will make its way ashore eventually. Beyond these top three rankings the picture becomes a little unclear as to which parameter is more offensive than another (Table 6.9.a).

'Foam/scum' and 'floating debris' parameters were generally ranked fourth and fifth (Table 6.9.a). These two pollution forms were intentionally left vague in their descriptions, the public being left to make their own assumptions. Foam / scum is very often of a natural composition; marine algae can easily be mistaken for sewage. A common non-toxic alga called *Phaeocystis*, found in British coastal waters, forms clouds of 'frog spawn' like colonies, sometimes mistaken for oil drops in the water. It can grow rapidly, or 'bloom', in early summer. When this bloom subsequently breaks down as the algae die, creamy-brown coloured foam can be formed. This foam may appear as a thin layer or, under rougher conditions, form slicks 1 to 2 metres deep. Although non-toxic this can look, and occasionally smell, very unpleasant, and can be mistaken for sewage. David (1971), found that foam and algae were often cited as indicators of water pollution by the public. Also, Alginates (extracts from seaweed), can occur naturally and stabilise the foam produced by waves on cliffs and rocky headlands. There are also certain rare toxic marine algae that can cause discoloration of the water known as 'red tides'. Crude sewage discharges rarely form foams or scums on the water surface. However, washing powders and detergents can cause localised foaming around discharge pipes. Sewage slicks tend to cause a brown or grey discoloration of the water (EA/SAS, 1999).

Any floating debris will almost certainly be representative of what can be found on the beach. Floating debris may be a more emotive subject than the same litter items found on the beach as people do not like to collide with items when they are swimming in the sea. Debris in the sea is often difficult to notice and evade, at least on land it can be seen from a distance and avoided. 'Floating debris', whilst not defined for the purposes of the questionnaire, can include faeces, SRD, litter, driftwood, seaweed, etc., all of which can be found on an undisturbed beach. It is possibly due to the fact that most beaches covered in this study were cleaned in the summer time, and therefore relatively free of litter, that interviewees classed beach litter so low and floating debris higher up the ranking order. Research conducted by Nicolson and Mace (1975) found that 17% of respondents placed 'floating debris' as the most important indicator of water pollution. These results are in close agreement with those of David, (1971), who reported a 20% response. Kruskal-Wallis One Way Analysis of Variance on Ranks was utilised and showed differences in the median values among the beaches were not statistically different for all categories at $P = 0.05$ level, except for 'floating debris'. The 'floating debris' parameter varied in rank position between 3rd at Rest Bay, and 6th at Dunraven Bay. Reasons for this difference are unclear.

'Unusual smell' was ranked relatively low on the list by respondents, perhaps due to the lack of any industry surrounding the beaches chosen for study. This is in contrast to studies by Ditton and Goodale (1974), where smell was an important parameter. However, their research was conducted in an industrialised area. Personal sensitivities to smell differ greatly, for this reason evaluating offensiveness of odours is difficult (Nicolson and Mace, 1975). The highest ranking attained by the 'unusual smell' parameter was at Dunraven Bay, near Bridgend (Table 6.9.a).

Two factors consistently occupied the bottom rankings, namely 'beach litter' and 'discoloured water' (Table 6.9.a). These were surprising on both fronts. Beach litter is the most immediate and common form of visual pollution experienced on beaches, this parameter (along with SRD) is experienced by all beach users, whereas some of the others would only be noticed if they entered, or at least closely inspected, the sea. It is perhaps the perceived lower health risk posed by this pollutant in comparison to well known risks from SRD and oil that results in its low ranking. Items of SRD are in most circumstances considered as an integral part of marine or beach litter, and the term 'beach litter' encompasses SRD as well as domestic and industrial physical wastes. However, for this study 'beach litter' and SRD were disassociated to enable more detail to be gained from the interviewees. Table 6.9.a shows that Whitmore Bay is unusual in that 'beach litter' was ranked higher than at any other beach (fourth), and 'foam/scum' and 'unusual smell' were ranked lower than at any of the other beaches. Perhaps the relatively high position of 'beach litter' is due to the shear number of people visiting this beach who generate huge amounts of litter, which was clearly visible in the afternoon when these survey took place.

'Discoloured water' was ranked as the least offensive form of pollution by beach users at the majority of sites, which is again perhaps unexpected as water in the Bristol Channel, especially at its eastern end near the Severn Estuary, is particularly turbid in appearance (Table 6.9.a). Beach users at the most easterly beaches (Whitmore Bay, Dunraven Bay, Rest Bay) were those that ranked this parameter higher than those frequenting the beaches of the Gower and Pembrokeshire to the west. 'Murky, dark water' was a significant response from interviewees when asked to cite the most important indicators of water pollution in studies carried out by David (1971) and Nicolson and Mace (1975). These studies though were carried out near lake and river systems where water clarity may be perceived as a more desirable attribute. Much research in this area has tended to consider just one aspect of environmental quality. However, the present study attempted to combine both terrestrial and marine pollution types in order to ascertain a broader more holistic view of the beach / coastal environment. Whether the two should be kept separate will be dependant on the aims of a study, in this case it was felt that the two could not realistically be separated. The presence of litter on a beach has been found to influence perceptions of water quality and this may be reciprocal. Discoloured water was used as a term rather than turbid water as it was thought it would be more widely understood.

Table 6.9.a Offensive forms of pollution – South Wales Coast Survey (1998). Rank 1 is most offensive, rank 8 least offensive. n=827

Rank	Beach Studied								
	All Beaches	Rest Bay	Whitmore Bay	Dunraven Bay	Tenby North	Oxwich Bay	Langland Bay	Whitesands	Saundersfoot
1	SRD	SRD	SRD	SRD	SRD	SRD	SRD	SRD	SRD
2	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)
3	Oil (in the sea)	Floating Debris	Oil (in the sea)	Oil (in the sea)	Oil (in the sea)	Oil (in the sea)	Oil (in the sea)	Oil (in the sea)	Oil (in the sea)
4	Floating Debris	Oil (in the sea)	Beach Litter	Foam/Scu m	Foam/Scum	Foam/Scum	Floating Debris	Floating Debris	Foam/Scum
5	Foam/Scu m	Foam/Scum	Floating Debris	Unusual Smell	Floating Debris	Floating Debris	Foam/Scum	Foam/Scum	Floating Debris
6	Unusual Smell	Unusual Smell	Discoloured Water	Floating Debris	Unusual Smell	Unusual Smell	Beach Litter	Unusual Smell	Unusual Smell
7	Beach Litter	Discoloured Water	Foam/Scum	Discoloure d Water	Beach Litter	Beach Litter	Unusual Smell	Beach Litter	Beach Litter
8	Discoloure d Water	Beach Litter	Unusual Smell	Beach Litter	Discoloured Water	Discoloured Water	Discoloured Water	Discoloured Water	Discoloured Water

Tables 6.9.b and 6.9.c summarise the findings from Table 6.9.a. Averaged rank position of each pollution type (Table 6.9.b), and the proportion of respondents who gave a particular rank are shown (Table 6.9.c). SRD is clearly ranked in first position as the most offensive form of pollution, with oil in second and third places. It can be seen that the average position for all pollution forms, bar the first three and final parameter, are closely grouped around fifth position, indicating therefore very little difference in offensiveness levels (Table 6.9.b). This was confirmed in Table 6.9.c.

Table 6.9.b Average rank position achieved by each pollution category for all beaches - South Wales Coast Survey - 1998. n=827. Rank 1 is most offensive, rank 8 least offensive

Pollution Form	Average Rank Position
Sewage Related Debris	1.7
Oil (on the beach)	3.5
Oil (in the sea)	4.0
Floating Debris	4.9
Foam/Scum	5.0
Unusual Smell	5.3
Beach Litter	5.4
Discoloured Water	5.8

Table 6.9.c highlights the rank proportion attained by each category for the whole sample. This table clearly reinforces the point that 'SRD' was the primary objectionable pollution form on beaches studied, over 76% of interviewees ranked it first. The three middle categories ('Unusual Smell'; 'Foam/Scum'; 'Floating Debris') are again shown to have no firm position in the ranking order. 'Unusual Smell' had the lowest percentage of respondents ranking it as the most offensive form of coastal pollution. 'Discoloured Water' was ranked in seventh and eighth position by more beach users than any other parameter.

Table 6.9.c Proportion of respondents ranking of each parameter (%) - South Wales Coast Survey - 1998. Bold figures relate to largest grouping. Rank 1 is most offensive, rank 8 least offensive. n=827

Rank	Pollution Parameter							
	Discoloured Water %	SRD %	Beach Litter %	Unusual Smell %	Foam /Scum %	Floating Debris %	Oil (on beach) %	Oil (in the sea) %
1	3.3	**76.3**	2.8	1.6	3.1	2.4	9.2	7.5
2	7.0	5.8	9.6	8.7	10.3	11.2	**31.9**	16.3
3	5.2	7.5	10.0	8.8	10.4	11.0	20.2	**27.0**
4	9.7	3.1	10.3	14.9	**19.2**	15.8	12.3	13.9
5	13.4	2.5	13.1	16.7	15.6	**19.0**	8.5	10.4
6	15.5	0.8	16.0	18.3	15.4	17.2	7.4	8.6
7	**23.0**	3.0	**20.4**	12.6	14.3	11.6	7.5	7.3
8	**23.0**	0.8	17.9	**18.5**	11.7	11.7	3.0	9.0

An almost identical result was obtained from further studies at south Wales beaches (carried out in 1999; Table 6.10.a). As was found at other south Wales beaches in 1998, SRD, and oil pollution occupied the three top rankings (i.e. were most offensive), with other forms of beach litter and discoloured water featuring in the final two positions. It is interesting to note that 'unusual smell' ranked at fourth position at beaches in the Bridgend / Porthcawl area. There is a sewage treatment plant only half a mile from Ogmore - by -Sea, and around two miles from Newton beach. Around the headland from Newton lies Sandy Bay. This treatment plant, like most sewage treatment plants, is known to have a history of odour pollution problems. It would appear that either the knowledge of the existence of this plant, or an actual offensive smell, affected the ranking of this pollution parameter at these three beaches. The other four beaches all ranked this type of pollution in sixth place. There did not appear to be any offensive smell at the time these studies were conducted, but there certainly would appear to be a link between unusual smell and these three beaches near the sewage treatment plant. As Nicolson and Mace (1975, page 1200) stated, 'odour presence was a difficult concept to grasp'. One anomaly that should be noted is the low ranking attached to 'oil in the sea' at Ogmore-by-Sea. It was placed at sixth position, whereas at all other beaches where questionnaire surveys were conducted interviewees placed this type of pollution at second or third. The reason for its position at Ogmore-by-Sea is not clear. One Way Analysis of Variance on Ranks showed differences in the median values among the beaches were not statistically different for all categories at P = 0.05 level, except for the 'oil in the sea' parameter.

Table 6.10.a. Offensive forms of pollution to beach users – South Wales Coast Survey 1999 Rank 1 is most offensive, rank 8 least offensive. n=589

Rank	Beach Studied							
	All Beaches	Ogmore-by-Sea	Sandy Bay	Port Eynon	Whitesands	Whitmore Bay	Rest Bay	Newton
1	SRD	SRD	SRD	SRD	SRD	SRD	SRD	SRD
2	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)	Oil (in the sea)	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)
3	Oil (in the sea)	Foam/Scum	Oil (in the sea)	Oil (in the sea)	Oil (on the beach)	Oil (in the sea)	Oil (in the sea)	Oil (in the sea)
4	Foam/Scum	Unusual Smell	Unusual Smell	Floating Debris	Foam/Scum	Foam/Scum	Floating Debris	Unusual Smell
5	Floating Debris	Floating Debris	Foam/Scum	Foam/Scum	Floating Debris	Floating Debris	Foam/Scum	Foam/Scum
6	Unusual Smell	Oil (in the sea)	Floating Debris	Unusual Smell	Unusual Smell	Unusual Smell	Unusual Smell	Floating Debris
7	Beach Litter	Beach Litter	Beach Litter	Discoloured Water	Discoloured Water	Beach Litter	Discoloured Water	Beach Litter
8	Discoloured Water	Discoloured Water	Discoloured Water	Beach Litter	Beach Litter	Discoloured Water	Beach Litter	Discoloured Water

The average rank given to each pollution parameter was determined to ascertain if there was any strong indication of level of offensiveness attached to each parameter by the public (Table 6.10.b). SRD is clearly confirmed as the top ranked item on an offensiveness scale, but the picture is less well defined further down the list. Many items are grouped closely together, particularly those around fifth position (Foam/Scum, Floating debris, Unusual smell), indicating that the views of where these items belong in a ranking scenario is not altogether fixed or robust. With the exception of SRD, and perhaps oil, there appears to be little difference in the level of offensiveness of the other pollution types.

Table 6.10.b. Averaged Rank of most offensive form of pollution – South Wales Coast Survey 1999. Rank 1 is most offensive, rank 8 least offensive. n=589

Pollution Form	Average Rank Position
Sewage Related Debris	1.6
Oil (on the beach)	3.8
Oil (in the sea)	4.2
Foam/Scum	4.8
Floating Debris	4.9
Unusual Smell	5.1
Beach Litter	5.8
Discoloured Water	6.0

Results from beaches studied on the south Wales coast (Tables 6.9.a to 6.10.b) were consistent with those found on beaches of the south shore of the Bristol Channel and mid/north Wales coast (Tables 6.11.a to 6.12.b). Surveys conducted on the south shore of the Bristol Channel again showed differences in the median values among the beaches were not statistically different for all categories at P = 0.05 level, except for 'floating debris'. This was confirmed using Kruskal-Wallis One Way Analysis of Variance on Ranks.

Table 6.11.a Offensive forms of pollution - South Shore of Bristol Channel Survey (2000). Bold figures relate to largest grouping. Rank 1 is most offensive, rank 8 least offensive. n=385

Rank	Beach Studied						
	All Beaches	Berrow	Minehead	Weston-super-Mare	Brean	Blue Anchor Bay	Ilfracombe
1	SRD	SRD	SRD	SRD	SRD	SRD	SRD
2	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)
3	Oil (in the sea)	Oil (in the sea)	Oil (in the sea)	Oil (in the sea)	Unusual Smell	Oil (in the sea)	Oil (in the sea)
4	Unusual Smell	Unusual Smell	Unusual Smell	Unusual Smell	Oil (in the sea)	Unusual Smell	Unusual Smell
5	Foam/Scum	Floating Debris	Floating Debris	Foam/Scum	Floating Debris	Floating Debris	Foam/Scum
6	Floating Debris	Foam/Scum	Foam/Scum	Floating Debris	Discoloured Water	Beach Litter	Beach Litter
7	Beach Litter	Beach Litter	Discoloured Water	Discoloured Water	Foam/Scum	Foam/Scum	Floating Debris
8	Discoloured Water	Discoloured Water	Beach Litter	Beach Litter	Beach Litter	Discoloured Water	Discoloured Water

Table 6.11.b Averaged Rank of most offensive form of pollution – South Shore of Bristol Channel Survey (2000). Rank 1 is most offensive, rank 8 least offensive. n=385

Pollution Form	Average Rank Position
Sewage Related Debris	1.8
Oil (on the beach)	3.4
Oil (in the sea)	4.0
Unusual Smell	4.5
Foam/Scum	5.0
Floating Debris	5.1
Beach Litter	5.4
Discoloured Water	5.6

Analysis of results from the mid/north Wales coast survey (2000) using One Way Analysis of Variance on Ranks showed differences in the median values among the beaches were not statistically different for all categories at $P = 0.05$ level.

Table 6.12.a Offensive forms of pollution – Mid/North Wales Coast Survey (2000). Bold figures relate to largest grouping. Rank 1 is most offensive, rank 8 least offensive. n=526

Rank	Beach Studied							
	All Beaches	Aberdyfi	Towyn	Barmouth	Harlech	Pwllheli	Llandudno	Rhyl
1	SRD	SRD	SRD	SRD	SRD	SRD	SRD	SRD
2	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)	Oil (on the beach)
3	Oil (in the sea)	Unusual Smell	Oil (in the sea)	Oil (in the sea)	Oil (in the sea)	Oil (in the sea)	Oil (in the sea)	Oil (in the sea)
4	Unusual Smell	Oil (in the sea)	Unusual Smell	Unusual Smell	Unusual Smell	Foam/Scum	Unusual Smell	Floating Debris
5	Foam/Scum	Foam/Scum	Foam/Scum	Foam/Scum	Foam/Scum	Unusual Smell	Foam/Scum	Foam/Scum
6	Floating Debris	Floating Debris	Beach Litter	Beach Litter	Floating Debris	Floating Debris	Beach Litter	Unusual Smell
7	Beach Litter	Beach Litter	Floating Debris	Floating Debris	Beach Litter	Discoloured Water	Discoloured Water	Beach Litter
8	Discoloured Water	Discoloured Water	Discoloured Water	Discoloured Water	Discoloured Water	Beach Litter	Floating Debris	Discoloured Water

Table 6.12.b Averaged Rank of most offensive form of pollution – Mid/North Wales Coast Survey (2000). Rank 1 is most offensive, rank 8 least offensive. n=526

Pollution Form	Average Rank Position
Sewage Related Debris	1.8
Oil (on the beach)	3.5
Oil (in the sea)	4.1
Unusual Smell	4.9
Foam/Scum	4.9
Floating Debris	5.3
Beach Litter	5.5
Discoloured Water	5.9

Perceived versus Actual Beach Grade

Interviewees were asked to describe the state of the beach they were on with regard to litter pollution from four specific criteria. The four options given related directly to the EA / NALG protocol, i.e. 'A', 'B', 'C', and 'D' (EA/NALG, 2000). Responses given by the public could then be compared to the *actual* grade / description attained by the beach from direct litter counts conducted at the same time as the questionnaire survey. There was a reasonable appreciation of the condition or grade of beaches by respondents (Table 6.13.a). In five of eight beaches the modal value described the state of the beach correctly, i.e. the *actual* grade was in line with the *perceived* grade given by the public. Where perceived condition was different to actual condition this was only by one grade. From these results it would appear that the public has a reasonable appreciation how a beach can be described with regard to beach litter. As previously stated, these beaches are regularly cleaned of beach debris during the summer season, which probably accounts for the majority of these beaches achieving a 'B' grade. With only very small numbers of SRD or potentially harmful litter needing to be present before 'C' and 'D' grades are awarded, it would be interesting to establish if respondents were able to perceive the beach condition correctly where relevant numbers of these two litter types were present in association with limited numbers of other more 'general' beach litter.

Table 6.13.a Actual vs. perceived beach condition. – (A-D relate to the Environment Agency/National Aquatic Litter Group (2000), protocol grades) - South Wales Coast Survey (1998). Figures represent number of responses.

Perceived Beach Description / Grade	Beach Studied							
	Rest Bay	Whitmore Bay	Dunraven Bay	Tenby North	Oxwich Bay	Langland Bay	Whitesands	Saundersfoot
Very good (A)	39	15	**8**	72	39	12	**48**	18
Good (B)	**68**	39	7	**80**	**91**	**39**	30	**55**
Fair (C	25	**51**	7	9	48	21	6	27
Poor (D)	1	18	0	2	3	1	0	3
Blank	0	1	0	0	0	0	0	0
Total	133	124	22	163	181	73	84	103
Actual Condition / Grade	**Good (B)**	**Fair (C)**	**Good (B)**	**Good (B)**	**Good (B)**	**Good (B)**	**Good (B)**	**Fair (C)**

Further studies of the south Wales coast (conducted in 1999), found that public perception of the beach grade was again generally in tune with the actual beach grade. The majority tended to either be accurate with their assessment or just one grade out, but there were some anomalies (Table 6.13.b). For example, there were as many people at Ogmore-by-Sea that stated the beach was an 'A' grade ('very good') beach as correctly identified it as a 'B' ('good') grade. The differences between these grades can be very small in terms of numbers of items, particularly where sewage or harmful litter is concerned (see EA/NALG, 2000; Table 5.1.1 and Appendix II). It cannot really be expected that these small differences would be detected by the uninitiated, especially as it would require a more concentrated search of the beach to identify small items of sewage, for example. Unless a beach is instantly recognisable as being heavily polluted, generally with a very large abundance of 'general' litter items or some large items, then it is perhaps unfair to expect the public to detect small differences in litter abundance that can affect the overall grading of a beach. It is this initial visual impression, often the first impression, of the beach which often determines the public perception of a stretch of coast. Perhaps the actual grade, unless heavily publicised and communicated to beach users, is less important than the perceived condition! The public may also find it misleading if they are unaware of small items of litter (especially SRD), and a beach is downgraded or upgraded for no 'apparent' reason.

Sandy Bay was graded as a 'poor' beach using the EA/NALG protocol scheme (EA/NALG, 2000), and this was the view of the majority of respondents. This beach had large amounts of general litter, particularly food and drink related debris, probably due to its position adjacent to a fairground. It is likely that this beach's proximity to the fair and Porthcawl town was its draw (*circa* 70% of interviewees at this beach were day trippers; Table 6.7.b), but there were many people on the beach even though the majority of interviewees considered it 'poor' in terms of litter pollution (Table 6.13.b). There was again significant numbers of people who considered it to be above a 'D' grade. Views at Port Eynon and Whitmore Bay were mixed as to the description of the beach, but the highest figures given were those for the correct grading. The majority of respondents at Whitesands and Rest Bay perceived the beach to be an 'A' grade, whereas both were 'B' grade. These two beaches are picturesque beaches with limited facilities and infrastructure surrounding them, it has perhaps for this reason that they were perceived as being at a higher standard than they actually were.

Newton, like Sandy Bay, is situated close to the large caravan parks of Porthcawl, and both these beaches were perceived to be of a 'poor' condition by the majority of interviewees. Whereas in the case of Sandy Bay this perception was correct, it was not the case at Newton where the beach was in fact graded as 'good' ('B' grade). It is interesting to note that at picturesque undeveloped beaches such as Whitesands, Rest Bay and to some extent Ogmore-by-Sea, the beach grade is overestimated and the perception is that the beach state is better than it truly is. This was also the case at Whitesands in 1998. The reverse is seen at Newton where the beach is near developments and infrastructures, the perception of the beach was lower than its correct state. Patterns are less clear at Whitmore Bay, where beach condition perception was essentially mixed (Table 6.13.b).

Table 6.13.b. Actual vs. perceived beach grade. – (A-D relate to the Environment Agency/National Aquatic Litter Group (2000), protocol grades). South Wales Coast Survey (1999). Figures represent number of responses.

Perceived Beach Description / Grade	**Beach Studied**						
	Ogmore-by-Sea	Sandy Bay	Port Eynon	Whitesands	Whitmore Bay	Rest Bay	Newton
Very good (A)	**43**	1	44	**89**	44	**48**	4
Good (B)	**43**	17	**46**	14	**57**	20	11
Fair (C)	23	28	34	0	32	6	35
Poor (D)	3	**57**	3	0	3	1	**51**
Blank	0	2	0	1	0	1	1
Total	112	105	127	104	136	76	103
Actual Condition / Grade	**Good (B)**	**Poor (D)**	**Good (B)**	**Good (B)**	**Good (B)**	**Good (B)**	**Good (B)**

Perceptions of beach grading at beaches of the southern shore of the Bristol Channel were sometimes very different to the true grade. At Berrow, Weston-super-Mare and Brean beaches were graded as ‘Poor’ (D grade), due to the presence of large amounts of SRD (Appendix IVb). However, public perceptions differed greatly, with beaches receiving either ‘A’ or ‘B’ grades. This was the largest discrepancy seen at any of the surveys conducted, and it can almost certainly be attributed to a lack of public awareness of the presence of small SRD items (Table 6.13.c).

Table 6.13.c. Actual vs. perceived beach grade. – (A-D relate to the Environment Agency/National Aquatic Litter Group (2000), protocol grades). South Shore of Bristol Channel Survey (2000). Figures represent number of responses.

Perceived Beach Description / Grade	Beach Studied					
	Berrow	Minehead	Weston-super-Mare	Brean	Blue Anchor Bay	Ilfracombe
Very good (A)	20	**53**	11	**14**	1	10
Good (B)	**50**	28	**21**	10	19	35
Fair (C)	26	9	16	8	**26**	**46**
Poor (D)	6	0	0	0	9	2
Blank	0	0	0	0	0	0
Total	102	90	48	32	55	94
Actual Condition / Grade	**Poor (D)**	**Very Good (A)**	**Poor (D)**	**Poor (D)**	**Good (B)**	**Good (B)**

Surveys of beaches along the Mid/North Wales coast established that on the whole they were very clean, the majority of these beaches were tourist attractions and were important to the local economy. As a consequence all these beaches were regularly cleaned, and therefore very little litter was present. The modal response to perception of beach condition was almost always in line with actual beach condition (Table 6.13.d). It is gratifying to note that the EA/NALG (2000), protocol view of grading was born out by the responses of the public.

Table 6.13.d. Actual vs. perceived beach grade. (A-D relate to the Environment Agency/National Aquatic Litter Group (2000), protocol grades) - Mid/North Wales Coast Survey (2000). Figures represent number of responses.

Perceived Beach Description / Grade	Beach Studied						
	Aberdyfi	Towyn	Barmouth	Harlech	Pwllheli	Llandudno	Rhyl
Very good (A)	34	19	**40**	**61**	31	25	18
Good (B)	**47**	**43**	34	26	**34**	**44**	**33**
Fair (C)	8	23	13	2	18	17	24
Poor (D)	0	3	1	0	6	2	5
Blank	0	0	1	0	0	1	0
Total	89	88	107	104	97	95	80
Actual Condition / Grade	**Very Good (A)**	**Good (B)**	**Very Good (A)**	**Very Good (A)**	**Very Good (A)**	**Good (B)**	**Good (B)**

Access to beaches by dogs

On all beaches surveyed the majority of people questioned did not think dogs should be allowed on either resort or rural beaches (Tables 6.14.a to 6.14.i). When all beaches surveyed in 1998 are totalled together, the percentage allocation of responses resulted in 85% and 54% 'no' answers for resort and rural beaches respectively (Table 6.14.b). Young *et al.*, (1996), made a similar finding for west Wales beaches. Greater acceptance of dog access on rural beaches is understandable, the lower number of visitors at rural beaches allows greater space for dogs and less potential for hindrance of beach users. Chi-square analysis was applied to total data for all beaches to ascertain if there were statistical differences in responses to dog access between resort and remote beaches. Analysis verified that interviewees views regarding access of dogs to beaches varied according to beach type: Chi-square χ^2 = 197.376, with 1 degree of freedom P=<0.05.

Anecdotal evidence from beach users when conducting surveys showed a high level of concern regarding dogs on beaches, particularly when there were children present. Mothers were particularly keen to see dogs banished from the beach. Dogs are considered by respondents not only a nuisance by their noise and boisterousness, but their faeces can have serious health effects on humans coming into contact with it. This is one parameter that could have been added to the list of offensive pollution forms.

Table 6.14.a Access of dogs to beaches. Response to question: Should dogs be allowed on beaches? South Wales Coast Survey (1998). Bold figures indicate largest grouping. Figures represent number of responses.

	All Beaches		Rest Bay		Whitmore Bay		Dunraven Bay		Tenby North		Oxwich Bay		Langland Bay		Whitesands		Saundersfoot	
Beach Type	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**
Yes	74	303	5	43	14	33	3	9	7	54	24	78	7	21	5	26	9	39
No	**752**	**478**	**120**	**74**	**104**	**77**	**18**	**11**	**147**	**90**	**145**	**88**	**63**	**43**	**70**	**45**	**85**	**52**
Unsure	56	99	8	16	5	13	1	2	9	19	12	15	3	9	9	13	9	12
Blank	1	3	0	0	1	1	0	0	0	1	0	0	0	1	0	0	0	0

Key: A refers to resort beaches; B to rural beaches.

Table 6.14.b Access of dogs to beaches – Percentage figure of responses – South Wales Coast Survey (1998)

Response by interviewee	All Beaches (1998 survey)	
	Should dog access be permitted on Resort beaches? %	Should dog access be permitted on Rural beaches? %
Yes	8	34
No	**85**	**54**
Unsure	6	11
Blank	<1	<1

In subsequent surveys the distinction was made that the question of dog access should only relate to the summer season (May to September). The majority of those completing the questionnaires felt that dog access should not be permitted during the summer months (May to September) on resort beaches, with rural beaches following suit at nearly all sites (Table 6.14.c). Overall results regarding dog access at beaches were almost identical to those gathered from surveys conducted in 1998 (84% in 1999 compared to 85% in 1998 for 'no' responses for resort beaches; 54% 'no' response for rural beaches in 1998 and 1999; Tables 6.14.b and 6.14.d). Analysis verified that interviewees views regarding access of dogs to beaches varied according to beach type: Chi-square χ^2 = 145.132, with 1 degree of freedom P=<0.05.

Table 6.14.c Access of dogs to beaches. Response to question: Should dogs be allowed on beaches? South Wales Coast Survey (1999). Figures represent number of responses.

	All Beaches		Ogmore-by-Sea		Sandy Bay		Port Eynon		Whitesands		Whitmore Bay		Rest Bay		Newton	
Beach Type	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**
Yes	56	223	22	43	1	21	11	42	3	24	5	39	3	17	11	**37**
No	**637**	**410**	**80**	**51**	**88**	**61**	**107**	**72**	**97**	**65**	**122**	**74**	**72**	**51**	**71**	36
Unsure	49	95	5	10	12	20	8	11	4	13	5	14	1	6	14	21
Blank	21	35	5	8	3	3	1	2	0	2	4	9	0	2	7	8

Key: A refers to resort beaches; B to rural beaches.

Table 6.14.d Access of dogs to beaches – Percentage figure of responses – South Wales Coast Survey (1999)

Response by interviewee	All Beaches (1999 survey)	
	Should access be permitted on Resort beaches? %	Should access be permitted on Rural beaches? %
Yes	7	29
No	**84**	**54**
Unsure	6	12
Blank	3	5

Results for the south shore of the Bristol Channel, and mid/north Wales, are broadly similar to the findings along the north shore (south Wales) coast of the Bristol Channel (Tables 6.14.e, 6.14.f; Tables 6.14.g, 6.14.h). Analysis verified that interviewees views regarding access of dogs to beaches varied according to beach type at beaches on the south shore of the Bristol Channel (2000): Chi-square χ^2 = 89.233, with 1 degree of freedom P=<0.05; and mid/north Wales beaches: Chi-square χ^2 = 69.110, with 1 degree of freedom P=<0.05. A very clear picture emerges regarding dog access, namely that the vast majority of respondents do not believe there should be any dogs on resort beaches during the summer, and a small majority believing this ought also be the case on rural beaches.

Table 6.14.e Access of dogs to beaches. Response to question: Should dogs be allowed on beaches? South Shore of Bristol Channel Survey (2000). Figures represent number of responses.

	All in one		Berrow		Minehead		Weston-super-Mare		Brean		Blue Anchor Bay		Ilfracombe	
Beach Type	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**
Yes	52	162	21	**47**	6	29	1	20	8	12	7	**26**	9	28
No	**336**	**199**	**72**	38	**81**	**47**	**44**	**24**	**20**	**16**	**42**	**26**	**77**	**48**
Unsure	23	42	7	10	1	12	3	4	3	3	5	2	4	11
Blank	10	18	1	3	2	4	1	2	2	1	1	2	3	6

Key: A refers to resort beaches; B to rural beaches.

Table 6.14.f Access of dogs to beaches – Percentage figure of responses – South Shore of Bristol Channel Survey (2000)

Response by interviewee	All Beaches (2000 survey - Bristol Channel)	
	Should access be permitted on Resort beaches? %	Should access be permitted on Rural beaches? %
Yes	12	39
No	**80**	**47**
Unsure	6	10
Blank	2	4

Table 6.14.g Access of dogs to beaches. Response to question: Should dogs be allowed on beaches? Mid/North Wales Coast Survey (2000). Figures represent number of responses.

	All Beaches		Aberdyfi		Towyn		Barmouth		Harlech		Pwllheli		Llandudno		Rhyl	
Beach Type	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**
Yes	89	204	13	36	15	31	16	33	17	32	10	21	7	18	10	23
No	**517**	**365**	**70**	**41**	**65**	**44**	**68**	**46**	**63**	**45**	**70**	**54**	**76**	**55**	**62**	**48**
Unsure	40	70	5	11	5	10	3	7	7	10	7	12	5	10	5	5
Blank	14	21	1	1	3	3	2	3	2	2	2	2	1	6	3	4

Key: A refers to resort beaches; B to rural beaches.

Table 6.14.h Access of dogs to beaches – Percentage figure of responses – Mid/North Wales Coast Survey (2000)

Response by interviewee	All Beaches (2000 survey - mid/north Wales)	
	Should access be permitted on Resort beaches? %	Should access be permitted on Rural beaches? %
Yes	14	31
No	**78**	**55**
Unsure	6	11
Blank	2	3

A summary of responses from all four surveys is displayed in Table 6.14.i. The overwhelming majority of respondents stated they did not believe dogs should be permitted on resort beaches (82%; n=2242), with 53% (n=1452) stating that dogs should be prevented from accessing rural beaches (Table 6.14.i).

Table 6.14.i Access of dogs to beaches – Percentage and numbers of responses – *All four surveys (1998-2000)*

Response by interviewee	All Beaches (*All four surveys 1998-2000*)	
	Should access be permitted on Resort beaches?	Should access be permitted on Rural beaches?
Yes	n=271 (10%)	n=892 (33%)
No	**n=2242 (82%)**	**n=1452 (53%)**
Unsure	n=168 (6%)	n=306 (11%)
Blank	n=46 (2%)	n=77 (3%)
TOTAL	n=2727 (100%)	n=2727 (100%)

Reasons for Beach Selection

It is important for leisure and tourism managers to be aware of the prime reasons for visitors selecting a beach to visit. Table 6.15.a sets out the priorities that beach users questioned in this study placed on different factors when deciding on a beach to frequent. Clean sand, followed by clean water, were found to be priorities. This concurs with other similar studies conducted along beaches of the south Wales coast where 'sand and water quality' were found to be the most important aspects of a beach by beach users (Morgan and Williams, 1995; Young *et al.*, 1996). Cutter *et al.* (1979), also established that cleanliness of the beach and water was the most important ideal characteristic cited by respondents, but when asked to state the reason for beach selection a larger proportion in their study stated that convenience (distance and ease of travel) was a higher priority than cleanliness.

Tables 6.15.a and 6.15.b reinforce the widely accepted view that beach cleanliness and safety are the driving forces behind beach selection. Kruskal-Wallis One Way Analysis of Variance on Ranks illustrated that differences in the median values among the beaches were not statistically different for the 'clean water', 'clean sand' and 'safety' categories at P = 0.05 level. The weakness with the closed-ended question used in this instance is that whilst a clean beach may be the priority for beach users, it is certainly not the only criteria for choosing a beach to visit. Therefore, it is perhaps better to ascertain what does *not* influence people when they choose a beach. People seemed to desire a mix of the factors listed in Table 6.15.a. The ranking system employed above requires the interviewee to rank a criteria, even if they do not take it into consideration.

Respondents stated that the number one priority for selecting a beach was cleanliness, and yet all beaches studied had some level of pollution. It could be that it is not until a beach is severely polluted, *or is perceived to be*, that beach users would begin to cease visits. This finding may go some way to vindicate the practice of daily beach cleans by local councils at tourist beaches, without such measures a heavily polluted beach may deter tourists that these communities require for economic survival. There is perhaps some danger in assuming that improved cleanliness will lead to increased recreational use if genuine health affects are the deterring factors, although if improvements are interpreted in terms of attractiveness, or aesthetic appearance, then certain benefits may be realised (Ditton and Goodale, 1974). Cutter *et al.*(1979), discovered inconsistencies between the ideal beach characteristics and the reasons for beach site selection. It may be in this study that the 'ideal' beach is envisaged rather than the imperfect one that the interviewee is currently situated.

As with Table 6.9.a and 6.9.b, the uppermost and lowest criteria are clear, with parameters in between having no definite position (Tables 6.15.a and 6.15.b). A refreshment kiosk at a beach appears to be the least important factor to those interviewed, even though all beaches had some level of food and drink outlet nearby. There is a tradition of taking a picnic to the beach, and maybe this explains the low ranking of this factor. Distance to travel to the beach was cited as a low priority, this was even the case with Whitmore Bay and Rest Bay which were composed mainly of locals or day trippers. This concurred with other work conducted at beaches on the south Wales coast (Nelson *et al.*, 1999b), but is in contrast to research carried out by Cutter *at al.* (1979). Car parking facilities was also considered a low priority by respondents (Tables 6.15.a and 6.15.b). The distance to travel parameter is linked to the car parking factor, in that if distance is unimportant then the use of the car and a car park are not deemed a priority. As with the refreshment kiosk, there were relatively large car parks adjacent to all these beaches (except for Tenby North which is backed by the town). Dunn's method of pairwise multiple comparison confirmed that Tenby North accounted for differences in the median values among the beaches ascertained using one way analysis of variance on ranks. Apart from Dunraven Bay, car parks were full on the days when surveys took place. Car parking may not be a high priority but by the numbers of people using the car park it must surely play a part in beach selection.

As with other studies (Nelson *et al.*, 2000b), the beach award / flag is *not* a defining factor in why beaches were chosen. Whilst people wish to visit clean beaches, there does not appear to be a strong link between awards and beach cleanliness, as *no* beach investigated in the 1998 study was free of SRD items. An award winning beach does *not* appear to be a priority in beach selection. Indeed, only four of the beaches studied had an award. Where the beach did have an award the rank of this parameter was higher than at those that did not have such an award. Kruskal-Wallis One Way Analysis of Variance on Ranks confirmed differences in the median values among the beaches were statistically different for the 'beach award' category at P = 0.05 level. The issue of beach award awareness and understanding is tackled later in this section, which will link to the answers given for this question.

Table 6.15.a Ranking of reasons for beach selection. South Wales Coast Survey (1998). Rank 1 is the most important reason for beach selection, rank 10 is least important. n=832

Rank	Beach Studied								
	All Beaches	Rest Bay	Whitmore Bay	Dunraven Bay	Tenby North	Oxwich Bay	Langland Bay	Whitesands	Saundersfoot
1	CS	CS	CS	CS	CS	CS	CS	CW	CS
2	CW	CW	CW	CW	CW	CW	CW	CS	CW
3	S	S	S	S	S	S	S	S	S
4	A	A	A	F	T	T	A	V	A
5	T	T	V	V	V	A	V	A	T
6	V	F	T	D	A	V	T	F	C
7	F	C	C	A	F	C	C	C	V
8	C	V	D	C	C	F	D	T	F
9	D	D	F	T	D	D	F	D	D
10	R	R	R	R	R	R	R	R	R

Key: CS = Clean sand; CW = Clean water; S = Safety; A = Accessibility; T= Provision of toilets; V = Views and landscape; D = Distance to travel to beach; F = Beach award rating scheme / flag; C = Car parking facilities; R = Refreshment kiosk

Table 6.15.b. Averaged rank of rationale for beach selection – South Wales Coast Survey (1998). Rank 1 is most important reason for beach selection, rank 10 is least important. n=832

Parameter	Average Rank Position
Clean Sand	2.5
Clean Water	2.7
Safety	4.3
Accessibility	5.5
Provision of Toilets	5.6
Views and Landscape	5.7
Beach Award Rating / Flag	6.3
Car Parking Facilities	6.3
Distance to Travel to Beach.	7.0
Refreshment Kiosk	8.4

Table 6.15.c illustrates where, and what proportion, of respondents ranked each parameter as important in their beach choice. The proportion of respondents who ranked 'clean sand' at either first or second position is approximately 64%, with less than 7% ranking this parameter below fifth position (Table 6.15.c). The modal response to the 'refreshment kiosk' parameter was eighth position (34%), with 28% ranking it in seventh place.

Table 6.15.c Percentage of respondents ranking each parameter of beach importance – South Wales Coast Survey (1998). Rank 1 is the most important reason for beach selection, rank 10 is least important. Bold figures are the largest grouping. n=832

Rank	Parameters considered in beach selection (% figures)				
	Views and Landscape	Provision of Toilets	Clean Water	Clean Sand	Distance to Travel to Beach.
1	11	5	27	**32**	3
2	4	5	**35**	32	2
3	**12**	10	16	17	6
4	10	**16**	8	9	8
5	11	15	5	4	10
6	11	14	3	4	9
7	10	12	2	1	12
8	10	11	2	1	14
9	11	8	1	<1	16
10	10	4	1	<1	**20**
Total	100	100	100	100	100

Rank	Parameters considered in beach selection (% figures)				
	Accessibility	Car Parking Facilities	Safety	Refreshment Kiosk	Beach Award Rating / Flag
1	7	3	14	<1	8
2	7	4	7	1	6
3	8	5	**17**	2	9
4	10	8	17	1	11
5	16	12	15	4	9
6	16	16	11	6	9
7	**17**	**19**	9	8	8
8	10	18	6	16	8
9	6	9	3	28	13
10	3	6	1	**34**	**19**
Total	100	100	100	100	100

'Clean Sand' and 'Clean Water' again were the uppermost two reasons given for selecting a beach to visit when a second assessment of the south Wales coast was undertaken a year later (i.e. 1999 survey), with 'Safety' being the third priority, this was also the case in 1998 (Tables 6.15.d and 6.15.a). There is a slight contradiction between the fact that 'Clean Sand' is the priority for selecting a beach, and yet in the case of Sandy Bay, and Newton the respondents considered the beach to be 'poor' and perceived it as having the lowest beach quality grade possible (Table 6.13.b). Whether this was because they did not realise the beach was dirty before visiting, and so then remained even though they did not particularly like it, or whether the stating that 'Clean Sand' is the paramount reason for choosing a beach is simply an aspirational statement and there is a sense of 'that's what one should say' cannot easily be determined. As with previous results (Table 6.15.a), the 'refreshment kiosk' was stated as the least important parameter when deciding on which beach to visit (Table 6.15.d). The beach award flag was found to be even less of a priority at these seven beaches than was experienced in former south Wales surveys (Table 6.15.e compared with Table 6.15.b). Statistical analysis using Kruskal-Wallis One Way Analysis of Variance on Ranks showed that the differences in median values among the treatment groups were not great enough to exclude the possibility that the difference was due to random sampling variability; therefore there was not a statistically significant difference across all beaches for each parameter at the P=0.05 level. The exception to this was the 'distance to travel to beach' category which displayed statistical differences across beaches studied; Dunn's method isolated Ogmore-by-Sea as the site that differed from the others using a multiple comparison procedure. Respondents had predominantly travelled over 10 miles to visit this beach (n=83; 74%; Table 6.7.b), with few locals or holiday makers present (Table 6.7.b). Therefore, distance was a greater priority to them.

Table 6.15.d Ranking of reasons for beach selection – South Wales Coast Survey (1999) Rank 1 is most important reason for beach selection, rank 10 is least important. n=604

Rank	Beaches Studied							
	All Beaches	Ogmore-by-Sea	Sandy Bay	Port Eynon	Whitesands	Whitmore Bay	Rest Bay	Newton
1	CS	CS	CS	CW	CW	CS	CS	CW
2	CW	CW	CW	CS	CS	CW	CW	CS
3	S	T	S	S	S	T	S	T
4	T	S	T	T	T	S	F	S
5	V	V	A	V	V	A	T	F
6	A	A	C	A	F	C	V	V
7	C	C	V	C	A	V	C	A
8	F	D	F	F	C	D	A	C
9	D	F	D	D	D	F	D	D
10	R	R	R	R	R	R	R	R

Key: CS = Clean sand; CW = Clean water; S = Safety; A = Accessibility; T= Provision of toilets; V = Views and landscape; D = Distance to travel to beach; F = Beach award rating scheme / flag; C = Car parking facilities; R = Refreshment kiosk

Table 6.15.e Averaged Rank of Rationale for beach selection – South Wales Coast Survey (1999). Rank 1 is most important reason for beach selection, rank 10 is least important. n=604

Parameter	Average Rank Position
Clean Sand	2.5
Clean Water	2.6
Safety	4.7
Provision of Toilets	5.0
Views and Landscape	5.9
Accessibility	6.0
Car Parking facilities	6.2
Beach Award Rating / Flag	6.4
Distance to Travel	7.3
Refreshment Kiosk	8.3

Views from beach users on the south shore of the Bristol Channel were broadly similar to those situated on the north shore (Tables 6.15.f and 6.15.g). In this instance statistical analysis using one way analysis of variance on ranks showed that the differences in median values among beaches were greater than would be expected by chance. Therefore, there was a statistically significant difference ($P = <0.001$) for the 'views and landscape' parameter, but no other category. Dunn's method again isolated just one beach that differed from the others using a multiple comparison procedure, namely Weston-super-Mare. Examination of Table 6.15.f illustrates the low rank attained by the 'views and landscape' parameter at this beach compared to others surveyed. Weston-super-Mare was the largest and most developed resort covered in this study on the south shore of the Bristol Channel, which may account for this difference.

Table 6.15.f Ranking of reasons for beach selection - South Shore of Bristol Channel Survey (2000). Rank 1 is the most important reason for beach selection, rank 10 is least important. n=383

Rank	Beaches Studied						
	All Beaches	Berrow	Minehead	Weston-super-Mare	Brean	Blue Anchor Bay	Ilfracombe
1	CS	CS	CS	CS	CS	CW	CW
2	CW	CW	CW	CW	CW	CS	CS
3	S	T	S	S	S	V	V
4	T	S	T	T	C	S	S
5	V	C	V	A	V	C	T
6	A	A	A	F	T	T	A
7	C	V	F	D	D	A	C
8	F	F	D	C	A	F	D
9	D	D	C	V	F	D	F
10	R	R	R	R	R	R	R

Key: CS = Clean sand; CW = Clean water; S = Safety; A = Accessibility; T= Provision of toilets; V = Views and landscape; D = Distance to travel to beach; F = Beach award rating scheme / flag; C = Car parking facilities; R = Refreshment kiosk

Table 6.15.g Averaged Rank of Rationale for beach selection – South Shore of Bristol Channel Survey (2000). Rank 1 is most important reason for beach selection, rank 10 is least important. n=383

Parameter	Average Rank Position
Clean Sand	2.4
Clean Water	2.8
Safety	4.8
Provision of Toilet	5.0
Views and landscape	5.4
Accessibility	5.7
Car Parking facilities	5.9
Beach Award Rating / Flag	6.5
Distance to Travel to Beach	6.8
Refreshment Kiosk	7.9

Results from mid/north Wales beaches were in line with other beaches on the Bristol Channel (Tables 6.15.h and 6.15.i). One point to note is the high position of 'views and landscape' at Aberdyfi and Harlech. This was the highest ranking given at any of the other beaches covered, highlighting the role beauty and value of aesthetic landscapes play to some beach users. Dunn's method of all pairwise multiple comparison procedures illustrated these two beaches to be statistically different to other beaches studied; this was confirmed using one way analysis of variance on ranks.

Table 6.15.h Ranking of reasons for beach selection – Mid/North Wales Coast Survey (2000). Rank 1 is most important reason for beach selection, rank 10 is least important. n=529

Rank	Beach Studied							
	All Beaches	Aberdyfi	Towyn	Barmouth	Harlech	Pwllheli	Llandudno	Rhyl
1	CS	CS	CS	CS	CS	CW	CS	CS
2	CW	CW	CW	CW	CW	CS	CW	CW
3	S	V	T	S	V	T	S	S
4	T	T	S	T	T	S	T	T
5	V	S	A	V	S	V	V	A
6	A	A	C	A	A	F	A	V
7	C	C	V	C	C	A	C	F
8	F	F	F	D	F	C	F	D
9	D	D	D	F	D	D	D	C
10	R	R	R	R	R	R	R	R

Key: CS = Clean sand; CW = Clean water; S = Safety; A = Accessibility; T= Provision of toilets; V = Views and landscape; D = Distance to travel to beach; F = Beach award rating scheme / flag; C = Car parking facilities; R = Refreshment kiosk

Table 6.15.i Averaged Rank of Rationale for beach selection – Mid/North Wales Coast Survey (2000). Rank 1 is most important reason for beach selection, rank 10 is least important. n=529

Parameter	Average Rank Position
Clean Sand	2.4
Clean Water	2.8
Safety	4.8
Provision of Toilets	5.0
Views and Landscape	5.4
Accessibility	6.0
Car Parking facilities	6.4
Beach Award Rating / Flag	6.7
Distance to Travel to Beach	7.1
Refreshment Kiosk	8.2

Beach Award and Rating Schemes

Public awareness of beach rating and award schemes was examined at eight beaches on the south Wales coast during 1998 using the '1998 Beach User Questionnaire' (Appendix V). In total out of 854 responses, around 58% of respondents were aware of such schemes; 40% being unaware (Table 6.16). This figure is higher than other research (Nelson *et al.*, 2000a), which experienced 49% awareness, albeit at different beaches. When each beach is looked at individually it was seen that only Whitmore Bay and Saundersfoot had the majority and modal amount, respectively, of people being unaware of such awards. Whitmore Bay does not possess any award, whereas Saundersfoot was the holder of a Seaside Award and a European Blue Flag. At other beaches, the majority were aware of these systems of beach award (Table 6.16).

Table 6.16. Number of respondents aware of beach award schemes (Beaches with awards are italicised - bold figures are largest groups) n=854. South Wales Coast Survey (1998)

Response	Beach Studied				
	All Beaches	*Rest Bay*	Whitmore Bay	*Dunraven Bay*	*Tenby North*
Yes	**509**	**73**	49	**13**	**98**
No	345	52	**67**	8	58
BLANK	29	8	8	1	7
Total	883	133	124	22	163

Response	Beach Studied			
	Oxwich Bay	*Langland Bay*	*Whitesands*	*Saundersfoot*
Yes	**113**	**50**	**63**	50
No	67	22	20	**51**
BLANK	1	1	1	2
Total	181	73	84	103

If the respondent was aware of beach rating and award schemes / flags, the question was posed, 'could they name any?' (Table 6.17). It was again made clear that these were not to include lifesaving safety flags. The response to the naming of the awards was very low (n=292; Table 6.17), far lower than the 509 that stated they were aware of award initiatives (Table 6.16).

Where an answer was given, if it was not the name of an award scheme, it was usually either the name of a town or beach that the interviewee thought had an award flag, or they named lifeguard flags (such responses are enumerated under the 'invalid response' row of Table 6.17). The response at most beaches was that if a person named an award it was almost certainly the European Blue Flag award, there was little or no mention of the Tidy Britain Group Seaside Award (3%, n=9), or any other rating scheme (<1%, n=2; Table 6.17). In fact approximately 82% (n=240; Table 6.17) of those that answered this question named the European Blue Flag Award, around 27% of the overall sample (where overall sample is n=883). It could be argued that the mention of the awards later on in the questionnaire (part 5; Appendix V) would allow people to fill in the section in question when they arrived at part 5. This though is not felt to be the case, due to the low numbers completing this question (n=292), and the failure to name any other schemes apart from the European Blue Flag. It would seem that separating the two 'Flag' sections had the desired affect of not influencing each other question (see 1998 Beach User Questionnaire' in Appendix V). Awareness of the European Blue Flag and Seaside Award vary significantly across the beaches, verified statistically using the Analysis of Variance ($P = <0.001$).There was not a statistically significant variation in awareness of other award schemes. With over a quarter (27%, n=240) of those questioned naming the European Blue Flag Award this can be considered somewhat of a success for those marketing and promoting the scheme. The extremely low awareness of the any other award scheme does not bode well for those involved in their promotion.

Table 6.17 Number of respondents naming a beach rating / award scheme. Figures refer to number of responses. South Wales Coast Survey (1998).

Type of award	**Beach Studied**				
	All Beaches N=292	Rest Bay N=53	Whitmore Bay N=28	Dunraven Bay N=11	Tenby North N=59
European Blue Flag	**240**	**39**	**8**	9	**52**
Seaside Award	9	3	0	2	1
Other award	2	2	0	0	0
Invalid response	41	9	20	0	6
Type of award	**Beach Studied**				
	Oxwich Bay N=45	Langland Bay N=29	Whitesands N=39	Saundersfoot N=28	
European Blue Flag	**44**	**28**	**34**	**26**	
Seaside Award	0	0	2	1	
Other award	0	0	0	0	
Invalid response	1	1	3	1	

Again only a small amount of people answered the question concerning what a flag at a beach portrays (416 out of 883 questionnaires; Table 6.18). This was an open ended question where the public were free to write what they liked. The majority of people *who answered the question* (60%, n=250) thought that it represented cleanliness at a beach, 6% (n=26) considered it meant safety, and 11% (n=45) believed that it meant both cleanliness and safety (Table 6.18). Over 2% (n=11) of total respondents *who gave an answer* thought that it meant danger. This contrasts with research conducted by Nelson (1998), who found that approximately 17% of respondents at Whitmore Bay stated that a beach award flag represented danger. However, in this research when Whitmore Bay is considered in isolation approximately 10% (n=4) of those answering the question at this beach stated that a flag represented danger (table 6.18). Approximately 10% (n=40)stated that they thought it meant that the beach met European Union (EU) standards, obviously referring to the European Blue Flag. A similar figure gave other answers, most commonly "a good beach". Only 47% of the total number of respondents answered this question, indicating a lack of knowledge of this subject (n=416 from 883 completed questionnaires; Table 6.18).

Table 6.18. Number of respondents describing beach award representation. South Wales Coast Survey (1998)

Description of beach award representation	**Beach Studied**				
	All Beaches	Rest Bay	Whitmore Bay	Dunraven Bay	Tenby North
Clean beach/water	**250**	**39**	**14**	**6**	**46**
Safety	26	6	5	0	5
Clean and safe	45	2	8	2	11
Danger	11	2	4	0	2
Other (e.g. "good beach")	44	4	7	2	7
Meet EU standards	40	4	1	3	6
Sub-Total	416	57	39	13	77
BLANK	467	76	85	9	86
Total	883	133	124	22	163

Description of beach award representation	Beach Studied			
	Oxwich Bay	Langland Bay	Whitesands	Saundersfoot
Clean beach/water	**63**	**26**	**35**	**21**
Safety	4	1	1	4
Clean and safe	6	4	4	8
Danger	1	2	0	0
Other (e.g. "good beach")	7	1	8	8
Meet EU standards	13	7	4	2
Sub-Total	94	41	52	43
BLANK	87	32	32	60
Total	181	73	84	103

Beach users were then asked if the beach they were on had a flag (Table 6.19). Again, it was pointed out that this did not include lifesaving safety flags. Given the number of people who still seemed to include the lifeguard flags in their answers these responses should be viewed in that light. This question was designed to assess if any notice was taken of these beach award flags. Obviously beach users could simply look over their shoulder to see if the beach had a flag, but often these were not clearly visible from their vantage point or they simply did not know where to look. Interviewees at Rest Bay and Whitesands responded positively in larger proportions than at other beaches (43%, n=57; 61%, n= 51 respectively; Table 6.19). Both these beaches did have some form of award and a flag flying to represent this. The majority of respondents were 'unsure' as to whether the beach they were visiting had any kind of award, this again proves the point that the presence or absence of a beach award is not the determining factor or even a major influence to the public when visiting a beach.

Table 6.19. Number of responses to the question: Does this beach have an award / flag? (Beaches with award schemes / flags in 1998 are italicised)

Response	Beach Studied			
	Rest Bay	Whitmore Bay	Dunraven Bay	*Tenby North*
Yes	**57**	9	2	47
No	3	28	5	11
Unsure	56	**65**	**12**	**80**
BLANK	17	22	3	25
Total	133	124	22	163
Response	**Beach Studied**			
	Oxwich Bay	Langland Bay	*Whitesands*	*Saundersfoot*
Yes	3	6	**51**	1
No	59	24	1	33
Unsure	**105**	**35**	27	**60**
BLANK	14	8	5	9
Total	181	73	84	103

Part 5 of the questionnaire (Appendix V) again related to beach award programmes. Instead of asking an open-ended question regarding the awareness of beach awards (as part 3), a closed question was designed that simply asked if the interviewee had heard of three beach award / rating schemes, namely the European Blue Flag, the Seaside Award, and the Good Beach Guide (Table 6.20) The first item to note is the level of recognition of the Good Beach Guide award, indeed all three awards had high levels of awareness. Over 41% (n=364) stated they had heard of the Good Beach Guide, almost 64% (n=562) were aware of the European Blue Flag, and around 27% (n=232) had heard of the Seaside Award (Table 6.20). These high figures of recognition has highlighted the problem with closed-ended questions such as this. Closed questions can appear leading. Earlier in the questionnaire (Appendix V), very few people named the Blue Flag and an almost negligible amount mentioned the Seaside Award or Good Beach Guide (Table 6.17).

Finally, interviewees were asked to mark which attributes applied to each award (Table 6.21), this was used in an attempt to ascertain the public level of understanding. The list of attributes was determined from a previous similar study conducted at south Wales beaches (Nelson, 1998). 'Sandy Beach' and 'Boating Facilities' parameters did not apply to any of the awards. The list of attributes for each award can be found in Appendix VI. The modal group of respondents stated that the European Blue Flag represented 'clean bathing water' (51%, n=458); that the Seaside Award represented a 'clean beach' (23%, n=205); and that the Good Beach Guide represented 'provision of toilet facilities' (28%, n=249; Table 6.21). These results illustrate a level of understanding by beach users as to what beach awards/flags represent. This is especially so with regard to the European Blue Flag, with only 45 (5%) interviewees stating that this award represented 'boating facilities' (Table 6.21).

Table 6.20. Respondents awareness of beach awards/flags. (Q: Have you heard of these awards?) Key: A= Good Beach Guide; B= European Blue Flag; C= Seaside Award

Response	All Beaches n=883			Rest Bay n=133			Whitmore Bay n=124			Dunraven Bay n=22			Tenby North n=163		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Yes	**364**	**562**	232	**68**	**88**	45	42	**51**	38	**10**	**16**	· **13**	**63**	**108**	38
No	319	181	**425**	37	22	**52**	**53**	46	**56**	8	4	6	62	30	**87**
Unsure	119	62	143	14	10	21	11	10	12	3	1	2	27	14	25
Blank	81	78	83	14	13	15	18	17	18	1	1	1	11	11	13

Table 6.20 continued

Oxwich Bay n=181			Langland Bay n=73			Whitesands n=84			Saundersfoot n=103		
A	B	C	A	B	C	A	B	C	A	B	C
78	**130**	33	**31**	**56**	18	**36**	**54**	20	36	**59**	27
64	33	**96**	30	8	40	22	11	**33**	**43**	27	**55**
28	7	41	6	3	**9**	14	7	19	16	10	14
11	11	11	6	6	6	12	12	12	8	7	7

Table 6.21 Respondents view of which attributes apply to each award? A= European Blue Flag; B= Seaside Award; C= Good Beach Guide

	All Beaches n=883			Rest Bay n=133			Whitmore Bay n=124			Dunraven Bay n=22			Tenby North n=163		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Clean Beach	427	**205**	245	67	**41**	**45**	40	**23**	24	12	9	**7**	81	33	**48**
Clean bathing water	**458**	183	209	**72**	34	34	**41**	19	20	**14**	**10**	**7**	**87**	28	39
Safety	294	200	212	44	37	38	31	21	18	9	**10**	5	62	**34**	41
Sandy beach	83	143	209	19	28	33	14	18	17	1	1	**7**	13	29	38
Provision of toilets	136	195	**249**	26	33	**45**	19	**23**	20	6	9	5	26	27	47
Boating facilities	45	96	120	10	12	24	8	8	13	2	2	1	11	19	23
Popular beach	66	123	193	10	14	37	19	18	**26**	2	4	3	10	23	33

	Oxwich Bay n=181			Langland Bay n=73			Whitesands n=84			Saundersfoot n=103		
	A	B	C	A	B	C	A	B	C	A	B	C
Clean Beach	101	39	53	39	15	18	40	**18**	**20**	**47**	27	30
Clean bathing water	**106**	36	47	**44**	15	17	**47**	16	18	**47**	25	27
Safety	62	**43**	50	22	17	21	28	13	13	36	25	26
Sandy beach	12	26	51	6	15	16	10	8	15	8	18	**32**
Provision of toilets	27	**43**	59	5	**18**	**25**	13	14	**20**	14	**28**	28
Boating facilities	6	20	26	2	15	9	3	6	8	3	14	16
Popular beach	10	24	38	4	15	18	5	7	15	6	18	23

Perception of Specific Forms of Beach Litter

Introduction to the use of Photographs

Many researchers have shown that colour photographs / slides can be used successfully as surrogates for real entities. For example, Herzog (1985) used photos to investigate aspects of the public's perception of recreational environments; Williams and Lavalle (1990), compared 'expert' and the general public's viewpoints of actual and photographic landscape assessments; and Nelson *et al.*, (1999b) assessed beach users knowledge of Award flags by photographic means. The techniques may be used to assess differences (or not) between various socio-economic, gender, visitor/local or age groups. Since House and Herring (1995) looked at public perception of litter, utilisation of photographs as a means of assessing the public's views on litter pollution has not generally been investigated. For specific methodology see Appendix V.

Results and Discussion - Perception Using Photographs

Items pictured in each photograph are named in Table 6.22, with certain photographs shown in Figures 6.2 to 6.11. Table 6.23 lists the beaches along with the respective rank of each photograph, and the average score given for each photograph at a certain beach is shown in parentheses. Table 6.23 reveals a level of consistency in results across the eight beaches. The syringe (photo 7; Figure 6.4) was ranked as being the most offensive item at each beach, with the condom (photo 25; Figure 6.9) and medical/pill container (photo 28; Figure 6.11) consistently appearing in the second or third most offensive positions. The same level of consistency is seen at the other end of the offensiveness spectrum, with photos number 3 (driftwood) and 26 (seaweed) occupying the bottom two positions across all beaches.

Table 6.22 Litter Items Shown In Each Photograph

Photograph Number	Item shown in Photograph
1	Glass Bottle
2	Plastic Packing Strap
3	Driftwood
4 (Figure 6.2)	Broken Glass
5 (Figure 6.3)	Sanitary Towel
6	Crisp Packet
7 (Figure 6.4)	Medical Syringe
8	Oil
9	Aluminium Drinks Can
10	Fishing Gear
11	Traffic/Road Cone
12 (Figure 6.5)	Disinfectant Container
13	Toiletry Container
14	Animal Faeces
15	Cigarette Butt
16	Polystyrene Food Carton
17	Spent Gun Cartridge
18	Plastic Drinks Bottle
19 (Figure 6.6)	Toilet Detergent/Cleanser
20 (Figure 6.7)	Cotton Bud Stick
21	Large Barrel
22	'4 pack' Ring/Yoke
23 (Figure 6.8)	Propane Gas Cylinder
24	Tyre
25 (Figure 6.9)	Condom
26	Seaweed
27 (Figure 6.10)	Tampon Applicator
28 (Figure 6.11)	Medical/Pill Container

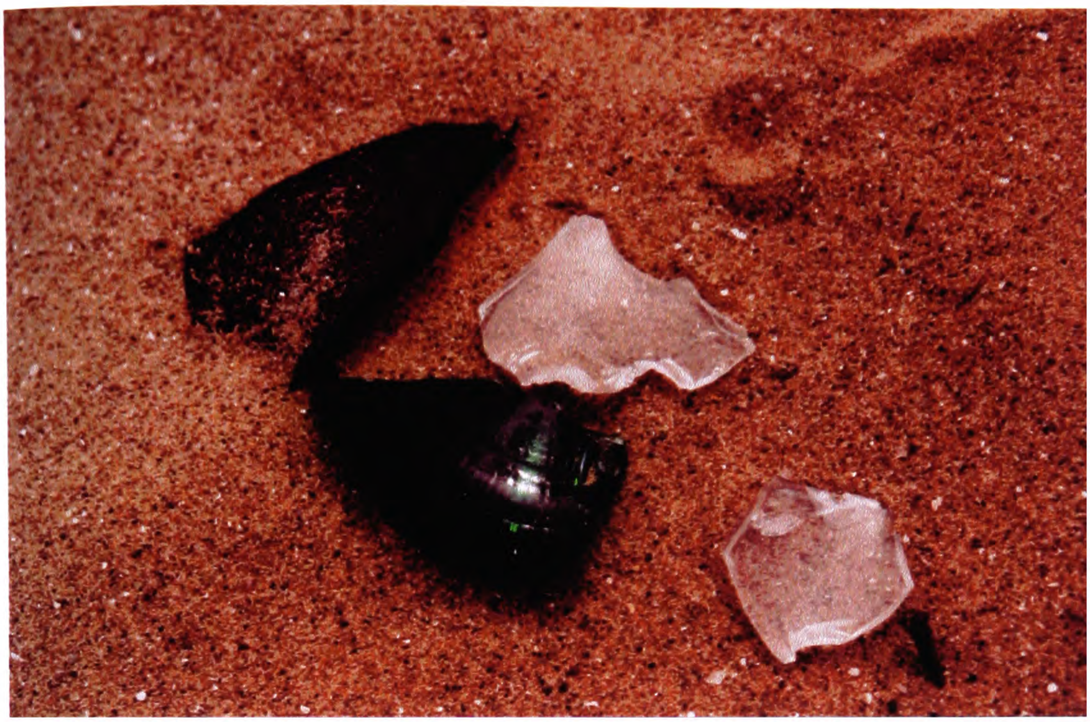

Figure 6.2 Broken glass

Figure 6.3 Sanitary towel

Figure 6.4 Medical Syringe

Figure 6.5 Disinfectant Container

Figure 6.6 Toilet Detergent/Cleanser

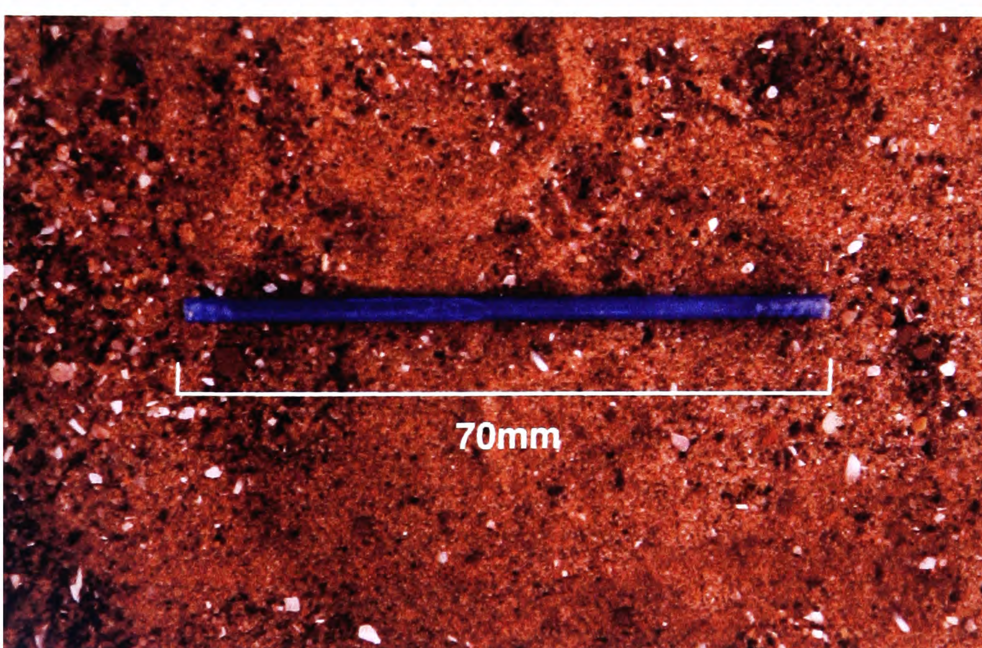

Figure 6.7 Cotton Bud Stick (Q tip)

Figure 6.8 Propane Gas Cylinder

Figure 6.9 Condom

Figure 6.10 Tampon Applicator

Figure 6.11 Medical/Pill Container

Table 6.23 **Public perception of litter items obtained through photographs. South Wales Coast Survey (1998). Photo rankings with score averages. n= number of respondents answering this question. Figures in parenthesis relate to average score attained by each item shown in the photograph. Rank 1 is most offensive, 28 least offensive.**

Beach	Whitmore Bay	Langland Bay	Oxwich Bay	Rest Bay	Saundersfoot	Dunraven Bay	Tenby North	Whitesands
	N=111	N=95	N=172	N=125	N=97	N=15	N=140	N=95
Rank	Photo number (average score)							
1	7 (8.9)	7 (9.0)	7 (8.8)	7 (8.8)	7 (8.8)	7 (9.0)	7 (8.8)	7 (8.8)
2	28 (8.7)	25 (8.9)	25 (8.6)	25 (8.7)	25 (8.6)	25 (8.9)	28 (8.6)	25 (8.7)
3	25 (8.6)	28 (8.8)	28 (8.6)	28 (8.4)	28 (8.6)	5 (8.7)	25 (8.6)	28 (8.6)
4	5 (8.4)	4 (8.5)	23 (8.2)	23 (8.3)	23 (8.3)	28 (8.4)	14 (8.3)	23 (8.3)
5	23 (8.4)	14 (8.4)	5 (8.2)	5 (8.1)	14 (8.2)	4 (8.3)	4 (8.3)	5 (8.2)
6	4 (8.2)	5 (8.4)	4 (8.2)	4 (8.1)	5 (8.1)	12 (8.3)	23 (8.2)	12 (8.2)
7	21 (8.0)	23 (8.4)	21 (7.8)	21 (7.9)	21 (8.0)	14 (8.3)	5 (8.1)	14 (8.1)
8	14 (8.0)	21 (8.2)	12 (7.7)	27 (7.7)	4 (7.9)	23 (8.1)	12 (7.9)	4 (8.0)
9	12 (7.9)	27 (8.1)	27 (7.7)	12 (7.6)	12 (7.8)	21 (8.0)	21 (7.8)	27 (7.9)
10	27 (7.6)	12 (8.0)	19 (7.4)	19 (7.6)	27 (7.5)	27 (7.8)	27 (7.6)	21 (7.8)
11	24 (7.4)	24 (8.0)	14 (7.4)	24 (7.5)	24 (7.3)	8 (7.6)	24 (7.6)	8 (7.7)
12	8 (7.4)	19 (7.8)	24 (7.4)	14 (7.3)	19 (7.2)	22 (7.4)	19 (7.5)	19 (7.7)
13	19 (7.1)	8 (7.7)	8 (7.3)	8 (6.8)	8 (7.1)	19 (7.0)	8 (7.1)	24 (7.4)
14	1 (6.5)	17 (7.0)	1 (6.5)	1 (6.8)	1 (6.3)	24 (7.0)	1 (6.5)	22 (7.0)
15	17 (6.3)	22 (6.9)	22 (6.4)	17 (6.6)	22 (6.2)	1 (6.8)	22 (6.4)	9 (6.7)
16	9 (6.0)	15 (6.7)	9 (6.4)	22 (6.4)	9 (6.1)	13 (6.8)	15 (6.3)	1 (6.6)
17	10 (5.9)	1 (6.7)	13 (6.3)	9 (6.3)	13 (5.8)	9 (6.7)	17 (6.3)	13 (6.5)
18	15 (5.8)	16 (6.6)	15 (6.2)	10 (6.2)	15 (5.8)	16 (6.7)	9 (6.3)	17 (6.5)
19	2 (5.6)	9 (6.6)	16 (6.2)	13 (6.2)	17 (5.7)	18 (6.5)	16 (6.2)	6 (6.3)
20	22 (5.6)	13 (6.4)	18 (6.1)	15 (6.1)	16 (5.6)	17 (6.3)	13 (6.0)	15 (6.3)
21	18 (5.4)	18 (6.3)	17 (6.1)	16 (6.0)	18 (5.6)	11 (6.2)	18 (5.9)	16 (6.2)
22	13 (5.3)	10 (6.2)	6 (6.0)	18 (5.9)	10 (5.5)	2 (6.1)	10 (5.6)	18 (6.2)
23	20 (5.3)	2 (6.1)	11 (5.7)	20 (5.7)	2 (5.2)	6 (6.1)	11 (5.6)	11 (5.9)
24	16 (5.2)	6 (5.9)	10 (5.5)	11 (5.6)	11 (5.1)	15 (5.8)	6 (5.5)	10 (5.8)
25	11 (5.1)	11 (5.8)	20 (5.5)	2 (5.5)	20 (4.9)	10 (5.7)	2 (5.4)	2 (5.7)
26	6 (4.7)	20 (5.6)	2 (5.4)	6 (5.4)	6 (4.9)	20 (5.6)	20 (5.3)	20 (5.5)
27	3 (4.1)	26 (3.0)	26 (2.8)	26 (3.3)	3 (3.0)	26 (2.8)	3 (3.4)	3 (2.5)
28	26 (3.8)	3 (2.6)	3 (2.8)	3 (3.2)	26 (2.8)	3 (2.7)	26 (3.2)	26 (2.4)

Ten of the top eleven most offensive items from the list of 28 photos, were either from the SRD, gross, or potentially harmful litter categories, there was no 'general litter' item until position 14 (Table 6.24). This confirmed the weighting given to these items within the protocol. It is pertinent to note that the medical/pill container (photo 28; Figure 6.11) does not have any labelling or markings, and is perhaps a classic example of an item *appearing* to be of danger or a hazard to health. The lack of labelling does not dispel the *perceived* danger, it may even exaggerate it, which is as relevant to the beach user as any *real* danger. This example shows that markings are not needed for there to be a perceived risk.

Table 6.24. All Beaches - Photo Rankings with Score Averages (5 is the median score, on a rating 1-9. N = 850. Highlighted rows are discussed in text.)

Offensiveness rank	Photo Number - Litter Item	Average Score	EA/NALG (2000) Protocol Category (see Table 5.1.1; Appendix II)
1	7- Medical Syringe	8.8	Potentially Harmful Litter
2	25- Condom	8.6	Sewage Related Debris
3	28- Medical/Pill Container	8.6	Potentially Harmful Litter
4	23- Gas Cylinder	8.3	Potentially Harmful Litter
5	5- Sanitary Towel	8.2	Sewage Related Debris
6	4- Broken Glass	8.2	Potentially Harmful Litter
7	21 - Large Barrel	7.9	Gross Litter
8	14- Animal Faeces	7.9	Non Human Faeces
9	12- Disinfectant Container	7.8	Potentially Harmful Litter
10	27- Tampon Applicator	7.7	Sewage Related Debris
11	24- Tyre	7.5	Gross Litter
12	19- Toilet Detergent/Cleanser	7.4	General Litter
13	8- Oil	7.2	Oil
14	1- Glass Bottle	6.6	General Litter
15	22- '4 pack' Ring/Yoke	6.4	General Litter
16	9- Aluminium Drinks Can	6.3	General Litter
17	17- Spent Gun Cartridge	6.3	General Litter
18	15- Cigarette Butt	6.1	General Litter
19	13- Toiletry Container	6.1	General Litter
20	16- Polystyrene Food Carton	6.0	General Litter
21	18- Plastic Drinks Bottle	5.9	General Litter
22	10- Fishing Gear	5.8	General Litter
23	11- Traffic/Road Cone	5.6	Gross Litter
24	6- Crisp Packet	5.5	General Litter
25	2- Plastic Packing Strap	5.5	General Litter
26	20- Cotton Bud Stick	5.4	Sewage Related Debris
27	3- Driftwood	3.1	------
28	26- Seaweed	3.1	------

Animal faeces is ranked high on the list, even though the picture was of horse faeces. The EA/NALG protocol stipulates that only dog faeces should be included in it's non-human faeces category, as 'faeces from animals such as sheep or horses should not be counted. These are not considered to be a general nuisance or hazard' (EA/NALG, 2000, page 8). Whether the public distinguishes between different forms of faeces when considering offensiveness was unclear at this time. A question would be used in later surveys to determine this fact.

The traffic/road cone received a low score considering it is an item of gross litter - the other gross litter items appear in the top half of the table (Table 6.24). A number of such large items on a beach may produce a different response, an individual large item would appear to be not very offensive. This highlights the problems in the use of photographs where scale and perspective is lost.

Cotton bud sticks (CBS; also known as Q tips) were extremely low on the list (position 26 of 28), indeed the average score was only just above the median value. This position and average score is in direct contrast to the other sewage related items, it even ranks below crisp packets. This low ranking is possibly due to CBS not being generally associated by the public with SRD.

A further part of the questionnaire was to ascertain whether the interviewee's were able to identify certain items of debris. This was not a test of the effectiveness of the photos, but an inquiry into whether people were actually aware of what items were potentially around them on the beach. Beach users were asked if they could identify the items in the photographs that were actually of the CBS (Figure 6.7), the tampon applicator (Figure 6.10) and the sanitary towel (Figure 6.3). It is clear from Tables 6.25a and 6.25b that there was a very low level of recognition of the CBS photograph. The average figure for the percentage of people that correctly identified the item was just 2% (n=18; Tables 6.25.a and b). The figures for each beach vary from 0% in Whitmore Bay, to 8% at Rest Bay. This very low level of recognition could possibly be part of the reason for the low position this item attains on the offensiveness ranking scale (Table 6.24).

A much higher level of recognition was experienced with both the tampon applicator and the sanitary towel. Tables 6.26.a and 6.26.b show the level of recognition of the tampon applicator across the eight beaches. The lowest level of recognition was around 50% at Whitmore Bay, with Oxwich Bay having a figure of 56%. The average figure for all beaches was 52%. When this is split into male and female categories it can be seen from Table 6.26.a that men had a lower recognition level than women. The average figure for men was 40%, with a figure of 59% for women. Through verification using a Chi square test at $P = 0.05$ level, it was confirmed that females had a significantly higher recognition of this item than males (Chi square value = 21.058).

The sanitary towel item was even more widely recognised than the tampon applicator. Tables 6.27.a and 6.27.b illustrate results from this portion of the study. Figures of recognition ranged from 85% at Oxwich bay, to 78% at Rest Bay, with an average of 81% for all beaches. Again, and unsurprisingly, men showed lower levels of recognition than women, with an average of 71% of men recognising the item as a sanitary towel, compared to 87% of women (Table 6.27.a). Using a Chi square test at $P = 0.05$ level, it was confirmed that females had a significantly higher recognition of the sanitary towel than males (Chi square value = 23.326). Further results from statistical analyses (Mann -Whitney Rank Sum test at $P= 0.05$ level) showed that there was a statistically significant difference between men and women with regard to their scoring of certain items of SRD (i.e. sanitary towel, condom, tampon applicator). The difference in the level of recognition of these items between the sexes would account for this. No difference was found in the results between groups of locals/non-locals, age groups, or those from different socio-economic groupings.

The level of recognition of these items is important in that results can be linked back to the offensiveness scores given by the public. The high levels of recognition for the two sanitary products helped result in a high position in the offensiveness table (Table 6.24). CBS's on the other hand have a very low level of recognition, which was reflected in the very low level of offensiveness attributed to this item. Over the eight beaches the CBS was identified as a straw in 57% of instances (Table 6.25.b). With this level of mis-identification it was likely that a low offensiveness rating would result. If the public were aware of the identity of this item, where it came from, and what that link meant, a much higher result could be expected. There appears to be a significant lack of appreciation amongst the public that many items of litter, particularly CBS's and feminine hygiene products, travel to the beach from their own homes via outfalls at the coast or on rivers. Whereas SRD is universally considered to be the most offensive item on a beach, for some items it was perhaps one of the least recognised categories of visual pollution. If people are not aware or cannot identify the debris they see around them on a beach, they will be unable to make the link back to its source and be unaware of potential hazards. The very low levels of recognition of the CBS does not help beach users realise that this item exists ubiquitously on beaches and that it comes from their own homes, and is an easily preventable form of pollution.

Potentially harmful litter achieve high ranks of offensiveness, with 5 of the top 10 most offensive items being from this category (Table 6.24). There is little ambiguity as to the identification of these items, the only doubt lies in the judgement of whether they are potentially harmful or not. It is the *potential* to harm which gives these items their high position within Table 6.24, whether they are of any real danger to the public or the environment is another matter. This is essentially the crux of the perception issue; how a beach is perceived with regard to pollution is as important to the community and businesses surrounding it as the actual state of cleanliness and any real threat posed.

The greatest differences in average photo score results between the eight beaches have been highlighted in Table 6.28. In these instances with a high maximum / minimum difference, all have Whitmore Bay giving either the largest or smallest score. The reason for this needs further investigation. These same litter items are all grouped in the EA/NALG 'general litter' category, and are in the bottom half of the table of offensiveness (Table 6.24), whereas the five litter items with the smallest max. / min difference are also the top five most offensive items (Table 6.24). This reaffirms the view that perception of what constitute the most offensive items is consistent across all beaches studied and all interviewees. The perception of items of general litter that have the greatest maximum / minimum differences between beaches (e.g. driftwood, crisp packet) would seem to be open to more subjectivity than items of SRD or potentially harmful litter.

The item with the highest maximum / minimum difference was the '4 pack ring/yoke' (photo 22) with a value of 1.8. This large disparity could be attributed to certain interviewees viewing the item as potentially harmful (e.g. to animals), while others perhaps viewed it as a relatively inoffensive form of litter pollution. There is evidence that these items can be a hazard to wildlife (e.g. Lucas, 1992).

Table 6.25.a Recognition of cotton bud stick by respondents (% rounded up)

	Whitmore Bay	Langland Bay	Oxwich Bay	Rest Bay	Saundersfoot	Tenby North	Dunraven Bay	Whitesands
Number correctly identifying item	0	1	2	10	1	2	0	2
n=	111	95	172	125	97	140	15	95
% correct	0	1	1	8	1	1	0	2
Number of men correct	0	0	0	4	1	1	0	0
% of men correct	0	0	0	8	3	2	0	0
Number of women correct	0	1	2	6	0	1	0	2
% of women correct	0	2	2	8	0	1	0	3

Table 6.25.b Level of Mis-identification of cotton bud stick. Responses given by interviewees when asked to identify item shown to them.

Response to naming of photograph	Response to photograph			
	Cotton bud stick	Drinking Straw	Don't know / Blank	Row Total
n	18	499	366	883
%	2	57	41	100

Table 6.26.a Recognition of tampon applicator by respondents (% rounded up)

	Whitmore Bay	Langland Bay	Oxwich Bay	Rest Bay	Saundersfoot	Tenby North	Dunraven Bay	Whitesands
Number correctly identifying item	55	52	96	67	48	70	8	51
n=	111	95	172	125	97	140	15	95
% correct	50	55	56	54	51	50	51	54
Number of men correct	12	13	20	22	16	20	4	13
% of men correct	36	41	39	43	46	38	37	38
Number of women correct	43	39	76	45	32	50	4	38
% of women correct	55	64	63	61	54	57	45	62

Table 6.26.b Level of Mis-identification of tampon applicator. Responses given by interviewees when asked to identify item shown to them.

	Response to photograph			
Response to naming of photograph	Tampon Applicator	Syringe	Don't know / Blank	Row Total
n	429	42	412	883
%	49	5	46	100

Table 6.27.a Recognition of sanitary towel by respondents (% rounded up)

	Whitmore Bay	Langland Bay	Oxwich Bay	Rest Bay	Saundersfoot	Tenby North	Dunraven Bay	Whitesands
Number correctly identifying item	90	78	146	98	78	113	12	80
n=	111	95	172	125	97	140	15	95
% correct	81	82	85	78	80	81	80	84
Number of men correct	22	27	39	33	27	35	3	25
% of men correct	71	72	76	66	70	68	55	74
Number of women correct	68	51	107	65	51	78	9	55
% of women correct	85	87.0	88	86	85	90	65	90

Table 6.27.b Level of Mis-identification of sanitary towel. Responses given by interviewees when asked to identify item shown to them.

	Response to photograph			
Response to naming of photograph	Sanitary Towel	Plaster	Don't know / Blank	Row Total
n	645	130	108	883
%	73	15	12	100

Table 6.28. Average photo scores for each beach with maximum - minimum differences

Beach	Whitmore Bay N=111	Langland Bay N=95	Oxwich Bay N=172	Rest Bay N=125	Saundersfoot N=97	Dunraven Bay N=15	Tenby North N=140	Whitesands N=95	Max - Min Difference
Photo number (see table 6.22	Average photo score given by respondents	Average photo score given by respondents	Average photo score given by respondents	Average photo score given by respondents	Average photo score given by respondents	Average photo score given by respondents	Average photo score given by respondents	Average photo score given by respondents	Average photo score given by respondents
1	6.5	6.7	6.5	6.8	6.3	6.8	6.5	6.6	0.5
2	5.6	6.1	5.4	5.5	5.2	6.1	5.4	5.7	0.9
3	4.1	2.6	2.8	3.2	3.0	2.7	3.4	2.5	1.6
4	8.2	8.5	8.2	8.1	7.9	8.3	8.3	8	0.6
5	8.4	8.4	8.2	8.1	8.1	8.7	8.1	8.2	0.3
6	4.7	5.9	6	5.4	4.9	6.1	5.5	6.3	1.6
7	8.9	9.0	8.8	8.8	8.8	9.0	8.8	8.8	0.2
8	7.4	7.7	7.3	6.8	7.1	7.6	7.1	7.7	0.9
9	6.0	6.6	6.4	6.3	6.1	6.7	6.3	6.7	0.7
10	5.9	6.2	5.5	6.2	5.5	5.7	5.6	5.8	0.7
11	5.1	5.8	5.7	5.6	5.1	6.2	5.6	5.9	1.1
12	7.9	8.0	7.7	7.6	7.8	8.3	7.9	8.2	0.7
13	5.3	6.4	6.3	6.2	5.8	6.8	6.0	6.5	1.5
14	8.0	8.4	7.4	7.3	8.2	8.3	8.3	8.1	1.1
15	5.8	6.7	6.2	6.1	5.8	5.8	6.3	6.3	0.9
16	5.2	6.6	6.2	6.0	5.6	6.7	6.2	6.2	1.5
17	6.3	7.0	6.1	6.6	5.7	6.3	6.3	6.5	1.3
18	5.4	6.3	6.1	5.9	5.6	6.5	5.9	6.2	0.9
19	7.1	7.8	7.4	7.6	7.2	7.0	7.5	7.7	0.8
20	5.3	5.6	5.5	5.7	4.9	5.6	5.3	5.5	0.8
21	8.0	8.2	7.8	7.9	8.0	8.0	7.8	7.7	0.5
22	5.6	6.9	6.4	6.4	6.2	7.4	6.4	7	1.8
23	8.4	8.4	8.2	8.3	8.3	8.1	8.2	8.3	0.3
24	7.4	8.0	7.4	7.5	7.3	7.0	7.6	7.4	0.7
25	8.6	8.9	8.6	8.7	8.6	8.9	8.6	8.7	0.3
26	3.8	3.0	2.8	3.3	2.8	2.8	3.2	2.4	1.4
27	7.6	8.1	7.7	7.7	7.5	7.8	7.6	7.9	0.6
28	8.7	8.8	8.6	8.4	8.6	8.4	8.6	8.6	0.4

Accumulations of Litter

There were few large accumulations of litter on any of the beaches covered along the Bristol Channel or mid/north Wales coast. Patches of litter occurred at all sites, but few distinct accumulations were visible from distance. The one exception was Sandy Bay, Porthcawl, where there existed a continuous line of litter at the back of the beach. As Table 6.29 illustrates, the interviewees at Sandy Bay had noticed these accumulations. The majority of respondents at Newton also stated that they had noticed accumulations at the beach, but the actual accumulations were not of an acute nature. At other beaches the majority of people had not noticed any accumulations of litter (Tables 6.30, and 6.31).

Table 6.29. Number of respondents noticing accumulations of litter on beach – South Wales Coast Survey (1999).

Responses to awareness of litter accumulations	**Beach Studied**						
	Ogmore-by-Sea	Sandy Bay	Port Eynon	Whitesands	Whitmore Bay	Rest Bay	Newton
Yes	21	**71**	14	2	21	10	**60**
No	**89**	32	**111**	**102**	**111**	**66**	40
Unsure	0	0	0	0	0	0	0
BLANK	2	2	2	0	4	0	3
Actual number of accumulations	3	19	2	1	1	0	4

Table 6.30 Number of respondents noticing accumulations of litter on beach - South Shore of Bristol Channel Survey (2000)

Responses to awareness of litter accumulations	**Beach Studied**					
	Berrow	Minehead	Weston-super-Mare	Brean	Blue Anchor Bay	Ilfracombe
Yes	7	4	12	2	9	14
No	**94**	**83**	**36**	**30**	**46**	**77**
Unsure	0	0	0	0	0	0
BLANK	0	3	0	0	0	3
Actual number of accumulations	14	0	8	3	1	1

Table 6.31. Number of respondents noticing accumulations of litter on beach - Mid/North Wales Coast Survey (2000)

Responses to awareness of litter accumulations	**Beach Studied**						
	Aberdyfi	Towyn	Barmouth	Harlech	Pwllheli	Llandudno	Rhyl
Yes	6	8	14	5	14	4	11
No	**83**	**79**	**75**	**84**	**73**	**83**	**68**
Unsure	0	0	0	0	0	0	0
BLANK	0	1	0	0	2	2	1
Actual number of accumulations	0	3	0	0	1	0	2

Presence of and Response to Faeces on Beaches

The EA / NALG (2000) protocol view that only human and dog faeces were offensive on a beach was tested. Responses illustrated in Tables 6.32.a, 6.32.b and 6.32.c, confirmed this view to some degree. At all beaches, human and dog faeces were selected as being offensive by larger numbers of people than were horse and sheep faeces, but the numbers selecting the latter two types were still significant. Over 90% of respondents considered dog faeces offensive; 80% did likewise with faeces of human origin; 60% selected horse faeces; 54% considered sheep faeces to be offensive on a beach.

Table 6.32.a. Number of respondents stating faeces type as offensive – South Wales Coast Survey (1999). ('BLANK' refers to incomplete question response)

Beach	Faeces Type				
	Horse	Human	Dog	Sheep	BLANK
All Beaches	455	613	694	412	16
Ogmore-by-Sea	64	86	96	54	1
Sandy Bay	63	80	99	55	3
Port Eynon	78	110	117	71	2
Whitesands	68	103	103	60	0
Whitmore Bay	79	106	127	76	2
Rest Bay	57	66	74	55	1
Newton	46	62	78	41	7

Table 6.32.b. Number of respondents stating faeces type as offensive - South Shore of Bristol Channel Survey (2000). ('BLANK' refers to incomplete question response)

Beach	Faeces Type				
	Horse	Human	Dog	Sheep	BLANK
All Beaches	255	368	377	243	11
Berrow	53	93	87	50	0
Minehead	70	74	83	68	4
Weston-super-Mare	31	43	42	31	2
Brean	17	29	27	14	1
Blue Anchor Bay	31	50	51	29	0
Ilfracombe	53	79	87	51	4

Table 6.32.c. Responses to Faeces found on beaches. Number of respondents stating faeces type as offensive - Mid/North Wales Coast Survey (2000). ('BLANK' refers to incomplete question response)

Beach	Faeces Type				
	Horse	Human	Dog	Sheep	BLANK
All Beaches	353	559	624	334	6
Aberdyfi	53	83	87	44	1
Towyn	41	69	82	36	0
Barmouth	57	81	86	57	1
Harlech	38	82	83	37	0
Pwllheli	50	71	84	50	1
Llandudno	41	71	85	37	0
Rhyl	49	58	72	49	3

Participation in Leisure Use of the Sea

The number and percentages of people entering the sea or not on the day surveys were conducted, are shown in Tables 6.33.a and 6.33.b respectively. Around 80% of respondents entered the sea; the two beaches that had the greatest proportion prepared to swim in the sea were the westward beaches of Port Eynon on the Gower, and Whitesands in Pembrokeshire (Tables 6.33.a and 6.33.b). These two beaches are not subject to the same degree of turbid water found in beaches to the east nearer the Severn Estuary. The two beaches that were perceived as 'poor' by the public with regard to debris pollution (Table 6.13.b), namely Sandy Bay and Newton, also had the highest percentage of respondents that did not enter the sea (Table 6.33.b). There would appear to be a link between turbid water and those wishing to enter the sea, and also a link between perceived beach quality and a reluctance to enter the sea.

Table 6.33.a Number of respondents entering the sea. – South Wales Coast Survey (1999)

Did respondent enter the sea?	All Beaches	Ogmore-by-Sea	Sandy Bay	Port Eynon	Whitesands	Whitmore Bay	Rest Bay	Newton
Yes, to swim	253	20	19	**77**	**76**	20	26	15
Yes, to paddle	**359**	**72**	**54**	41	27	**84**	**36**	**45**
No	145	18	31	9	1	32	14	40
BLANK	6	2	1	0	0	0	0	3

Table 6.33.b Percentage of respondents entering the sea – South Wales Coast Survey (1999)

Did respondent enter the sea?	All Beaches %	Ogmore-by-Sea	Sandy Bay	Port Eynon	Whitesands	Whitmore Bay	Rest Bay	Newton
Yes, to swim	33	18	18	**61**	**73**	15	34	14
Yes, to paddle	**47**	**64**	**51**	32	26	**62**	**47**	**44**
No	19	16	30	7	1	23	19	39
BLANK	1	2	1	0	0	0	0	3

When all beaches are considered in totality, approximately 29% of beach users entered the sea to swim, with 49% entering the sea simply to paddle (Tables 6.33.a, 6.33.b, 6.33.c, 6.33.d).

Table 6.33.c Number of respondents entering the sea - South Shore of Bristol Channel Survey (2000)

Did respondent enter the sea?	All Beaches	Berrow	Minehead	Weston-super-Mare	Brean	Blue Anchor Bay	Ilfracombe
Yes, to swim	65	7	14	6	4	11	23
Yes, to paddle	**231**	**56**	**61**	**32**	**24**	**18**	**40**
No	121	39	12	10	4	26	30
BLANK	3	0	2	0	0	0	1

Table 6.33.d Number of respondents entering the sea – Mid/North Wales Coast Survey (2000)

Did respondent enter the sea?	All Beaches	Aberdyfi	Towyn	Barmouth	Harlech	Pwllheli	Llandudno	Rhyl
Yes, to swim	220	17	35	**41**	37	**54**	7	8
Yes, to paddle	**312**	**55**	**40**	40	**39**	30	**44**	**44**
No	123	17	12	7	13	3	38	27
BLANK	4	0	1	1	0	2	0	0

Presentation of Beach Grade

At present the EA/NALG (2000), protocol stipulates a grading scheme for the aesthetic quality of beaches on an 'A', 'B', 'C', 'D' scale, with 'A' representing a clean beach and 'D' equating to a heavily polluted beach. With the multitude of award and rating schemes already in use within the UK (e.g. Green Coast Award, run by Keep Wales Tidy; European Blue Flag etc.) any additional grading system would need to be readily understood if it were to be communicated to the public. To this end, different types of presentation systems were proposed and presented to the public for their views (Table 6.34; see Appendix V for methodology).

Responses from interviewees regarding the preferred form of beach grade presentation is illustrated in Tables 6.35 to 6.37, with the key to the grading type given in Table 6.34. Presentation type F was firmly established in sixth place when rankings are averaged (Tables 6.35 to 6.37). On examination it can be seen that the top four types of presentation are grouped closely together (Tables 6.35 to 6.37). Fifth position is filled by type B, which is the current system used by the Environment Agency in the U.K., and is widely adopted by those utilising the EA / NALG (2000), protocol. At each survey, grading scheme D, which is a system of 'stars', was ranked as being the preferred system of rating a beach with regard to litter.

Table 6.34 Key to Beach Grade Presentation Types in Tables 6.35-6.37

Labels used in Tables 6.35 - 6.37	Types of Beach Grade Presentation			
A	Very Good	Good	Fair	Poor
B	A	B	C	D
C	Grade 1	Grade 2	Grade 3	Grade 4
D	✡✡✡✡	✡✡✡	✡✡	✡
E	Very Clean	Clean	Dirty	Very Dirty
F	Absent	Trace	Unacceptable	Objectionable

Table 6.35. Averaged Rank of rating systems – South Wales Coast Survey (1999). For key see Table 6.34

Grading Scheme	Average Rank Position
[illegible]	2.7
A	2.9
C	3.1
E	3.1
B	3.9
F	5.2

Table 6.36. Averaged Rank of rating systems -- South Shore of Bristol Channel Survey (2000). For key see Table 6.34

Grading Scheme	Average Rank Position
D	2.6
A	2.9
C	3.0
E	3.2
B	3.9
F	5.2

Table 6.37 Averaged Rank of rating systems – Mid/North Wales Coast Survey (2000) For key see Table 6.34

Grading Scheme	Average Rank Position
D	2.7
C	2.9
A	2.9
E	3.3
B	3.8
F	5.4

Beach Importance With Respect to Holiday

Leisure and tourism managers place great emphasis on the beach as a tool for attracting visitors to towns and local businesses. It is therefore relevant to establish how important the beach is to the end user. On a scale of one to five, one meaning 'not important' and five signifying 'very important', interviewees were asked to select how important the beach was to their holiday. The modal amount of respondents quoted that the beach was 'very important' to their holiday, with only 15 interviewees selecting '1' ('not important') from 809 respondents (Tables 6.38 and 6.39).

Table 6.38. Responses to question regarding 'beach importance' - South Shore of Bristol Channel Survey (2000)

Beach Importance	Both Beaches	Blue Anchor Bay	Ilfracombe
1 (not important)	4	2	2
2	4	2	2
3	39	13	26
4	29	10	19
5 (very important)	51	**17**	**34**
Blank	22	11	11

Table 6.39. Responses to question regarding 'beach importance' – Mid/North Wales Coast Survey (2000)

Beach Importance	Beach Studied							
	All Beaches	Aberdyfi	Towyn	Barmouth	Harlech	Pwllheli	Llandudno	Rhyl
1 (not important)	11	1	2	2	2	0	2	1
2	19	2	1	2	2	1	2	4
3	119	23	12	11	9	10	26	16
4	124	21	13	17	23	10	18	15
5 (very important)	**351**	**40**	**57**	**49**	**45**	**57**	**41**	**42**
Blank	36	2	3	8	8	11	0	2

Perception of what constitutes a 'poor' (D grade) beach

An open-ended question was posed, stating: *'How many items of the following would need be present for you to consider this 100m stretch of beach to be described as poor?'* Respondents were required to give answers for 'general', 'gross', and 'SRD' litter forms (defined in Appendix II). The responses were low for the 'general litter' category, once outliers were removed the average figure was only 10.1 (Table 6.40). This is a very low number, especially as almost without exception beaches have a greater amount of litter present than this. 'Gross litter' and 'SRD' received low numbers, these figures would seem slightly more realistic if still lower than the figures put forward in the EA / NALG protocol (Table 5.1.1; Appendix II).

Table 6.40 Number of items needed to be present to describe a 'poor' beach. South Wales Coast Survey (1999)

Litter Group	**General**	**Gross**	**SRD**
Average Response	10.1	2.7	1.1

Would beach users visit a beach that had a certain number of litter items?

Based on figures obtained in earlier questionnaires (Table 6.40), respondents were asked if they would visit a stretch of beach that had a certain number of different litter items present. A modicum of realism became apparent when respondents were asked if they would visit a stretch of beach that had 10 items of general litter present (Table 6.41.a). Almost 35% stated that they would, 44% would not, while 21% were unsure. On every beach studied in the course of this research, except one, there were more than 10 items of 'general litter', and often considerably more (Appendix IVb). The figure of 10 was derived from the average of answers given in the 1999 survey (Table 6.40), but they seem unrealistic at present. This again illustrates the public perception and idealism being different from reality. Under the EA / NALG protocol scheme (EA/NALG, 2000), a beach with 10 items of general litter is classified as an 'A' grade beach, which would appear to a fair assessment due to the widespread and ubiquitous existence of this type of pollution.

Table 6.41.a Responses to question: 'Would you visit a stretch of beach that had 10 'general litter' items?' - Mid/North Wales Coast Survey (2000)

Response	**Beach Studied**							
	All Beaches	Aberdyfi	Towyn	Barmouth	Harlech	Pwllheli	Llandudno	Rhyl
Yes	229	32	29	6	24	**45**	18	27
No	**290**	**36**	**46**	**74**	**40**	28	**51**	**40**
Unsure	139	21	11	8	25	16	20	13
BLANK	2	0	2	1	0	0	0	0

The majority of respondents (81%) stated that they would not visit a stretch of beach that contained three items of gross litter (Table 6.41.b). Three items of gross litter would constitute a 'B' grade using the EA/NALG (2000), protocol, still some way from the 15 required for a 'D' grade beach.

Table 6.41.b Responses to question: 'Would you visit a stretch of beach that had 3 'gross litter' items?'- Mid/North Wales Coast Survey (2000)

Response	**Beach Studied**							
	All Beaches	Aberdyfi	Towyn	Barmouth	Harlech	Pwllheli	Llandudno	Rhyl
Yes	40	6	6	5	4	8	3	5
No	**536**	**72**	**68**	**78**	**74**	**71**	**76**	**64**
Unsure	73	10	14	5	10	8	8	8
BLANK	11	1	0	1	1	2	2	3

The overwhelming majority of respondents (approximately 92%) stated that they would not visit a stretch of beach that had just one item of SRD (Table 6.41.c). One item of SRD equates to a 'B' grade beach following the grading scheme used in the EA/NALG (2000), protocol. Again, respondents were on beaches, or stretches thereof, that contained SRD, but whether they were aware of its existence is debatable. It is admirable that people would not tolerate beaches polluted by such items, but whether this another contradiction in that they *do* visit such beaches, or an over ambitious aim, is open to question.

Table 6.41.c Responses to question: 'Would you visit a stretch of beach that had 1 'sewage related debris' item?' - Mid/North Wales Coast Survey (2000)

Response	Beach Studied							
	All Beaches	Aberdyfi	Towyn	Barmouth	Harlech	Pwllheli	Llandudno	Rhyl
Yes	19	1	2	14	2	4	1	3
No	**606**	**81**	**82**	**75**	**83**	**80**	**85**	**72**
Unsure	25	6	3	0	4	3	2	1
BLANK	10	1	1	0	0	2	1	4

The figures obtained on the south shore of the Bristol Channel were almost identical with results from beaches in mid and North Wales (Tables 6.42.a, 6.42.b, and 6.42.c). Approximately 43% would not visit a stretch of beach with 10 items of 'general litter'; 77% would not go to a beach with three items of 'gross litter'; and, 91% would not if there was one SRD item.

Table 6.42.a Responses to question: 'Would you visit a stretch of beach that had 10 'general litter' items?' - South Shore of Bristol Channel Survey (2000)

Response	Beach Studied					
	All Beaches	Berrow	Minehead	Weston-super-Mare	Brean	Blue Anchor Bay	Ilfracombe
Yes	145	**43**	21	17	**16**	15	33
No	**179**	38	**50**	**19**	11	**21**	**40**
Unsure	90	20	17	12	5	16	20
BLANK	6	0	2	0	0	3	1

Table 6.42.b Responses to question: 'Would you visit a stretch of beach that had 3 'gross litter' items?' - South Shore of Bristol Channel Survey (2000)

Response	Beach Studied						
	All Beaches	Berrow	Minehead	Weston-super-Mare	Brean	Blue Anchor Bay	Ilfracombe
Yes	35	10	4	4	3	4	10
No	**326**	**79**	**70**	**40**	**24**	**45**	**68**
Unsure	52	13	13	3	5	5	13
BLANK	8	0	3	1	0	1	3

Table 6.42.c Responses to question: 'Would you visit a stretch of beach that had 1 'sewage related debris' item?' - South Shore of Bristol Channel Survey (2000)

Response	Beach Studied						
	All Beaches	Berrow	Minehead	Weston-super-Mare	Brean	Blue Anchor Bay	Ilfracombe
Yes	8	2	0	0	1	3	2
No	**385**	**95**	**85**	**46**	**28**	**48**	**83**
Unsure	25	4	4	1	3	4	9
BLANK	3	1	1	1	0	0	0

6.2.3 Summary

Perception of Beach Quality and Beach Management Opinions

Two thousand, seven hundred and twenty six respondents completed questionnaires at 25 beaches. The modal group was female aged 30-39. The majority of respondents were employed and almost universal agreement existed regarding SRD as the most offensive type of pollution. Respondents generally perceived the beach grade to be in line with the actual grade according to the EA/NALG (2000) protocol The overwhelming majority of respondents stated they did not believe dogs should be permitted on resort beaches (82%; n=2242), with 53% (n=1452) stating that dogs should be banned rural beaches. Beach choice was determined by clean sand and water, refreshment facilities and beach award flags were minor considerations. Less than 2% could name any award scheme other than the European Blue Flag. Approximately 29% of beach users entered the sea to swim, with 49% entering the sea simply to paddle. Two beaches rated as poor, Newton and Sandy Bay, both in Porthcawl, had the highest percentages of people who did not enter the sea. The 'star' system of presenting the beach grade was most preferable to the public rather than the current 'A,B,C,D' rating of the EA/NALG, (2000) protocol. Over 90% of people interviewed would not visit a beach with 1 item of SRD; 75% would not visit one with 3 items of 'gross' litter; and 44% stated they would not visit a beach with 10 items of 'general' litter.

Perception of litter items with the use of photographs

Beach user perceptions of various items of commonly found beach debris were assessed with the use of a questionnaire at eight south Wales, UK., beaches during the summer of 1998 (n=883). Photographs of each of 28 debris items were utilised as a visual aid. The perception of particular litter items was virtually universal amongst beach users with the most offensive forms of visual pollution being items that were potentially harmful (e.g. syringe, gas canister) along with items of SRD (e.g. sanitary towels, tampon applicators, condoms). One item of SRD, namely CBS, attained a very low offensiveness rating. The least offensive debris items were found to be of 'natural' origin (i.e. seaweed, driftwood).

The ability to identify certain items was found to be a contributory factor in the level of offensiveness attached to the litter. An average of only 2% of the interviewees correctly identified CBS's. Males incorrectly identified sanitary towels in 29% of instances compared to only 13% of women. Similarly, men incorrectly identified tampon applicators 60% of the time, with 41% of women doing likewise. Chi square statistical tests indicated that women had a significantly higher level of recognition of female sanitary products than males. This difference in awareness of the items identity contributed to lower levels of offensiveness rating by males than females. Items *perceived* to be of potential threat to health provoked a high level of offensiveness from beach users, whether there was any *real* danger or not. The high level of offensiveness attributed to the SRD and potentially hazardous items cements the weighting given to these items within the EA/NALG protocol (EA/NALG, 2000).

7 CONCLUSIONS

Research undertaken in this study has resulted in a number of key findings concerning beach litter. Various aspects of beach litter were investigated, each one helping to piece together the holistic approach that is required in dealing with this type of pollution. A multi-disciplinary approach was utilised investigating abundance, types and distribution of litter on beaches, along with assessment of the public perception of aspects of marine debris and their viewpoints of various aspects significant to the coast. The disparate portions of litter research examined in each chapter help to piece together the whole 'system' that one must view the litter pollution problem. A loop exists which starts with people (in their homes/at the beach/working offshore etc.), who are the originators of debris, these items are transported via rivers or by oceanic processes and ultimately end up on the beach. This loop is completed by those people who use and visit beaches (tourists/visitors etc.) and those that use the sea (recreational boaters/fisherman/merchant seaman etc.) and who are ultimately affected by the adverse properties of this form of pollution. This research has pulled together the numerous parts of this loop by covering the various sources of litter, the different transport pathways that exist, quantification of litter on beaches, and finally the views and perceptions of beach users.

Pocket beaches should be treated differently to linear beaches with respect to litter surveys. The latter can be subjected to differentiation of the beach by transects - usually assumed to be three in number - with some degree of success, although the number of transects should reflect the overall size of the beach. Pocket beaches need to be considered as a whole and their relative small size allows them to be surveyed in their entirety. The use of small size transects can lead to misrepresentation of the true picture of the beach condition. Litter on a beach acts in much the same way as sediments, especially in the case of a cobble beach (Tresilian Bay). Differing distribution patterns experienced across a beach (Tresilian Bay) over a five year period is to be expected, and this confirms the notion that a whole beach survey is appropriate on beaches such as these.

As with many other world-wide litter studies, plastics were the most numerous litter items found. Additionally, polystyrene made up a large proportion of the litter, although problems do exist with counts of this material. Polystyrene readily breaks down into small pieces, often resulting in huge numbers of individual fragments which can imbalance the results of a litter study as well as proving hazardous to bird life. The small amount of glass found on the beach is indicative of the reduction in use of this material in preference to plastic. Also, pebble beaches break down glass which makes it difficult to find in the voids between the pebbles.

'Pre clean up' (PCU) surveys of beaches revealed the beach standing stock, with 'after clean up' (ACU) surveys giving accumulation rates. In this study, time intervals between Tresilian beach surveys, carried out in spring, was *circa* two weeks, i.e. consecutive spring tidal cycles. The amount of litter standing stock over a five year period decreased from 1,689 in 1994 to 1,040 in 1998 - a 38% decrease. Whether this is indicative of a reduction in the amount of waste reaching the sea from rivers and beaches and subsequently washing ashore can be confirmed in time, as only very long term monitoring can answer this question. The level of re-accumulation of litter on the beach from the PCU to ACU varied from year to year, being 19% in 1994 and 46% in 1998. The litter amount for the PCU survey at any one time is *at most* five times that of the subsequent ACU survey. This indicates that the litter found was simply in transit, that is, it is on a pathway and has not yet arrived at a sink.

The use of beach clean ups is a short sighted, temporary cure to the litter problem and can only be justified in areas of high tourism income, and with the current absence of an effective solution to this form of pollution. However, beach cleans can serve as instructive exercises where members of local communities are involved. Over the five year experimental period at Tresilian, removal of all beach litter and assessing litter inputs after a spring tidal cycle, showed the inadequacy of such clean ups as the litter problem is not solved by such means. Litter cut off at *source* is the only real answer.

No significant statistical difference was found between litter data collected by different survey groups. Results did not highlight any differences in the *correct* identification of individual items of marine debris. For example, cotton bud sticks have been known to be misidentified as drinking straws. This was partially borne out in the one misrecorded instance at Tresilian Bay. Correct identification of litter plays a very important role in data collection for beach debris surveys. If a plastic bottle is recorded simply without reference to its markings or original contents, then a vital information link is left missing. Possible sources, whether geographical or socio-economic, can only be established for certain litter items with the maximum amount of detail. The plastic bottle could have contained an alcoholic or soft drink or engine oil, all with potentially different sources. Many surveys (e.g. Coastwatch UK; Beachwatch) give data recording sheets to their field workers which have pre-defined categories of waste. This *can* possibly lead to misidentification or misallocation of litter if the categories are not well defined in instruction sheets or adequate training is not given. This ultimately leads to incorrect sourcing of debris and therefore targeting of the wrong groups in order to help prevent further pollution. What is of most concern was the misidentification of potentially hazardous items of litter. Careful instruction on this point is therefore necessary when selecting volunteers for such work.

Replication of results can be achieved between groups of people, which is invaluable when considering large scale surveys. In this study surveyors were university students. Whether other socio-economic groupings would produce different results requires further investigation. In addition, the beach substrate is a factor which needs careful consideration. Beaches composed of pebbles tend to allow smaller litter items such as plastic pellets and cotton bud sticks to move downward between the voids, thus preventing easy discovery and recording. Such small items are more readily encountered on sandy beaches. Whether data collection replication is achieved on sandy beaches, where there are higher proportions of visible micro-litter, is uncertain and demands extended research.

This study has further compounded the evidence that beaches will soon be inputted with litter even after complete clearance. Average litter re-accumulation levels found by colour coding fresh litter between spring tidal cycles in a winter study, were found to be considerably lower than previously recorded on the same beach in spring surveys mentioned above (165 litter items compared to 558). This emphasises the fact that litter clearance of a beach is purely a temporary measure that does not cure the problem, i.e. litter must be cut off at *source*. This discrepancy helps to illustrate the fact that any systematic monitoring regime should ideally encompass as many seasonal periods as is possible.

There was a correlation between fresh litter inputs to the beach and wind speed, i.e. wave energy. These new inputs consisted of sea borne and exhumed litter. The importance of burial and exhumation of litter on cobble beaches has been highlighted. Debris items previously considered to be new inputs to the beach may only be litter that has been buried on a previous occasion and exhumed. On one such survey, 39 out of 209 items were exhumed from the Tresilian cobble ridge. As with almost all studies conducted on marine debris the dominant litter material was plastics, with beverage containers making a very significant contribution to the composition. Land based sources were considered to be the dominant input at this beach. These plastic drink bottles accumulated more readily on the beach surface than did other litter items. This was especially so with regard to larger (≥500ml) bottles. Litter size is important in that items larger in size than the surrounding cobbles will be exhumed in accordance to the Bagnold (1968) and Middleton (1970) theories. Smaller litter items were apparently more predisposed to remain buried for longer. Litter found in pits dug into the cobble ridge was typical of litter found at the beach surface, the only difference being that the items were small in size. The level of burial and subsequent exhumation is dependant on several factors, such as beach aspect, cobble amount, debris size, wave energy, etc. From this Tresilian beach study, it has been established that a proportion of what appears at the beach surface as a potential new input from the sea, may be litter that has been exhumed.

Twenty two beaches were investigated along the Welsh coast and southern shore of the Bristol Channel, with regard to establishing thresholds in measurement terms. Methodological procedures followed the EA/NALG (2000) protocol. This involved taking 100m stretch of beach, counting litter items according to 7 distinct categories and grading the beach. Minimal area curves were used to indicate the proportion of litter categories that occurred within this distance. In addition, similar analysis was undertaken on the long (3km) linear beach of Merthyr Mawr-Newton at

6 distinct points. In addition, litter at various down beach positions were enumerated. Results indicated:

- **Transect widths / Species Area Curves**. For a long 3km uncleaned stretch of beach, 80-90% of litter genus categories were found within 25m of the 100m stretch of investigated beach. For four cleaned beaches, this figure was 80-100%. Results illustrated that an overwhelming majority of the information regarding litter 'types' can be attained within a relatively small transect. For comparisons to be made, surveyors must ensure that whatever transect or survey size is utilised, it remains consistent. For unusual, large, or rare items then a 100m, or even longer, study area maybe required before such items are encountered.

- **Litter location within beach transects**. Litter below the strandline composed *circa* 1% of all litter found on 21 beaches. It is proposed that litter counting on a beach stops at the current high water strandline.

- **Beach grading**. This was carried out at one long (3km) beach stretching between Merthyr Mawr and Newton. The beach was subdivided into six sections 0.5km distance apart. Results indicated a large variation in beach grading (B-D) together with litter abundance ranging from 201 to 1,525 items of litter/100m stretch. On such long beaches, a single figure survey point is *not* to be recommended.

With regard to sourcing, PCA analyses indicated extremely strong outliers at Berrow, Hartland Quay and Merthyr Mawr beaches. This could well be due to the very high litter numbers of certain items occurred compared to other beaches. Taking these out of the analysis produced two other outlier groups, namely Freshwater West and the River Ogmore/Merthyr Mawr. Comparisons between site and litter type PCA plots illustrated similar orientations between litter groupings and specific sites. For example, Freshwater West was associated with fishing and shipping source groups. Similarly, Merthyr Mawr and the River Ogmore sites were associated with riverine source items. Weston, Brean and Sand Bay, all located near each other in the inner Bristol Channel, were also grouped closely together, showing a similarity in types and/or abundance of litter. Cluster analysis extended this grouping to include most of the southern shore beaches, indicating a difference with the northern shore. Reasons for this could be that the northern shore is a heavily industrialised and urbanised region. Also, it has a high energy coastline facing the prevailing south westerly winds, which result in the coastline experiencing higher wave energies. The southern shore is basically an agricultural and tourist region with many large, wide, sand beaches. PCA analysis with regard to litter types showed very distinct groupings, i.e. shipping, fishing, SRD, and riverine litter items. Beach user groupings were not well developed, possibly as a result of different transport mechanisms. Cigarette stubs interestingly plotted out as a distinct entity on PCA figures and these are an obvious beach user litter item. This was illustrated in particular by introduction of litter results from four Turkish beaches. These beaches together with the UK roadside litter survey illustrated high levels of a land based litter source. These can be compared with the many diverse source inputs for the Bristol Channel. Qualitative and quantitative similarity coefficients proved less informative than PCA. Litter source 'markers' proved inconclusive and further research is needed on this topic.

A total of 25 surveys were carried out to establish public perception of various aspects of beach litter between 1998 and 2000. Two thousand seven hundred and twenty seven people were interviewed regarding their opinions, views and perceptions of coastal pollution and related beach management issues. This large sample size helps to provide a robust and clear picture of the attitudes of beach users visiting a geographical spread of beaches along the Bristol Channel coast. Other beaches outside the Bristol Channel area were also studied as 'added value' and to serve as a comparison. The Bristol Channel is a unique marine/estuarine environment, and results encountered may be different to those witnessed in other parts of the UK.

The majority of respondents were employed people, with the modal group being females aged 30 to 39. Sewage related debris was perceived to be the most offensive type of pollution, with the presence of oil also proving universally unacceptable. The determining factors for beach selection were 'clean sand', and 'clean water', with parameters such as 'refreshment kiosk' and a beach award being least important. A vast majority of interviewees (82%) felt that dogs should not be allowed on resort beaches during the summer months, with 53% concurring for rural beaches.

Recognition and awareness levels of beach award schemes was found to be poor. Approximately 48% of interviewees stated they were aware of such schemes, with 27% specifically naming the European Blue Flag scheme. Fewer than 2% of respondents were able to name any other award scheme apart from the European Blue Flag. It appears from this study that little attention is paid to these award programs by the public, particularly when it comes to decisions regarding beach use.

Beaches that were perceived by the public to be 'poor' from a litter pollution standpoint, also experienced the largest proportion of beach users unwilling to enter the sea. A link was evident between perception of a polluted beach and a willingness to participate in leisure activities in the sea. In total, approximately 29% of beach users entered the sea to swim, with 49% entering the sea simply to paddle. Over 90% of people interviewed stated they would not visit a beach with 1 item of SRD; 75% would not visit a beach with 3 items of gross litter. These results contradict the presence of people at beaches studied, where almost without exception, they contained at least one item of SRD. Whether respondents were aware that such items existed on the beach they were currently visiting was unclear. When asked to grade the beach on a scale used by the Environment Agency (EA/NALG, 2000), results were generally in agreement.

The general public's view of specific debris items on beaches was consistent. Potentially hazardous items, such as a syringe, along with items of SRD, were found to be the most offensive forms of litter, with the least offensive items being those of a 'natural' nature - driftwood and seaweed. This was the case for all eight beaches studied along the south Wales coast. The high level of offensiveness attributed to SRD and potentially hazardous items cements the weighting given to these items within the EA/NALG (2000) protocol.

Items are often considered offensive because of a perceived health hazard, rather than there actually being any real danger. This perception is very relevant to beach users and its importance cannot be ignored. If there is the perception that a beach is heavily polluted, or contains items that pose a threat to health or induce a feeling of discomfort, then this can lead to a loss of tourists and subsequent financial implications.

The lack of recognition of certain items of SRD is of concern with respect to people's viewpoints as to what litter is present on a beach. It was found that: only 2% of respondents correctly identified CBS; 40% of men and 59% of females identified tampon applicators; 71% of men and 87% of females correctly identified the sanitary towel. Chi square analysis indicated that women had a much higher recognition level of the latter two sewage items enumerated above. This is not unexpected, but greater levels of education are needed amongst both sexes to alert them as to what litter is present on beaches. Only with this knowledge can larger strides be made in the effort to prevent the public using their toilet as a 'wet bin'. This will consequently lead to reductions in such items reaching beaches, by cutting off this aspect of litter at *source*. This is the ultimate aim of *all* litter prevention scenarios.

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Appendices

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Appendix I

Background detail of beaches studied

Beaches Studied

Beaches of the South Shore of the Bristol Channel

1. Hartland Quay, Devon (SS 222 247)

With regard to this study, this beach represents the western limit of beaches covered on the southern shore of the Bristol Channel. A hotel and small shops sit above this beach, which was the site of a former quay. The inaccessible location and lack of facilities results in this beach receiving very few visitors. This is a pocket beach, (*circa* 150m in width), backed by a large pebble ridge surrounded by very steep cliffs.

2. Westward Ho!, Devon (SS 435 295)

Westward Ho! is a tourist town with many guest houses, holiday homes, caravan parks, shops, pubs and restaurants. The beach is a stretch of flat sand backed by a pebble ridge and country park. There are car parking and toilet facilities nearby. The whole beach is popular for surfing, canoeing and other water sports (British Resorts Fact Pack, 2000).

3. Croyde Bay, Devon (SS 435 395)

Croyde Bay is small compared to the other resorts in North Devon, e.g. Putsborough. Even so it is a very wide beach (*circa* 100m at low tide and extends for >1km). It has a sand substrate and is backed by dunes and the village of Croyde. The village contains many places to eat, buy gifts and hire beach equipment including surfboards as Croyde Bay is one of the best surfing beach's in North Devon. There are numerous camp sites and car parking areas near the beach.

4. Putsborough, Devon (SS 445 408)

This is a very picturesque beach that lies between the village of Croyde and the small town of Woolocombe. The beach has a large rocky headland at one end, with the other stretching out towards Woolocombe. The large expanse (>4km to Woolocombe) of golden sand has some large rocks protruding through the surface and a small pebble ridge occurs at its rear. There is a small refreshment kiosk and car park above the beach together with a large hotel at the top of the cliff behind the beach. The beach is popular for water sport activities.

5. Woolocombe, Devon (SS 454 437)

This beach is backed by a car park and the small coastal tourist town of Woolocombe, which has a mix of pubs, restaurants and shops. The beach is accessed down steps from the town streets or from Putsborough to the west - see above. It consists of sand backed by rolling hills owned by the National Trust.

6. Ilfracombe, Devon (SS 515 475)

Like Weston-super-Mare, Ilfracombe is a traditional British seaside resort. The town contains numerous guest houses and hotels, and is full of café's, shops, pubs and 'take aways'. The town has more than one beach, although none are heavily used. The beach covered in this study sits within the harbour area and is surrounded by shops and food outlets. The harbour contains small pleasure crafts, and also has visits from large pleasure craft which bring visitors from south Wales or from further east along the coast.

7. Combe Martin, Devon (SS 585 465)

This sandy pocket beach sits within a small inlet, flanked by headlands and backed by the small village of Combe Martin. A small river flows at one edge of the beach. The area behind the beach includes a small car park and toilet, together with shops and food outlets.

8. Lynmouth, Devon (SS 725 495)

The small village of Lynmouth is a popular tourist destination for day trippers, but the beach is not used intensively. The beach consists of large revetment rocks and pebbles and sits adjacent to the harbour entrance, which can only accept small vessels. The River Lyn flows through the village and meets the sea forming a delta near the beach.

9. Minehead, Somerset (SS 980 465)

This large sand beach runs parallel to a road with car parking spaces and to shops, food outlets, toilet facilities and amusement arcades. There is a large Butlin's holiday resort to the east of the town, which is only across the road from the beach. The beach depth is circa 50m and extends >1km. The beach is artificial as a result of nourishment.

10. Dunster, Somerset (ST 001 450)

Dunster beach stands at the western end of a large stretch of beach which continues eastwards (> 4km) to meet with Blue Anchor Bay. There is a small stream cutting across the centre of the beach. The beach is backed by a car park, which houses a refreshment kiosk, and a caravan park. The beach is a mixture of pebbles and grits with an extent at low tide of *circa* 1km.

11. Blue Anchor Bay, Somerset (ST 025 435)

The beach at Blue Anchor Bay is a sand and pebble beach backed by large red sandstone cliffs. A pub/hotel sits overlooking the beach at the top of the cliff. There are no facilities at the beach as such, although a caravan park and refreshment vans are not far away. Large scale erosion in this bay has necessitated a big expenditure on coastal defence structures e.g. concrete sea walls, groynes, revetments etc.

12. Berrow, North Somerset (ST 292 517)

The beach at Berrow is a very long (> 5km to Brean) stretch of sand, backed by sand dunes. Unusually, access from the town to the beach is on a road through the dunes and cars are permitted to park on the beach. In summer, 'Take away' food vans and ice cream vans are situated on the beach. The toilet facilities are at the entrance of the access road some 500m behind the beach. Berrow town hosts many caravan parks, food and drink outlets, an amusement park and other tourist related businesses, as a result the beach is very popular with visitors in the summer months. The tidal range for this beach and the remaining ones on the southern shore is macro, resulting in an extent of beach at low tide of >1km at low tides.

13. Brean, North Somerset (ST 296 561)

Brean is at the eastern end of the same coastal stretch of beach as Berrow. This 10km long sand beach stretches from Burnham-on-Sea to Brean Down. Like Berrow, cars are permitted onto the beach, but there is no long access road through dunes. The beach is backed by a long (>1km) rock revetment structure and dunes. The beach is not as popular as Berrow, but is close to the Berrow facilities. There are toilet facilities at the access point to the beach. Some of the caravan parks have direct access to the dunes and beach.

14. Weston-super-Mare, North Somerset (ST 314 616)

Weston-super-Mare, one of the largest coastal Victorian resorts in the West Country, is a traditional coastal tourist town that has attracted visitors for many decades. The town has a pier and many attractions around the beach and has two distinct beaches. The beach covered in this study is a very long (>1km) sand beach, with the promenade directly backing on to it. There is car parking, a tourist information centre, toilets and shops all in close proximity and donkey rides on the beach. Much of the beach is a dog free zone during the summer season.

15. Sand Bay, Weston-super-Mare, North Somerset (ST 330 648)

Sand Bay lies north of Weston -super-Mare around a headland. It is a very long sand beach, a number of kilometres in length. At low-tide, very large mud flats are exposed. A small road runs parallel to the beach on which a café and other food and tourist outlets can be found. There is also a small car park near the beach centre which has toilet facilities. The beach does not experience large numbers of visitors due to its position away from the main link roads.

Beaches in Wales

16. Whitmore Bay, Barry Island, Vale of Glamorgan (ST 115 663)

The beach is predominantly composed of fine grained sand, faces south to the Bristol Channel and has a surface area of 200,000m^2. It is 800m long and 250m wide to low water. The resort has a highly developed commercial and tourist hinterland, including a residential holiday camp, funfair, amusements, shops, public houses and night-clubs. Barry Island is a popular destination for holiday makers, day trippers and locals. Tourism is very important to the area, the beach attracting 850,000 people during 1994, providing 13.4% of the employment sector (VOG, 1996).

17. Tresilian Bay, Vale of Glamorgan (SS 945 679)

See Chapter 4, preamble.

18. Dunraven Bay, Southerndown, Bridgend (SS 885 730)

This is the main recreational 'honeypot' beach of the Glamorgan Heritage Coast and is a large (300m) wide sand beach backed by a large pebble storm beach. The enclosing cliffs are composed of Lias limestone on the west and central areas together with a large headland of Carboniferous limestone blocking eastward longshore movement. It houses the headquarters of the Glamorgan Heritage Coast ranger service. All beaches in Bristol Channel region are macro-tidal.

19. Ogmore - by -Sea, Bridgend (SS 860 750)

This beach is another of the 'honeypots' of the Glamorgan Heritage Coast, along with Dunraven Bay, Col-huw and Nash Point. The coastal environment along the Glamorgan Heritage Coast has been described as one of the most aggressive in the temperate zones (Grimes, 1986). The beach is backed by a large car park and lifeguard station. It has toilet facilities but no permanent café, it does though have ice-cream vans in the car park around the summer period. The beach is a mixture of sand and rocks and is a series of small bays. The beach is separated from Traeth -yr -Afon beach and the Merthyr Mawr sand dune system by the River Ogmore.

20. Traeth-yr-Afon (Merthyr Mawr), Bridgend (SS 858 762)

Merthyr Mawr beach (Traeth-yr-Afon) is an extensive sandy beach situated at the western end of the Glamorgan Heritage Coast. Merthyr Mawr beach is separated from the rest of the Heritage Coast by the River Ogmore. The area is partly estuarine with an open sea fetch on a 240 degree bearing, with a tidal range of around 6m. There are strong prevailing south westerly winds, which can reach up to 50 km per hour, that drive robust waves. Longshore and subsequent debris movement is from west to east (Simmons and Williams, 1993). The beach is backed by a large dune system, that covers an area of 250 hectares. The large tidal range in this area allows for exposure of great areas of sand, which upon drying allow for the formation of the dunes. Merthyr Mawr beach is relatively inaccessible, especially compared with other beaches in its vicinity.

21. Newton, Porthcawl, Bridgend (SS 839 768)

Newton Beach lies at the western end of the long stretch of sand (3km) that includes Traeth -yr - Afon (Merthyr Mawr Beach) at its western extremity. The sand beach is backed by a small pebble ridge and small scale revetment structures, as well as 4 stone groynes. The beach is backed by a small car park and shelter. Nearby is a small public house and an entrance to the Trecco Bay caravan park. The beach is a very popular location for wind surfers.

22. Sandy Bay, Porthcawl, Bridgend (SS 823 766)

Sandy Bay (some 200m in width and 100m in depth at low tide) is a popular tourist and day visitor beach. The beach is dominated by two prominent features: the long harbour/sea wall acts as a boundary at the western end of the beach, and directly behind the beach lies the 'Coney Beach Pleasure Park', a fairground and amusement attraction. The close proximity of this well known south Wales visitor attraction results in many day trippers visiting the beach as well as the holiday makers that stay in the Sandy Bay and Trecco Bay caravan parks, adjacent to the fairground. There are donkey rides, trampolines and other small attractions on the beach itself. The fairground has both rides and also many refreshment, fast-food and tourist stores within it.

23. Rest Bay, Porthcawl, Bridgend (SS 803 775)

This is sited to the west of Porthcawl, a small coastal resort town located on the south Wales coastline. It is a large sandy (3-400m) beach which has been granted Blue Flag status and a Tidy Britain Group Resort Beach Seaside Award in 1999. Low reefs of Carboniferous limestone flank the beach and it is one of the main recreational beaches in the area.

24. Langland Bay, Gower, Swansea (SS 607 872)

Langland Bay is a pocket beach (*circa* 100m in length) flanked by Carboniferous Limestone headlands, situated in an intensively used stretch of Gower coastline. The beach is backed by chalets, tennis courts and a car park, with the western headland housing a golf course. The bay also supports a café and other small retail premises. Langland is well known for its excellent surf and ideal conditions for water sports. Water based activities which take place include surfing, bathing, canoeing, wind-surfing and recreational fishing. There are two unique features to Langland Bay - the rows of green beach huts that are leased for the season by Swansea City Council and the large mock-gothic mansion that looks out over the sea from the middle section of the beach.

25. Oxwich Bay, Gower, Swansea (SS 510 872)

The 300ha. Oxwich National Nature Reserve established in 1963, is part of this bay which extends for > 3 km. Post Pleistocene sea level rise reworked sand deposits were moved shoreward to form a beach/dune system which developed as a series of parallel sand waves increasing in height landward. It is a pocket beach flanked by stabilised dunes, the bay itself is the second largest on the Gower Peninsula. Military exercises during World War II seriously damaged the dune vegetation, which did not recover until the mid sixties. Management objectives have been dune stability and diversity, and allowing access for recreation. There is a large car park, hotel, toilet facilities, refreshment kiosks and an information centre located at the rear of the bay's main car park.

26. Port Eynon, Gower, Swansea (SS 473 852)

The Gower Peninsula extends some 30km., and amongst many beautiful beaches is Port Eynon. The village contains some small tourist shops, a car park and toilet facilities. The beach also has small sand hills between it and the village. The once wide (*circa* 500m) stretch of sandy bay has now receded drastically behind newly revealed rocky outcrops that had not been exposed since Prehistoric times.

27. Pendine Sands, Carmarthenshire (SN 243 077)

This is an extremely large (several kms. in length) expanse of sand beach which can extend seawards > 400m. It has extensive small scale coastal protection abutting against the land, comprising block revetments and groynes. The beach lies at the mouth of the Tywi river and land use in the hinterland consists mainly of agriculture.

28. Wiseman's Bridge, Pembrokeshire (SN 146 061)

The rocks surrounding this pebble/sand beaches comprise Coal Measure and Millstone Grits, specifically the shales of the Lower Coal Series. A hotel and associated small car park is located on a bluff occupying the central portion of the beach. Coastal protection is provided by a large block revetment stretching several metres in height from the beach to the top of the bluff (*circa* 7m), and extending some 150m.

29. Saundersfoot, Pembrokeshire (SN 143 054)

This large, south east facing beach is one of the most popular stretches of coastline in Pembrokeshire. The beach is sandy and is approximately 4 km in length at low tide (Young *et al.*, 1995). Although now a major holiday resort, Saundersfoot developed initially as a harbour for the export of locally mined coal in the 19th and early 20th centuries. Many shops, restaurants, and other outlets relating to the tourist industry are based directly above the beach. Holder of a Tidy Britain Group Resort Beach Seaside Award and an EU Blue Flag in 1999.

30. North Beach, Tenby, Pembrokeshire (SN 135 005)

Tenby is Pembrokeshire's main holiday resort, and its beaches reflect this - plenty of facilities and often crowded. North Beach consists of a sweep of golden sand, with occasional rocks, including the prominent Goskar Rock, dotting the beach. It extends to >400m in length and a width of >50m. It is backed by the harbour and castle at the southern end. There is a promenade above the beach all the way from the harbour to the cliffs at the north end. The beach is also backed by food and other retail premises. The southern end of the beach is well sheltered from Pembrokeshire's predominantly south westerly winds (Alderson, 1993). Holder of a Tidy Britain Group Resort Beach Seaside Award and an EU Blue Flag in 1999.

31. South Beach, Tenby, Pembrokeshire (SN 130 000)

Less commercialised and much larger than North Beach, South Beach stretches in a long sweep of sand for 2kms from St. Catherine's Island to Giltar Point. It is backed by The Burrows, a large area of vegetated sand dunes. At low tide it is possible to walk along the beach to St. Catherine's Island.

32. Freshwater West, Pembrokeshire (SR 882 998)

Another impressive sweep of golden sand, backed by dunes, and with cliffs at either end of the 2km. beach, Freshwater West is one of Pembrokeshire's 'wilder' beaches. At high tide most of the sand is submerged so that all that remains is the ubiquitous pebble and shingle bank, whilst at low tide the remains of a 6000 year old drowned forest can sometimes be seen some several hundred metres from the coastline. There is little bathing at this beach as not only are there strong currents, but the beach is pounded by the biggest waves in Pembrokeshire and has the additional hazard of quicksand.

33. West Angle Bay, Pembrokeshire (SM 852 032)

Angle lies within the Milford Haven and as a result is susceptible to direct inputs of shipping debris. It is a sheltered sand and rock cove and is approximately 250m long. It is a enclosed by two headlands, and has good views of St. Ann's Head and of the passing shipping traffic. There are café and toilet facilities, as well as a nearby caravan park.

34. Broadhaven, Pembrokeshire (SM 859 136)

This is a very large expanse (>2km in length and *circa* 0.4 km. at low tide width) of sand beach surrounded by the western exposure of the Lower Coal Measures. The beach is backed by a small revetment which protects the main road and small town of Broadhaven. The area behind the beach consists of guest houses, hotels, and small shops.

35. Nolton, Pembrokeshire (SM 855 185)

Nolton is a small, sand substrate, pocket beach consisting mainly of cobble size material, and is flanked by lower Palaeozoic rocks. Several houses are located at the back of the beach.

36. Whitesands Bay, St. David's, Pembrokeshire (SM 732 268)

One of the most popular beaches in Pembrokeshire, Whitesands is a large, (*circa* 1km in length), sandy beach enclosed by prominent headland, which can become very busy with holidaymakers in the summer. The beach is also popular with recreational water users, especially surfers and sail boarders as well as sea anglers on the headlands. It is exposed to the prevailing westerly and south westerly winds. Part of the sand dunes, which remain at the centre of the beach, have been converted to a car park that has a cafeteria and toilets. The city, and tourist centre, of St. David's is some 5km. away, otherwise Whitesands is completely rural. Holder of a Tidy Britain Group Resort Beach Seaside Award and an EU Blue Flag in 1999.

37. Poppit Sands, Ceridigion (SN 153 487)

This beach consists of a lifeguard hut and an extensive area of sand, more than several hundred metres in extent at low tide. It is located on the Teifi estuary and the rear of the beach is flanked by sand dunes. There is a café and souvenir shop with car park. Being close to Cardigan (3km.), it is a popular beach and is busy in summer. It faces north east, which gives shelter from the prevailing south westerly winds.

38. Mwnt, Ceridigion (SN 193 519)

This is a small (*circa* 100m.), pocket beach composed of fine grain sand, which is enclosed by near vertical cliffs. Only one entrance exists to the beach via a steep pathway and no habitation exists within the bay.

39. Aberdyfi, Gwynedd (SN 606 958)

This beach sits on the banks of the river Dyfi, near its mouth. The beach has sand dunes at part of its rear and a wall and car park at the other end. The village contains some small café's and shops. There is a quayside and yachting club at the town end of the beach. The site is popular with windsurfers and other boating activities.

40. Towyn, Gwynedd (SH 963 802)

This long sandy beach has many groynes adjacent to the concrete sea wall. It is a popular beach with a promenade running parallel along the beach length. The promenade contains some shop and food outlets. A car park is located behind the central area of the beach. The beach width is *circa* 400m at low tide.

41. Barmouth, Gwynedd (SH 609 157)

Another long sandy beach which continues some 20km. to Harlech, having a huge expanse (>4km) of sand extending from the edge of the usable beach to low tide mark. Dunes commence at the northern extremity of the beach and these run along the coastline until they meet the Lleyn peninsula. The area is dominated by a large sand bar that extends from the river mouth. There is the usual mix of tourist shops and food and drink premises in the area behind the beach.

42. Harlech, Gwynedd (SH 570 312)

Harlech, is a very undeveloped and picturesque beach, with a sandy substrate and large dunes backing it. There is a short inclined walk to the beach from the car park through the sand dunes, a distance of some 200m. There are toilet facilities in the car park, and a shop around half a mile further up the access road towards the main highway. The beach is similar to the dune region of Barmouth.

43. Pwllheli, Gwynedd (SH 372 341)

A linear beach composed of pebble/shingle and sand, with a car park just behind some small dunes and vegetation at the rear of the beach. The tidal range is circa 50m. Pwllheli is situated on the Lleyn Peninsula in north Wales and is a small tourist centre. There are few shops or other amenities near the beach. It has a Blue Flag and Seaside Award.

44. Llandudno, Conwy (SH 783 827)

This is one of the oldest, grandest and most famous tourist resorts of the North Wales coast. The large 5km. sweep of the bay is backed by a wide promenade and many hotels and guest houses and is sheltered by two great headlands. A 120 year old pier at the west end of the beach houses amusement arcades, food and tourist shops. There is a slipway at the west end of the beach. Large amounts of seaweed and rocks are exposed at low tide. The beach extends to a width of some 50m at low tide.

45. Rhyl, Denbighshire (SJ 002 822)

This is another large tourist centre along the north Wales coast. Rhyl has seen much investment in recent times and attracts visitors from the Midlands and North-west of England. The sand beach is long (many kms.), is very deep in width at low tide (*circa* 1km.) and has several small groynes. Steps at the rear of the beach lead to the promenade. The long promenade, and the streets opposite, house numerous shops, guest houses, food retailers, amusement arcades, rides and shows.

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Appendix II

Environment Agency/National Aquatic Litter Group Protocol (EA/NALG, 2000)

Assessment of Aesthetic Quality of Coastal and Bathing Beaches

Monitoring Protocol and Classification Scheme

ENVIRONMENT AGENCY
and
THE NATIONAL AQUATIC LITTER GROUP

ASSESSMENT OF AESTHETIC QUALITY OF COASTAL AND BATHING BEACHES

MONITORING PROTOCOL AND CLASSIFICATION SCHEME

MAY 2000

Appendix III

Description of Litter Sources

Description of Litter Sources (Earll *et al.*, 1999)

- **Tourism (beach users)**: Examples would include large number of sweet, crisp and ice cream wrappers, soft drinks containers (plastic and aluminium) beach equipment, spades, clothing, sun tan oil, etc.

- **Sewage related debris**: The plastic products, which are routinely flushed down the toilet, include cotton bud sticks, condoms, disposable panty liners and plastic tampon applicators.

- **Fly-tipping – land**: Deliberate dumping of wastes including building waste, large domestic objects, car repair and servicing and DIY.

- **Land and (urban and rural) run off**: The debris that would be washed off the roads and into drains and subsequently rivers, including sweet / crisp wrappers, soft drink containers, car parts. Rural run off includes items such as agricultural products (e.g. feed bags, wire, bailer cord etc.)

- **Offshore installations**: Products of commercial and galley operations offshore and maintenance work.

- **Shipping:** pallets, tyres as fenders, large oil drums, domestic and industrial plastic containers, cloth, water-proof fabrics.

- **Fishing related debris**: Net, lines, floats, lobster pots – materials used by the industry to catch fish and run their vessels.

Appendix IVa

Eigen Analysis Data for Litter Sourcing

CONTENTS OF APPENDIX IVa - Eigen Analysis Data Used For Litter Sourcing

06/02/01 13:14:59

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Welcome to Minitab, press F1 for help.
Saving file as: A:\BEACHES.MPJ
```

Principal Component Analysis: SRD, FRD, UPF, DRD, FOOD, HOUS, DIY, PACK, MISC, G

Eigenanalysis of the Covariance Matrix

Eigenvalue	36865	4211	1797	259	146	62
Proportion	0.849	0.097	0.041	0.006	0.003	0.001
Cumulative	0.849	0.946	0.988	0.994	0.997	0.998

Eigenvalue	41	30	2	0	0	0
Proportion	0.001	0.001	0.000	0.000	0.000	0.000
Cumulative	0.999	1.000	1.000	1.000	1.000	1.000

Variable	PC1	PC2	PC3
SRD	0.863	-0.269	0.331
FRD	-0.005	0.769	0.593
UPF	0.413	0.529	-0.725
DRD	0.090	0.165	0.097
FOOD	0.272	-0.020	0.026
HOUS	0.001	0.011	0.038
DIY	0.004	0.007	-0.003
PACK	0.025	-0.004	0.029
MISC	0.049	0.167	0.008
GROS	0.000	-0.000	0.008
HARM	0.000	-0.003	0.002
FAE	0.001	-0.001	0.001

Plot COMP_2 * COMP_1

Plot COMP 2 * COMP 1

Plot COMP 2 * COMP 3

Plot COMP_2 * COMP_3

Plot COMP_2 * COMP_3

Principal Component Analysis: SRD, FRD, UPF, DRD, FOOD, HOUS, DIY, PACK, MISC, G

Eigenanalysis of the Correlation Matrix

Eigenvalue	4.9476	2.5939	1.6666	1.0939	0.6045	0.4818
Proportion	0.412	0.216	0.139	0.091	0.050	0.040
Cumulative	0.412	0.628	0.767	0.858	0.909	0.949

Eigenvalue	0.3630	0.1275	0.0720	0.0402	0.0069	0.0021
Proportion	0.030	0.011	0.006	0.003	0.001	0.000
Cumulative	0.979	0.990	0.996	0.999	1.000	1.000

Variable	PC1	PC2	PC3	PC4
SRD	0.413	-0.089	-0.191	-0.042
FRD	0.093	0.095	0.669	0.178
UPF	0.396	-0.087	0.104	0.045
DRD	0.337	0.046	0.218	0.276
FOOD	0.421	-0.099	-0.184	0.049
HOUS	0.078	0.601	0.008	-0.078
DIY	0.198	0.475	-0.095	0.183
PACK	0.319	-0.077	-0.122	-0.238
MISC	0.315	-0.106	0.453	0.009
GROS	0.055	0.594	-0.068	-0.177
HARM	0.032	0.000	-0.350	0.819
FAE	0.352	-0.077	-0.259	-0.295

Plot COMP 2 * COMP 1

Plot COMP_2 * COMP_1

Plot COMP_2 * COMP_3

Plot COMP 2 * COMP 3

Plot COMP 3 * COMP 1

Plot COMP 4 * COMP 1

Plot COMP_4 * COMP_1

Plot COMP_4 * COMP_3

06/02/01 14:17:17

Cluster Analysis of Observations: SRD, FRD, UPF, DRD, FOOD, HOUS, DIY, PACK, MIS

Standardized Variables, Squared Euclidean Distance, Ward Linkage

Amalgamation Steps

Step	Number of clusters	Similarity level	Distance level	Clusters joined		New cluster	Number of obs. in new cluster
1	21	99.90	0.138	5	9	5	2
2	20	99.86	0.182	3	6	3	2
3	19	99.82	0.246	3	4	3	3
4	18	99.80	0.266	7	8	7	2
5	17	99.46	0.719	3	5	3	5
6	16	99.45	0.737	7	21	7	3
7	15	98.83	1.554	10	13	10	2
8	14	98.49	2.007	3	7	3	8
9	13	97.63	3.157	3	11	3	9
10	12	97.10	3.865	12	20	12	2
11	11	95.75	5.661	14	15	14	2
12	10	93.28	8.947	1	22	1	2
13	9	92.69	9.733	12	18	12	3
14	8	87.24	16.995	12	14	12	5
15	7	86.71	17.698	3	10	3	11
16	6	77.98	29.327	1	2	1	3
17	5	76.71	31.014	12	19	12	6
18	4	66.45	44.671	1	12	1	9
19	3	48.18	69.004	1	3	1	20
20	2	23.16	102.327	1	17	1	21
21	1	-16.96	155.752	1	16	1	22

Final Partition

Number of clusters: 1

	Number of observations	Within cluster sum of squares	Average distance from centroid	Maximum distance from centroid
Cluster1	22	252.000	2.887	8.622

* NOTE * Dendrogram was not cut
Cluster membership cannot be saved

Cluo 'SRD'-'FAE';

Cluster Analysis of Observations: SRD, FRD, UPF, DRD, FOOD, HOUS, DIY, PACK, MIS

Squared Euclidean Distance, Ward Linkage

Amalgamation Steps

Step	Number of clusters	Similarity level	Distance level	Clusters joined		New cluster	Number of obs. in new cluster
1	21	99.99	65.000	3	9	3	2
2	20	99.99	85.000	7	8	7	2
3	19	99.98	127.000	3	5	3	3
4	18	99.97	225.500	3	6	3	4
5	17	99.94	485.700	3	4	3	5

6	16	99.92	604.943	3	7	3	7
7	15	99.92	612.000	10	11	10	2
8	14	99.89	817.000	21	22	21	2
9	13	99.80	1515.302	3	10	3	9
10	12	99.54	3476.156	3	13	3	10
11	11	99.19	6081.667	1	21	1	3
12	10	99.14	6474.309	3	17	3	11
13	9	98.56	10798.000	2	15	2	2
14	8	98.56	10825.853	1	3	1	14
15	7	98.50	11218.000	12	18	12	2
16	6	97.61	17950.000	19	20	19	2
17	5	97.46	19072.667	2	14	2	3
18	4	92.71	54674.000	12	19	12	4
19	3	79.07	156948.571	1	12	1	18
20	2	63.86	270977.048	1	2	1	21
21	1	-66.78	1.2503E+06	1	16	1	22

Final Partition

Number of clusters: 1

	Number of observations	Within cluster sum of squares	Average distance from centroid	Maximum distance from centroid
Cluster1	22	911679.500	143.141	772.493

* NOTE * Dendrogram was not cut
Cluster membership cannot be saved

Cluo 'SRD'-'FAE';

Cluster Analysis of Observations: SRD, FRD, UPF, DRD, FOOD, HOUS, DIY, PACK, MIS

Squared Euclidean Distance, Ward Linkage

Amalgamation Steps

Step	Number of clusters	Similarity level	Distance level	Clusters joined		New cluster	Number of obs. in new cluster
1	21	99.99	65.000	3	9	3	2
2	20	99.99	85.000	7	8	7	2
3	19	99.98	127.000	3	5	3	3
4	18	99.97	225.500	3	6	3	4
5	17	99.94	485.700	3	4	3	5
6	16	99.92	604.943	3	7	3	7
7	15	99.92	612.000	10	11	10	2
8	14	99.89	817.000	21	22	21	2
9	13	99.80	1515.302	3	10	3	9
10	12	99.54	3476.156	3	13	3	10
11	11	99.19	6081.667	1	21	1	3
12	10	99.14	6474.309	3	17	3	11
13	9	98.56	10798.000	2	15	2	2
14	8	98.56	10825.853	1	3	1	14
15	7	98.50	11218.000	12	18	12	2
16	6	97.61	17950.000	19	20	19	2
17	5	97.46	19072.667	2	14	2	3
18	4	92.71	54674.000	12	19	12	4
19	3	79.07	156948.571	1	12	1	18
20	2	63.86	270977.048	1	2	1	21
21	1	-66.78	1.2503E+06	1	16	1	22

Final Partition

Number of clusters: 4

	Number of observations	Within cluster sum of squares	Average distance from centroid	Maximum distance from centroid
Cluster1	14	15697.714	28.959	67.550
Cluster2	3	14935.333	69.437	79.734
Cluster3	4	41921.000	97.574	128.782
Cluster4	1	0.000	0.000	0.000

Cluster Centroids

Variable centrd	Cluster1	Cluster2	Cluster3	Cluster4	Grand
SRD	6.9286	218.6667	12.5000	733.0000	69.8182
FRD	9.1429	10.6667	127.2500	26.0000	31.5909
UPF	12.1429	64.3333	107.5000	390.0000	53.7727
DRD	12.8571	50.6667	49.5000	86.0000	28.0000
FOOD	12.6429	93.3333	29.7500	232.0000	36.7273
HOUS	2.7857	4.3333	3.0000	4.0000	3.0909
DIY	1.2857	2.3333	1.5000	5.0000	1.6364
PACK	6.5000	9.3333	6.0000	31.0000	7.9091
MISC	6.5714	10.0000	29.2500	56.0000	13.4091
GROS	0.7143	0.6667	0.0000	1.0000	0.5909
HARM	0.4286	1.3333	0.2500	0.0000	0.5000
FAE	0.0000	0.3333	0.0000	1.0000	0.0909

Distances Between Cluster Centroids

	Cluster1	Cluster2	Cluster3	Cluster4
Cluster1	0.0000	235.6351	158.8203	852.5065
Cluster2	235.6351	0.0000	249.7795	627.6182
Cluster3	158.8203	249.7795	0.0000	807.9426
Cluster4	852.5065	627.6182	807.9426	0.0000

Cluo 'SRD'-'FAE';

Cluster Analysis of Variables: SRD, FRD, UPF, DRD, FOOD, HOUS, DIY, PACK, MISC,

Correlation Coefficient Distance, Ward Linkage

Amalgamation Steps

Step	Number of clusters	Similarity level	Distance level	Clusters joined		New cluster	Number of obs. in new cluster
1	11	98.77	0.025	6	10	6	2
2	10	98.34	0.033	1	5	1	2
3	9	88.62	0.228	1	12	1	3
4	8	86.99	0.260	3	9	3	2
5	7	82.21	0.356	6	7	6	3
6	6	78.23	0.435	3	4	3	3
7	5	76.22	0.476	1	8	1	4
8	4	62.85	0.743	2	3	2	4
9	3	33.46	1.331	1	2	1	8
10	2	31.77	1.365	6	11	6	4
11	1	-29.50	2.590	1	6	1	12

Cluv 'SRD'-'FAE';

—— 16/02/01 12:15:52 ——

Welcome to Minitab, press F1 for help.

Results for: Worksheet 2

Principal Component Analysis: T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T12,

Eigenanalysis of the Correlation Matrix

Eigenvalue	14.165	6.007	3.982	3.035	2.579	1.916
Proportion	0.315	0.133	0.088	0.067	0.057	0.043
Cumulative	0.315	0.448	0.537	0.604	0.662	0.704
Eigenvalue	1.762	1.476	1.407	1.233	1.198	1.004
Proportion	0.039	0.033	0.031	0.027	0.027	0.022
Cumulative	0.743	0.776	0.807	0.835	0.861	0.884
Eigenvalue	0.821	0.683	0.617	0.587	0.470	0.425
Proportion	0.018	0.015	0.014	0.013	0.010	0.009
Cumulative	0.902	0.917	0.931	0.944	0.954	0.964
Eigenvalue	0.346	0.294	0.248	0.192	0.133	0.085
Proportion	0.008	0.007	0.006	0.004	0.003	0.002
Cumulative	0.971	0.978	0.983	0.988	0.991	0.993
Eigenvalue	0.064	0.058	0.047	0.036	0.029	0.024
Proportion	0.001	0.001	0.001	0.001	0.001	0.001
Cumulative	0.994	0.995	0.996	0.997	0.998	0.998
Eigenvalue	0.020	0.019	0.016	0.009	0.005	0.004
Proportion	0.000	0.000	0.000	0.000	0.000	0.000
Cumulative	0.999	0.999	0.999	1.000	1.000	1.000
Eigenvalue	0.003	0.001	0.001	0.000	0.000	0.000
Proportion	0.000	0.000	0.000	0.000	0.000	0.000
Cumulative	1.000	1.000	1.000	1.000	1.000	1.000
Eigenvalue	0.000	0.000	-0.000			
Proportion	0.000	0.000	-0.000			
Cumulative	1.000	1.000	1.000			

Variable	PC1	PC2	PC3
T1	-0.203	-0.109	-0.206
T2	-0.179	-0.170	0.205
T3	-0.179	-0.170	0.205
T4	-0.231	-0.130	0.087
T5	-0.181	0.136	0.034
T6	-0.039	0.173	0.027
T7	-0.164	-0.193	0.233
T8	-0.079	0.334	0.108
T9	-0.246	-0.004	-0.148
T10	-0.080	0.053	0.122
T11	-0.041	-0.185	0.368
T12	-0.039	-0.108	0.353
T13	-0.162	0.260	0.031
T14	-0.221	0.189	-0.029
T15	-0.207	-0.022	-0.031
T16	-0.133	-0.007	-0.106
T17	-0.165	0.220	0.029
T18	0.022	0.127	-0.042
T19	-0.160	0.230	0.051
T20	-0.229	-0.061	-0.174
T21	-0.042	-0.193	0.374
T22	-0.232	-0.082	-0.154

T23	-0.021	0.118	0.115
T24	-0.086	-0.087	-0.142
T25	-0.100	0.004	-0.008
T26	-0.038	0.066	0.121
T27	0.000	0.054	-0.011
T28	-0.018	-0.019	0.141
T29	-0.211	-0.017	-0.025
T30	0.015	0.033	0.007
T31	-0.042	0.185	0.188
T32	-0.041	-0.092	0.242
T33	-0.232	-0.086	-0.084
T34	-0.044	0.194	0.110
T35	-0.240	0.033	-0.064
T36	-0.029	0.074	0.140
T37	-0.178	0.001	-0.071
T38	-0.052	0.242	0.093
T39	-0.214	-0.167	0.061
T40	-0.238	-0.124	-0.122
T41	0.011	0.005	-0.031
T42	-0.150	0.151	0.080
T43	-0.234	-0.079	-0.121
T44	-0.081	0.299	0.090
T45	-0.069	0.234	0.141

Plot Eigv2 * Eigv1

Plot Eigv2 * Eigv3

Plot Scor2 * Scor1

Plot Scor2 * Scor3

Principal Component Analysis: T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T12,

Eigenanalysis of the Covariance Matrix

Eigenvalue	19191	4799	1950	858	473	78
Proportion	0.697	0.174	0.071	0.031	0.017	0.003
Cumulative	0.697	0.871	0.942	0.973	0.990	0.993
Eigenvalue	39	32	28	22	17	15
Proportion	0.001	0.001	0.001	0.001	0.001	0.001
Cumulative	0.994	0.995	0.996	0.997	0.998	0.998
Eigenvalue	10	9	6	5	3	2
Proportion	0.000	0.000	0.000	0.000	0.000	0.000
Cumulative	0.999	0.999	0.999	1.000	1.000	1.000
Eigenvalue	2	2	1	1	1	0
Proportion	0.000	0.000	0.000	0.000	0.000	0.000
Cumulative	1.000	1.000	1.000	1.000	1.000	1.000
Eigenvalue	0	0	0	0	0	0
Proportion	0.000	0.000	0.000	0.000	0.000	0.000
Cumulative	1.000	1.000	1.000	1.000	1.000	1.000
Eigenvalue	0	0	0	0	0	0
Proportion	0.000	0.000	0.000	0.000	0.000	0.000

Cumulative	1.000	1.000	1.000	1.000	1.000	1.000
Eigenvalue	0	0	0	0	0	0
Proportion	0.000	0.000	0.000	0.000	0.000	0.000
Cumulative	1.000	1.000	1.000	1.000	1.000	1.000
Eigenvalue	0	0	-0			
Proportion	0.000	0.000	-0.000			
Cumulative	1.000	1.000	1.000			

Variable	PC1	PC2	PC3
T1	-0.061	-0.683	-0.402
T2	-0.001	-0.009	-0.000
T3	-0.001	-0.009	-0.000
T4	-0.003	-0.025	-0.002
T5	-0.017	-0.017	-0.005
T6	-0.018	0.007	-0.001
T7	-0.003	-0.027	-0.012
T8	-0.814	0.422	-0.134
T9	-0.045	-0.166	-0.062
T10	-0.034	-0.209	0.818
T11	0.002	0.000	0.005
T12	0.001	0.002	0.004
T13	-0.459	-0.351	0.309
T14	-0.329	-0.349	-0.135
T15	-0.004	-0.029	0.018
T16	-0.016	-0.063	-0.070
T17	-0.009	-0.005	-0.002
T18	-0.010	0.017	-0.007
T19	-0.091	-0.068	0.134
T20	-0.019	-0.133	-0.033
T21	0.000	0.000	0.000
T22	-0.009	-0.068	-0.037
T23	-0.005	-0.014	0.069
T24	-0.000	-0.029	-0.015
T25	-0.000	-0.002	0.001
T26	-0.001	0.001	-0.003
T27	-0.000	0.001	-0.001
T28	0.000	0.000	0.002
T29	-0.004	-0.013	-0.007
T30	0.002	0.002	0.018
T31	-0.001	-0.000	0.005
T32	0.001	0.001	-0.002
T33	-0.006	-0.047	-0.028
T34	-0.003	0.002	-0.002
T35	-0.003	-0.008	-0.001
T36	-0.001	0.000	0.015
T37	-0.001	-0.003	-0.002
T38	-0.002	0.001	0.002
T39	-0.001	-0.006	-0.000
T40	-0.003	-0.029	-0.011
T41	0.000	-0.000	0.000
T42	-0.014	-0.014	0.023
T43	-0.005	-0.037	-0.016
T44	-0.039	0.009	0.022
T45	-0.002	0.001	0.001

Plot Eigcov2 * Eigcov1

Plot Scocov2 * Scocov1

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Results for: Worksheet 1

Principal Component Analysis: T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T12,

Eigenanalysis of the Correlation Matrix

Eigenvalue	8.4755	5.3321	4.2248	3.3314	2.9896	2.4864
Proportion	0.188	0.118	0.094	0.074	0.066	0.055
Cumulative	0.188	0.307	0.401	0.475	0.541	0.596
Eigenvalue	2.1296	1.9758	1.7671	1.5596	1.4621	1.1927
Proportion	0.047	0.044	0.039	0.035	0.032	0.027
Cumulative	0.644	0.688	0.727	0.762	0.794	0.821
Eigenvalue	1.1400	1.0925	0.9276	0.8344	0.7686	0.7374
Proportion	0.025	0.024	0.021	0.019	0.017	0.016
Cumulative	0.846	0.870	0.891	0.909	0.926	0.943
Eigenvalue	0.5517	0.3560	0.2965	0.2508	0.1963	0.1890
Proportion	0.012	0.008	0.007	0.006	0.004	0.004
Cumulative	0.955	0.963	0.970	0.975	0.980	0.984
Eigenvalue	0.1628	0.1184	0.1088	0.0871	0.0590	0.0500
Proportion	0.004	0.003	0.002	0.002	0.001	0.001
Cumulative	0.987	0.990	0.992	0.994	0.996	0.997
Eigenvalue	0.0463	0.0298	0.0288	0.0179	0.0120	0.0048
Proportion	0.001	0.001	0.001	0.000	0.000	0.000
Cumulative	0.998	0.998	0.999	0.999	1.000	1.000
Eigenvalue	0.0036	0.0016	0.0009	0.0005	0.0002	0.0000
Proportion	0.000	0.000	0.000	0.000	0.000	0.000
Cumulative	1.000	1.000	1.000	1.000	1.000	1.000
Eigenvalue	0.0000	-0.0000	-0.0000			
Proportion	0.000	-0.000	-0.000			
Cumulative	1.000	1.000	1.000			

Variable	PC1	PC2	PC3
T1	0.008	0.186	-0.111
T2	-0.190	-0.006	-0.100
T3	-0.190	-0.006	-0.100
T4	-0.231	0.097	-0.089
T5	-0.209	0.018	0.138
T6	-0.062	-0.007	0.186
T7	-0.214	0.164	-0.000
T8	-0.165	-0.094	0.355
T9	-0.182	-0.094	0.257
T10	-0.127	-0.280	-0.244
T11	-0.120	-0.173	-0.235
T12	-0.200	-0.024	-0.074
T13	-0.115	-0.126	0.032
T14	-0.204	-0.142	0.306
T15	-0.159	-0.161	-0.222
T16	-0.066	0.229	-0.113
T17	-0.126	0.055	-0.026
T18	0.087	-0.008	0.107
T19	-0.139	-0.250	-0.002
T20	-0.023	-0.145	-0.055
T21	-0.130	0.091	-0.085
T22	-0.152	0.285	-0.125

T23	-0.087	-0.188	-0.107
T24	-0.011	0.140	-0.174
T25	-0.107	-0.050	-0.079
T26	-0.233	0.150	0.152
T27	-0.071	0.070	0.110
T28	-0.128	-0.012	-0.182
T29	-0.199	0.163	0.074
T30	0.013	-0.101	-0.014
T31	-0.187	-0.146	0.018
T32	-0.188	0.225	-0.108
T33	-0.199	0.276	-0.007
T34	-0.138	-0.076	0.271
T35	-0.192	0.020	-0.165
T36	-0.155	-0.261	-0.047
T37	-0.147	-0.033	0.225
T38	-0.142	-0.007	0.098
T39	-0.086	-0.117	-0.242
T40	-0.005	0.130	-0.110
T41	0.017	-0.024	0.036
T42	-0.163	-0.252	-0.057
T43	-0.209	0.077	0.031
T44	-0.037	-0.169	-0.158
T45	-0.194	0.193	-0.026

Plot Eigv2 * Eigv1

Plot Eigv2 * Eigv3

Plot Scor2 * Scor1

Plot Scor2 * Scor3

Pltx Scor2 * Scor1 * Scor3

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Cluster Analysis of Observations: T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11,

Standardized Variables, Squared Euclidean Distance, Ward Linkage

Amalgamation Steps

Step	Number of clusters	Similarity level	Distance level	Clusters joined		New cluster	Number of obs. in new cluster
1	44	99.97	0.177	3	24	3	2
2	43	99.88	0.713	3	6	3	3
3	42	99.79	1.258	3	42	3	4
4	41	99.66	2.108	20	26	20	2
5	40	99.60	2.438	41	43	41	2
6	39	99.53	2.863	7	20	7	3
7	38	99.51	3.005	5	23	5	2
8	37	99.41	3.647	3	14	3	5
9	36	99.38	3.801	40	41	40	3
10	35	99.17	5.116	3	13	3	6
11	34	99.14	5.292	5	21	5	3
12	33	99.03	5.960	7	19	7	4
13	32	98.71	7.928	7	9	7	5
14	31	98.67	8.146	3	25	3	7
15	30	98.64	8.356	3	35	3	8
16	29	98.28	10.529	3	22	3	9
17	28	98.06	11.891	3	4	3	10
18	27	97.89	12.925	3	15	3	11
19	26	97.77	13.660	8	10	8	2
20	25	97.75	13.823	3	5	3	14
21	24	96.48	21.589	3	40	3	17
22	23	94.89	31.314	11	34	11	2
23	22	94.42	34.219	38	39	38	2
24	21	94.21	35.515	16	17	16	2
25	20	93.55	39.551	12	27	12	2
26	19	93.34	40.845	3	11	3	19
27	18	91.71	50.813	2	28	2	2
28	17	90.80	56.395	3	8	3	21
29	16	89.38	65.084	3	7	3	26
30	15	88.58	70.018	2	12	2	4
31	14	87.61	75.990	18	44	18	2
32	13	84.33	96.095	1	2	1	5
33	12	83.03	104.041	36	38	36	3
34	11	81.65	112.482	16	32	16	3
35	10	81.52	113.303	29	45	29	2
36	9	81.24	115.006	3	36	3	29
37	8	78.74	130.358	1	16	1	8
38	7	75.87	147.915	18	29	18	4
39	6	73.74	161.020	1	33	1	9
40	5	66.84	203.286	1	18	1	13
41	4	53.68	283.970	1	3	1	42
42	3	41.17	360.667	1	31	1	43
43	2	27.07	447.155	1	30	1	44
44	1	-69.59	1039.736	1	37	1	45

Final Partition

Number of clusters: 1

	Number of observations	Within cluster sum of squares	Average distance from centroid	Maximum distance from centroid
Cluster1	45	1980.000	5.394	22.546

Cluo 'T1'-'T45';

Cluster Analysis of Observations: T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11,

Squared Euclidean Distance, Ward Linkage

Amalgamation Steps

Step	Number of clusters	Similarity level	Distance level	Clusters joined		New cluster	Number of obs. in new cluster
1	44	100.00	20.000	3	13	3	2
2	43	100.00	28.000	14	24	14	2
3	42	99.99	45.333	3	25	3	3
4	41	99.99	77.000	7	26	7	2
5	40	99.98	129.067	3	14	3	5
6	39	99.98	147.000	8	15	8	2
7	38	99.97	211.933	3	10	3	6
8	37	99.97	212.333	7	19	7	3
9	36	99.97	230.000	23	42	23	2
10	35	99.97	238.333	6	8	6	3
11	34	99.95	327.667	4	6	4	4
12	33	99.95	339.667	7	9	7	4
13	32	99.94	407.000	5	21	5	2
14	31	99.92	550.000	44	45	44	2
15	30	99.92	599.000	18	20	18	2
16	29	99.92	612.667	23	35	23	3
17	28	99.92	618.000	38	43	38	2
18	27	99.89	766.000	11	12	11	2
19	26	99.88	845.167	3	5	3	8
20	25	99.88	878.000	38	41	38	3
21	24	99.87	929.833	3	4	3	12
22	23	99.79	1546.333	7	18	7	6
23	22	99.78	1608.889	3	7	3	18
24	21	99.76	1718.000	22	38	22	4
25	20	99.76	1720.133	11	23	11	5
26	19	99.76	1753.000	16	17	16	2
27	18	99.66	2476.533	11	36	11	6
28	17	99.53	3394.000	22	40	22	5
29	16	99.51	3568.667	2	44	2	3
30	15	99.48	3788.497	3	31	3	19
31	14	98.93	7760.494	3	11	3	25
32	13	98.68	9568.333	16	34	16	3
33	12	98.39	11730.000	1	29	1	2
34	11	98.27	12602.239	2	3	2	28
35	10	98.26	12623.000	27	32	27	2
36	9	97.02	21686.000	1	28	1	3
37	8	96.84	22982.000	22	39	22	6
38	7	95.68	31394.494	2	16	2	31
39	6	92.85	51958.333	27	33	27	3
40	5	92.57	54004.765	2	22	2	37
41	4	78.00	159998.188	2	27	2	40
42	3	60.84	284761.077	1	2	1	43
43	2	41.55	425011.796	1	37	1	44
44	1	-77.14	1.2880E+06	1	30	1	45

Final Partition

Number of clusters: 1

	Number of observations	Within cluster sum of squares	Average distance from centroid	Maximum distance from centroid
Cluster1	45	1211950.000	103.101	793.540

Cluo 'T1'-'T45';

Principal Component Analysis: T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T12,

Eigenanalysis of the Correlation Matrix

Eigenvalue	7.1379	4.7640	4.1021	3.5862	2.7532	2.6353
Proportion	0.162	0.108	0.093	0.082	0.063	0.060
Cumulative	0.162	0.270	0.364	0.445	0.508	0.568
Eigenvalue	2.0342	1.8059	1.6661	1.4667	1.3471	1.3162
Proportion	0.046	0.041	0.038	0.033	0.031	0.030
Cumulative	0.614	0.655	0.693	0.726	0.757	0.787
Eigenvalue	1.1266	1.0723	0.9323	0.8789	0.8363	0.6344
Proportion	0.026	0.024	0.021	0.020	0.019	0.014
Cumulative	0.812	0.837	0.858	0.878	0.897	0.911
Eigenvalue	0.5792	0.4884	0.4364	0.3542	0.2930	0.2694
Proportion	0.013	0.011	0.010	0.008	0.007	0.006
Cumulative	0.924	0.936	0.945	0.954	0.960	0.966
Eigenvalue	0.2501	0.1977	0.1710	0.1569	0.1265	0.1119
Proportion	0.006	0.004	0.004	0.004	0.003	0.003
Cumulative	0.972	0.976	0.980	0.984	0.987	0.989
Eigenvalue	0.0888	0.0687	0.0639	0.0556	0.0460	0.0426
Proportion	0.002	0.002	0.001	0.001	0.001	0.001
Cumulative	0.991	0.993	0.994	0.996	0.997	0.998
Eigenvalue	0.0288	0.0224	0.0183	0.0124	0.0085	0.0066
Proportion	0.001	0.001	0.000	0.000	0.000	0.000
Cumulative	0.998	0.999	0.999	1.000	1.000	1.000
Eigenvalue	0.0040	0.0026				
Proportion	0.000	0.000				
Cumulative	1.000	1.000				

Variable	PC1	PC2	PC3
T1	-0.002	-0.122	-0.135
T2	0.063	0.284	-0.205
T3	0.181	0.089	-0.112
T4	0.235	-0.046	-0.101
T5	0.232	0.001	-0.073
T6	0.013	0.241	-0.126
T7	0.229	-0.112	-0.152
T8	0.216	-0.031	0.064
T9	0.227	-0.038	0.070
T10	0.140	0.158	0.280
T11	0.111	0.175	0.177
T12	0.140	0.044	-0.047
T13	0.147	-0.044	0.183
T14	0.231	0.141	0.040
T15	0.187	0.057	0.166
T16	0.072	-0.162	-0.192
T17	0.097	0.041	-0.038
T18	-0.082	0.353	-0.129
T19	0.052	0.358	0.017
T20	-0.007	0.292	-0.046
T21	0.127	-0.041	-0.101
T22	0.045	0.189	-0.246
T23	0.102	0.030	0.246
T24	-0.022	0.160	-0.150
T25	0.133	-0.026	0.101

T26	0.258	-0.117	-0.134
T27	0.095	-0.108	-0.030
T28	0.109	0.034	-0.006
T29	0.205	-0.038	-0.220
T30	-0.010	-0.010	0.088
T31	0.221	-0.015	0.181
T32	0.177	-0.102	-0.211
T33	0.205	-0.155	-0.254
T34	0.178	-0.016	0.038
T35	0.172	0.048	-0.080
T36	0.169	0.185	0.230
T37	0.182	-0.052	0.034
T38	0.169	-0.037	0.015
T39	0.102	0.066	0.170
T40	0.010	-0.100	-0.110
T41	-0.011	-0.006	0.045
T42	0.200	0.099	0.249
T43	0.118	0.184	-0.261
T44	-0.052	0.382	-0.128

Principal Component Analysis: C60, C61, C62, C63, C64, C65, C66, C67, C68, C69,

Eigenanalysis of the Correlation Matrix

Eigenvalue	6.6943	4.3643	3.6127	2.5248	2.4245	2.0482
Proportion	0.152	0.099	0.082	0.057	0.055	0.047
Cumulative	0.152	0.251	0.333	0.391	0.446	0.492
Eigenvalue	1.9361	1.7182	1.6334	1.5352	1.4927	1.3413
Proportion	0.044	0.039	0.037	0.035	0.034	0.030
Cumulative	0.536	0.576	0.613	0.648	0.681	0.712
Eigenvalue	1.1910	1.0922	1.0518	0.9489	0.9292	0.8576
Proportion	0.027	0.025	0.024	0.022	0.021	0.019
Cumulative	0.739	0.764	0.788	0.809	0.830	0.850
Eigenvalue	0.7519	0.6705	0.5719	0.5359	0.4990	0.3975
Proportion	0.017	0.015	0.013	0.012	0.011	0.009
Cumulative	0.867	0.882	0.895	0.907	0.919	0.928
Eigenvalue	0.3738	0.3677	0.3400	0.2909	0.2744	0.2459
Proportion	0.008	0.008	0.008	0.007	0.006	0.006
Cumulative	0.936	0.945	0.952	0.959	0.965	0.971
Eigenvalue	0.2218	0.2116	0.1705	0.1267	0.1170	0.1091
Proportion	0.005	0.005	0.004	0.003	0.003	0.002
Cumulative	0.976	0.981	0.985	0.987	0.990	0.993
Eigenvalue	0.0794	0.0615	0.0537	0.0439	0.0364	0.0314
Proportion	0.002	0.001	0.001	0.001	0.001	0.001
Cumulative	0.994	0.996	0.997	0.998	0.999	1.000
Eigenvalue	0.0111	0.0100				
Proportion	0.000	0.000				
Cumulative	1.000	1.000				

Variable	PC1	PC2	PC3
C60	-0.112	0.167	-0.047
C61	-0.200	0.303	-0.006
C62	-0.252	0.141	-0.054
C63	-0.217	0.118	-0.016
C64	-0.197	0.132	-0.118
C65	-0.004	0.270	0.126
C66	-0.227	-0.070	-0.190

C67	-0.207	-0.144	0.229
C68	-0.173	-0.123	0.214
C69	-0.024	-0.238	0.005
C70	-0.101	0.057	0.008
C71	-0.143	0.103	0.041
C72	-0.083	-0.170	-0.077
C73	-0.120	0.110	0.358
C74	-0.174	-0.126	0.088
C75	-0.163	-0.080	-0.245
C76	-0.106	0.003	0.038
C77	0.098	0.237	0.216
C78	-0.155	0.122	0.326
C79	-0.107	0.092	0.181
C80	-0.138	0.026	-0.091
C81	-0.001	0.237	-0.268
C82	-0.183	-0.171	0.192
C83	-0.092	0.241	-0.125
C84	-0.162	-0.118	-0.036
C85	-0.192	-0.119	-0.017
C86	-0.018	-0.144	-0.001
C87	-0.160	-0.031	-0.014
C88	-0.119	0.093	-0.119
C89	-0.035	-0.135	0.147
C90	-0.274	-0.092	0.027
C91	-0.126	-0.044	-0.198
C92	-0.150	0.026	-0.354
C93	-0.158	-0.035	0.001
C94	-0.217	0.002	-0.052
C95	-0.073	0.171	0.041
C96	-0.163	-0.171	0.111
C97	-0.164	-0.090	0.076
C98	-0.120	-0.051	-0.165
C99	-0.018	0.014	-0.172
C100	0.015	-0.034	0.052
C101	-0.254	-0.092	0.031
C102	-0.133	0.318	0.011
C103	-0.039	0.297	0.148

Plot COMPONENT 2 VAR * COMPONENT 1 VAR

Plot COMPONENT 2 VAR * COMPONENT 3 VAR

Plot COMPONENT 2 SCORE * COMPONENT 1 SCORE

Plot COMPONENT 2 SCORE * COMPONENT 3 SCORE

Plot P/A COMP 2 VAR * P/A COMP 1 VAR

Plot P/A COMP 2 VAR * P/A COMP 3 VAR

Plot P/A COMP 2 SCORE * P/A COMP 1 SCORE

Plot P/A COMP 2 SCORE * P/A COMP 3 SCORE

Principal Component Analysis: T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T12,

Eigenanalysis of the Correlation Matrix

Eigenvalue	6.3262	5.5051	4.2653	3.5150	3.0485	2.7360
Proportion	0.144	0.125	0.097	0.080	0.069	0.062
Cumulative	0.144	0.269	0.366	0.446	0.515	0.577
Eigenvalue	2.4569	2.0764	1.7440	1.6250	1.4394	1.2396
Proportion	0.056	0.047	0.040	0.037	0.033	0.028
Cumulative	0.633	0.680	0.720	0.757	0.789	0.818
Eigenvalue	1.1117	0.9597	0.8415	0.7196	0.6821	0.6224
Proportion	0.025	0.022	0.019	0.016	0.016	0.014
Cumulative	0.843	0.865	0.884	0.900	0.916	0.930
Eigenvalue	0.4965	0.4463	0.3488	0.3190	0.2888	0.2289
Proportion	0.011	0.010	0.008	0.007	0.007	0.005
Cumulative	0.941	0.951	0.959	0.966	0.973	0.978
Eigenvalue	0.1745	0.1570	0.1167	0.0978	0.0897	0.0745
Proportion	0.004	0.004	0.003	0.002	0.002	0.002
Cumulative	0.982	0.986	0.988	0.991	0.993	0.994
Eigenvalue	0.0616	0.0517	0.0373	0.0248	0.0208	0.0156
Proportion	0.001	0.001	0.001	0.001	0.000	0.000
Cumulative	0.996	0.997	0.998	0.998	0.999	0.999
Eigenvalue	0.0141	0.0112	0.0068	0.0021	0.0010	0.0001
Proportion	0.000	0.000	0.000	0.000	0.000	0.000
Cumulative	1.000	1.000	1.000	1.000	1.000	1.000
Eigenvalue	0.0000	0.0000				
Proportion	0.000	0.000				
Cumulative	1.000	1.000				

Variable	PC1	PC2	PC3
T1	-0.050	-0.029	0.131
T2	-0.089	-0.022	-0.282
T3	-0.113	-0.169	-0.126
T4	-0.132	-0.272	-0.004
T5	-0.141	-0.237	-0.054
T6	-0.045	0.088	-0.286
T7	-0.115	-0.221	0.056
T8	-0.052	-0.078	0.084
T9	0.009	0.030	0.118
T10	0.075	-0.183	-0.147
T11	0.354	-0.169	-0.078
T12	0.350	-0.175	-0.079
T13	-0.079	-0.149	0.027
T14	-0.126	-0.098	-0.251
T15	0.346	-0.190	-0.078
T16	-0.077	-0.109	0.141
T17	-0.061	-0.071	-0.045
T18	-0.034	0.155	-0.360
T19	-0.070	0.004	-0.326
T20	-0.026	0.093	-0.251
T21	0.355	-0.167	-0.073
T22	-0.076	-0.018	-0.196
T23	-0.040	-0.121	-0.030
T24	-0.055	0.054	-0.130
T25	-0.062	-0.155	0.026

T26	-0.146	-0.283	0.042
T27	-0.066	-0.131	0.093
T28	-0.062	-0.123	-0.042
T29	-0.020	0.065	-0.177
T30	0.347	-0.160	-0.068
T31	-0.086	-0.199	-0.020
T32	-0.115	-0.217	0.048
T33	-0.139	-0.251	0.092
T34	0.011	0.034	0.117
T35	-0.104	-0.196	-0.077
T36	-0.066	-0.130	-0.160
T37	-0.083	-0.166	0.004
T38	-0.096	-0.206	0.003
T39	0.355	-0.167	-0.073
T40	-0.030	-0.031	0.099
T41	0.003	0.022	0.014
T42	-0.072	-0.178	-0.094
T43	-0.118	-0.081	-0.217
T44	-0.040	0.102	-0.340

Principal Component Analysis: C60, C61, C62, C63, C64, C65, C66, C67, C68, C69,

Eigenanalysis of the Correlation Matrix

Eigenvalue	6.7107	4.4103	3.3908	2.6179	2.3353	2.0329
Proportion	0.153	0.100	0.077	0.059	0.053	0.046
Cumulative	0.153	0.253	0.330	0.389	0.442	0.489
Eigenvalue	1.9506	1.7711	1.6111	1.4703	1.4542	1.3074
Proportion	0.044	0.040	0.037	0.033	0.033	0.030
Cumulative	0.533	0.573	0.610	0.643	0.676	0.706
Eigenvalue	1.2492	1.0658	1.0320	0.9984	0.8947	0.8242
Proportion	0.028	0.024	0.023	0.023	0.020	0.019
Cumulative	0.734	0.759	0.782	0.805	0.825	0.844
Eigenvalue	0.7729	0.6663	0.5832	0.5455	0.4984	0.4570
Proportion	0.018	0.015	0.013	0.012	0.011	0.010
Cumulative	0.861	0.877	0.890	0.902	0.913	0.924
Eigenvalue	0.3827	0.3528	0.3322	0.3048	0.2837	0.2572
Proportion	0.009	0.008	0.008	0.007	0.006	0.006
Cumulative	0.933	0.941	0.948	0.955	0.962	0.967
Eigenvalue	0.2246	0.2137	0.2005	0.1491	0.1387	0.1159
Proportion	0.005	0.005	0.005	0.003	0.003	0.003
Cumulative	0.972	0.977	0.982	0.985	0.988	0.991
Eigenvalue	0.0940	0.0770	0.0718	0.0575	0.0354	0.0343
Proportion	0.002	0.002	0.002	0.001	0.001	0.001
Cumulative	0.993	0.995	0.997	0.998	0.999	0.999
Eigenvalue	0.0146	0.0092				
Proportion	0.000	0.000				
Cumulative	1.000	1.000				

Variable	PC1	PC2	PC3
C60	-0.146	0.179	-0.049
C61	-0.218	0.276	-0.031
C62	-0.258	0.110	-0.065
C63	-0.222	0.089	-0.029
C64	-0.211	0.121	-0.116
C65	-0.019	0.286	0.113
C66	-0.223	-0.096	-0.192

C67	-0.193	-0.143	0.253
C68	-0.155	-0.128	0.232
C69	-0.034	-0.209	0.012
C70	-0.087	-0.001	-0.038
C71	-0.137	0.055	0.004
C72	-0.105	-0.103	-0.035
C73	-0.131	0.154	0.343
C74	-0.159	-0.156	0.067
C75	-0.170	-0.081	-0.226
C76	-0.114	0.010	0.048
C77	0.081	0.264	0.195
C78	-0.178	0.146	0.296
C79	-0.109	0.114	0.185
C80	-0.097	-0.065	-0.144
C81	-0.027	0.222	-0.294
C82	-0.183	-0.156	0.214
C83	-0.121	0.236	-0.137
C84	-0.159	-0.124	-0.015
C85	-0.189	-0.123	0.015
C86	-0.022	-0.128	0.024
C87	-0.162	-0.045	-0.010
C88	-0.109	0.093	-0.110
C89	-0.002	-0.167	0.066
C90	-0.265	-0.108	0.039
C91	-0.128	-0.061	-0.200
C92	-0.158	0.006	-0.355
C93	-0.106	-0.075	0.021
C94	-0.222	-0.017	-0.052
C95	-0.086	0.166	0.028
C96	-0.157	-0.169	0.134
C97	-0.164	-0.092	0.090
C98	-0.070	-0.130	-0.181
C99	-0.022	0.005	-0.186
C100	0.014	-0.022	0.062
C101	-0.248	-0.108	0.046
C102	-0.157	0.299	-0.016
C103	-0.069	0.298	0.112

Plot COMPONENT 2 VAR * COMPONENT 1 VAR

Plot COMPONENT 2 VAR * COMPONENT 3 VAR

Plot COMPONENT 2 SCORE * COMPONENT 1 SCORE

Plot COMPONENT 2 SCORE * COMPONENT 3 SCORE

Plot P/A COMP 2 VAR * P/A COMP 1 VAR

Plot P/A COMP 2 VAR * P/A COMP 3 VAR

Plot P/A COMP 2 SCORE * P/A COMP 1 SCORE

Plot P/A COMP 2 SCORE * P/A COMP 3 SCORE

Appendix IVb

Beach Litter Survey Data

		Sand Bay 20/7/00	Sand Bay 22-3-00	23/8/00 Aberdyfi	Towyn 23/8/00	Barmouth	Harlech	Pwllheli
		S1	S2	S3	S4	S5	S6	S7
Soft drink bottle container	T1	0	2	0	2	0	0	3
Aluminium can - beer or soft drink	T2	0	0	0	0	1	0	0
Milk container	T3	1	1	0	0	0	0	0
Toiletry container, toothpaste, toothbrush, shampoo, deoderant	T4	1	0	0	0	0	0	0
Food container - marg, mayo	T5	5	0	0	0	0	0	0
Take away food container/plastic cups/wooden forks-plastic spoon	T6	0	0	0	0	4	0	2
Detergent container	T7	0	0	0	0	0	0	0
CBS	T8	239	66	0	11	0	0	2
SRD	T9	7	0	0	1	0	0	0
Netting/line	T10	0	2	3	11	0	11	1
Other fishing (lobster pot, fish box, etc)	T11	0	0	0	0	0	0	1
Shipping general :tyre with rope, fender, buoy	T12	2	0	0	0	0	0	0
Unidentifiable Fragments	T13	38	25	3	11	9	11	2
Sweet wrappers, straw, lolly sticks, small cartons of soft drink	T14	119	44	5	15	15	12	10
Packing strap	T15	0	0	0	2	0	0	1
Polystyrene	T16	4	1	0	0	0	0	0
Cigarette lighter	T17	0	1	0	0	0	0	0
Cigarette stubs	T18	0	0	1	0	0	4	10
Beverage Bottle top, Tamper proof rings	T19	12	9	1	9	0	0	1
Plastic bag	T20	2	2	0	0	15	2	2
Secondary use container	T21	0	0	0	0	0	0	0
Land sourced items: e.g. Hub cap, traffic cone, shopping trolley etc.	T22	0	0	0	0	0	0	0
Shotgun cartridge	T23	0	1	0	0	0	0	0
Cloth, shoe	T24	0	1	0	0	0	0	0

Party popper	T25	0	2	0	0	0	0	0
Pen	T26	2	1	0	0	0	0	0
Syringe	T27	0	0	0	0	0	0	0
Balloon	T28	0	0	0	0	0	0	0
toy	T29	0	1	0	0	0	0	0
tangles	T30	0	0	0	0	0	0	0
4 pack holder	T31	1	1	0	0	0	0	0
Polyurethane	T32	0	0	0	0	0	0	0
DIY/Maintenance - (diesel injector cleaner, bucket, etc.)	T33	2	0	0	0	0	0	0
Toilet freshener	T34	3	1	0	0	0	0	0
Flower pot	T35	0	0	0	0	0	0	0
Wood	T36	6	0	0	0	0	0	0
Balloon	T37	1	0	0	1	0	0	0
Piping/ducting	T38	0	0	0	0	0	0	0
25l oil drum	T39	0	0	0	0	0	0	0
5/10 l oil containers	T40	0	0	0	0	0	0	0
bait bag	T41	0	0	0	0	0	0	0
plastic sheet	T42	11	3	0	0	0	0	0
glass bottle	T43	3	0	0	0	0	0	0
paper	T44	0	0	0	0	0	0	0
light bulb	T45	0	0	0	0	0	0	0
TOTAL		459	164	13	63	44	40	35

Broadhaven 6/11/00	Tenby North 6/11/00	Tenby South 6/11/00	Nolton 6/11/00	Mwnt 6/11/00	Poppit Sands 6/11/00	Wisemans Bridge 6/11/00	Pendine Sands 6/11/00	Croyde 10/9/00
S8	S9	S10	S11	S12	S13	S14	S15	S16
0	0	2	2	12	1	0	2	1
0	0	0	1	1	1	0	0	3
0	0	0	0	4	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	8	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	1
0	6	0	1	4	1	0	0	3
0	0	0	1	0	2	0	0	3
17	0	10	10	21	3	1	10	37
2	0	0	0	0	0	0	1	0
0	1	0	3	3	1	0	3	0
7	13	0	32	19	4	4	7	6
6	4	0	2	2	6	0	3	18
7	0	0	0	0	2	0	0	3
0	3	0	0	1	0	1	0	0
1	0	0	3	0	1	0	0	0
0	10	0	0	0	0	0	1	0
10	0	1	29	16	1	1	6	18
0	0	7	0	0	1	0	0	2
0	0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	2	0
0	0	0	1	6	0	0	0	2

0	0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0
1	0	1	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0
0	0	0	0	0	0	2	0	0
0	0	0	0	0	0	0	0	18
0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	1	0
0	0	0	0	2	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	2	1	0	0	0
0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	5	0	0	0	2
0	0	0	0	4	1	0	0	0
0	0	0	0	4	1	0	0	0
0	0	0	0	0	0	0	0	0
52	38	21	86	114	28	10	37	121

Putsborough 10/9/00	Putsborough 22/3/00	Woolocombe 10/9/00	Woolocombe 22/3/00	Lynmouth 20/9/00	Lynmouth 21/3/00	Blue Anchor 20/9/00	Blue Anchor 21/3/00
S17	S18	S19	S20	S21	S22	S23	S24
1	6	1	0	0	44	6	0
0	0	0	0	8	0	3	0
0	2	0	0	0	1	0	0
0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0
0	1	2	2	14	1	7	0
0	0	0	0	0	2	0	0
14	0	1	4	0	0	0	0
0	0	1	5	0	0	1	0
58	12	1	20	5	5	0	1
0	0	0	0	0	0	0	0
2	0	0	0	0	0	1	0
17	3	3	0	0	0	28	0
13	0	6	1	16	2	5	0
0	0	0	1	0	0	0	0
2	20	0	10	0	16	0	0
0	0	0	0	0	0	0	0
1	0	25	16	0	0	2	0
46	7	2	2	2	2	8	0
2	0	1	0	1	1	7	1
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	2

3	0	0	1	0	0	0	0
1	1	0	0	0	0	3	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	2	0	0	0	0	0	0
0	0	0	0	0	0	1	0
28	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	5	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	5	0	0	0	0	0	0
11	2	0	1	0	2	2	0
0	0	0	0	0	0	0	0
199	66	43	63	46	77	74	4

Dunster Beach 21/3/00	Minehead 21/3/00	Westward Ho! 21/3/00	Brean 21/3/00	Weston 21/3/00	Berrow 21/3/00	Hartland Quay 22/3/00	Combe Martin 22/3/00	Freshwater West	Angle
S25	S26	S27	S28	S29	S30	S31	S32	S33	S34
2	1	29	10	30	5	24	4	11	7
3	0	7	7	3	1	1	14	0	2
0	0	3	1	0	0	5	0	1	0
0	0	3	0	0	1	8	0	2	2
0	1	2	1	15	10	1	0	3	6
1	3	14	2	25	14	0	1	0	0
0	0	2	5	0	1	25	0	1	0
0	0	0	135	265	711	0	1	20	24
0	0	1	12	5	20	0	1	3	0
4	3	79	18	1	26	18	66	237	124
0	0	0	0	0	0	21	0	3	0
0	0	1	2	0	0	5	0	2	0
8	4	117	40	115	390	7	219	66	28
6	11	26	70	66	234	1	41	27	8
1	0	3	0	0	2	1	1	9	4
0	1	0	7	0	15	0	3	1	0
0	0	0	1	0	9	0	1	0	0
0	17	1	0	8	14	0	0	0	1
1	0	10	27	32	75	0	17	37	42
2	0	0	2	0	4	0	0	9	1
0	0	1	0	0	0	6	0	0	0

0	0	0	0	0	2	0	0	0	0
0	0	0	0	3	3	0	30	12	3
1	0	5	2	0	1	1	1	4	1
0	0	0	0	0	0	0	0	1	0
0	0	0	0	1	0	0	0	0	0
0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	0	0	0	1	0
1	1	2	5	0	2	1	0	0	0
0	0	0	0	0	0	0	0	0	0
1	0	1	1	0	1	0	2	1	0
0	0	0	0	0	0	3	1	0	0
0	0	1	3	0	1	4	0	0	0
0	0	0	3	0	2	0	0	0	0
0	0	0	0	0	2	0	0	1	0
0	0	0	0	0	0	0	0	7	2
0	0	0	0	1	0	0	0	0	0
0	0	0	0	2	2	0	0	1	0
0	0	0	0	0	0	2	0	1	0
0	0	1	0	0	0	3	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	10	0	0	15	0
0	0	0	3	0	0	0	0	0	1
2	0	2	0	0	42	0	4	4	0
0	0	0	0	0	2	0	1	0	0
33	42	311	357	573	1602	137	408	480	256

Blue Anchor 6/8/00	Ilfracombe 8/8/00	Merthyr Mawr 26/1/98	Tresilian 20/12/98	Tresilian 4/1/99	Tresilian 17/1/99	Tresilian 3/2/99	Tresilian 21/2/99	Tresilian 8/3/99	Merthyr Mawr 1/4/98
S35	S36	S37	S38	S39	S40	S41	S42	S43	S44
5	0	310	42	165	91	61	10	34	10
6	6	90	3	0	3	1	0	4	7
0	0	5	0	0	0	0	0	0	2
0	0	13	0	0	0	0	0	0	2
7	0	14	1	0	1	0	0	2	8
2	13	3	0	0	0	0	0	2	8
0	0	15	3	0	0	1	0	0	3
4	0	34	0	0	0	0	0	0	29
1	2	96	0	0	0	0	0	0	4
2	5	66	2	1	2	1	0	0	6
0	0	0	0	0	0	0	0	0	1
1	1	0	1	0	0	0	0	0	5
41	49	230	22	28	25	27	24	39	15
14	31	272	0	0	0	0	0	2	30
0	0	15	0	0	0	0	0	0	5
0	0	28	8	45	5	4	0	0	14
0	0	5	0	0	0	0	0	1	3
1	0	0	0	0	0	0	0	0	0
1	1	57	0	0	0	0	0	0	6
1	3	73	0	0	0	0	0	0	2
0	0	0	0	0	0	0	0	0	1

0	0	36	9	4	4	1	0	2	11
1	0	1	0	0	0	0	0	0	1
2	7	10	18	13	10	3	3	7	3
0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1
1	1	8	1	0	0	0	0	0	4
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1
0	0	0	2	0	0	0	0	0	5
0	0	25	1	5	1	2	0	2	5
0	0	0	0	0	0	0	0	0	0
0	0	5	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0
0	0	2	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0
0	0	3	1	0	0	0	0	0	0
0	0	15	0	2	0	0	0	0	0
0	2	0	0	0	0	0	0	0	0
0	8	10	0	0	0	0	0	0	1
0	0	21	0	0	0	0	0	0	3
3	0	4	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1
93	129	1467	114	263	142	101	37	95	201

River Ogmore 1/4/98	Kempley	Kemer 1	Kemer 2	Kemer 3	Çirali 1	Çirali 2	Çirali 3	Side 1	Side 2	Konyaalti 1
S45	S46	S47	S48	S49	S50	S51	S52	S53	S54	S55
18	9	2	17	8	4	2	3	7	10	9
0	8	2	2	2			1	2	2	8
0	1		1							1
5						1			1	
7	4	3	2				1		1	
0	2		16	5	4		1	11	4	13
4										
24										
0					1		1			
0		51	14	50						
0			2	1				1		
0					1	2			3	
18		3	7	4				7	7	
18	39	17	48	9	1	3	1	23	13	16
1	4									
12	1		1							
0			1	2			1			
0		97	108	143	42	41	46	43	51	106
2	1	29	64	70	6	4	7	9	16	39
1	17	1	10	20			1	15	8	16
0										

7	45		6	1	1			3	3	6
0										
1			6	8	3	3	2	2	11	4
1										
3										
1										
0		1								
3	3							1	1	
0										
0										
4										
13	1							2		
0										
1	1	1								
0			3	1				2	2	
0										
2										
0										
0										
0										
0	1									
2	4		1		3	2	1	1	5	3
0		18	35	64	2	1		19	32	55
2										
150	141	225	344	388	68	59	66	148	170	276

Konyaalti 2	Konyaalti 3	Konyaalti 4	
S56	S57	S58	TOTAL
1	4	3	1033
1	2	2	208
	1		30
	1		41
	2	1	106
8	15	59	259
			63
			1599
2	6		176
		45	1060
			33
5	1		46
		10	1792
10	20	66	1427
			62
			203
			30
80	93	96	1058
20	34	80	870
	5		237
			9

2	28	20	195
			68
6	5	21	171
			6
			10
			4
			6
		1	40
			46
			11
			21
			70
			9
			15
1			25
			7
	1		10
			7
			21
			2
			66
2	4	3	72
11	37	42	400
			6
149	259	449	11630

Appendix IVc

Calculation of Quantitative Coefficients
(see pages 150-151)

Table A Data used in Raabe and Czenaowski coefficients. Bold text refers to minimum percentage representation for use in Raabe's coefficient

Litter 'Species'	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Freshwater West	11	1	2	3	1	20	3	237	66	27	9	1	37	9	12	4	1	1	15	4	464
Merthyr Mawr	310	5	13	14	15	34	96	66	230	272	15	28	57	73	1	10	1	3	10	4	1257
																				Total	**1721**
Lesser measures of common litter 'species' -used for Czekanowski coefficient	11	1	2	3	1	20	3	66	66	27	9	1	37	9	1	4	1	1	10	4	277
Transformed data - Freshwater West - used for Raabe coefficient	**2.4**	**0.2**	**0.4**	**0.6**	**0.2**	4.3	**0.6**	51.1	**14.2**	**5.8**	1.9	**0.2**	8.0	**1.9**	2.6	0.9	0.2	0.2	3.2	0.9	100.0
Transformed data - Merthyr Mawr - used for Raabe coefficient	24.7	0.4	1.0	1.1	1.2	**2.7**	7.6	**5.3**	18.3	21.6	**1.2**	2.2	**4.5**	5.8	**0.1**	**0.8**	**0.1**	**0.2**	**0.8**	**0.3**	100.0

See Table B for Key

Raabe = 2.4 + 0.2 + 0.4 + 0.6 + 0.2 + 2.7 + 0.6 + 5.3 + 14.2 + 5.8 + 1.2 + 0.2 + 4.5 + 1.9 + 0.1 + 0.8 + 0.1 + 0.2 + 0.8 + 0. 3 = 42.5%

Czekanowski = 2(277) / 1721 = 0.32

Table B Key to Litter 'Species' in Table A

Litter 'Species number used in Table A	Litter 'Species' common to Freshwater West and Merthyr Mawr - used in Table A
1	Soft drink bottle container
2	Milk container
3	Toiletry containers: e.g. toothpaste, toothbrush, shampoo, deodorant
4	Food containers - e.g. margarine, mayonnaise
5	Detergent containers
6	Cotton bud sticks
7	Sewage related debris
8	Netting/line
9	Unidentifiable plastic fragments
10	Sweet wrappers, straw, lollipop sticks, small sachets/cartons of soft drink etc.
11	Packing strap
12	Polystyrene
13	Beverage Bottle tops, tamper proof rings
14	Plastic bag
15	Shotgun cartridge
16	Cloth, shoe
17	Party popper
18	25l oil drum
19	plastic sheet
20	paper

Appendix IVd

Tresilian Bay Litter Survey Data 1994-1998

Beach Litter Survey – Tresilian Beach – 6/5/94 PCU

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
TYRES AND RUBBER	4	3	3	16	15	7	9	4	2	3	7	8	9	1	2	2
CLOTHING	3	4	3	1	4	0	2	0	1	3	0	1	3	0	0	1
SHOES	3	3	1	1	11	9	13	4	0	0	7	4	3	0	2	0
POLYSTYRENE	7	1	21	43	46	40	50	3	1	3	5	45	84	15	17	0
STRING, ROPE	5	0	3	0	3	5	1	0	1	1	3	6	3	1	1	0
METAL	1	0	1	3	0	11	0	5	8	5	2	3	1	5	1	0
PLASTIC	11	7	47	47	65	70	66	18	13	24	9	35	95	26	21	15
POLYSTYRENE CONTAINERS	0	0	1	1	5	0	0	0	0	0	0	0	0	0	0	3
PAPER CONTAINERS	1	1	2	1	4	0	0	0	2	0	0	0	2	0	1	1
METAL CONTAINERS	3	0	4	5	14	5	14	0	0	1	6	10	11	0	5	0
PLASTIC CONTAINERS	8	2	10	49	103	100	42	1	0	3	13	9	15	8	11	1

Beach Litter Survey – Tresilian Beach – 24/5/94 ACU

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
TYRES AND RUBBER	1	2	0	3	0	2	0	1	1	0	0	0	1	0	1	2
CLOTHING	1	0	0	0	3	0	1	0	1	0	0	0	1	4	0	1
SHOES	0	0	2	2	1	1	0	1	1	0	0	0	0	0	0	0
POLYSTYRENE	0	3	8	27	26	1	0	1	0	5	6	10	17	0	2	1
STRING, ROPE	0	1	1	0	3	1	0	0	0	0	0	0	3	0	0	0
METAL	0	0	0	2	3	0	1	0	0	0	1	3	0	0	0	1
PLASTIC	8	7	4	9	11	3	0	6	1	2	4	5	16	11	9	4
POLYSTYRENE CONTAINERS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PAPER CONTAINERS	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
METAL CONTAINERS	10	0	2	2	2	1	0	0	3	1	0	2	0	2	5	0
PLASTIC CONTAINERS	0	3	2	3	3	10	0	0	0	1	1	1	6	0	1	2

Beach Litter Survey – Tresilian Beach – 27/4/95 PCU

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
TYRES AND RUBBER	14	3	7	18	9	14	3	5	2	7	5	5	5	10
CLOTHING	0	3	2	0	0	1	0	4	1	1	0	1	2	0
SHOES	5	8	14	9	7	17	3	0	9	0	4	4	9	12
POLYSTYRENE	1	3	50	85	98	305	4	17	3	12	10	12	10	7
STRING, ROPE	2	2	0	3	2	3	0	3	2	0	2	0	2	8
METAL	1	11	3	1	3	8	4	7	2	0	3	8	18	4
PLASTIC	2	26	50	94	48	119	50	26	8	21	19	12	42	11
POLYSTYRENE CONTAINERS	0	0	0	0	0	11	0	0	0	0	0	12	10	0
PAPER CONTAINERS	0	1	0	0	0	1	0	0	0	0	0	2	0	0
METAL CONTAINERS	0	1	10	0	0	6	0	0	3	5	0	8	12	1
PLASTIC CONTAINERS	2	8	93	119	60	127	0	2	7	2	2	13	18	14
FOAM						32								
CARPET						1								
LEATHER						1								
WOOD*			131	136			80			57		120		
NET (FISHING)						3								

Beach Litter Survey – Tresilian Beach – 11/5/95 ACU

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
TYRES AND RUBBER	8	2	7	3	17	4	6	2	3	8	1	2	2	1
CLOTHING	1	4	0	0	1	3	0	0	0	0	0	0	0	1
SHOES	7	7	3	6	4	6	1	2	0	5	0	2	0	0
POLYSTYRENE	4	16	11	36	55	64	6	1	7	6	8	28	2	1
STRING, ROPE	7	1	2	5	0	1	0	0	0	0	1	2	0	0
METAL	3	1	1	4	4	13	2	0	1	1	1	10	1	0
PLASTIC	7	10	18	4	49	15	4	5	11	12	7	52	3	1
POLYSTYRENE CONTAINERS	2	0	1	0	0	1	0	0	0	0	1	0	0	0
PAPER CONTAINERS	1	5	0	0	0	1	0	0	0	2	0	0	0	0
METAL CONTAINERS	3	1	2	0	3	6	1	2	2	3	1	0	0	0
PLASTIC CONTAINERS	7	6	11	16	5	12	2	4	0	3	3	1	0	0
FOAM					23				2					

Beach Litter Survey – Tresilian Beach – 14/5/96 PCU

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
TYRES AND RUBBER	4	0	2	3	4	1	1	1	5	1	3	2	3	1	1
CLOTHING	1	3	1	0	2	0	0	1	0	0	1	0	0	0	0
SHOES	0	0	1	0	0	0	0	0	0	1	1	0	0	1	0
POLYSTYRENE	0	2	0	35	18	14	17	0	1	0	3	31	21	3	2
STRING, ROPE	1	1	1	0	0	0	0	0	1	0	6	3	1	1	0
METAL	3	1	1	1	0	0	0	0	0	0	0	0	4	10	0
PLASTIC	18	5	7	23	9	11	3	0	6	6	12	31	26	15	4
POLYSTYRENE CONTAINERS	0	0	8	1	1	0	0	1	0	0	3	1	0	1	0
PAPER CONTAINERS	37	1	1	2	0	0	0	1	1	0	1	0	20	12	2
METAL CONTAINERS	12	2	0	2	2	1	0	1	11	0	2	10	11	20	4
PLASTIC CONTAINERS	11	2	6	15	3	1	7	3	3	3	7	0	9	17	8
GLASS	0	2	1	1	2	0	0	1	1	0	0	0	1	6	4

Beach Litter Survey – Tresilian Beach – 31/5/96 ACU

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
TYRES AND RUBBER	1	2	0	1	1	4	1	8	6	1	4	4	0	0	0
CLOTHING	0	4	2	1	1	1	3	13	3	1	4	0	0	0	0
SHOES	0	3	4	1	3	4	1	5	3	0	2	4	3	1	1
POLYSTYRENE	0	0	11	8	6	22	6	3	0	1	2	4	1	0	2
STRING, ROPE	2	2	0	2	6	15	0	4	0	2	0	1	2	1	1
METAL	0	3	0	1	2	5	4	1	5	0	5	2	0	0	3
PLASTIC	4	19	20	18	28	46	20	19	24	13	16	22	23	6	18
POLYSTYRENE CONTAINERS	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1
PAPER CONTAINERS	1	0	0	0	0	1	3	0	0	1	0	2	0	0	0
METAL CONTAINERS	2	2	1	11	7	1	7	4	2	0	0	7	3	2	0
PLASTIC CONTAINERS	7	6	8	24	10	0	13	4	13	2	0	7	3	2	0
GLASS	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0

Beach Litter Survey – Tresilian Beach – 24/4/97 PCU

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
TYRES AND RUBBER	9	23	5	5	5	3	3	2	0	0	0	4	0	0	0
CLOTHING	1	7	35	1	3	1	1	1	0	0	0	1	0	0	0
SHOES	9	38	2	6	5	0	5	1	0	3	2	0	1	0	0
POLYSTYRENE	6	339	110	32	24	34	6	2	3	0	0	5	10	0	2
STRING, ROPE, NET	6	21	2	3	1	6	7	1	0	0	0	1	0	0	0
METAL	1	3	6	5	4	0	2	0	0	0	4	1	1	1	0
PLASTIC	11	254	149	64	42	19	13	4	2	0	0	12	5	1	1
POLYSTYRENE CONTAINERS	0	0	46	0	0	0	0	0	0	0	0	0	0	0	0
PAPER CONTAINERS	0	3	1	0	2	0	0	0	0	0	0	0	0	1	0
METAL CONTAINERS	2	11	2	3	2	5	1	3	0	1	1	0	0	5	0
PLASTIC CONTAINERS	8	152	67	71	31	14	24	6	1	0	2	5	4	5	2
GLASS	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Beach Litter Survey – Tresilian Beach – 7/5/97 ACU

	A	B	C	D	E	F	G	H	I	J	K
TYRES AND RUBBER	0	5	0	0	4	7	1	1	2	2	9
CLOTHING	0	1	3	3	1	0	2	0	3	1	0
SHOES	0	5	0	7	2	2	1	1	0	0	3
POLYSTYRENE	5	7	12	22	13	9	4	13	1	1	2
STRING, ROPE, NET	0	2	1	2	2	0	2	5	2	0	1
METAL	2	1	1	0	0	6	2	1	3	1	0
PLASTIC	5	8	14	9	21	9	12	10	2	6	14
POLYSTYRENE CONTAINERS	0	0	0	0	0	0	0	0	0	0	0
PAPER CONTAINERS	1	0	0	2	2	0	0	2	0	1	1
METAL CONTAINERS	1	1	1	5	6	4	0	5	0	3	4
PLASTIC CONTAINERS	13	3	3	17	15	5	1	5	0	5	3
GLASS	0	0	0	1	1	0	0	0	5	0	0

Beach Litter Survey – Tresilian Beach – 17/3/98 PCU

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
TYRES AND RUBBER	2	3	2	2	4	2	3	5	4	0	2	3	1	4	0
CLOTHING	4	3	1	2	4	1	3	1	1	1	1	1	2	6	0
SHOES	4	4	4	3	7	1	2	4	6	1	2	1	3	1	2
POLYSTYRENE	7	16	15	4	11	0	7	2	1	6	1	8	9	8	3
STRING, ROPE, NET	4	5	4	3	3	3	4	1	1	2	2	1	2	1	3
METAL	2	2	5	3	7	0	1	0	0	3	0	2	1	7	2
PLASTIC	18	20	36	12	55	4	11	13	4	21	20	63	26	29	18
POLYSTYRENE CONTAINERS	2	1	2	1	3	0	0	0	0	1	0	0	1	1	0
PAPER CONTAINERS	0	0	2	0	2	0	0	0	0	0	0	0	0	1	0
METAL CONTAINERS	3	5	4	3	11	1	4	0	2	2	4	3	6	1	8
PLASTIC CONTAINERS	12	22	34	14	49	16	24	19	7	7	9	15	35	39	27
GLASS	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0

Beach Litter Survey – Tresilian Beach – 14/4/98 ACU

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
TYRES AND RUBBER	2	2	1	0	0	2	2	3	1	3	0	3	4	0	0
CLOTHING	0	0	1	0	0	2	1	0	0	1	1	1	1	2	1
SHOES	3	1	2	3	3	5	4	1	2	1	2	1	4	1	0
POLYSTYRENE	1	0	0	4	5	7	1	0	1	1	4	4	5	5	2
STRING, ROPE, NET	3	0	1	4	1	0	3	0	1	1	2	2	3	8	1
METAL	2	0	1	1	0	2	0	1	0	0	1	0	1	0	0
PLASTIC	7	7	1	6	8	13	6	9	6	7	6	17	13	11	3
POLYSTYRENE CONTAINERS	2	0	0	0	0	1	0	0	0	0	1	1	1	0	0
PAPER CONTAINERS	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0
METAL CONTAINERS	1	2	1	3	1	2	1	1	0	0	1	2	2	5	1
PLASTIC CONTAINERS	7	6	14	15	21	17	11	9	12	13	8	15	15	12	0
GLASS	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Appendix V

Beach user questionnaires and their Specific Methodologies

Specific Methodologies for Beach User Questionnaires

South Wales (North Shore of Bristol Channel) Coast Survey (1998)

The questionnaire was made up of five parts. Part 1 related to socio-economic, demographic, and geographic factors, along with matters such as the type of accommodation used, if the interviewee was on holiday. The subsequent section was a mix of beach quality, management and selection questions (Part 2).

- Respondents were required to place in order what they considered to be the most offensive forms of beach / sea pollution. The eight criteria were a mix of physical forms of pollution commonly found on beaches and within the sea.

- Interviewees were asked to describe the state of the beach they were on with regard to litter pollution from four specific criteria. The four options given related directly to the EA / NALG protocol (EA/NALG, 2000). Results given by the public could then be compared to the *actual* grade / description attained by the beach from direct litter counts conducted at the same time as the questionnaire survey. The publics perception of what constitutes a 'very good', or 'A' grade, beach was examined.

- Respondents were asked to select 'yes', 'no', or 'unsure' to the question; 'do you think dogs should be allowed on: a) resort beaches, and b) rural beaches'. Subsequent questionnaires included the stipulation that this was only related to the summer season - May to September. No definition of what constitutes a resort or a rural beach was given on the questionnaire, this was left to the discretion of the person completing the form. It was felt that the distinction between resort and rural beaches needed to be made when asking this question, it was hypothesised that people may have a different view of beach use, particularly with regard to dog access, for resort and rural beaches.

- Those taking part were required to rank ten criteria in order of what they considered to be the most important reasons for beach selection. The ten options given were a range of physical, and pollution factors, as well as facilities at the beach.

Part 3 of the survey form related to beach awards. The purpose was to establish what level of public awareness existed with regard to beach rating and award schemes. Many of these schemes are represented in the form of a flag, usually flying at the beach where an award has been achieved. The public were asked if they were aware of these schemes; could they name any; could they describe their appearance; what a flag at a beach represented; and, if the beach they were on had an award. It was made clear throughout this section that when referring to flags, this did not include lifesaving safety flags. The principal behind these award schemes is a very worthy one, great effort and importance is placed on attaining such an award by local councils, and businesses are assumed to benefit from increased numbers of tourists and beach users. The aim of this question was to evaluate what value the public placed on these schemes.

Part 4, the major portion of this questionnaire, involved the use of a selection of photographs in order to assess public perception of certain litter items. A scaled response format was chosen, which required respondents to separately rate each photograph on an offensiveness scale. Participants were asked to score, on a scale of 1, 'not offensive', to 9, 'very offensive', each litter item shown in the photograph. One draw back was the large number of photos used, with the danger that the repetition required lead to 'top of the head' responses rather than a more evaluated response. The other problem is the order in which the photos were shown, which can lead to comparison problems. For example, a respondent may give an item the maximum score of nine on the offensiveness rating scale, and then find that a later photograph is more offensive to them, but only has the option to give the maximum nine score again. This may lead to many of the photographs gaining a similar high overall scoring. The order in which the photos in this study were shown was determined by random numbers. The alternative was to conduct a pilot study to find the most offensive items and then place them in descending order in the full survey, i.e. in this case show the syringe first (Figure 6.4). This though can be leading and give rise to spurious results, so the random generated order was deemed most appropriate. One must remember that credit should be given to the public in overcoming all of these uncertainties and allow them to come to their own decisions and evaluations.

As part of this photographic portion of the study, respondents were also asked if they were able to identify and name the three separate items of sewage related debris shown to them (Figures 6.3, 6.7, and 6.10). The rationale was to establish if beach users were able to identify items of sewage related debris that are commonly found on beaches along the Bristol Channel coast.

Part 5 again related to beach awards. The section was kept separate from part 3 so that untainted answers would be given. In this section, respondents were asked directly if they had heard of the European Blue Flag award, the Good Beach Guide, and the Seaside Award. It was assumed that they would not go back to part 3 and fill in the question asking them to name any awards, this is the reason for splitting the two sections on awards. From seven parameters the interviewees were then asked to select those which applied to each award. Some of the parameters were red herrings and others were genuinely part of the award criteria.

Space was left at the bottom of the form for any additional comments that the interviewees would like to make regarding the coastal environment.

South Wales (North Shore of Bristol Channel) Coast Survey (1999)

The questionnaire consisted of three parts designed to obtain; personal details of the respondents; the views and perceptions of the interviewees regarding beach quality; and, their opinion with respect to beach management questions. The section covering the personal details of the interviewees was similar to the 1998 survey, the only difference being that the accommodation section had 'Youth Hostel' added as an additional choice, and the Hotel/Bed and Breakfast option was split into two separate categories.

The beach quality portion of the questionnaire contained questions that had been included in the 1998 survey, together with several additions. There was no litter perception study using photographs in this survey, nor was the issue of beach award recognition tackled. The 1998 study had shown that the public appeared to lose interest near the end of completing the questionnaire and the quality of responses was seen to decline, it was decided that a shortened questionnaire should be used. The use of photographs in 1998 proved to be a very useful and worthwhile experiment, but it also proved to be costly, due to photo reproduction, as well as time consuming.

The next question was open-ended and designed to assess what level litter needed to exist for the public to describe the beach as 'poor'. Three types of litter were specifically included, these were General Litter (e.g. drinks cans, sweet wrappers), Gross Litter (i.e. items larger than 50cm in one dimension, e.g. shopping trolley, traffic cone), and Sewage Related Debris (e.g. sanitary towel, condom). The respondents were simply asked to place a number alongside each of the three types.

Following this, an effort was made to establish if beach users had noticed any accumulations present. The idea behind this question stemmed from the 'accumulation' category included within the EA / NALG protocol classification (EA/NALG, 2000). There was much debate between participants involved in devising the scheme as to what constituted an accumulation of litter. The definition eventually established was, 'An accumulation is defined as a discrete aggregation of litter clearly visible when approaching the survey area, either in clearly distinguishable piles or as a single continuous strip along the entire 100 metres section.' (EA/NALG, 2000, p.8).

The next question was also formulated as a consequence of issues arising from the EA / NALG protocol (EA/NALG, 2000). One of the categories in this grading scheme was animal faeces, with the following definition explaining what was to be included : 'The numbers of animal faeces (dogs) should be counted in the survey zone. Faeces from animals such as sheep or horses should not be counted. These are not considered to be a general nuisance or hazard.'. It was therefore decided to establish what types of faeces on a beach were considered offensive by the public. Four choices were given, with the respondents allowed to tick as many as they wanted to confirm that they found that particular faeces type offensive. The four categories used were, horse, human, dog and sheep.

Those filling out the questionnaire were asked if they entered the sea to swim, if they entered just to paddle, or if they did not enter the sea at all. It was hypothesised that views of sea/beach pollution may be influenced by the usage of the sea while visiting a beach. Other research has found differences between participants and non-participants in recreational activity where pollution perceptions were concerned. For example (Ditton and Goodale, 1974, page 21). stated that 'recreation participation and resource use patterns are related to perceptions and attitudes regarding that resource'. It could therefore be argued that those not using a resource, in this case the sea, should not be consulted as to their views. This was not felt to be constructive in obtaining the opinion of the wider public, especially as the reason that those people were 'non-participants' may be because of their perceptions. David (1971) recognised that nonusers have an interest and 'stake' in water, and therefore surveyed representative samples rather than just users at selected sites.

Communication of beach grades to the public is an important consideration of any award scheme. Initial drafts of the litter protocol developed by NALG contained many proposed phraseologies for describing beach state. To determine the preference and understanding of beach users of various forms of presentation, respondents were required to rank in order of preference the different ways of presenting the beach grade with regard to the level of litter pollution.

The remaining questions were also used in the 1998 survey. Namely, the opinion of the most offensive forms of beach / sea pollution; perceived beach condition / grading compared to actual beach state; should dogs be allowed on beaches; and the beach users most important reason for selecting a beach to visit.

South Shore of Bristol Channel Survey and Mid/North Wales Coast Survey (2000)

This questionnaire used was almost identical to the 1999 survey, there were though two differences. Results from the question posed in 1999, which required the respondent to enumerate the amount of items of different types of litter that would be needed on a 100m stretch of beach for them to consider it as 'poor', were averaged for use in this survey. From these results the question was reconstructed in an attempt to ascertain if those at the beach would visit a stretch 100m in length that had 'X' number of items. The three open ended questions posed were; 10 items of general litter; 3 items of gross litter; and, 1 item of sewage related debris. The rationale was to test if figures given in 1999 were realistic indicators of the level of litter pollution that people would tolerate at a beach.

Additionally, on a scale of one to five, one meaning 'not important' and five signifying 'very important', interviewees were asked to select how important the beach was to their holiday. The very fact that these people were on the beach showed that there was an empathy, but this question was designed to quantify the importance.

BEACH USER QUESTIONNAIRE - 1998

To be completed by interviewer. Beach: Date: Time:

We would appreciate your views regarding beach quality, your opinions may help to improve the coastal environment. You may miss any questions you are not comfortable with. It will only take a few minutes.

Part 1 - Personal Details

Q1 *Age:* .... **Q2** *Sex:* Male [ ] Female [ ] **Q3** *Religion:*...

Q4 *Occupation:*...
.

Q5 *Are you here on:* Holiday[ ] Just for the day (travelled over 10m) [ ] Live locally [ ]

Q6 *If you are on holiday, where are you staying?* Hotel/B&B [ ] Camping [ ]
Caravan [ ] Self Catering [ ] With Friends/Relatives [ ]

Q7 *What is your home town?:* ....

Part 2 - General Beach Quality

- Please put in order what you consider the most offensive forms of beach/sea pollution on a scale of 1 to 8. **1** being the **most offensive** followed by 2, then 3 etc., **8** being **least offensive**.

*Place a **different** number in **each** box*

Discoloured Water [ ]
Sewage Related Debris [ ]
Beach Litter [ ]
Unusual Smell [ ]
Foam/Scum [ ]
Floating Debris [ ]
Oil (on the beach) [ ]
Oil (in the sea) [ ]

- How would you describe the state of this beach with regards to litter pollution?

Tick **one box** only

(A) Very Good [ ]
(B) Good [ ]
(C) Fair [ ]
(D) Poor [ ]

- Do you think dogs should be allowed on:
  a) Resort Beaches? Yes [ ] No [ ] Unsure [ ]
  b) Rural Beaches? Yes [ ] No [ ] Unsure [ ]
- Please put in order the most important reasons for selecting a beach to visit on a scale of 1 to 10. **1** being the **most important** followed by 2, then 3 etc., **10** being **least important**.

*Place a **different** number in **each** box*

Views and Landscape	[ ]	Accessibility	[ ]
Toilet Facilities	[ ]	Car Parking	[ ]
Clean sea water	[ ]	Safety	[ ]
Clean sand	[ ]	Refreshment kiosk	[ ]
Distance to travel to beach	[ ]	Beach Award Flag	[ ]

Part 3 - Flags - Beach Awards I

- *Are you aware of the existence of beach rating and award schemes, sometimes represented in the form of a flag?* ***(Note: not lifesaving safety flags)***
  Yes [ ] No [ ]

- *If yes to the above, can you name any?*..
  ....
  ....

- *What does a flag at a beach represent?* ***(Note: not lifesaving safety flags)***........................
  ....
  ......

- *Does this beach have a flag?* Yes [ ] No [ ] Unsure[ ]

If so, do you know what kind? ***(Note: not lifesaving safety flags)***
....
......
....
....

Part 4 - Litter Pollution

Please name the item shown in photograph:

5?..

20?..27?...

- **Please circle on the scale how offensive each of the following litter items shown in the photographs is to you.**

	Not offensive								Very offensive
Photo 1	1	2	3	4	5	6	7	8	9
Photo 2	1	2	3	4	5	6	7	8	9
Photo 3	1	2	3	4	5	6	7	8	9
Photo 4	1	2	3	4	5	6	7	8	9
Photo 5	1	2	3	4	5	6	7	8	9
Photo 6	1	2	3	4	5	6	7	8	9
Photo 7	1	2	3	4	5	6	7	8	9

Photo 8	1	2	3	4	5	6	7	8	9
Photo 9	1	2	3	4	5	6	7	8	9
Photo 10	1	2	3	4	5	6	7	8	9
Photo 11	1	2	3	4	5	6	7	8	9
Photo 12	1	2	3	4	5	6	7	8	9
Photo 13	1	2	3	4	5	6	7	8	9
Photo 14	1	2	3	4	5	6	7	8	9

Photo 15	1	2	3	4	5	6	7	8	9
Photo 16	1	2	3	4	5	6	7	8	9
Photo 17	1	2	3	4	5	6	7	8	9
Photo 18	1	2	3	4	5	6	7	8	9
Photo 19	1	2	3	4	5	6	7	8	9
Photo 20	1	2	3	4	5	6	7	8	9
Photo 21	1	2	3	4	5	6	7	8	9

Photo 22	1	2	3	4	5	6	7	8	9
Photo 23	1	2	3	4	5	6	7	8	9
Photo 24	1	2	3	4	5	6	7	8	9
Photo 25	1	2	3	4	5	6	7	8	9
Photo 26	1	2	3	4	5	6	7	8	9
Photo 27	1	2	3	4	5	6	7	8	9
Photo 28	1	2	3	4	5	6	7	8	9

*Are there any items of beach litter, which you have **not** been shown, that you find particularly offensive?*

....

....

....

Part 5 - Flags - Beach Awards II

- *Have you heard of the following?:*

Good Beach Guide	Yes [ ]	No [ ]	Unsure [ ]
EEC Blue Flag	Yes [ ]	No [ ]	Unsure [ ]
Seaside Award Flag	Yes [ ]	No [ ]	Unsure [ ]

- *Please tick which attributes apply to each of the awards below?*

	EEC BLUE FLAG	SEASIDE AWARD	GOOD BEACH GUIDE
Clean beach			
Clean bathing water			
Safety			
Sandy beach			
Provision of toilets			
Boating facilities			
Popular beach			

Comments

Are there any comments you would like to make about the coastal environment?

....

....

....

THANK YOU FOR YOUR TIME AND EFFORT IN COMPLETING THIS QUESTIONNAIRE

Enquiries:
David Tudor, Faculty of Applied Sciences, Bath Spa University College, Newton Park, Newton St Loe, Bath, BA2 9BN.

BEACH USER QUESTIONNAIRE - 1999

We would appreciate your views regarding beach quality, your opinions may help to improve the coastal environment. You may miss any questions you are not comfortable with. It will only take a few minutes.

Part 1 - Personal Details

Q1 *Age:* .... **Q2** *Sex:* Male [ ] Female [ ]

Q3
Occupation:..
.

Q4 *Are you here :*
On Holiday [ ] Just for the day (travelled over 10m) [ ] Live locally [ ]

Q5 *If you are on holiday, where are you staying?* Hotel [ ] B&B [ ]
Camping [ ] Caravan [ ] Self Catering [ ]
With Friends/Relatives [ ] Youth Hostel [ ]

Q6 *What is your home town?:* ....

Part 2 - Beach Quality

- How would you describe the condition of this 100 metre stretch of beach with regards to litter pollution? (50 metres either side of where you are)

	Tick **one box** only
(A) Very Good	[ ]
(B) Good	[ ]
(C) Fair	[ ]
(D) Poor	[ ]

- How many items of the following would need be present for you to consider this 100m stretch of beach to be described as poor?:

  General litter (e.g. crisp packet, drinks can): ....
  Gross litter (>50cm, e.g. barrel, shopping trolley): ....
  Sewage related debris (e.g. condom, sanitary towel, cotton bud stick): ....

- Have you noticed any accumulations / piles of litter on this stretch of beach?
  Yes [ ] No [ ]

- Which of these types of faeces do you find offensive on a beach?
  Horse [ ] Human [ ] Dog [ ] Sheep [ ]

- Do you enter the sea? No [ ] Yes, but only to paddle [ ] Yes, swim [ ]

- Please rank what you consider the most offensive forms of beach/sea pollution. **1** being the **most offensive** followed by 2, then 3 etc.

	Place a __different__ number in __each__ box	**Example**
Discoloured Water	[ ]	**[5]**
Sewage Related Debris	[ ]	**[7]**
Beach Litter	[ ]	**[6]**
Unusual Smell	[ ]	**[1]**
Foam/Scum	[ ]	**[2]**
Floating Debris	[ ]	**[3]**
Oil (on the beach)	[ ]	**[etc]**
Oil (in the sea)	[ ]	**[etc]**
Any other? (please state)	[ ]	**[etc]**

- Please rank what you consider to be the best form of presentation to grade a beach, with regards to litter/debris. **1** being the best, followed by 2, 3,4, 5, 6.

						Example
a)	Very Good	Good	Fair	Poor	[ ]	**[2]**
b)	A	B	C	D	[ ]	**[4]**
c)	Grade 1	Grade 2	Grade 3	Grade 4	[ ]	**[1]**
d)	✡✡✡✡	✡✡✡	✡✡	✡	[ ]	**[3]**
e)	Very Clean	Clean	Dirty	Very Dirty	[ ]	**[etc]**
f)	Absent	Trace	Unacceptable	Objectionable	[ ]	**[etc]**

Part 3 - Beach Management

- In the summer season (May - September) do you think dogs should be allowed on:
  a) Resort Beaches? Yes [ ] No [ ] Unsure [ ]
  b) Rural Beaches? Yes [ ] No [ ] Unsure [ ]

- Please rank the *most important reasons for selecting a beach* to visit. **1** being the **most important** followed by 2, then 3 etc.

Place a __different__ number in __each__ box

Views and Landscape	[ ]	Accessibility	[ ]
Toilet facilities	[ ]	Car Parking	[ ]
Clean sea water	[ ]	Safety	[ ]
Clean sand	[ ]	Refreshment kiosk	[ ]
Distance to travel to beach	[ ]	Beach Award Flag	[ ]
Any other? (please state)	[ ]		

THANK YOU FOR YOUR TIME AND EFFORT IN COMPLETING THIS QUESTIONNAIRE

__Enquiries__: David Tudor, Faculty of Applied Sciences, Bath Spa University College, Newton Park, Newton St Loe, Bath, BA2 9BN.

BEACH USER QUESTIONNAIRE - 2000

We would appreciate your views regarding beach quality, your opinions may help to improve the coastal environment. You may miss any questions you are not comfortable with. It will only take a few minutes.

Part 1 - Personal Details

1 *Age:* .... **2** *Sex:* Male [ ] Female [ ]

3 *Occupation:*..

4 *Are you here* (Tick **one box** only) *:*
On Holiday [ ] Just for the day (travelled over 10 miles) [ ] Live locally [ ]

5 *If you are on holiday, where are you staying?* (Tick **one box** only)
Hotel [ ] B&B [ ] Caravan [ ] Camping [ ]

Self Catering [ ] With Friends/Relatives [ ] Youth Hostel [ ]

6 *What is your home town?:* ....

Part 2 - Beach Quality

- How would you describe the condition of this 100 metre stretch of beach with regards to litter pollution? (50 metres either side of where you are)

  Tick **one box** only
  (A) Very Good [ ]
  (B) Good [ ]
  (C) Fair [ ]
  (D) Poor [ ]

- Would you visit a stretch of beach (100 metres) that had:
  - 10 items of general litter? (e.g. crisp packet, drinks can) - Tick **one box** only
    Yes [ ] No [ ] Unsure [ ]
  - 3 items of gross litter? (>50cm, e.g. barrel, shopping trolley) - Tick **one box** only
    Yes [ ] No [ ] Unsure [ ]
  - 1 item of sewage related debris? (e.g. condom, sanitary towel) - Tick **one box** only
    Yes [ ] No [ ] Unsure [ ]

- Have you noticed any accumulations / piles of litter on this stretch of beach?
  (Tick **one box** only) Yes [ ] No [ ]

- Which of these types of faeces do you find offensive on a beach? (Tick **as many** as required)
  Horse [ ] Human [ ] Dog [ ] Sheep [ ]

- Do you enter the sea? (Tick **one box** only) No [ ] Yes, to paddle [ ] Yes, to swim [ ]

  If not, is there a reason why?..
  ....

- How important is the beach to your holiday? Please indicate on the scale (Circle **one box** only).

Not Important				Very Important
1	2	3	4	5

- Please rank what you consider the most offensive forms of beach/sea pollution. **1** being the **most offensive** followed by 2, then 3 etc.

	*Place a **different** number in **each** box*	**Example**
Discoloured Water	[ ]	**[5]**
Sewage Related Debris	[ ]	**[7]**
Beach Litter	[ ]	**[6]**
Unusual Smell	[ ]	**[1]**
Foam/Scum	[ ]	**[2]**
Floating Debris	[ ]	**[3]**
Oil (on the beach)	[ ]	
[etc]		
Oil (in the sea)	[ ]	**[etc]**
Any other? (*Optional; please state*)	[ ]	**[etc]**

- With regards to pollution/litter on a beach; please rank what you consider to be the best form of presentation to grade a beach. **1** being the best, followed by 2, 3,4, 5, 6. *Place a **different** number in **each** box.*

						Example
a)	Very Good	Good	Fair	Poor	[ ]	**[2]**
b)	A	B	C	D	[ ]	**[4]**
c)	Grade 1	Grade 2	Grade 3	Grade 4	[ ]	**[1]**
d)	✡✡✡✡	✡✡✡	✡✡	✡	[ ]	**[3]**
e)	Very Clean	Clean	Dirty	Very Dirty	[ ]	**[etc]**
f)	Absent	Trace	Unacceptable	Objectionable	[ ]	**[etc]**

Part 3 - Beach Management

- In the summer season (May - September) do you think dogs should be allowed on:
  a) Resort Beaches? (Tick **one box** only) Yes [ ] No [ ] Unsure [ ]
  b) Rural Beaches? (Tick **one box** only) Yes [ ] No [ ] Unsure [ ]

- Please rank the *most important reasons for selecting a beach* to visit. **1** being the **most important** followed by 2, then 3 etc.

*Place a **different** number in **each** box*

Views and Landscape	[ ]	Accessibility	[ ]
Toilet facilities	[ ]	Car Parking	[ ]
Clean sea water	[ ]	Safety	[ ]
Clean sand	[ ]	Refreshment kiosk	[ ]
Distance to travel to beach	[ ]	Beach Award Flag	[ ]
Any other? (*Optional; please state*)	[ ]		

THANK YOU FOR YOUR TIME AND EFFORT IN COMPLETING THIS QUESTIONNAIRE

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Appendix VI

Beach Award Schemes

Criteria Comparison Between the European Blue Flag & Seaside Award Beaches 2000

CRITERIA	BLUE FLAG	SEASIDE AWARD
region	• Europe	• UK
flag	• blue with white circle	• yellow with blue flash
water	• bathing water directive guideline standards for microbiological and physico-chemical parameters • urban waste water treatment directive	• bathing water directive mandatory standards for microbiological parameters
beach character	• resort	• resort and rural
dogs	• banned from the beach	• banned from the beach* • seafront dogs on leads* • dog refuse bins*
public telephones	• available if there are no lifeguards	• available* • within 5 minutes walk* • checked daily*
toilets	• provided • adequate for: - numbers of visitors - disabled people - cleaned and regularly maintained throughout the day	• provided* • adequate for: - numbers of visitors - disabled people - cleaned and regularly maintained throughout the day
litter bins	• adequately provided • emptied and maintained regularly	• adequately provided • every 25 metres (approx.) • appropriate style • emptied and maintained regularly
bathing safety	• lifesaving equipment • lifeguards recommended • zoning of different users	• lifesaving equipment • lifeguards recommended * • patrolled areas defined* • zoning of different users
supervision		• daily (between 10.00 a.m. and 6.00 p.m.)*
cleansing	• daily	• daily up to EPA standards
drinking water	• provided	• provided
access	• safe for all including disabled visitors • no unauthorised vehicles, camping or dumping	• safe for all including disabled visitors • no unauthorised vehicles, camping or dumping
first aid	• provided	• provided and attended with times displayed
incidents	• public warning of	• public warning of

	pollution	pollution • records must be kept and made available for inspection*
information displayed	• current water quality • award criteria • environmental initiatives • bye laws & codes of conduct • beach management & award administration contact details	• current and previous 4 years' water quality • award criteria • map of award area • car parks • sampling points • beach management & award administration contact details • managing authority contact • safety information including attendance times • defined award area • environmental initiatives • bye laws & codes of conduct
environmental care	• recycling facilities (recommended) • promote sustainable transport e.g. cycling and public transport (recommended)	

NB Rural beaches do not have to comply with those criteria marked *

The Difference between a Seaside Award 'Resort' and 'Rural' beach

A RESORT BEACH is one which has varied facilities and provides varied recreation opportunities. it would normally be adjacent to or within easy and reasonable access to the urban community and typically would include a cafe or restaurant, shop, toilets, supervision, first aid and could be reached by public transport

- **water quality:**

- complies with European legislation
- no discharges affecting the beach area

- **safety:**

- provision of lifesaving equipment
- first aid facilities
- record of incidents

- **management:**

- supervision
- actively promoted
- dog control and dog refuse bins
- public telephones
- toilets, including for disabled people
- drinking water
- safe access including for disabled people
- adequate parking with reserved spaces for disabled peoples' vehicles
- zoning of conflicting uses
- safe, well-maintained buildings
- emergency action plans

- **cleanliness:**

- no litter, industrial waste, oil or rotting seaweed
- appropriate and adequate litter bins
- cleansing standards to comply with EPA code of practice standards

- **information:**

- lifesaving equipment / lifeguards
- map of award area and facilities
- management contact address
- current and historic water quality
- public telephone
- times of supervision and first aid
-codes of conduct
- award(s) criteria
- liaison with other conservation groups
- initiatives to protect the environment and educate the public

A RURAL BEACH is one which has limited facilities and has neither been actively managed and developed as a resort nor is part of any significant development. The beach would be visited and enjoyed for its intrinsic qualities and is where local interest and management maintains a clean environment.

- **water quality:**

- complies with European legislation
- no discharges affecting the beach area

- **safety:**

- provision of lifesaving equipment
- locally considered safe for swimming
- warning of potential hazards

- **management:**

- amenities in good condition
- checked regularly by a 'guardian'
- safe, well maintained access
- no unauthorised camping, dumping or driving

- **cleanliness:**

- no litter, industrial waste, oil or rotting seaweed
- litter bins or litter management strategy

- **information:**

- lifesaving equipment
- map of award area and facilities
- management contact address
- current and historic water quality
- advice about nearest telephone and emergency services
- protection of local environment including encouraging the disposal of litter and dog faeces