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**HEALTH EFFECTS OF SEA BATHING (EH 9021)**
**PHASE III STUDIES IN 1991**

**Interim report, April 1991 to March 1992**

**DoE 3164**

**SEPTEMBER 1992**

HEALTH EFFECTS OF SEA BATHING (EH 9021) - PHASE III
STUDIES IN 1991

Interim report, April 1991 to March 1992

Report No: DoE 3164

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# PREFACE

In 1984 in its 10th Report, the Royal Commission on Environmental Pollution expressed widespread concern about pollution of bathing beaches by sewage and noted that, although the risks of contracting serious illness from bathing in such water appeared to be very small, the same could not be said of milder intestinal complaints such as 'travellers diarrhoea'. It recommended that epidemiological studies should be carried out to establish the risks under UK conditions. There has also been concern that the microbiological standards of the bathing water Directive 76/160/EEC, were not based upon an assessment of risks. More recently, under the Water Act 1989, the Secretary of State is empowered to impose statutory water quality objectives and the National Rivers Authority (NRA) to enforce them. The NRA has recently proposed that contact recreation should be recognized as a use class for controlled waters and that microbiological standards could be appropriate.

Since April 1989, WRc has been awarded by the Department of the Environment three successive contracts to investigate the Health Effects of Sea Bathing. These have been co-funded by the Department of Health, the Welsh Office and NRA (under their programme Nº 228, Bathing Water Epidemiology). The present contract, awarded from 1 April 1991 to 31 March 1992 (Reference PECD 7/7/377) is to enable definitive studies to be conducted at a total of ten beaches in the summers of 1991 and 1992.

This report details the work undertaken in the first year of Phase III and assesses the total knowledge obtained in the three years of the studies.

# SUMMARY

This is the third annual report of progress in the UK national study into the health effects of sea bathing, which will be completed by March 1993. Two methods, tested and validated in pilot studies carried out in the summer of 1989, are being used to establish the relationships, if any, between microbiological quality of coastal water and the risks to health of bathers. Research of this kind was recommended by the Royal Commission on Environmental Pollution in their 10th Report (1984) and commended by the House of Commons Select Committee on the Environment. It is relevant for the establishment of statutory water quality objectives for recreation by the Secretary of State, as proposed recently by the National Rivers Authority. The microbiological criteria of the bathing water Directive 76/160/EEC are not based on assessment of risk, which this research will provide.

Studies involving 10437 subjects have now been carried out at eight beaches, using two complementary methods - a survey to determine symptoms reported by holidaymakers participating in various beach activities at beaches differing widely in water quality and a controlled study using healthy adult volunteers divided into bathers and non-bathers, whose health is ascertained by detailed questionnaire, medical interviews and clinical examination.

Although firm conclusions cannot be drawn until the research is complete, correlations have been found between water quality and relative risks of gastrointestinal symptoms in water users, between relative rates of reporting certain symptoms, particularly gastrointestinal, and with the degree of water contact. Those water users most likely to report elevated symptoms are the 15-24 year old group.

Recommendations are made for the conduct of the studies at five beaches in 1992/93 and for reporting the results. Both methods have been reported to the MED POL Phase II programme of WHO/UNEP and recognized.

The work covered was co-funded by the Departments of the Environment and Health, the Welsh Office and the National Rivers Authority.

Report No: DoE 3164

## ACKNOWLEDGEMENTS

The overall direction of the Phase III studies, with those of Phases I and II, continued to be advised by the Department of Environment's working group on the Possible Health Risks of Bathing in Water Contaminated by Sewage. More immediate conduct of the studies was steered by a Steering Committee, chaired by WRc, which contained representatives from the funding agencies - the Departments of the Environment and of Health, the Welsh Office and the National Rivers Authority - and from the subcontractors - the Institute of Public Health (IPH), University of Surrey and the Centre for Research into Environment and Health (CREH), St David's University College, Lampeter.

The Department of the Environment's Nominated Officer for the master contract, Health Effects of Sea Bathing - Phase III (Reference Nº PECD 7/7/377) was Dr Elizabeth McIntosh. The Department's Project Officer was Mr H Jones, with whom day-to-day contact was maintained. The Author also acknowledges advice given by the representatives of the Department of Health, Dr Ann Dawson and of the Welsh Office, Mr J E Saunders (now retired) and Dr H J Prosser. Mr D Lowthion of the National Rivers Authority, Southern Region acted as Project Officer for the NRA contract, Bathing Water Epidemiology (Reference Nº A11.1) and provided much local information on the beaches and on their choice.

The Beach Survey studies were conducted by a team directed by Professor R Balarajan (IPH). Dr G Rees, Farnborough College of Technology was retained as microbiological consultant.

The Cohort Study was directed by Dr D Kay and Professor F Jones of CREH. Epidemiological advice was provided by Dr R Salmon of the Communicable Disease Surveillance Centre, Welsh Unit, Public Health Laboratory Service and Professor J M Fleischer, State University, New York, was retained for statistical advice.

Permission for carrying out the Beach Survey studies at Paignton, Lyme Regis, Rhyl and Morecambe was given by the relevant committees of the District Councils as shown below. The assistance of the officers of those Councils, shown in parentheses, is gratefully acknowledged.

| | | |
|---|---|---|
| Paignton | - | Borough of Torbay (Mr R Bowles, Environmental Health Officer; Mr R J Sweet, Director of Arts and Recreation). |
| Lyme Regis | - | West Dorset District Council (Mr D D Derrien, Director of Planning and Environmental Services). |
| Rhyl | - | Borough of Rhuddlan (Mr D T Owen, Borough Health Officer/Housing Manager) |
| Morecambe | - | Lancaster City Council (Mr G Shaw, Director of Environmental and Public Services). |

Permission for carrying out the Cohort Study at Southsea was given by the City of Portsmouth's Environmental Health and Improvements Subcommittee, Chairman - Councillor A M Bentley. Much practical assistance was given by Councillor Bentley, and by Mr A M Higgins, Chief Environmental Health Officer, Mr J Briggs, Resort Manager and Ms Alison Rawlings, Assistant Communications Executive.

The Author acknowledges the statistical advice given by his colleague, Mr R F Lacey.

Relations with the press, radio and television and the issue of two press briefing notes were managed by Mr R I Odell, WRc Corporate Relations, assisted by Mrs S E Smith and Miss P Adams, in liaison with the Department of the Environment's Press Office, Ms Alison Rawlings of Portsmouth City Council and the Author.

# 1. BACKGROUND TO THE PROJECT

## 1.1 Sea bathing and health development of UK Policies

Although unquantified, the beneficial effects of seaside holidays and use of coastal waters for bathing and other forms of recreation are well known. Furthermore, tourism and industries supporting it are a major source of income of coastal towns. However, because the United Kingdom is a maritime nation, a significant proportion of waste water is disposed to the sea and there are about 200 discharges, serving 12.5 million people.

For many years, there has been discussion over the health risks to bathers from discharges of sewage into the sea. The first major study in the United Kingdom was that of the Committee of Bathing Beach Contamination of the Public Health Laboratory Service (PHLS 1959, Medical Research Council 1959), which considered two major diseases, enteric fever (typhoid and paratyphoid fever) and paralytic poliomyelitis. Careful epidemiology, with the methods available at the time, showed that enteric fever was not associated with coastal regions, that some cases at resorts were wrongly ascribed to bathing and that, in the few cases unequivocally linked with bathing, water had been grossly polluted. There was no significant association between bathing history and poliomyelitis.

The PHLS Committee concluded that the risks to health of serious illness from bathing in sewage-contaminated water were negligible, that chance cases probably arose from contact with intact, infected, faecal material and that public health requirements would be reasonably met by improving grossly unsanitary beaches and by preventing, as far as possible, pollution of beaches with undisintegrated matter during the bathing season.

The PHLS Committee could find no logical basis for setting microbiological standards for coastal water, for two reasons:

1. Considerable differences in dispersion of bacterial counts at individual beaches, as well as of mean counts between beaches made comparison difficult.

2. Epidemiological information at the time (e.g. those of the US Public Health Service, Stevenson 1953) was inconclusive and current standards in other countries could not be justified epidemiologically.

The recommendations of the PHLS Committee influenced United Kingdom policy subsequently. Discharge of sewage by properly designed long sea outfall was encouraged by the Working Party on Sewage Disposal (1970) and by the Royal Commission on Environmental Pollution (1984) in its Tenth Report. However, the Royal Commission noted widespread concern about pollution of beaches and discharge of untreated or partly treated sewage. It particularly noted that, although the risk of contracting serious illness appeared to be very small, this could not be said of milder intestinal complaints, such as 'travellers' diarrhoea'. Controlled epidemiological studies had meanwhile been carried out by the United States Environmental Protection Agency (USEPA) in marine (Cabelli 1983) and fresh water (Dufour 1984) and showed positive relationships between bacteriological quality of water and the swimming-associated risks of reporting gastrointestinal symptoms, including those highly suggestive of viral gastroenteritis (highly credible gastrointestinal symptoms). The Royal Commission indicated the need for epidemiological studies to be carried out in the United Kingdom, but recognized that there would be major problems in designing adequate studies. It also recognized that, in many cases, discharge of coastal sewage to the sea through well designed long sea outfalls, was the best practicable environmental option.

Another significant development has been the implementation of the EC bathing water Directive 76/160/EEC, particularly the extension of the scope of microbiological monitoring to include large numbers of identified beaches (414 in England and Wales in 1991), which are sampled weekly on at least 20 occasions throughout the bathing season and extension of monitoring for enteroviruses and salmonella to include all identified beaches twice per season. This has served to identify those beaches where improvements in discharge arrangements are needed to achieve compliance and has provided the public with information on quality, either through notice boards at the beaches or through reports compiled by the National Rivers Authority (NRA 1991a) and consumer organisations (e.g. Marine Conservation Society 1992).

The urban wastewater treatment Directive, 91/271/EEC will require all significant discharges of sewage, including those to the sea, to be given at least primary treatment.

The following responses to these developments have taken place since 1985:

1. In 1985, the UK water industry embarked on a major programme of construction of sewage works and sea outfalls, to be completed in 2000.

2. The announcement of a £1.4 billion, ten-year programmed to improve bathing waters to meet the standards of the Directive 76/160/EEC.

3. The first phase of a £1.5 billion investment programme to treat sewage discharges in coastal water.

4. The announcement by the Minister of State for the Countryside and Environment, on 17 May 1989, that WRc had been contracted to carry out a pilot study in 1989 to assess the risk of contracting illnesses from sea bathing.

5. The requirement, under the Water Act 1989, Section 105, for the Secretary of State to draw up and the National Rivers Authority to implement a scheme of statutory water quality objectives (SWQOs) for all controlled waters (including coastal waters).

The National Rivers Authority (1991b) has submitted a discussion document to the Secretary of State concerning the form which SWQOs might take. One of the use categories defined is 'contact recreation', for which microbiological standards, including the bathing water Directive 76/160/EEC, might be appropriate.

In general, UK policies have been guided in the belief that the public health needs of coastal recreation are best served by a steady improvement in arrangements for treating and discharging coastal sewage. A review article (Pike 1992) has compared these policies with those which have applied in North America and Europe.

## 1.2 Previous epidemiological studies

### 1.2.1 The needs of epidemiology

One of the objectives of the work carried out by WRc under the two previous contracts (Phase I Pilot Study, 1989/90 and Phase II, 1990/91) was to review extensively past epidemiological and case history studies, in order to put the results obtained in context. Readers are referred to the two Final Reports (Pike 1990, 1991) for full details.

The difficulties of carrying out epidemiological research on health effects of bathing in sewage-contaminated waters were referred to by the Royal Commission on Environmental Pollution (1984). In general, there are as follows:

1. The need to control for confounding factors e.g. food and drink intake, spread by personal contact, influences of age, sex, socio-economic factors.

2. The need for adequately-sized exposed and control groups in order that results can be expressed within a suitably-sized target level of statistical significance. Because attack rates are usually low, very large groups of subjects have to be recruited.

3. The need to define the illness. Because the viral agents thought to be responsible for the more minor complaints reported, are not normally isolatable from clinical samples, reliance has to be made on reporting of symptoms.

4. The need to define exposure to the hazard, i.e. pathogens in sewage-contaminated water. Since the agents are not known or not identifiable directly, analysis must be made of faecal indicator bacteria in the water, since these are associated with any enteric pathogens. No constancy of correlation exists between numbers of pathogens and indicators.

5. Since numbers of indicator bacteria vary greatly with time at single places on a beach and along a beach, there are problems of relating individual bathers to quality of water to which they were exposed.

6. The need to relate to intensity and duration of contact with water, on the grounds that risk is increased with increased contact.

7. The need to comply with ethical requirements of medical research.

8. Where self-reporting of symptoms is used, the need to minimize or control external suggestibilities of subjects' perception e.g. by publicity and reports by the news media.

9. The need to distinguish between real and spurious associations when attempting to draw conclusions about cause and effect. Nine criteria were proposed by Bradford Hill (1965) for use in assessing the likelihood of causality between environmental exposure and disease and those have been used in assessing the significance of published research into sea bathing and health (Pike 1990, 1991).

### 1.2.2 Previous studies already reviewed

The review sections of the two Final Reports (Pike 1990, 1991) have shown that a great deal of epidemiology and case history of illness and symptomatology of bathing has been published. This will only be summarized here.

Case histories have shown that outbreaks of the following more serious illnesses have resulted from bathing in severely contaminated waters:

1. Typhoid and paratyphoid fevers (Medical Research Council 1959, PHLS 1959, Galbraith *et al* 1987, Harvey and Price 1981)
2. Shigellosis (Rosenberg *et al* 1976)
3. Infectious hepatitis (Bryan *et al* 1974)
4. Norwalk virus - headache, fever, myalgia (Baron *et al* 1982)
5. Adenovirus type 4 - pharyngo-conjunctival fever (D'Angelo *et al* 1979)
6. Primary amoebic meningo-encephalitis - *Naegleria fowleri* (Galbraith *et al* 1987)
7. Leptospirosis (Waitkins 1986, Ferguson 1990)
8. Cryptosporidiosis (Gallagher *et al* 1989)
9. Cyanobacterial toxicoses (National Rivers Authority 1990, Turner *et al* 1990)
10. Outer ear canal inflammation (*Otitis externa*) (Calderon and Mood 1982)
11. Swimmers' itch - cercariae of certain schistosomes, liberated by pond snails, attack the skin (Eastcott 1988)

A consideration of the reservoirs and mode of spread of those infections will show that not all are associated with sewage-polluted waters (Cartwright 1991). For example, *Naegleria fowleri* is able to multiply in hot springs and infects by inhalation. Leptospires are passed with the urine of infected aquatic rodents and infect man through cuts and abraded skin. The schistosomes responsible for swimmers' itch are liberated by the secondary host, aquatic snails in warm, weed-infested pools harbouring snails. The toxins liberated by blooms of certain cyanobacteria ('blue-green algae') affect by skin contact and by swallowing water. None of these three examples has occurred in sea water or is directly related to faecal pollution, and incidents are not related to high counts of faecal bacteria. *Otitis externa* is caused by opportunistically pathogenic bacteria on the skin and outer ear canal being induced to infect by prolonged wetting of the ears and the high temperatures and humidity in indoor swimming pools (Calderon and Mood 1982, Robson and Leung 1990). In the early US studies (Stevenson 1953), users of an efficiently chlorinated swimming pool at Dayton, Kentucky reported predominantly eye, ear, nose and throat ailments, whereas swimmers in the nearby polluted Ohio River reported more gastrointestinal symptoms, exemplifying those arguments.

The results of epidemiology are summarized in Table 1.1, taken from the last Final Report (Pike 1991, Table 16). It includes the results of the Phase I and II studies. Because the conclusions are repeatedly found, there is good reason to suppose that they are generally applicable. They also show the features of biological gradient, plausibility and coherence listed in Bradford Hill's (1965) criteria.

### 1.2.3 The UK epidemiological studies, 1989-1991

In 1988, the Department of the Environment convened a group of experts to advise on the need for epidemiological study of the health effects of sea bathing and the way in which such a study could be carried out. This group contained experts from the Departments of the Environment and Health, the Public Health Laboratory Service, Health Authorities, Water Authorities (later, the National Rivers Authority), WRc, Universities, the Scottish Development Department, the Welsh Office and the Department of the Environment for Northern Ireland. Two types of study were recommended:

1. Beach Survey Study. Holidaymakers on the beach of their own volition are approached by trained interviewers to participate. Information on bathing history, personal details and confounding factors is collected by interview on the beach and subsequently by telephone a week later. Water quality is monitored intensively on interview days.

2. Controlled Cohort Study. Healthy adult volunteers are enrolled and are randomly divided into equivalent bathing and non-bathing groups on the day of exposure. They are medically examined and questioned about symptoms, previous or subsequent bathing history and confounding factors immediately before and some time after exposure. The beach is one which is known to meet the microbiological standards of the EC bathing water Directive and the experimental protocol has been approved by the Committee on Ethical Issues in Medicine of the Royal Society of Physicians.

The beach chosen for the Pilot Study (Phase I) in 1989 was Langland Bay, near Swansea (National Grid Reference SS 606871).

The Beach Survey Study was conducted over 20 days in August, wit involvement of 4045 holidaymakers on the beach and a secondary, detailed telephone follow-up, seven days later, of a sub-sample of 791. The latter group provided the more internally consistent data and it was decided to base the collection of health information upon telephone interview in later studies. Despite fine weather, it was found difficult to recruit up to the target of 4000 subjects in the 20 days and because 70 per cent of subject were

**Table 1.1 Observations from the UK Epidemiological Studies and Others Reviewed in the Phase I and II Reports (Pike 1990, 1991)**

| Observations | Qualifying remarks and investigation |
|---|---|
| Swimmers report a higher incidence of certain illnesses than non-swimmers | Chicago, Lake Michigan, Ohio River and pool, Long Island (Stevenson 1951) |
| | Brittany: eye, ear, nose and throat complaints (Foulon *et al* 1983) |
| | Marine and freshwater US EPA studies (Cabelli 1983, Dufour 1984) |
| | Head immersion related to ear and eye infections (Mujeriego *et al* 1982) |
| | No relationship for waters with <25 enterococci/100 ml (Fattal *et al* 1987) |
| | Differences not significant in Great Lakes pilot study (University of Toronto (1980) |
| | On Ontario beaches (Seyfried *et al* 1985a) |
| | In Ontario lakes and streams (Lightfoot 1989) |
| | Hong Kong beaches: gastroenteritis, total illness, diarrhoea (Hong Kong Government 1986, Cheung *et al* 1988, Holmes 1989) |
| | Ardeche basin, France (Ferley *et al* 1989). Acute and 'objective' gastrointestinal, ear, nose and throat, skin after river bathing |
| | Two UK beaches: general illness, stomach upset, nausea and diarrhoea (Brown *et al* 1987) |
| | Sydney, Australia (Water Board 1990): ear, eye, gastrointestinal, coughs, colds, sore throat, influenza |
| | UK Pilot Study, Langland Bay, 1989 (Pike 1990, Jones *et al* 1991): ear, eye, throat in beach survey and cohort studies; diarrhoea <u>less</u> common |
| | Blackpool 1990 Alexander and Heaven 1991): in waters failing EC Bathing Water Directive, children of 6-11 years using water show more vomiting, diarrhoea, itchy skin, fever, lack of energy and loss of appetite, but statistical analysis flawed |
| | UK 1990 Phase II studies (Pike 1991): Ramsgate (Balarajan 1991), gastrointestinal diarrhea; if waders excluded, respiratory. Moreton, cohort study - sore throat, dry cough, ear, stomach pain, loose motions, flu, cold, gastrointestinal, chest; in accompanying children - more of any symptom and of stomach upset in those bathing |

Table 1.1 continued

| Observations | Qualifying remarks and investigation |
|---|---|
| The rate of illness is related to the degree or duration of exposure to water | Chicago, Lake Michigan, Ohio River and pool, Long Island Sound; rates rose with days of swimming experience (Stevenson 1953)<br>Poorly chlorinated swimming pool, pharyngo-conjunctival fever (D'Angelo *et al* 1979)<br>Negative relationship with number of days a week swimming (New York) or swimming events per day (Alexandria) (Cabelli 1983)<br>Rates in head immersers >non head immersers > non-bathers (Foulon *et al* 1983)<br>In windsurfers, St. Lawrence River (Dewailly *et al* 1986)<br>Ontario lakes: ear, respiratory and gastroenteritis symptoms greater in head immersers than non-head immersers and non bathers (Seyfried *et al* 1985a)<br>UK Pilot Study, Langland Bay, 1989 (Pike 1990): beach study suggests that risk follows the order non-participants > waders > swimmers > divers > surfers, for major symptoms aggregated<br>Sydney, Australia (Water Board 1990): ear, eye, gastro-enteritis; the rate of increase being greater in freshwater than in the sea UK Phase II studies, 1990 (Pike 1991, Balarajan *et al* 1991): Ramsgate - surfers/divers report more respiratory and eye infection than waders and bathers |
| Children bathing show a greater incidence of illness than older people | Under 5's >5-10 year olds > remainder: Alexandria (Cabelli 1983)<br>In 0-4 year olds, significant excess of enteric and respiratory symptoms, compared with non-swimmers (Fattal *et al* 1987)<br>Under 10's experienced more HCGI and skin rashes (NJDOH 1989)<br>UK Pilot Study, Langland Bay, 1989 (Pike 1990): 15-24 age group most susceptible to ear, throat, respiratory and all symptoms aggregated |

Table 1.1 continued

| Observations | Qualifying remarks and investigation |
| --- | --- |
| | UK Phase II studies 1990 (Pike 1991, Balarajan *et al* 1991): Ramsgate beach survey: for any major symptom, eye, ear, nose and throat and respiratory, 15-24 age group > 25-34 > 5-14; for diarrhoea, 25-44 > 45+ > 5-14. |
| The rate of illness is related to the counts of faecal indicator bacteria | Higher illness rates on days when total coliform MPN > 2300/100 ml (Stevenson level of 1951)<br>Ohio River swimmers (total coliform median MPN 2700/100 ml) experienced higher gastroenteritis rates than pool swimmers, but *vice versa* for eye, ear, nose and throat symptom (Stevenson 1953)<br>Long Island Sound: non significant difference in symptoms for bathers at beaches with significantly different total coliform MPN's (814, 398/100 ml) (Stevenson 1953, USDHEW 1960)<br>US EPA studies in marine (Cabelli 1983) and freshwater (Dufour 1984)<br>Brittany: diarrhoea (Foulon *et al* 1987)<br>Malaga, Spain: morbidity rates for mycoses and ear and eye infections greater on satisfactory than on unsatisfactory beaches (Mujeriego *et al* 1982)<br>Enterococcus count related to ear infection (Mujeriego 1982)<br>Relationships not significant in Ontario lake and river study (Lightfoot 1989)<br>Relationships not significant in New Jersey Ocean Health Study; low bacterial counts in sea and lakes (NJDOH 1989)<br>Ardeche basin, France (Ferley *et al* 1989): faecal streptococci best index of 'objective' and acute gastrointestinal disease<br>UK Phase II study, 1990 (Pike 1991), Moreton Cohort Study: significant associations between reporting of various symptoms and various microbial indicators (Table 11) |

Table 1.1 continued

| Observations | Qualifying remarks and investigation |
|---|---|
| *E. coli* or faecal coliform bacteria are not as satisfactory as other faecal indicator bacteria in correlation with illness rates | Enterococci superior, US marine waters (Cabelli 1983)<br>Enterococci superior in grouping illness in 0-4 year olds Fattal *et al* (1987)<br>*E. coli* showed higher correlation (0.804) than enterococci (0.744) for HCGI in freshwater (Dufour 1984)<br>Total staphylococci better than faecal coliforms and faecal streptococci for predicting total illness, eye and skin disease, Great Lakes (Seyfried *et al* 1985b)<br>Ardeche basin, France (Ferley *et al* 1989): for freshwater bathing, faecal streptococci superior for predicting 'objective' and acute gastrointestinal disease<br>UK Phase II study, 1990) (Pike 1991): Moreton Cohort study: significant associations between various indicator bacteria<br>Illness in freshwater pool swimmers related to total staphylococci and bather density (Calderon *et al* 1991) |
| Residents near the beach are less susceptible than visitors to swimming-associated gastroenteritis | Alexandria residents and Cairo visitors on Alexandria beaches (Cabelli 1983) |
| What are the most active age-groups for bathing? | 10-19 years > 5-9 years: Chicago, Lake Michigan (Stevenson 1953)<br>5-9 years > 20-24 > 10-14 > 15-19: Ontario lakes and rivers (Lightfoot 1989) |

holidaymakers, avoiding multiple recruitment was a significant problem. However, 75 per cent of family groups approached were willing to be interviewed by telephone.

The Controlled Cohort Study took place on 2 September 1990 (a Saturday). Of 465 people who enrolled for the study 276 (59 per cent) completed the schedule of interviews, exposure and clinical examinations. It was found that recruitment was encouraged by favourable local publicity for the study and by recruitment in the city shopping centre and by active co-operation by the local authority in attending to transport and features on the beach. In this study, the schedule of interviews was as follows:

1. Interview, medical examination, collection of throat, ear swabs and faeces 23 days pre-exposure.

2. Exposure day - randomisation into bathing and non-bathing cohorts. Bathers told to immerse in selected strip of sea at least three times over not less than ten minutes in the water.

3. Interview, medical examination, collection of throat, ear swabs and faeces three days after exposure.

4. Postal questionnaire, three weeks after exposure.

In Phases II and III, this was modified in the light of experience and on advice, by taking swabs and faeces only at the post-exposure interview (3), which was conducted seven days post-exposure.

During the conduct of the exposure, water was sampled for microbiological examination every 20 minutes at three depths and in each of the five 20 m-wide strips of water assigned for bathing. This design was used in Phase II, but in Phase III in 1991 at Southsea, only three 20 m-wide strips were used.

The designs used in Phase I were generally found to be satisfactory and were examined in subsequent years, except where noted above. It was also considered that both types of study should not be carried out at the same beach. Publicity was avoided as far as possible in conducting the Beach Survey, to avoid biasing subjects' perception of symptoms. This conflicted with the need for positive publicity to encourage recruitment for the Controlled Cohort Study.

The decision was made by the funding agencies to proceed with a definitive study in 1990, using the information gained in the pilot study. The Beach Survey Study was carried out at Ramsgate Sands beach in Kent (TR 387 650), involving 1883 successful telephone interviews and the Controlled Cohort Study at Moreton, Merseyside (SJ 257 918), involving 303 volunteers completing the one week post-exposure examination.

The overall main conclusions from Phases I and II are shown in Table 1.1, in conjunction with those from previously reported studies. Because of the success of Phase I, in that few modifications need to be made to the original design, it is hoped to be able to use the results together with those from subsequent studies in the final analysis to be presented at the conclusion of Phase III in 1993.

Recommendations were made for the size of the definitive studies to be carried out in Phase III. Based upon a background attack rate of 4 percent in non-bathers and a relative risk for bathers of 1.5, the size of a controlled cohort study needed to guarantee detection of a statistically significant effect was calculated as about 4000 subjects, broken down into separate studies at eight beaches known to be 'very clean' and 'just passing' the EC criteria. For the Beach Survey Study, it was recommended that a total of 18 000 interviews should be conducted, involving nine beaches, apportioned as 'very clean', 'just passing' and 'failure'.

Taking into account this advice and that presented by the group of experts, the Department of the Environment and its co-funding agencies announced the intention to place the present contract for Phase III, to cover the two summers of 1991 and 1992 and to carry out Beach Surveys at eight beaches (each involving 2000 subjects) and two controlled cohort studies, the decision for the second to depend upon results from the first in 1991. This means that the UK's epidemiological study at conclusion in 1993 will embrace results from 13-14 beaches and will involve in the region of 21 000 holidaymakers (Beach Survey Studies) and 1300 volunteers (Controlled Cohort Study).

The needs of an epidemiological study into the health effects of sea bathing were listed in Section 1.2.1. The UK study is the only one so far to attempt to meet all the needs. The two types of study are complementary. The merit of the Beach Survey approach, which is developed from that of the USEPA, is that it enables large numbers of holidaymakers to be screened efficiently with little effect upon their perception of illness. However, it is weakened because the quality of water at the time and place that a person bathes is not precisely defined and health effects are measured by reporting of symptoms. On the other hand, the Controlled Cohort Study obtains precise information upon those factors, although it is limited, for ethical reasons, to adult subjects and to waters meeting the quality requirements of the bathing water Directive. Reported attack rates are higher in both bathers and non-bathers than in corresponding Beach Survey Studies, no doubt because the subjects are made more aware of the purpose of the study and have increased perception.

#### 1.2.4 Subsequent development

The reports upon the Phase I and Phase II studies (Pike 1990, 1991) contained detailed assessments of published case histories and epidemiology. Developments since March 1991 have been minor and are summarised below.

Calderon *et al* (1991) conducted a study of swimming and non-swimming members of 104 families in a small community, using the bathing area of a 1.2 ha recreational lake, supplied by a small brook, unpolluted by human discharges but liable to contamination by wild animals in the forest park. Subjects kept daily diaries, over June-August, of bathing activities and health symptoms. Illnesses contracted within three days of bathing were regarded as health-related. Water samples were taken at 1000, 1200 and 1400 at knee depth on 49 days. The symptomatic gastrointestinal attack rate was 22.9 per 1000 person-days of exposure in swimmers and 2.6 in non-swimmers; relative risk 8.7 (highly significant), adjusted for age 6.3 (highly significant). A consideration of swimming activity following rainy days, when counts of indicator bacteria were elevated, and after dry weather, suggested that morbidity was not caused by pollution of brook water by wild animals. There was a significant association between ill swimmers and high counts of staphylococcus (>45 per 100 ml) or high numbers of bathers (>50 per day) in the water, which suggested swimmer to swimmer transmission of illness through the water.

New Guidelines for Canadian Recreational Water Quality have been published (MNHW 1992). These apply to both fresh and marine waters. The maximum limits for faecal indicator bacteria (geometric means of at least five samples in a period not exceeded 30 days) are those of the US Environmental Protection Agency (USEPA 1986), but with qualifications. No single-sample upper limits are defined. For marine waters, the geometric mean limit is 350 enterococci/litre. Resampling is required when any sample exceeds 700/litre. If it can be shown that *Escherichia coli* or faecal coliform bacteria adequately demonstrated the presence of faecal contamination in marine waters, these may be substitutes. The significances of enteroviruses, salmonellae, *Pseudomonas aeruginosa, Staphylococcus aureus,* protozoal parasites, toxic phytoplankton and coliphages in recreational waters are reviewed in depth, but no criteria are set.

The following papers have been published in 1991/92 which are directly or indirectly related to the Health Effects of Sea Bathing contracts:

A description of the pilot controlled cohort study at Langland Bay in 1989 (Jones *et al* 1991).

A summary letter of the results of the beach study at Ramsgate in 1990 (Balarajan *et al* 1991). This was followed by a criticism of the lack of detail (Hall and Rodrigues 1992), fully answered (Balarajan *et al* 1992).

A paper describing studies carried out at Ramsgate in 1990, in parallel with the beach survey study (but not part of the contract), evaluating the value of F-specific RNA bacteriophages and somatic coliphages as indication of marine pollution (Morinigo *et al* 1992). The former were never detected in samples containing 1-10 pfu of enteroviruses/litre, whereas the latter were constantly found in such waters and at numerical levels exceeding the G and I values for faecal coliform bacteria (100 and 2000 per 100 ml respectively). Somatic coliphages were considered to be optimal indicators of water quality.

A comparative review of European, British and North American standards for recreational water quality and an analysis of the rationales used to devise them (Pike 1992).

Under the Water Act 1989, consolidated into the Water Resources Act 1991, the Secretary of State is empowered to prescribe and the National Rivers Authority (NRA) to enforce statutory Water Quality Objectives. The NRA has proposed (NRA 1991) that the main elements will include, for each stretch of controlled water (including coastal water), identification of the class of use, corresponding quality standards (including those of relevant EC Directives) and dates for compliance. One of the use classes proposed is 'Water Contact Activities'. The bathing water Directive 76/160/EEC has been incorporated into Statutory Instrument Nº 1597, The Bathing Water (Classification) Regulations 1991.

# 2. OBJECTIVES AND PROGRAMME

## 2.1 Funding and objectives

The Department of the Environment awarded WRc the master contract, Health Effects of Sea Bathing - Phase III (Contract Reference PECD 7/7/377) for the period 1 April 1991 - 31 March 1993. This is jointly funded by the Departments of the Environment and Health, the Welsh Office and the National Rivers Authority (under their Programme Reference A11.1, Bathing Water Epidemiology).

The objectives of the programme of research are:

1. To undertake an epidemiological study to determine the risks, if any, to health of swimming in coastal water contaminated by sewage.

2. To establish the relationship, if any, between microbiological quality of coastal water and the risk to health of bathers.

## 2.2 The role of WRc

The programme specifies that, in 1991/92, four beach survey studies as developed in Phases I and II and a cohort study shall be carried out using subcontractor(s) engaged by open tender and supervised by WRc. In 1991/92, four beach survey studies and, if required, a further cohort study, would be performed. The duties of WRc, as contractor, are specified as follows:

1. With prior approval of the Department of the Environment (DOE) and other funding agencies, engage subcontractor(s), by the process of open tender, to organize and execute the studies document and conduct a statistical examination of the accumulated data.

2. Prepare the tender documents in consultation with the funding agencies.

3. Be responsible for the day to day management of the contract and oversee work to be carried out by the subcontractor(s) so as to ensure the efficient execution of the programme work. In particular to ensure comparability of microbiological analyses between the two types of study and to supervise the inter- and intra-laboratory quality control.

4. In association with the Press Office of the DoE, be responsible for the public relations for the study and contacts with the media and the Local and Health Authorities in the survey areas including any necessary negotiations.

5. Advise the subcontractor(s) on the format of the questionnaires for both studies, which will be based on those employed in the 1990 study, and on the methods of statistical analysis employed. The presentation of the results for all the studies undertaken should be produced in a compatible format.

6. In consultation with officials nominated by the DoE, and the National Rivers Authority, determine the beaches to be used for the study. During the 1991 bathing season, four bathing waters of varying microbiological quality will be selected for beach surveys and one beach that passes the mandatory standard laid down in the Bathing Water Directive (76/160/EEC) will be chosen for a cohort study. Similar studies will be undertaken in 1992.

7. Submit regular reports on progress and a final report to the DoE. An interim report on the results of the 1991 surveys will be produced by the 31 March 1992 and the final report, which will include analysis of all 14 studies (1989-1992) will be presented to the DoE by 31 March 1993.

Tender documents were prepared by WRc, in association with the four funding agencies and were widely distributed with invitations to submit tenders. Replies were considered by the funding agencies and the successful applicants were:

For a total of eight beach survey studies in the summers of 1991 and 1992, the Institute of Public Health (IPH), University of Surrey, Guildford, Director, Professor R Balarajan.

For a cohort study in 1991, and, if required, in 1992, the Centre for Research into Environment and Health (CREH), St David's University College, Lampeter, Directors Professor F Jones and Dr D Kay.

The two research organizations were subsequently engaged by WRc sub-contract.

WRc were requested by DOE to form and chair a steering group to guide progress of the research. This comprised representatives from the four funding agencies, the Public Health Laboratory Service, the Principal Investigators of the subcontracting organizations and WRc. It met on three occasions during the period June - October 1991.

Answers to enquiries and requests for interviews by press and news media were dealt with as they arose, subcontractors being requested to direct all enquiries to WRc and DOE. The following press briefing notes were issued in 1991/92 by WRc, in collaboration with DOE.

1. 21 May 1991. WRc awards sub-contracts to carry out studies on the health effects of sea bathing.

2. 13 June 1991. Health effects of sea bathing - Phase III: Healthy volunteer cohort study, Southsea.

3. 6 July 1991. Health effects of sea bathing - Phase III: Healthy volunteer cohort study, Southsea.

4. July 1991. Health effects of sea bathing - Phase III. Studies to be carried out at five beaches this summer.

Additional WRc assisted in preparing articles published in *Water Bulletin* (28 June 1991, p7) and in NRA's *The Water Guardians* (March issue 1991, pp4-5).

To avoid holidaymakers' perception of symptoms being biased and to protect the tourist interest of the co-operating local authorities, the location of the beach survey studies was not revealed until under way. Once studies were under way and noticed by news correspondents, they were requested to avoid sensationalism and to report fairly. Because recruitment for the cohort study required publicity and creation of a climate favourable for co-operation, press conferences were organized by WRc, when the decision of the local authority's (Portsmouth City Council) Health and Improvements Sub-Committee had been given, to launch recruitment (13 June 1991) and on the day of the study at Southsea (6 July), so that the correspondents could learn the objectives of the study and see the study in progress on the beach, without impeding the work of the research team.

A further role of WRc, implicit in the programme, has been to provide a peer review and statistical approval of the results of the two studies for the funding agencies.

## 2.3 Programme for the beach survey studies

WRc has engaged the Institute of Public Health, University of Surrey to carry out the survey by questionnaire of holidaymakers on the beaches of their own volition to determine attach rates of symptoms and their relationships to microbiological quality of the sea water. The programme specified contractually is as follows:

1. The recruitment questionnaire, and procedures, to be used for selecting bathers and non-bathers at the beach and the follow-up questionnaire will be based on those used for the 1990 beach survey. Any modifications will require the approval of the contractor.

2. Surveys each year during the bathing seasons of 1991 and 1992 of four bathing waters. The beaches will be chosen by WRc on the advice of the funding agencies. Each survey will be carried out over twenty interview days during four weeks of the bathing season at the selected beaches. At least six weekend days will be included. The aim will be to conduct two thousand completed interviews for each bathing water either with individuals or with family groups. The interviews will be divided about equally between bathers and non-bathers.

3. To monitor on survey days at the 30 cm depth stipulated in the Bathing Water Directive 76/160/EEC every two hours, starting no later than 10.00 a.m. and continuing until at least 4.00 p.m. at a minimum of three stations at the most frequented beach sections for microbiological indicators. These will include total and faecal coliforms, faecal streptococci and bacteriophages. All samples must be kept refrigerated and processed within six hours of sampling. On each survey day replicate sub-samples of the first and last samples are to be taken and analyzed. The subcontractor must satisfy the contractor of the analytical quality control of all analyses. In the event of more than one laboratory undertaking sample analysis inter-laboratory comparisons must be carried out. The methods of microbiological analysis for the indicator organisms must be identical to that used in the cohort study. In addition, at least twenty samples will be taken over the

survey period for the determination of enteric viruses and oocysts of *Cryptosporidium* sp.

4. To collect information on the weather and sea conditions, including salinity on the survey days.

5. To engage professional interviewers to carry out the beach interviews and the agreed follow-up questionnaire by telephone seven days after the beach interview. Sufficient interviews will be conducted at each beach to enable 2000 follow-up interviews to be completed.

6. To statistically analyze, after discussions with the WRc, the data obtained and present an interim report of results to the contractor by 31 December 1991 with the final report submitted by 31 December 1992.

## 2.4 Programme for the Cohort Study

WRc engaged the Centre for Research into Environment and Health, St David's University College, Lampeter to carry out the Cohort Study in 1991. This involved the recruitment of volunteers and the use of questionnaires and clinical sampling to elucidate the health risks of sea bathing and its relationship to the microbiological quality of the sea water. The programme is as follows:

1. The questionnaires used in the study shall be based on those used in the 1990 cohort study. Any alterations to them must have the approval of the contractor. The design and execution of the study must follow the protocols already approved by the Royal College of Physicians Committee on Ethical Issues in Medicine. The study should have prior approval of the ethics committee of the District Health Authority.

2. The bathing water chosen each year by the contractor, with the advice of the funding agencies, will conform to the mandatory coliform standards laid down in the Bathing Water Directive 76/160/EEC.

3. To recruit sufficient healthy volunteers to enable four hundred completed analyses to be carried out. These uncoerced volunteers must be over eighteen years of age. The group will be randomly split into equal bathing and non-bathing cohorts. Subjects will not receive remuneration for their co-operation in this project, but essential out-of-pocket expenses will be refunded to an agreed maximum.

4. To sample the water prior to bathing, at different times and locations to determine the pattern of bacterial and viral contamination. On the day of exposure, two hundred samples will be collected for bacteriological analyses of which at least one third will be at the 30 cm depth required by the Bathing Water Directive 76/160/EEC. These analyses will include total coliform organisms, faecal coliforms, faecal streptococci and staphylococci. A subset of the samples will be analyzed for enteroviruses, *Cryptosporidium* and bacteriophages. Analyses must

be carried out within six hours of sampling and the analytical quality control specified. The methods of microbiological analysis for all indicator organisms must be identical to that used in the beach survey.

5. To collect information on weather and sea conditions throughout the test day.

6. To take bathing and non-bathing cohorts to the beach on one day during the bathing season. On that day packed lunches will be provided for both bathing and non-bathing cohorts. Samples of the packed lunches will be examined by the PHLS. The bathing cohort will be allowed free access to the water and instructed to immerse their heads in the water on at least three occasions during normal swimming activities. At least twenty trained and supervised field staff will be available to provide safety cover and closely monitor the activities of both cohorts. Non-bathers will not be allowed to swim and alcohol intake for both cohorts will be carefully controlled.

7. To interview on the day before bathing, the day of bathing, seven days and four weeks after exposure, the participants and record their perceived assessment of any symptoms. On the day before bathing and seven days after bathing, they will be medically examined, and will provide faecal, nasal and oral samples for analysis.

8. To statistically analyze, after discussion with the WRc, the data obtained and produce an interim report by December 1991, with the final report submitted by December 1992.

DOE subsequently agreed to extend the sub-contract with CREH to 31 March 1992, to enable the data obtained in the Phase I pilot study at Langland Bay in 1989 to be re-coded and amalgamated with the Phase II and Phase III studies (Moreton, Southsea) to enable the effects of water quality (faecal streptococci) and of confounding factors, such as food intake, upon health, to be determined. The funding agencies have since recommended that a fourth cohort study should be carried out in 1992.

## 2.5 Reporting

The reports from IPH on the four beach survey studies conducted at Paignton, Lyme Regis, Rhyl and Morecambe in August 1991 and from CREH on the cohort study at Southsea on 6 July 1991 are bound into this Interim Report as Appendices A and B respectively. They have been presented to the Committee of Experts appointed by DOE to review progress on the Contract. Because they contain full details of methods and experimental protocols which have been fully developed in Phases I and II and described (Pike 1990, 1991) and of results, these will only be summarized in the subsequent sections of this Interim Report. However, the results obtained in 1991 will be discussed with those previously obtained in order to assess the progress of the programme from 1989 to date.

# 3. BEACH SURVEY STUDIES

## 3.1 Choice of beaches

In Phase III, the aim is to select eight beaches displaying a gradation of water quality, so that a relationship between mean counts of faecal bacteria and of relative health risk can be ascertained. The desirable features of individual beaches are as follows:

1. Popular, well-defined and compact to assist interviewing of the target of 2000 holidaymakers within 20 days.

2. Attracting visitors, rather than residents.

3. Affected, if at all, by a single point source of sewage, rather than by estuaries or storm-sewage overflow.

4. The nearness of laboratory facilities.

5. Avoidance of the site used for the cohort study or one where news publicity or other activities might influence holidaymakers' perceptions of health.

6. Selection of beaches in different geographical regions of Britain.

Acting on advice on these factors supplied by NRA Regional Offices and from DOE, the following beaches were chosen for the studies and permission was obtained from the respective District Councils:

| | | | |
|---|---|---|---|
| Paignton, Devon | (Borough of Torbay) | - | Figure 3.1 |
| Lyme Regis, Dorset | (West Dorset District Council) | - | Figure 3.2 |
| Rhyl, Clwyd | (Borough of Rhuddlan) | - | Figure 3.3 |
| Morecambe, Lancs. | (City of Lancaster) | - | Figure 3.4 |

Rhyl replaced the original choice of Prestatyn, as the beach was closed to allow engineering work to take place on the sea defences.

## 3.2 Description of beaches

In Figures 3.1-3-4, the microbiological sampling points are indicated by the capital letters A - C and lines normal to the shore. Recruitment was carried out on the corresponding three stretches of beaches and promenade on either side of the sampling points. The scale of the maps is shown by the kilometre co-ordinates of the National Grid references.

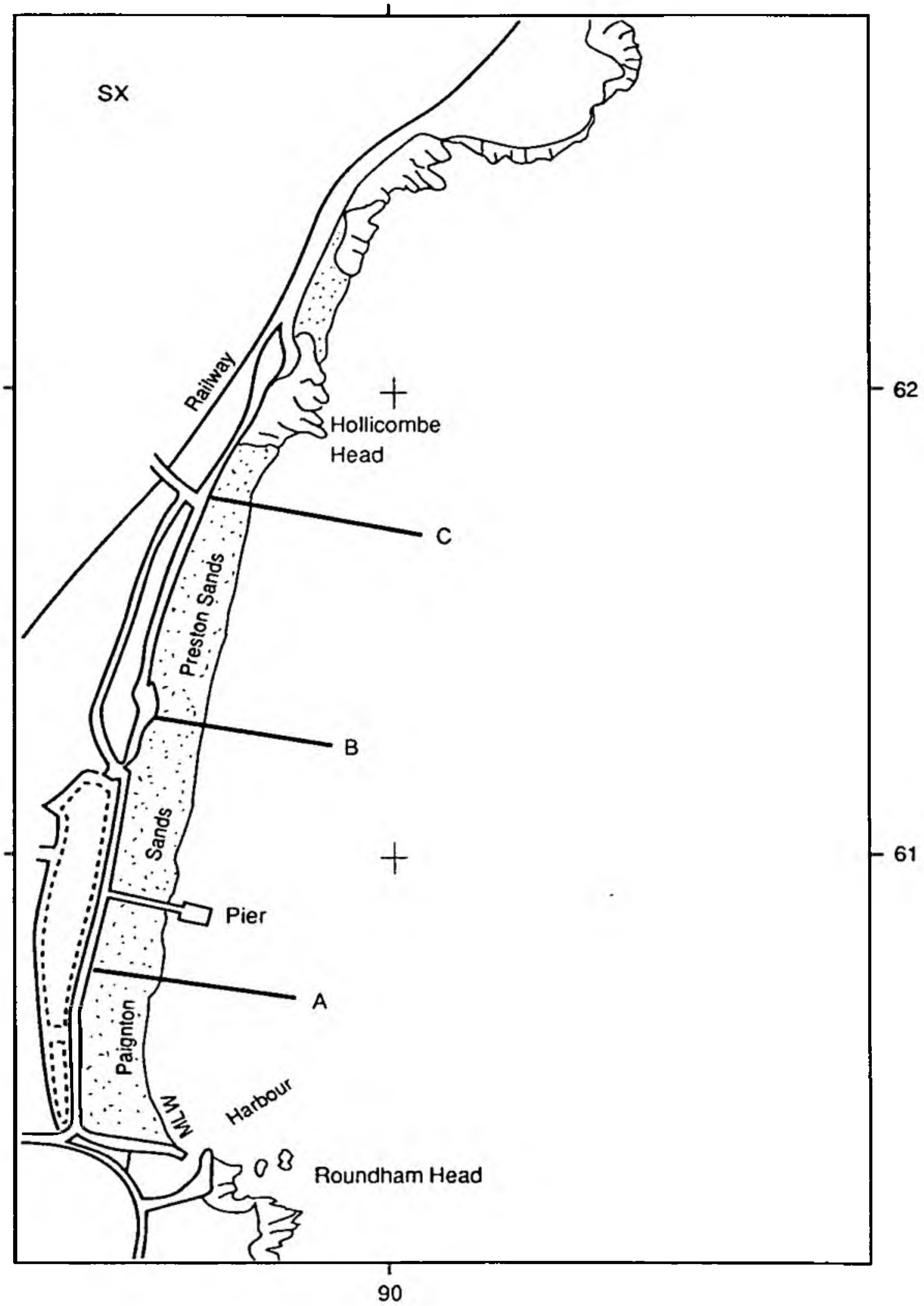


**Figure 3.1 Paignton. Beach sampling stations and National Grid km co-ordinates**

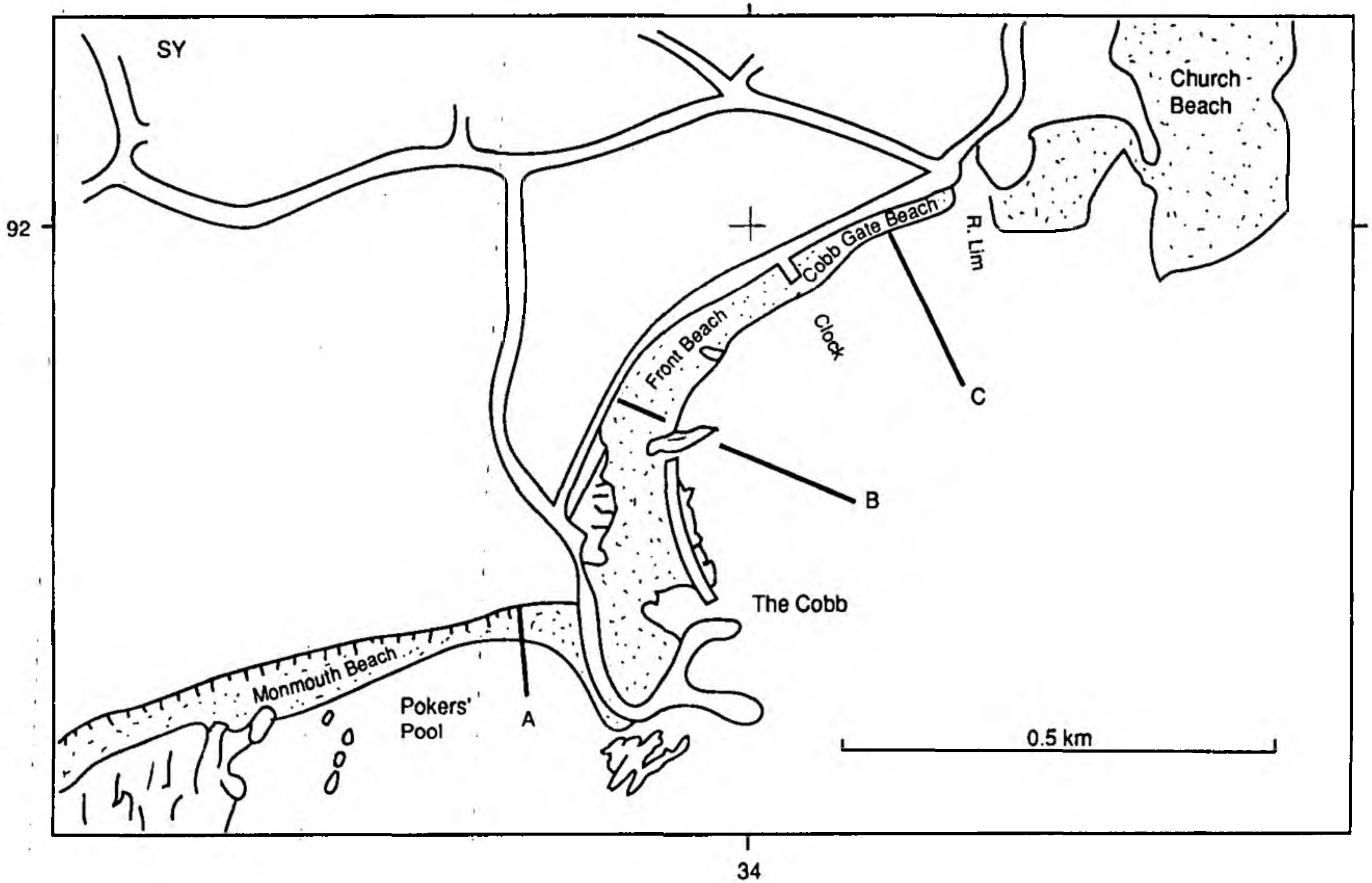


**Figure 3. 2. Lyme Regis. Beach sampling stations and National Grid km co-ordinates**

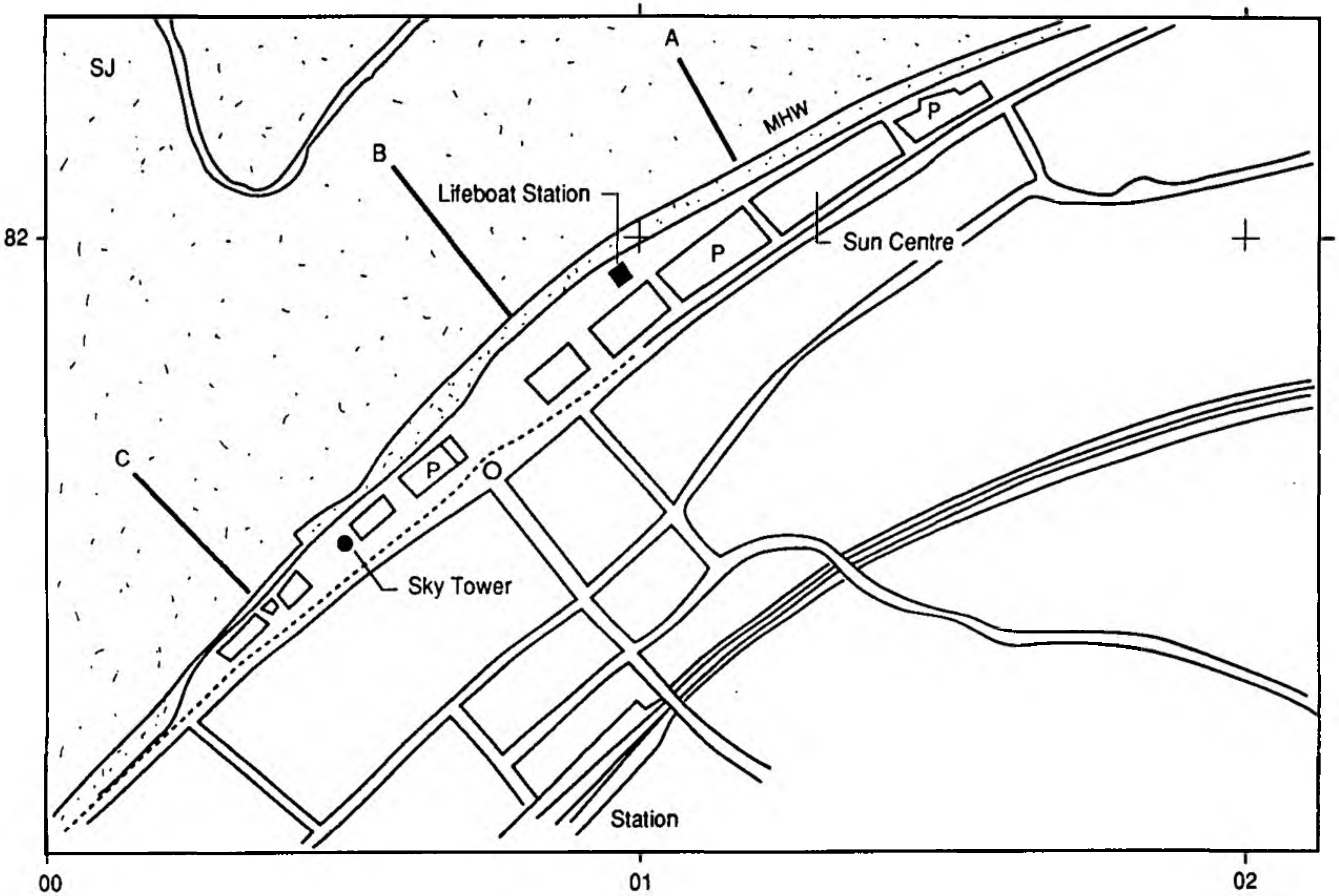


**Figure 3. 3. Rhyl. Beach sampling stations and National Grid km co-ordinates**

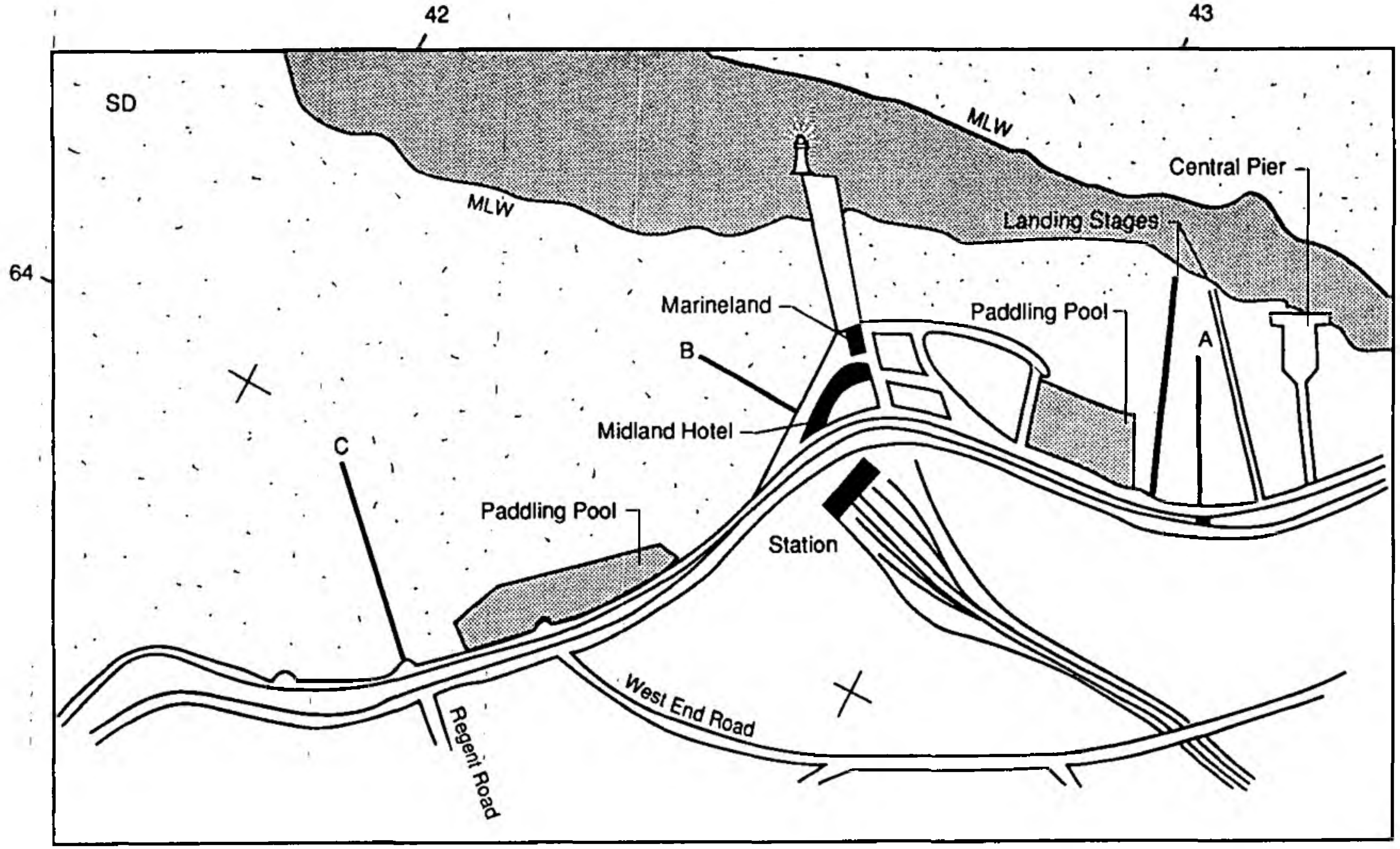


**Figure 3. 4. Morecambe. Beach sampling stations and National Grid km co-ordinates**

The areas of recruitment for holidaymakers were defined by landmarks near the seafront as follows:

Paignton:

- Harbour to Pier
- Pier to outcrop separating Paignton Sands and Preston Sands
- Preston Sands beach to Hollicombe Head

Lyme Regis:

- Monmouth Beach, westward from Cobb Harbour Wall to rocks
- Front Beach, from the Cobb to clock on esplanade
- From esplanade clock to mouth of River Lim (Cobb Gate Beach)

Rhyl:

- Sun Centre, eastwards
- Sun Centre to Sky Tower
- Sky Tower to western end of beach

Morecambe:

- Stone Jetty (Marineland) north-westwards past Central Pier to boat slip
- Stone Jetty (Marineland) south-westwards to paddling pool
- Paddling pool to end of sandy beach

## 3.3 Survey methods

The methods were nearly identical to those used in 1990 at Ramsgate and are specified in Appendix A, pp 2-4. Professional marker researchers were engaged to recruit a target of 2000 holidaymakers at each beach over 20 days, including six weekend days. Quotas were assigned as follows and maintained as far as possible:

- Subjects aged 5 - 60 years
- Control Group, not entering the water, 30%
- Subjects entering the sea in three days prior to interview, 70%

- Exposed subjects further stratified - 35% waders, 35% swimmers and divers
- Quotas maintained daily, regardless of weather

Subjects were identified as holidaymakers, day trippers and local residents and the areas in which they were recruited were noted (Section 3.2), for future identification with water quality. The questionnaire (Appendix A) was designed to avoid alerting the subjects' perception of pollution and health by the order and nature of questions:

- Personal details
- Aim given as improving facilities and the environment
- Water activity over last three days?
- Residence at this or other resorts - duration?
- Foods eaten?
- Part of beach used?
- Water activities?
- Anticipated duration of stay?
- Appointment for telephone interview

The follow-up, computer assisted telephone interviewing was carried out a week later by a different team, not involved in the beach interviewing. The questionnaire (Appendix A) followed the following order of questioning and evaded reference to symptoms until the end:

- Dates when the subject used the beach, where recruited
- Foods purchased and eaten at the resort
- Water activities at that beach since interview
- Visits to and activities at other beaches
- Duration of stay at the resort
- Experience of defined symptoms after first interview:
    - — At the resort since first interview?
    - — Since leaving the resort?
    - — Consultation of doctor, or purchase of medicine?

The coding and analysis of the survey data was carried out by the Institute of Public Health, not by the market researchers, again to retain objectivity and anonymity.

The statistical methods have been explained in the Report for the 1990 Survey (Pike 1991, pp 40-42). Logistic regression analysis was used to predict the relative odds of reporting symptoms for the various classes of age group, sex, water activities and location of beach. This technique is now widely used in analysis of epidemiological data, its advantages being as follows:

1. It enables the effects of different variables to be examined and tested for significance.

2. It corrects for the type of statistical distribution in the variables and can accommodate continuous data, numbers of occurrences and binary (yes/no) data.

3. The predicted odds ratios or relative risks are provided with confidence limits, so that their significance can be assessed.

4. Odds ratios and relative risks assume a multiplicative model of risk, which takes proper account of the variabilities in the level of immunity shown by different persons, including those in the control group.

Subjects who remained on the beach, but did not enter the water were regarded as the control (unexposed) group. Water activity was categorized by increasing exposure from wading, through swimming to diving or surfing. Symptoms were grouped according to the table on page 7 of Appendix A. Diarrhoea was examined both in the gastrointestinal group and separately. For groups of symptoms, reporting of one or more symptoms counted as a positive response. The group 'major symptoms' excludes skin symptoms.

The odds ratios ('relative risks') were presented using as the reference categories non-exposed persons, males and the 5 - 14 year age group. Data for the four beaches were first examined individually and then combined, using Paignton as the reference.

## 3.4 Sampling and microbiological methods

Commencing on 1 August 1991, samples were taken 30 cm below the surface in water 1 m deep at the three points A - C on each beach (Figures 3.1-3.4), every two hours between approximately 1000 and 16 000 hours. The first sample in each run was taken at point A exactly at 1000 hours. Samples were placed in chilled, light-proof, insulated containers and delivered immediately to the Public Health Laboratories at Preston (for Rhyl and Morecambe samples) or Exeter (for Paignton and Lyme Regis). These samples were analyzed, using standard membrane filtration methods (Report 1983):

1. Total coliform bacteria: incubation upon 0.2% sodium lauryl sulphate broth for 4 h at 30 °C, followed by 14 h at 37 °C;

2. Faecal coliform bacteria: as (a) but incubation for 4 h at 30 °C, followed by 14 h at 44 °C;

3. Faecal streptococci: Incubation upon Slanetz and Bartley's medium for 4 h at 37 °C, followed by 44 h at 44 °C.

Samples were taken simultaneously for somatic coliphage examination (Morinigo *et al* 1992). There were refrigerated and transported to the Robens Institute, University of Surrey, for examination.

### 3.4.1 Analytical quality control

On every third day (Paignton and Lyme Regis, seven occasions between 1-19 August; Rhyl and Morecambe, nine occasions, 2-26 August), samples were taken for determination of enteroviruses, rotaviruses and cryptosporidium.

Analytical quality control checks were carried out as follows for coliform bacteria and faecal streptococci;

1. <u>Within samples and laboratories</u>: Examination of duplicate samples taken at point A - C at each beach on the 1000 and 1600 hours sampling runs.

2. <u>Between laboratories</u>: On four occasions (2, 8, 14, 17 August), six samples were taken at 1000 and 1600 from sites A - D at each beach and were split into two sub-samples, analyzed respectively by the Preston and Exeter Public Health Laboratories.

3. <u>Independent Assessment</u>: Preserved water samples were supplied by Newcastle-upon-Tyne Public Health Laboratory to Exeter and Preston for simultaneous analysis. Results were reported back to Newcastle.

### 3.4.2 Statistical analysis of data

Because bacteriological counts are usually distributed approximately log-normally, they were transformed to logarithms for analysis and results were presented as geometric means or medians. The frequent absence of detectable viruses or coliphages in many samples meant that the geometric mean could not be calculated and averages are given instead. Analysis of variance and other more detailed procedures were used to examine the components of variability in replicated samples and analyses. Survey data were examined by logistic regression analysis or other methods. These are described in the appropriate sections.

## 3.5 Results and observations

### 3.5.1 General approach

The results are considered in great detail in Appendix A, both for individual beaches and for the four beaches combined. The reader is referred to these. In what follows, the results of the surveys and microbiological examinations are considered in summary, together with those obtained in Phases I (Langland Bay) and II (Ramsgate), so that the overall progress of the UK's research can be assessed.

### 3.5.2 Recruitment

Table 3.1 demonstrates the success of recruitment on the beach and by subsequent telephone interview at the six beaches studied so far.

The target of 2000 holidaymakers was achieved within 20 days at Lyme Regis and Paignton, where the weather was generally good throughout. At Rhyl and Morecambe, cold, rainy weather in the first two weeks of August and the expanse of sand and mud flats at low tide impaired recruitment of the exposed categories. The recruitment period was extended to 26 days at both resorts. The target was achieved at Rhyl, but not at Morecambe. News reporting of pollution on north-western beaches, specifically mentioning Morecambe, may also have made visitors unwilling to bathe.

Table 3.1 Total number of subjects interviewed on the four beaches and by telephone a week later; comparison with Langland Bay and Ramsgate

| Beach | Interviews on beach | | Interviewed by | |
|---|---|---|---|---|
| | Total | Ages 5-60 | Telephone | (% response)* |
| Paignton | 2 203 | 2 181 | 2 038 | 93 |
| Lyme Regis | 2 206 | 2 159 | 2 065 | 96 |
| Rhyl | 2 183 | 2 138 | 1 964 | 92 |
| Morecambe | 927 | 908 | 790 | 87 |
| Subtotal | 7 519 | 7 386 | 6 857 | 93 |
| Langland Bay | 4 045 | - | 791 | 20 |
| Ramsgate | 2 010 | - | 1 883 | 94 |
| Totals | 13 574 | | 9 531 | |

Notes: * Responses to telephone interviews are percentages of the 5-60 years age group interviewed on the beach, except for Langland Bay, where telephone interviews were a sample and Ramsgate, where there was no upper age restriction.

Table 3.1 shows that 13 574 subjects have been recruited to date on the beach and telephone interviews have been obtained for 9531. Assuming success at the four beaches to be used in 1992, data can be expected for about 17 000 telephone interviews by the conclusion of the study. Except for the pilot study at Langland Bay, where only 20% of the beach subjects were given a telephone interview, there is a high degree of consistency in the numbers of people recruited who respond to the telephone interview (92%).

Table 3.2 compares the age and sex distributions of subjects completing the telephone interview and the percentage entering the water. At the four beaches of 1992, quotas were imposed upon the beach recruiting (Section 3.3), limiting the non-exposed category to 30%, whereas the aim at Langland Bay and Ramsgate was to recruit exposed and non-exposed equally. The 70% exposed target could not be met at Morecambe. The Table also shows that nearly two-thirds of subjects were under 35 years old (excluding under-fives in 1991) and slightly more than half were female.

**Table 3.2 Distribution of subjects by age, sex and water activity at the four beaches and a comparison with Langland Bay and Ramsgate**

| Beach | Total subjects | Distribution (%) | | |
|---|---|---|---|---|
| | | Under 35 | Male | Entered water |
| Paignton* | 2038 | 64.4 | 46.9 | 81.6 |
| Lyme Regis* | 2065 | 62.6 | 48.5 | 80.8 |
| Rhyl* | 1964 | 75.4 | 45.7 | 81.7 |
| Morecambe* | 790 | 63.2 | 41.6 | 46.6 |
| Ramsgate Bay | 791 | 50.0 | 50.3 | 47.5 |
| Ramsgate | 2010 | 55.7 | 49.2 | 55.4 |

Notes: Distributions are of those completing telephone interview, one week after beach interview.
* A quota of 30% not entering the water was imposed; actual on beach recruitment: Paignton 29%, Lyme Regis 28%, Rhyl 23%, Morecambe 57%.

### 3.5.3 Patterns of beach-going

Table 3.3 analyzes beach-going patterns. Although holidaymakers were commoner overall than day-trippers or locals, there were differences between beaches. Rhyl was equally popular with holidaymakers and day trippers, while people recruited at Morecambe were mainly day-trippers.

Table 3.3 Percentage distribution of subjects by beach-going pattern and a comparison with Langland Bay and Ramsgate

| Beach | Holidaymakers | Day Trippers | Locals |
|---|---|---|---|
| Paignton | 62 | 25 | 13 |
| Lyme Regis | 56 | 38 | 6 |
| Rhyl | 49 | 46 | 5 |
| Morecambe | 49 | 37 | 14 |
| Langland Bay* | 74 | - | 26 |
| Ramsgate | 25 | 55 | 20 |

Notes: Distribution of those responding to telephone interview.
* Two classes only recorded, holidaymakers and locals

### 3.5.4 Patterns of water activity

Table 3.4 reflects the success in recruiting to the quotas of 50% non-exposed at Langland Bay and Ramsgate and 30% at the four beaches in 1991, rather than preferences for the activities. Comparison with the footnote to Table 3.3 shows that the proportions of non-exposed interviewed on the beaches in 1991 was greater than those subsequently interviewed by telephone, perhaps indicating that the non-exposed were less interested in participating further. Table 3.4 shows the difficulties in recruiting reasonable numbers of divers and surfers.

Table 3.4 Percentage distribution of subjects by type of water activity and a comparison with Langland Bay and Ramsgate

| Beach | Non-exposed | Waders | Swimmers | Surfers/ divers |
|---|---|---|---|---|
| Paignton | 18 | 32 | 39 | 11 |
| Lyme Regis | 19 | 33 | 37 | 11 |
| Rhyl | 18 | 49 | 27 | 6 |
| Morecambe | 53 | 34 | 9 | 4 |
| Langland Bay | 52 | 21 | 20 | 7 |
| Ramsgate | 45 | 30 | 21 | 4 |

Note: Distributions of those responding to telephone interview. Non-exposed quota 50% at Langland Bay and Ramsgate, 30% elsewhere.

There were no quotas imposed for interviewing locals, day-trippers and holidaymakers. Table 3.5, therefore, shows that the unexposed and the surfer/divers were more likely to be locals, waders the day-trippers and swimmers the holidaymakers.

**Table 3.5 Distribution of water activities by beach-going patterns**

| Water activity | Beach-going pattern by likelihood: Most likely | Intermediate | Least likely |
|---|---|---|---|
| Not entering the water | Locals | Day Tripper | Holidaymaker |
| Wading | Day Tripper | Holidaymaker | Locals |
| Swimming | Holidaymaker | Locals | Day Tripper |
| Surfing/Diving | Locals | Holidaymaker | Day Tripper |

Note: For Ramsgate and four beaches of 1991. Likelihood estimated by ranking popularity of each activity by beach-going pattern and water activity, across beaches.

Table 3.6 analyzes, for the five beaches of 1990-91, the age distribution of participants in the various water activities. Children of 5-14 mainly participated in swimming, surfing and diving. Waders were most likely to be children or older adults (25-44 years), surfers/divers (5-24 years) and those not entering the water adults.

**Table 3.6 Age Distribution (%) of subjects by water activity**

| Age range | Not entering water | Waders | Swimmers | Surfers/divers |
|---|---|---|---|---|
| 5 - 14 | 4.6 | 27.2 | 44.4 | 39.5 |
| 15 - 24 | 15.9 | 12.9 | 17.6 | 23.7 |
| 25 - 34 | 27.3 | 25.1 | 14.7 | 16.1 |
| 35 - 44 | 33.0 | 22.8 | 14.7 | 14.4 |
| 45 - 54 | 12.8 | 8.1 | 6.6 | 5.7 |
| 54 + | 6.4 | 3.7 | 2.0 | 0.6 |

Note: For four beaches of 1991 and Ramsgate; unweighted averages.

### 3.5.5 Reporting of symptoms

Table 3.7 gathers together the crude incidence rates for reporting the seven groups of symptoms for the five categories of water activity at the six beaches examined so far. Those where activities where symptom rates were significantly elevated, compared with the unexposed, are marked with an asterisk. Apart from significant elevation of gastrointestinal symptoms at Rhyl and Morecambe, diarrhoea at Morecambe and Ramsgate and skin symptoms at Lyme Regis and isolated elevations with other combinations, this table of crude rates shows little to suggest any great effect of water activity on symptom rates. The four studies of 1991 show, however, in both the exposed and the non-exposed, a similarly high perception of symptoms to that shown in the previous two studies.

Table 3.7 Crude rates (per 1000) of reporting symptoms at the four sites of 1991, Langland Bay and Ramsgate

| Class of symptom and location | Water activity No | Water activity Yes | Waders | Swimmers | Surfers/ divers |
|---|---|---|---|---|---|
| 1. Major | | | | | |
| Paignton | 195 | 239 | 226 | 227 | 317* |
| Lyme Regis | 205 | 234 | 231 | 218 | 294 |
| Rhyl | 267 | 266 | 259 | 277 | 269 |
| Morecambe | 235 | 293 | 290 | 279 | 357 |
| Langland Bay | 68 | 122* | 83 | 143* | 182* |
| Ramsgate | 215 | 263* | 253 | 263 | 333 |
| 2. Eye | | | | | |
| Paignton | 19 | 37 | 28 | 38 | 60* |
| Lyme Regis | 48 | 40 | 29 | 44 | 54 |
| Rhyl | 56 | 42 | 35 | 58 | 28 |
| Morecambe | 59 | 24 | 22+ | 15 | 71 |
| Langland Bay | 7 | 29* | 12 | 39 | 54 |
| Ramsgate | 49 | 59 | 52 | 58 | 119* |
| 3. Ear, Nose and Throat | | | | | |
| Paignton | 107 | 142 | 134 | 138 | 179* |
| Lyme Regis | 104 | 133 | 137 | 113 | 190 |
| Rhyl | 169 | 146 | 142 | 153 | 148 |
| Morecambe | 145 | 160 | 151 | 132 | 321* |
| Langland Bay | 31 | 77* | 48 | 78 | 164 |
| Ramsgate | 85 | 127 | 84 | 168 | 226 |
| 4. Respiratory | | | | | |
| Paignton | 73 | 67 | 80 | 62 | 92 |
| Lyme Regis | 68 | 68 | 63 | 72 | 72 |
| Rhyl | 111 | 88 | 83 | 88 | 130 |
| Morecambe | 83 | 106 | 103 | 88 | 179 |
| Langland Bay | 12 | 19 | 6 | 39 | <18 |
| Ramsgate | 54 | 65 | 59 | 68 | 95* |
| 5. Gastrointestinal | | | | | |
| Paignton | 64 | 78 | 74 | 65 | 133* |
| Lyme Regis | 58 | 85 | 84 | 75 | 122* |
| Rhyl | 67 | 105* | 106* | 104* | 93 |
| Morecambe | 64 | 122* | 114* | 147* | 143 |
| Langland Bay | 39 | 32 | 36 | 32 | 18 |
| Ramsgate | 52 | 79 | 66 | 93 | 95 |

Table 3.7 continued

| Class of symptom and location | Water activity No | Water activity Yes | Waders | Swimmers | Surfers/ divers |
|---|---|---|---|---|---|
| 6. Diarrhoea | | | | | |
| Paignton | 32 | 29 | 31 | 23 | 46 |
| Lyme Regis | 28 | 37 | 40 | 26 | 63* |
| Rhyl | 33 | 47 | 57* | 34 | 19 |
| Morecambe | 31 | 63* | 66* | 59 | 36 |
| Ramsgate | 36 | 57* | 53 | 65* | 48 |
| 7. Skin | | | | | |
| Paignton | 35 | 46 | 38 | 43 | 83* |
| Lyme Regis | 10 | 41* | 38* | 40* | 50* |
| Rhyl | 44 | 48 | 43 | 58 | 43 |
| Morecambe | 45 | 43 | 40 | 29 | 107 |

Notes: * Significantly elevated compared with control group (no water activity) from results of logistic regression analysis, + significantly lower.
No data recorded for diarrhoea or skin symptoms at Langland Bay, or for skin symptoms at Ramsgate - no significant effects of water activity found.

Table 3.8 summarizes the odds ratios ('relative risks', OR's) reported in the studies at the individual six beaches after an overall analysis comparing ORs exposed against non-exposed, and (a) exposure compared against unexposed males aged 5-14 and (b) exposure by different water activities against unexposed males aged 5-14 not entering the water.

Table 3.8 indicates the relative susceptibility of the 15-24 age group at a number of beaches for reporting significantly elevated ORs of 'major' (i.e. one or more of all symptoms taken together, except skin symptoms), ear nose and throat, respiratory and gastrointestinal symptoms, as well as confirming the significant elevations for the beaches and activities recorded in Table 3.9.

Further discussion of Tables 3.8 and 3.9 will be deferred until the microbiological results have been presented.

Table 3.8 Odds ratios derived by logistic regression analysis for symptoms recorded at individual beaches in 1991 and at Langland Bay and Ramsgate

| Class of symptom and location | Entering water(a) | Waders (b) | Swimmers (b) | Surfers/ divers(b) |
|---|---|---|---|---|
| 1. One or more ('Major') | | | | |
| Paignton | 1.18 | 1.14 | 1.09 | 1.75* |
| Lyme Regis | 1.08 | 1.08 | 0.98 | 1.43 |
| Rhyl | 1.00 | 0.96 | 1.12 | 1.07 |
| Morecambe | 1.28 | 1.24 | 1.25 | 1.87 |
| Langland Bay | 1.90* | 1.26 | 2.34* | 3.04* |
| Ramsgate | 1.31* | 1.25 | 1.31 | 1.81* |
| Other significant values(b): | | Ages 15-24: Rhyl 1.54*, Langland Bay 2.75*, Ramsgate 1.52* Females: Rhyl, 1.27* | | |
| 2. Eye | | | | |
| Paignton | 2.00 | 1.48 | 2.14 | 3.72* |
| Lyme Regis | 0.78 | 0.59 | 0.93 | 1.14 |
| Rhyl | 0.71 | 0.62 | 1.06 | 0.48 |
| Morecambe | 0.35 | 0.29 | 0.23 | 1.43 |
| Langland Bay | 3.71* | nd | nd | nd |
| Ramsgate | 1.24 | 1.10 | 1.22 | 2.65* |
| 3. Ear, Nose and Throat | | | | |
| Paignton | 1.32 | 1.28 | 1.26 | 1.74* |
| Lyme Regis | 1.18 | 1.21 | 0.89 | 1.59* |
| Rhyl | 0.89 | 0.85 | 1.00 | 0.93 |
| Morecambe | 0.96 | 0.89 | 0.72 | 2.43* |
| Langland Bay | 2.77* | - | - | - |
| Ramsgate | 1.08 | 1.16 | 0.86 | 1.70 |
| Other significant values: | | Ages 15-24: Paignton 1.63*, Rhyl 1.86*, Ramsgate 1.72* | | |

Table 3.8 continued

| Class of symptom and location | Entering water(a) | Waders (b) | Swimmers (b) | Surfers/ divers(b) |
|---|---|---|---|---|
| 4. Respiratory | | | | |
| Paignton | 1.02 | 1.21 | 0.81 | 1.20 |
| Lyme Regis | 0.78 | 0.80 | 0.77 | 0.80 |
| Rhyl | 0.73 | 0.70 | 0.75 | 1.14 |
| Morecambe | 1.40 | 1.37 | 1.12 | 2.22 |
| Langland Bay | 1.27 | nd | nd | nd |
| Ramsgate | 1.40 | 1.22 | 1.41 | 2.85* |
| Other significant values: | | Age 15-24: Ramsgate 2.39*, Langland Bay 9.38* | | |
| 5. Gastrointestinal | | | | |
| Paignton | 1.09 | 1.08 | 0.89 | 1.95* |
| Lyme Regis | 1.40 | 1.40 | 1.23 | 2.02* |
| Rhyl | 1.76* | 1.74* | 1.85* | 1.68 |
| Morecambe | 2.03* | 1.79* | 2.93* | 3.08 |
| Langland Bay | 0.69 | nd | nd | nd |
| Ramsgate | 1.47* | 1.36 | 1.74* | 0.95 |
| Other significant values: | | (b) Morecambe, Age 25-34 1.63* Female 1.66* | | |
| 6. Diarrhoea | | | | |
| Paignton | 0.89 | 0.91 | 0.71 | 1.54 |
| Lyme Regis | 1.35 | 1.40 | 0.98 | 2.55* |
| Rhyl | 1.85 | 2.07 | 1.38 | 0.75 |
| Morecambe | 2.43* | 2.40* | 3.02 | 1.76 |
| Ramsgate | 1.88* | 1.66 | 2.26* | 1.84 |
| Other significant value: | | (b) Age 45-54 2.33* | | |
| 7. Skin | | | | |
| Paignton | 1.22 | 1.06 | 1.11 | 2.35* |
| Lyme Regis | 3.86* | 3.70* | 3.90* | 4.49* |
| Rhyl | 0.96 | 1.20 | 1.88 | 1.39 |
| Morecambe | 1.01 | 0.95 | 0.62 | 2.28 |

### Notes for Table 3.8

Notes:
(a) Analysis for two types of exposure (entering or not entering water), age and sex. Odds ratio for not entering water, male, age 5-14 is 1.00. Data of Appendix A, Table 13 for 1991 studies.
(b) Analysis for four types of exposure, age and sex. Odds ratio for male, not entering water, age 5-14 is 1.00. Data of Appendix A, Table 14 for 1991 studies. No records for skin symptoms and diarrhoea at Langland Bay or for skin symptoms at Ramsgate - no significant odds ratios found.

nd = no data

* Significantly elevated from basal ratio of 1.00

### 3.5.6 Results of microbiological analyses

Table 3.9 displays the geometric mean counts and the standard deviations of $\log_{10}$ counts at the six beaches. Its shows there is good overall, but not perfect, rank correlation between the results for the three determinands. Overall, the rank order of beaches in terms of increasing bacterial counts is Lyme Regis (lowest) >Paignton >Langland Bay >Rhyl >Ramsgate >Morecambe. This relates to the days of study.

**Table 3.9 Geometric mean counts (per 100 ml) of faecal indicator bacteria at the four beaches in 1996 and at Langland Bay and Ramsgate. Standard deviations of $\log_{10}$ counts in parentheses**

| Beach | Nº of samples | Total coliform bacteria | Thermotolerant coliform bacteria | Faecal streptococci |
|---|---|---|---|---|
| Paignton | 360 | 235(0.36) | 103(0.39) | 32(0.42) |
| Lyme Regis | 360 | 104(0.50) | 40(0.50) | 14(0.41) |
| Rhyl | 468 | 3540(0.30) | 310(0.59) | 88(0.30) |
| Morecambe | 468 | 3380(0.37) | 447(0.70) | 100(0.41) |
| Langland Bay | 162 | 260(0.35) | 158(0.25) | 29(0.40) |
| Ramsgate | 228 | 1200(0.36) | 550(0.31) | 100(0.38) |

The size of the logarithmic standard deviations indicates the total variables caused by changes in bacterial numbers with position on the beach, with time and by sampling and analytical errors. Apart from the values for thermotolerant coliform bacteria at Rhyl and Morecambe, the values lie in the range 0.3 - 0.5.

At these two towns, the greater variability could be explained by bad weather, by proximity of sewage discharges and by failure to 'resuscitate' bacteria on membrane filters by prior incubation for four hours at 30 °C during the first two day of analysis.

Another way of comparing the bacteriological results is to examine percentage compliance with the maximum bacterial counts specified in the bathing Water Directive 76/160/EEC (Table 3.10). This shows that three beaches met the mandatory requirements for coliform bacteria, Lyme Regis, Paignton and Langland Bay, but that none met the guideline criteria. It must be pointed out, however, that this conclusion relates only to the period of the study, when sampling was intensive and that the level of compliance would be different for the schedules of weekly or fortnightly monitoring at single points on recognized beaches at one time of day during the bathing season.

**Table 3.10 Percentage compliance of samples taken at the six beaches with the Mandatory (I-value) and Guideline (G-value) criteria in the Bathing Water Directive 76/160/EEC**

| | Criteria (Counts/100 ml) | | | |
|---|---|---|---|---|
| Beach | I<br>Total Coliforms<br>> 10 000 | I<br>Faecal Coliforms<br>> 2000 | G<br>Faecal Coliforms<br>> 100 | G<br>Faecal Streptococci<br>> 100 |
| Lyme Regis | 99.6 | 98.0 | 71* | 89* |
| Paignton | 99.6 | 96.6 | 45* | 74* |
| Rhyl | 78* | 87* | 20* | 41* |
| Morecambe | 74* | 74* | 19* | 45* |
| Langland Bay+ | 100 | 100 | 59* | 21* |
| Ramsgate | - | 88* | - | - |

Notes:
* Failure of 95 percent of samples to meet the mandatory criteria and of 80 percent (faecal coliform bacteria) or 90 percent (faecal streptococci) to meet the guideline criteria.
\+ Triplicate samples thrice daily from two stations, 31 July - 2 September 1989
\- No data

Table 3.11 summarizes the incidence and average levels of enteroviruses, rotaviruses, coliphages and cryptosporidial oocysts at the six beaches.

Table 3.11 Detection rates (samples positive/samples examined) and average counts* of viruses and cryptosporidial oocysts in samples taken at the six beaches

| Beaches | Enteroviruses in 10 l | Rotaviruses in 10 l | Coliphages in 1 ml | Cryptosporidia in 10 l |
|---|---|---|---|---|
| Paignton | 3/21(0.14) | 0/21 | 30/63(1.1) | 0/21 |
| Lyme Regis | 3/21(0.33) | 0/21 | 32/63(1.1) | 0/21 |
| Rhyl | 12/27(2.4) | 0/27 | 47/78(1.3) | 0/27 |
| Morecambe | 12/27(4.7) | 0/27 | 33/78(1.0) | 0/27 |
| Langland Bay | 5/15(0.53) | 5/15(15) | - | (4)+ |
| Ramsgate | 5/18(0.50) | 0/18 | 18/18(24) | - |

Notes:
* Shown in parentheses. For enteroviruses, pfu/10-l, for rotaviruses fluorescent foci/10-l, for coliphages pfu/ml and for cryptosporidia oocysts/10-l.
\+ In 15 samples, 5 oocysts found in total volume of 1260 ml.

### 3.5.7 Quality control of microbiological analyses

#### Within laboratory variability

WRc's recommendation was that duplicate analyses should be made of the first and last samples to be processed by each laboratory, giving a total of 40 comparisons at each laboratory. The aim was to measure residual within laboratory errors of analysis separately from those caused by variation between samples.

In the event, duplicate samples were taken on the first and last runs of sampling days at each beach and location. Full analysis of variability was not undertaken; however, WRc carried out a detailed analysis of variance of 84 Morecambe samples which were analyzed for total coliform bacteria between 1-7 August.

The analysis of variance in Table 3.12 was carried out on $\log_{10}$ counts. It shows that there was a highly significant difference between days of the study, times of day and sampling stations and for their first and second order interactions. Such interactions are commonly found in such data because of tidal currents and wind affecting dispersion of pollution.

The residual mean square can be considered as an estimate of the variance attributable both to duplicate sampling and to analysis and these effects cannot be separated. However, its size was low enough to permit these significant effects to be detected. The variations of the geometric means for the seven days does not suggest any 'learning curve', as the laboratory undertook the analysis, but that real differences in count occurred between days. This sample of duplicate results suggests that analytical procedures were being correctly carried out for total coliform bacteria.

Table 3.12 Analysis of variance of $\log_{10}$ total coliform counts from analysis of duplicate samples taken at 1000 and 1600 hours at Sites A-C at Morecambe on 1-7 August 1961

| Factors | Degrees of freedom | Sum of squares | Mean square | F-Ratio |
|---|---|---|---|---|
| Times of day | 1 | 2.4276 | 2.4276 | 24.2*** |
| Stations | 2 | 1.3740 | 0.6870 | 6.86** |
| Days | 6 | 13.6616 | 2.2769 | 22.7*** |
| Times x Stations | 3 | 1.0436 | 0.3479 | 3.47* |
| Times x Days | 6 | 8.9919 | 1.4987 | 14.96*** |
| Stations x Days | 12 | 5.3385 | 0.4449 | 4.40*** |
| Times x Stations x Days | 12 | 3.8441 | 0.3203 | 3.20** |
| Residual | 41 | 4.1098 | 0.1002 | |
| Total | 83 | 40.7911 | | |

Notes:
* $0.05 > p > 0.01$
** $0.01 > p > 0.001$
*** $0.001 > p$

### Between-laboratory variability

The results from the analysis of split samples by the two Public Health Laboratories at Exeter and Preston is shown in Table 3.13. The road journey between them took about 8 hours and was such that samples at the 'away' laboratory often could not be analyzed until the day after. Counts of faecal bacteria in sea water steadily decline with storage, even in darkness at refrigeration temperatures. It was also discovered on 2 August that initial low temperature incubation ('resuscitation') was not being given at Preston in the analyses of faecal coliform and faecal streptococci. Taken together, this could account for the non-equivalence of counts at the 'home' and 'away' laboratories, with the exception of the Paignton samples examined for faecal streptococci. The ratios 'Away/Home' in Table 3.13 are those expected as a result of decay of total coliform bacteria over 8-18 hours storage in the dark at 5-10 °C.

A way of overcoming the effect of delays in analysis is to arrange for both 'home' and 'away' samples to be stored identically and examined simultaneously by prior arrangement. This enables efficiencies of the laboratories to be compared, although counts are equally affected by storage.

#### Between laboratory variability assessed externally

Both laboratories participated in analysis of check samples provided by Newcastle Public Health Laboratory. It is a feature of this scheme that individual laboratories are notified whether or not their results lie between the 95 percent confidence limits of the mean result.

Table 3.13 Examination of split samples from the four beaches of 1991 by the Exeter and Preston Public Health Laboratories to ascertain between-laboratory variability

| Determinand | Beach (and home laboratory) | Average Counts (per 100 ml) Home Laboratory | Average Counts (per 100 ml) Away Laboratory | Ratio Away/ Home |
|---|---|---|---|---|
| Total coliforms: | Lyme Regis(E) | 137 | 94 | 0.69 |
| | Paignton(E) | 610 | 498 | 0.82 |
| | Rhyl(P) | 7024 | 5159 | 0.73 |
| | Morecambe(P) | 5845 | 4911 | 0.84 |
| Faecal coliforms: | Lyme Regis | 43 | 22 | 0.51 |
| | Paignton | 320 | 202 | 0.63 |
| | Rhyl | 1055 | 2784 | 2.6 |
| | Morecambe | 2090 | 2945 | 1.4 |
| Faecal streptococci: | Lyme Regis | 9.4 | 7.2 | 0.76 |
| | Paignton | 35 | 43 | 1.2 |
| | Rhyl | 198 | 259 | 1.3 |
| | Morecambe | 255 | 277 | 1.1 |

Note: Samples taken at Sites A-C, at each beach, at 1000 and 1500 on 2, 8, 14 and 17 August, split into duplicates and analyzed by Exeter(E) or Preston(P) Public Health Laboratories.

## 3.6 Analysis and discussion

### 3.6.1 Differences in relative risks between sites in 1991

It would not be surprising to find differences in absolute (crude) attack rates reported by the exposed and unexposed at different beaches. Such differences could reflect any of the following factors:

The state of community health.
Circulation of pathogens in sewage and in the sea.
Immunity acquired in response to challenge by pathogens while bathing.
Past bathing history and day-tripper, holidaymaker or local resident status.
Weather conditions affecting how long people bathe.
Subjects' perception of illness, modified by publicity from news media and environmental groups.

Scrutiny of the crude attack rates (Table 3.7) and the corrected odds ratios (Table 3.8) shows that such local differences may have been detected. IPH have examined the data for the four beaches of 1991 further by logistic regression analysis, using the non-exposed at Paignton as the reference (odds ratio = 1.00). The results of this overall analysis are presented in Table 3.14. The source of these results (Appendix A, page 54-55) does not indicate which of these corrected odds ratios were significantly elevated above the reference level. Because these results are the overall best fit of the odds ratios of Table 3.8 (water activity and symptom) to the four sites, there are some individual differences in odds ratios between Tables 3.8 and 3.14. However, Table 3.14 shows that, taken as a whole:

1. Relative risks increased in the following rank order for beaches: Paignton < Lyme Regis < Rhyl < Morecambe.

2. Relative risks increased with increasing degree of exposure to water: non-exposed < waders < swimmers < surfers/divers.

3. The changes in relative risks with location and activity were in the increasing order: 'major symptoms' (i.e. one or more symptoms reported) < gastrointestinal < diarrhoea.

### 3.6.2 Relative risks and water quality

One of the main conclusions from previous epidemiological studies (Table 1.1) is that the rate of reporting gastrointestinal symptoms is related to bacteriological quality of the water. Such an association was detected in the Cohort Study at Moreton in 1990 (Pike 1991). Now that six beaches have been examined in the Beach Surveys of Phases I-III, it is possible to examine the relationships between odds ratios for the four classes of water activity at the six beaches for different symptoms and $\log_{10}$ geometric mean bacterial counts, using the data of Table 3.8 and 3.9. This has been done in Table 3.15, for combinations of odds ratios for symptoms and water activities, selected as follows:

1. Odds ratios for symptoms and activities which were elevated significantly, compared with no exposure (see Table 3.7).

2. Cases where a high, positive correlation appeared likely between odds ratio and counts of various indicator bacteria.

3. Inclusion, regardless of correlations, of odds ratios for major symptoms for water activity.

Data for diarrhoea in the Beach Survey at Langland Bay were lacking. The correlations in Table 3.15 can be judged by the size of the correlation coefficients, r, the slope of the regression line, m, and the prediction of odds ratios for counts of indicator bacteria at the imperative (I-value) and guideline (G-value) levels in the Bathing Water Directive.

**Table 3.14 Odds ratios for three classes of symptoms, corrected for location of beach, and water activity***

| Beach | Non-Exposed | Water Activity<br>Waders | Swimmers | Surfers/ divers |
|---|---|---|---|---|
| (a) 'Major' symptoms (one or more reported): | | | | |
| Paignton | 1 | 1.08 | 1.07 | 1.50 |
| Lyme Regis | 1.00 | 1.08 | 1.07 | 1.50 |
| Rhyl | 1.20 | 1.30 | 1.29 | 1.81 |
| Morecambe | 1.24 | 1.34 | 1.33 | 1.87 |
| (b) Gastrointestinal symptoms: | | | | |
| Paignton | 1 | 1.55 | 1.38 | 2.26 |
| Lyme Regis | 1.07 | 1.60 | 1.48 | 2.42 |
| Rhyl | 1.32 | 1.97 | 1.82 | 2.98 |
| Morecambe | 1.41 | 2.11 | 1.94 | 3.19 |
| (c) Diarrhoea: | | | | |
| Paignton | 1 | 1.66 | 1.16 | 2.14 |
| Lyme Regis | 1.19 | 1.96 | 1.37 | 2.54 |
| Rhyl | 1.50 | 2.49 | 1.74 | 3.22 |
| Morecambe | 1.66 | 2.74 | 1.92 | 3.55 |

Notes: * Data from Appendix A, pp 54-55. Reference level is for non-exposed at Paignton (odds ratio = 1.00).

Because the number of comparisons (six; except for diarrhoea - five) is small, none of the correlations reach the conventional levels ($r > 0.811$ or $0.878$ respectively for 4 or 3 degrees of freedom) for bare significance ($P < 0.05$). However, once the 1992 programme is complete, information should be available for 9-10 beaches, for which the critical values of the correlation coefficient are 0.6 and 0.632 (for 7 and 8 df respectively). On this basis, the following relationships are worth considering:

Total coliforms, diarrhoea and water activity ($r = 0.82$)
Total coliforms, diarrhoea and wading (0.85)
Total coliforms, diarrhoea and swimming (0.71)
Total coliforms, gastrointestinal symptoms and water activity (0.75)
Total coliforms, gastrointestinal symptoms and wading (0.77)
Total coliforms, gastrointestinal symptoms and swimming (0.80)
Faecal streptococci, diarrhoea and water activity (0.75)

The analysis of Table 3.15 contains certain surprises:

1. The apparent superiority of total coliform bacteria over the more specific faecal indicators as a predictor of odds ratios.

2. The lack of correlation between odds ratios for 'major' symptoms, water activity and $\log_{10}$ bacterial counts.

3. The lack of correlation between the odds ratios for surfing/diving/gastrointestinal symptoms and total coliforms and the negative correlation between diarrhoea/surfing/diving and total coliforms.

It would be unwise to attempt a detailed explanation of those anomalies unless they are confirmed when Phase III is complete. However, it may be instructive to consider the following arguments:

1. Lack of significant correlation may imply that one (or either) of the two variates (odds ratio, bacterial count) is constant or unaffected by the other, or that their values are affected by other factors.

2. Reference to the data of Table 3.8 shows that odds ratios for surfing/diving were lower than expected at Ramsgate for gastrointestinal symptoms (0.95) and at Rhyl for diarrhoea (0.75), whereas the highest was at Lyme Regis (2.55) despite total coliform counts being lowest.

3. Although surfing/diving displays overall the greatest odds ratios (Tables 3.8, 3.14), the act of surfing will take the surfer beyond the areas of water covered by sampling perhaps, although not necessarily, into water nearer marine discharges. Sampling, as required in the Bathing Water Directive, may not adequately represent the water quality

## Table 3.15 Correlations between $\log_{10}$ geometric mean bacterial counts at beaches (x) and odds ratios (y) for various symptoms and water activities

| Independent variable log10 bacterial count(x) | Dependent variable odds ratio (y) | Regression statistics Correlation coefficient(r) | Slope (m) | Constant (c) | Predicted odds ratio for bacterial count at: I- value | G-value |
|---|---|---|---|---|---|---|
| Total Coliforms: | D, water activity | 0.823 | 0.697 | -0.347 | 2.5 | - |
| | D, wading | 0.848 | 0.712 | -0.384 | 2.5 | - |
| | D, swimming | 0.71 | 0.988 | -1.206 | 2.8 | - |
| | D, surfing/diving | -0.681 | -0.638 | 3.55 | 0.99 | - |
| | GI, water activity | 0.749 | 0.548 | -0.142 | 2.1 | - |
| | GI, wading | 0.772 | 0.328 | 0.520 | 1.8 | - |
| | GI, swimming | 0.803 | 0.903 | -0.899 | 2.7 | - |
| | GI, surfing/diving | 0.139 | 0.155 | 1.49 | 2.1 | - |
| | M, water activity | 0.221 | 0.089 | 1.10 | 1.4 | - |
| Faecal Coliforms: | D, water activity | 0.568 | 0.376 | 0.892 | 2.1 | 1.6 |
| | GI, water activity | 0.259 | 0.156 | 1.08 | 1.6 | 1.4 |
| | M, water activity | 0.221 | 0.089 | 1.10 | 1.4 | 1.3 |
| Faecal Streptococci: | D, water activity | 0.749 | 1.15 | -0.296 | - | 2.0 |
| | GI, water activity | 0.626 | 0.836 | -0.007 | - | 1.7 |
| | M, water activity | -0.132 | -0.119 | 1.490 | - | 1.3 |

Notes: Geometric mean counts from Table 3.9, odds ratios from Table 3.8. Linear regression of y on x to give equation y = mx + c. I- value for total coliforms 10,000/100 ml, for faecal coliforms 2000/100 ml. G-value for faecal coliforms and faecal streptococci 100/100 ml.
D = diarrhoea, GI = gastrointestinal, M = major.

experienced by surfers, so that local factors distort any water quality - risk relationship.

4. The category 'major' symptoms embraces responses to one or more of the widely different individual symptoms, representing illnesses which can be acquired by swallowing or inhaling pathogens derived from sewage, those derived from elsewhere or by disturbance of the body's defences, enabling skin bacteria to invade opportunistically (Section 1.2.2; Cartwright 1991). Only those symptoms related to sewage-borne pathogens will be related to counts of faecal indicator bacteria.

# 4. COHORT STUDY AT SOUTHSEA

## 4.1 Selection and description of beach

One of the conditions agreed in the submission of the research protocol to the Committee on Ethical Issues in Medicine of the Royal College of Physicians was that a beach chosen for the Cohort Study should have met the mandatory microbiological requirements of the Bathing Water Directive. It is also desirable that the beach should adjoin a large centre of population, so as to obtain sufficient healthy adult volunteers who are not unduly inconvenienced by the need to attend appointments for interview and exposure. There is also a need for support from the local authority, because of the publicity needed for recruitment, the attention from news media and because of providing the venues for recruitment, interview, car parking and facilities on the beach exposure day.

The South Parade Pier beach (NGR SZ 653 982) at Southsea had passed the mandatory criteria in 1989 and 1990 and it was considered that water quality would be considerably improved in 1991, since the commissioning of the new long sea outfall some weeks before the projected study date. In previous years, sewage from the existing Victorian sewer network and the modern intercepting tunnel, designed to prevent flooding and premature discharge of storm outfall, was pumped to Eastney Pumping Station for discharge to tidal retention tanks and the short sea outfalls at the mouth of Langstone Harbour. The new works involve improved pre-treatment at Eastney Pumping Station, conversion of the tidal tanks for storing storm water, improvement of the storm outfall to discharge below water at all tidal states and construction of a 5.7 km long sea outfall to discharge up to 197 000 $m^3 d^{-1}$, at an average depth of 17 m below mean low water spring tides. The new works came into operation a few weeks before the exposure day.

Permission was given by the Environmental Health and Improvement Sub-Committee of Portsmouth City Council on 24 May, for the Study to take place. Local ethical clearance was obtained from the Portsmouth Consultant Community Physician.

The site chosen, between the Pyramids Centre and the South Parade Pier is shown in Appendix B, Figures 3.1 and 3.2. The area of beach for the exposure was 60 m wide, divided into three 20 m wide strips, normal to the shore. The foreshore is of flat pebbles with some sand at low water. Exposure day was Saturday, 6 July and bathers entered the water between 1400 and 1700 on a rising tide. The conditions recorded were as follows:

| | |
|---|---|
| High water | - 0612, 1856 |
| Water temperature | - 17 °C (previous day) |
| Cloud cover | - none |
| Wind | - South-east 2-4 |
| Wave height | - 1-2 feet, crest to trough. |

A violent thunderstorm occurred at 2200-2300 the previous night. The seawater temperature, measured at 30 cm depth in 1 m of water was 20.7 °C during the exposure.

## 4.2 Recruitment and interviews

The contractual programme (Section 2.4) was rigidly followed and is given in detail in Appendix B, Section 3. The course was as follows:

| | |
|---|---|
| 13 June: | Press briefing by WRc, CREH and Portsmouth City |
| 14-29 June: | Recruitment of volunteers, Cascades shopping centre |
| 4-5 July: | Pre-exposure interviews in Guildhall, Portsmouth |
| 6 July: | Exposure day. Press briefing in the morning |
| 12-13 July: | First 7-day post exposure interview, medical and clinical examination in Guildhall |
| 27 July: | Postal questionnaire, three weeks post-exposure |

## 4.3 Microbiological sampling and analysis

### 4.3.1 Faecal indicator bacteria

During the exposure period, 1400-1700 samples were taken simultaneously every 30 minutes, on the four lines, 20 m apart, normal to the shore at the waters' edge (surf zone), at 30 cm depth in 1 m of water (as required in the Bathing Water Directive) and at chest depth. Additional samples were taken by boat. Samples were analyzed in the mobile laboratory by Altwell Ltd for:

Total coliform bacteria
Faecal coliform bacteria
Faecal streptococci
Total staphylococci
*Pseudomonas aeruginosa*

Additionally 17 samples were taken for analyses of salmonellae, enteroviruses, rotaviruses and Cryptosporidium oocysts (Appendix B, Section 4.2). Full details of methods are given in Appendix III of Appendix B.

Analytical quality control was provided in three ways:

1. The taking of seven duplicate samples, examined for total and faecal coliform bacteria, faecal streptococci, total staphylococci and *Pseudomonas aeruginosa*.

2. Eight duplicate samples from each of the 1430 and 1630 runs were analyzed by Altwell Ltd and by the Southern Region Laboratory of the National River Authority. Analyses for total and faecal coliform bacteria and faecal streptococci.

3. Triplicate analyses for faecal coliform bacteria of samples taken on all runs at all locations and depths, presented as counts on three replicate membrane filters.

Methods used are detailed in Appendix III of Appendix A.

### 4.3.2 Analysis for pathogens

Residual volumes of sea water from bacteriological analysis were pooled and the bulk of 7.5 litres was examined for Salmonella spp.

Seventeen 10-litre samples, 15 taken half-hourly at each of the 20, 40 and 50 m sampling points, 30 cm below the surface in 1m depth of water and two offshore, were analyzed for enteroviruses and rotaviruses by Dr Helen Merritt of Enviros Ltd.

Portable filtration equipment was used to concentrate 151 litres of water from the middle of the sampling grid for analysis of Cryptosporidium oocysts.

Five samples of cheese sandwiches, supplied to all subjects, were analyzed for faecal bacteria and *Salmonella* spp by Portsmouth District Pathology/Public Health Laboratory.

## 4.4 Clinical and medical examinations

Certification of medical fitness to participate was made at the pre-exposure interview. During the post-exposure (7-day) interview, all subjects were given an examination of their throats and ears by physicians. Ear and throat swabs were taken for bacteriological examination. Throat swabs were examined virologically. Faeces samples taken seven days post-exposure were analyzed for *Salmonella, Shigella, Campylobacter* and *Escherichia coli* 0/157. Those from subjects reporting gastrointestinal symptoms were examined for *Cryptosporidium* and other parasites.

A full set of the questionnaire and medical recording forms is provided in Appendix II of Appendix B.

## 4.5 Results and observations

### 4.5.1 Recruitment, exposure and interviews

Table 4.1 compares the progress of recruitment and participation at Southsea with that at Langland Bay and Moreton. The patterns are similar. The drop-out rates between initial recruiting and the pre-exposure interviews are high (41-57%), but with a willingness, once at this stage, to continue to the end of the study.

**Table 4.1 Progress of recruitment and participation in the cohort study at Southsea 1991 and a comparison with those at Langland Bay (1989) and Moreton (1990)**

| Stage of the study | Participants Southsea | Langland Bay | Moreton |
|---|---|---|---|
| Initial recruiting, Portsmouth City Centre | 1044 | 465 | 832 |
| Pre-exposure interviews 4-5 July | 449 | 276 | 390 |
| Exposure day, 6 July | 387 | 266 | 303 |
| Follow-up questionnaire and medical interviews, 12-13 July | 339 | 262* | 303 |
| Further telephone or postal responses to follow up questionnaire | 47 | - | - |
| Final postal questionnaire, 27 July | 360 | 259 | 287 |

Notes: * The first follow-up interview at Langland Bay was conducted three days post-exposure

### 4.5.2 Reporting of symptoms

Table 4.2 shows the rates of reporting of those symptoms which differed significantly between bathers and non-bathers. The subjects were assigned randomly into the two cohorts between the pre-exposure and exposure day interviews. It is, therefore, interesting but fortuitous that those assigned to the non-bathing groups appeared to report being less well before assignment. On the exposure day, the cohorts were equivalent, in all respects.

One week post-exposure, gastrointestinal symptoms, nausea and loose motions were reported significantly more frequently by the bathers. At the three-week postal questionnaire, bathers reported significantly more gastrointestinal symptoms, nausea, skin symptoms and grouped symptoms.

Of the 13 food categories examined, only fresh mayonnaise consumption differed significantly between the cohorts, being more than expected among bathers. This was shown not to have any effect upon reporting of nausea or any gastrointestinal symptoms.

Outcomes considered more serious were cases when the subject visited the doctor, lost days from work or visited a hospital. These amounted to totals of 7, 6 and 1 respectively seven days post-exposure and to 8, 16 and 2 at three weeks post-exposure. The differences between bathers and non-bathers was not significant (Appendix III of Appendix B).

No significant differences were found between the cohorts in respect of medical diagnoses of reported ear and throat conditions (Appendix III or Appendix B).

**Table 4.2 Rates of reporting and relative risks of those symptoms which showed significant differences* between bathing and non-bathing cohorts**

| Symptoms | Rates of reporting (%) Bathers (B) | Non-Bathers (N) | Risk, B/N |
|---|---|---|---|
| (a) Pre-exposure: | | | |
| Running nose | 12.4 | 22.6 | 0.55 |
| Chest symptoms | 19.8 | 31.2 | 0.63 |
| Ear/eye symptoms | 3.4 | 8.6 | 0.39 |
| Any | 46.9 | 58.5 | 0.80 |
| (b) On exposure day: | | | |
| None significant | - | - | - |
| (c) Post-exposure, 1 week: | | | |
| Gastrointestinal symptoms | 44.1 | 25.0 | 1.76 |
| Nausea | 17.5 | 7.0 | 2.51 |
| Loose motions | 23.7 | 15.2 | 1.56 |
| (d) Post-exposure, 3 weeks: | | | |
| Gastrointestinal symptoms | 40.7 | 26.9 | 1.51 |
| Nausea | 15.2 | 4.1 | 3.70 |
| Skin symptoms | 13.9 | 7.0 | 1.97 |
| Any symptoms | 64.8 | 51.8 | 1.22 |
| Bathing symptom | 63.8 | 51.8 | 1.23 |

Notes: * $P < 0.05$
From Appendix IV and Figures 5.12 and 5.13

### 4.5.3 Reported symptoms, clinical findings and medical diagnosis

Tables 5.8 and 5.10 of Appendix B show that there was little coincidence between (a) results of microbiological examinations of throat and ear swabs and perceived sore throats and ear infections, or (b) between perception of these complaints and medical diagnosis of these conditions at seven days post-exposure, regardless of cohort.

Search for pathogens in samples of faeces taken seven days post-exposure gave the following results:

*Campylobacter jejuni* isolated in one (a non-bather) of 325 samples. *Giardia lamblia* isolated from two subjects (bather, non-bather) of 108 examined three weeks post-exposure. None of 111 samples from subjects reporting gastrointestinal symptoms at seven days or three weeks post-exposure contained virus particles by electron microscopy

### 4.5.4 Results of microbiological analyses

Geometric mean counts of bacterial determinands for all samples are shown in Table 4.3 and of viruses, in Table 4.4. When the beaches are ranked in order of coliform bacteria, Southsea is intermediate between Langland Bay and Moreton, but this order is not preserved with the other bacterial and viral determinands. No cryptosporidia, salmonellae or rotaviruses were detected at Southsea.

Percentage compliances with the bacteriological criteria of the Bathing Water Directive are shown in Table 4.5.

**Table 4.3 Geometric mean bacterial counts (per 100 ml) during the cohort study at Southsea, 6 July 1991, and a comparison with those at Langland Bay 1989 and Moreton 1990**

| Determinand | Southsea | Langland Bay | Moreton |
|---|---|---|---|
| Total coliform bacteria | 71 | 37 | 258 |
| Faecal coliform bacteria | 75 | 19.7 | 157 |
| Faecal streptococci | 18.5 | 32 | 26 |
| Pseudomonas aeruginosa | 5.5 | 0.17 | 3.7 |
| Total staphylococci | 360 | ND | 134 |

Note: ND - analysis not done

**Table 4.4 Frequencies of isolation of viruses in 10-litre samples at Southsea, Langland Bay and Moreton**

| Viruses | Frequencies of isolation Southsea | Langland Bay | Moreton |
|---|---|---|---|
| Enteroviruses | 4/17 (17.5) | 1/15 (0.13) | 5/15 (2.0) |
| Rotaviruses | 0/17 (0.0) | 3/15 (1.1) | 2/10 (0.2) |

Notes: Frequencies are number of samples positive/number of samples taken
Average count of enterovirus plaque-forming units and rotavirus fluorescent foci shown in parentheses

**Table 4.5 Percentages of samples, not exceeding the Imperative (I) and Guideline (G) criteria of the bathing water directive 76/160/EEC at Southsea, Langland Bay and Moreton**

| Determinand | Southsea | | Langland Bay | | Moreton | |
|---|---|---|---|---|---|---|
| | I | G | I | G | I | G |
| Total coliforms | 100 | 100 | 100 | 100 | 100 | 9.3* |
| Faecal coliforms | 100 | 28.6* | 100 | 92.6 | 100 | 83 |
| Faecal streptococci | - | 96.4 | - | 87.0* | - | 52* |

Notes: Samples were taken 30 cm below the surface in 1 m deep water.
N° of samples taken: Southsea 28, Langland Bay 54, Moreton 54.
* Not complying with percentile requirement

#### 4.5.5 Quality control of microbiological analyses

Analyses of the results of replication of samples and analyses were provided by CREH in Tables 1 and 2 of their Appendix III (Appendix B). These are:

1. Seven duplicate samples analyzed for five indicator bacteria by Altwell Ltd - no significant differences in counts between duplicates except for total coliform bacteria ($p = 0.040$).

2. Sixteen duplicate samples examined by Altwell Ltd and Southern Region, National River Authority - no significant differences.

Additional statistical analyses were carried out by WRc on replicated data supplied by CREH. This data consisted of 96 samples, which had undergone triplicate determinations for faecal coliform bacteria by Altwell Ltd and the subset of 16 duplicate samples, which had been analyzed in parallel by Altwell Ltd and Southern Region, National Rivers Authority. The data were presented as counts per 100 ml, but the numerical results suggested that 100 ml volumes had been filtered. This enabled the data to be converted back to counts of colonies on the original membranes. If this assumption is correct, it enables the differences between replicate membrane filtrations from the same sample bottle to be compared with the irreducible background error (Poissonian) caused by taking pipetted samples of water from a bottle containing randomly distributed bacteria. It should be noted that additional variations are caused by taking duplicate samples of water from the sea, again caused because bacterial concentrations will vary from place to place and with time, in addition to variability caused by taking small samples from the sea. The results of the WRc statistical analyses of the data are as follows:

1. Within-laboratory precision. The 96 samples analyzed in triplicate for faecal coliform bacteria contained 282 usable determinations. A generalized linear model was used to assess measurement error between repeat determinations within samples. The error was slightly greater than expected for Poissonian error (i.e. withdrawing samples from a randomly mixed population of bacteria in the water). Four values were unexpectedly low, and when these were removed, the data was consistent with a Poissonian model. Four outliers in 282 results is acceptable on chance grounds. There is no evidence that the precision achieved by Altwell could be improved.

2. Variability between samples. The data set of (1) above contains triplicate measurements of faecal coliform bacteria at four locations (0-60 m strips), four depths and seven runs (times at 30 minute intervals). This data does not permit the variability caused by taking samples from the sea - as compared with analytical errors in the laboratory - to be assessed directly. However, it can be estimated by equating it with the variance of the high-level interaction, location x depth x time. Use of the generalized linear model showed that this interaction was much larger than could be accounted for the Poissonian error, suggesting that sampling of the sea is an important source of variability as well as that of laboratory analysis. This was further investigated by analysis of variance, using the $\log_{10}$ values of bacterial counts (per 100 ml) (Table 4.6). This shows that the main factors accounting for variability were depth, time and depth x time, thereby confirming the results shown in Appendix B, Figure 5.3, to which the boat samples could be added. The residual standard deviation for $\log_{10}$ counts was 0.249. It implies that the inter-95 percentile range for $\log_{10}$ counts when sampling at the same point in time and space would be about 1.0 (i.e. a ten-fold range).

Table 4.6 Analysis of variance of $\log_{10}$ faecal coliform counts determined at Southsea, 6 July 1992

| Factors of freedom | Degrees square | Sum of square | Mean ratio | F |
|---|---|---|---|---|
| Depth | 3 | 24.600 | 8.20 | 132.7*** |
| Time | 6 | 1.762 | 0.294 | 4.76** |
| Location | 3 | 0.176 | 0.0585 | 0.95 |
| Depth x time | 16 | 5.582 | 0.349 | 5.64*** |
| Location x time | 26 | 1.498 | 0.0576 | 0.93 |
| Location x depth | | | | |
| Residual | 30 | 1.855 | 0.0618 | |
| Total | 84 | 35.473 | 0.4223 | |

Notes:
** 0.01 > P > 0.001
*** 0.001 > P
Uses samples for which there were three satisfactory determinations.
Missing values do not present a problem with the analysis.
Residual error is the 'Depth x time x location' factor and represents errors of sampling the sea and of laboratory analysis.

## 4.6 Analysis and discussion

### 4.6.1 Reporting of symptoms

The significant elevations in the bathing cohort of gastrointestinal symptoms and the related nausea and loose motions at one week post-exposure is in accord with the finding of the US EPA's studies in marine and brackish waters (Cabelli 1983) that symptoms highly indicative of gastrointestinal infection occur usually within 48 hours of exposure. Because, on the exposure day, before going in the water, the two cohorts did not differ significantly in reporting health effects, the effects at seven days post-exposure can be regarded as being related to bathing. The same conclusion applies to those symptoms, significantly elevated three weeks post-exposure - gastrointestinal, nausea and skin symptoms.

The lack of association between subjects' reporting of symptoms, medical diagnosis and clinical findings follows the results obtained at Langland Bay and Morecambe. The issues raised are considered in the Report on Phase II, p 59 (Pike 1991) and can be summarized thus:

1. Subjects were reporting minor symptoms and few were overtly ill, because few found it necessary to buy medicine or visit the doctor or a hospital for attention.

2. The pathogens involved in some of the symptoms were not detectable by the methods used.

3. Subjects reporting symptoms may have had their perception of symptoms raised by publicity connected with recruitment and the aims of the Study or by articles produced by news media.

### 4.6.2 Reporting of symptoms and water quality

It is the main aim of the UK study to show the extent to which the health of bathers in sea water is related to the quality of the water. A search was made for those symptoms which were significantly elevated seven days and three weeks post-exposure in bathers, which were also associated with significant differences in water quality (Appendix B, Figures 5.12 and 5.13, Tables 5.5 and 5.6). Significantly higher bacterial counts were found to have been experienced by bathers reporting loose motions or nausea seven days post-exposure, compared with bathers not reporting these symptoms (Table 4.7). No other significant associations were found. The indicator organisms involved were total coliform bacteria and total staphylococci. The list of symptoms involved is much less than in the same analysis of Moreton data (Pike 1991, Table 11), which also included sore throat, dry cough, ear infection, stomach pain, flu/cold grouped and gastrointestinal grouped.

### 4.6.3 Further Analysis of Effects of Water Quality and Confounding Factors Upon Reporting of Gastrointestinal Symptoms

CREH have commenced a breakdown study of data for gastrointestinal symptoms, water quality and confounding factors obtained at Langland Bay, Moreton and Southsea, to determine their relative effects, by using logistic regression analysis. This is not yet complete and preliminary results only are given below.

Table 4.7 The geometric mean bacterial counts which were experienced by bathers reporting those symptoms which were significantly elevated seven days post-exposure (Table 4.2) and which are significantly greater than those experienced by the bathers who did not report those symptoms

| Symptom | Nº of bathers reporting | not-rept'g | Bacterial indicators type* | depth of measurement | Geometric mean reporting | not-rept'g |
|---|---|---|---|---|---|---|
| Loose motions | 40 | 131 | ts | surf | 1090 | 848 |
| Nausea | 29 | 142 | tc | 30 cm | 176 | 143 |
| | | | ts | surf | 1132 | 857 |
| | | | ts | 30 cm | 939 | 725 |

Notes: * ts, total staphylococci; tc, total coliform bacteria
Data from Appendix B : Table 5.5 and Figure 5.12

Only faecal streptococci at chest depth were significantly related to gastrointestinal symptoms post-exposure. This applied to Langland Bay and Moreton data alone and combined, and to Southsea data, which has yet to be combined. The addition of non-water related risk factors, e.g. food intake, increased the significance of the models, but addition of interactive terms (water x non-water related factors) or study location did not. The non-water related factors had an effect on gastrointestinal symptoms equal to or greater than the count of faecal streptococci at Moreton and Langland Bay combined when counts were 60 per 100 ml or less. Above this level, the faecal streptococcus count is the more important predictor of gastrointestinal symptoms.

### 4.6.4 Analytical quality control

The analytical quality control procedures (Section 4.5.5) have shown an entirely satisfactory state of affairs in the cohort study, notably in the precision of analyses themselves, the ability of the methods to reveal significant differences with depth and time of sampling and their interaction and that there were no significant different counts of faecal coliform bacteria between locations (i.e. strips) of beach.

However, it should be noted that to measure within laboratory precision, data should be presented as counts of colonies on replicated membrane filters. The taking of duplicate samples at any location on the beach introduces errors of sampling, because bacteria are not homogeneously distributed in the sea in terms of space and time. Design of the protocol of replicate sampling and analysis is essential if laboratory precision and sampling efficiency are to be measured separately.

# 5. GENERAL ANALYSIS AND DISCUSSION

## 5.1 Achievement of objectives

It is opportune to examine how far the two objectives, set out in Section 2.1, have been attained so far.

The first objective is to undertake an epidemiological study to determine the risks, if any, to health of swimming in coastal water contaminated by sewage. This will be attained by the end of the summer of 1992, when a further four Beach Surveys, making ten studies in all, and (if deemed necessary) a fourth Cohort Study should have been carried out. Very few modifications were made to the protocols of the two methods tested in the Phase I Pilot Studies at Langland Bay in 1989 (Pike 1990) and it is considered that the results of the Pilot Study could be accommodated into the complete set of data obtained so far. The principal modifications made to the protocols so far are:

1. The Beach Survey Study embraces approximately 2000 successful telephone interviews, carried out seven days after initial recruitment of holidaymakers on the beach. The telephone interview was shown to provide more consistent and reliable data than direct interviews on the beach.

2. To ensure adequate coverage, quotas are given to market researchers interviewing on the beach to ensure adequate recruitment of age classes, sex and water activities. The last class embraced 50 percent taking part in no water activity in Phases I and II and was modified to 30 percent in Phase III.

3. In the Pilot Cohort Study, clinical samples were taken before exposure as well as at the interview, three days post-exposure. Epidemiological advice from the Public Health Laboratory Service (PHLS) was taken, and on the basis of the findings obtained, it was decided to carry out clinical examinations of ear and throat swabs only at the time of the first post-exposure interview, which was moved to seven days after the exposure.

4. The scope of the questionnaires used in the Cohort Studies was extended, on the advice of PHLS epidemiologists, to obtain more information on confounding factors and to increase the objectivity of reporting of symptoms.

It has been noted (Section 2.4) that the programme of work for the Cohort Study in 1991 has been extended to permit the data for the Pilot Study at Langland Bay to be amalgamated with that obtained in the studies at Moreton and Southsea. This has been done.

The study directors of the two subcontractors, IPH and CREH attended a meeting on Microbial Pollution of the Mediterranean Sea, held by the World Health Organization/United Nations Environmental Programme, MED POL Phase II, in Athens on 15-18 May, 1991. The protocols of both studies were presented and are acknowledged as alternative approaches, for use in future epidemiological studies, in their own right.

The second objective is to establish the relationship, if any, between microbiological quality of coastal waters and the risk to health of bathers. The results of Section 3.5 and 4.5 and their discussion in Sections 3.6 and 4.6 show that associations between water activity and particular symptoms have been demonstrated at all beaches examined so far. Although such individual results may have popular appeal to those interested in showing that bathing in British coastal waters is hazardous to health and that standards of water quality need to be made even more stringent, it must be pointed out that 'Observation first - hypothesis later' is poor science. The second objective poses the statistical null hypothesis that there is no significant effect of water quality on health, and thereby sets the proper challenge to disprove it, by showing that the observations of elevated risk in bathers were unlikely to have occurred by chance and represent a real effect. The conventional level of probability, which is accepted as an indication of bare statistical significance and not caused by chance, is that for the result to have occurred by chance in less than one in twenty trials (i.e. $p < 0.05$).

Some consideration must, therefore, be given to interpreting the individual findings of significant associations between symptoms and water activity at individual beaches. The following observations are relevant.

1. The studies of Phases I - III are a national study, the results of which are intended to be applicable to beaches in the United Kingdom. The end product of the second objective will be to show whether, nationally, there is a relationship between water quality and bathing.

2. It is accepted that there may be local differences which may affect reporting of symptoms and that these should be recognized. However, the choice of beaches and their geographical distribution should be such as to enable the main effect - of water quality upon relative rates of reporting symptoms - to be distinguished.

3. It should be borne in mind, that where large numbers of comparisons are made between various symptoms and classes of water use, some levels of association may well exceed the conventional 'one in twenty' probability purely by chance. Any positive association deemed 'significant' statistically must be examined to see if the association is plausible (Bradford Hill 1965) on biological and medical grounds.

4. It must be recognized that only those illnesses which are transmitted by pathogens excreted in sewage and which are normally contracted by swallowing or inhaling water will demonstrate a relationship between counts of micro-organisms indicative of faecal pollution and relative risk of reporting.

5. Illnesses of the type described in Cartwright (1991), in which opportunistically pathogenic organisms, carried transiently as commensals on the body, are enabled to infect as a result of the body's defences being lowered by prolonged exposure to water, will probably not show any relationship at all between microbial indicator counts and relative rates of reporting. They should, however, display a relationship between intensity or duration of contact with water and relative rates of reporting.

## 5.2 Interpretation of findings and strategies suggested for 1992/9

The points 1 - 5 indicate strategies which should be employed in the final year of Phase III.

The report on the four Beach Surveys of 1991 (Appendix A) suggests that a 'north-south divide' appears in the relations between water quality and relative risk. This is apparent in Table 3.14, because the waters at the two southern beaches were of higher quality than those at the northern. This geographical association disappears when the data for Langland Bay and Ramsgate are added. Nevertheless, the beaches used so far have been in Wales, and on the southern coast of England and in the north-west. It is considered that examples of highly satisfactory and unsatisfactory beaches should be chosen from eastern England and from the north Devon - Cornwall coastline, so obtaining a satisfactory distribution of beaches of varying quality all around England and Wales. Regretfully, Scottish beaches may have to be discounted because of lower bather densities and less certain weather.

It would seem prudent not to make general statements, at this stage, about the effects of water quality on health until the data sets are complete. However, it seems plausible to suggest that gastrointestinal symptoms are related to waterborne infection caused by pollution, since this is being shown by both studies.

Symptoms of the skin, and possibly of the ear, nose and throat, which do not seem to be clearly related to the bacteriological quality of the water, but which nevertheless appear to be partly related to degree of water contact, particularly in surfers and divers, may belong to the class of illnesses caused by opportunistic pathogens and by prolonged exposure to water. Again, this argument is plausible, but conclusions should not be drawn until Phase III is complete.

Because the protocols tested in Phase I have received little modification, it will be to the benefit of the whole study to include them in the final analysis.

The effect of news media publicity during the studies upon subjects' perception of illness is difficult to ascertain. The crude rates of reporting (Tables 3.7 and 4.2) in the UK studies have been far higher than reported in studies elsewhere and tend to be higher in the Cohort Studies, where advance publicity is needed to foster recruitment. The strategy adopted has been to launch recruitment in the Cohort Studies with a vigorous and positive campaign involving local and national media and the technical press and to make no announcements at all about the Beach Survey, other than that they will take place. When the locations have been discovered, the news media have been told to respect the aims of the study. The study at Morecambe undoubtedly suffered from bad weather in August 1991, as well as a concerted media campaign aimed at pollution of beaches on the Fylde coast which referred to enteroviruses being isolated from sea water. The above strategy, involving open-ness, as far as possible, and an approach of reasonableness towards environmental groups, seems the best policy, and will be continued.

The insistence upon analytical quality control procedures is essential where several laboratories are involved in analysis of bacteriological samples. Close supervision detected the failure to 'resuscitate' faecal coliform bacteria in the first two days at one laboratory. It also indicated that precision overall was more than adequate and, at one laboratory, probably could not be improved. However, in 1991, data was not supplied in the correct form needed to distinguish errors caused by sampling sea water from those introduced during membrane filtration and, in one case, replication exceeded that necessary. Steps need to be taken to prevent these recurring.

## 5.3 Comparison of findings with those reported in other studies

Concordance of findings is very important, because it adds to plausibility of the results and the greater likelihood that the effects are real.

Table 5.1 summarizes past findings and those of Phases I and II are added to show the extent of concordance. Table 5.1 compares the overall observations of Table 1.1 and shows that the findings of the UK studies so far generally support them or amplify them. Important aspects are the greatest susceptibility of the 15-24 age group, which may represent the most vigorous and adventurous of water-goers and indications that there may be three classes of symptoms covered by the study - those representing attack by faecally-borne organisms (since related to water quality and exposure), those related only to exposure and not to water quality and those not related to either. It is also likely that the most suitable indicators for predicting risks from faecally borne infection to health might be clarified when the study is complete.

Table 5.1 Comparison of observations from past epidemiological studies (Table 1.1) and those obtained in the UK studies to date

| Past observations | Observed in UK studies |
|---|---|
| 1. Swimmers report a higher in incidence of certain illnesses than non-swimmers. | Confirmed, but statistically significant only in certain cases. |
| 2. The rate of illness is related to the degree or duration of exposure to water. | A general trend found, which is most marked with gastrointestinal symptoms and increases in the order no activity < wading < swimming < surfing/diving. |
| 3. Children bathing show a greater incidence of illness than older people. | Not measured in under fives, but the highest relative risks are shown by the 15 - 24 age group. |
| 4. The rate of illness is related to of counts of faecal bacteria. | The correlation is greatest for total the level coliform bacteria and, to a lesser indicator extent, faecal streptococci and gastrointestinal symptoms, but more data is needed before firm conclusions can be made. |
| 5. *E. coli* or faecal coliform are not as satisfactory as other faecal indicator bacteria in correlation with illness rates. | See remarks for observation 4. No bacteria indicator appears superior overall. |
| 6. Residents near the beach are less susceptible than visitors to swimming-associated gastroenteritis. | Not investigated from the data so far. |
| 7. What are the most active age-groups for bathing? | Not investigated. |

# 6. CONCLUSIONS

Because Phase III is only half complete and the entire UK Study so far only embraces three-fifths of the Beach Surveys and three-quarters of the Cohort Studies envisaged, it would be most unwise to draw interim conclusions rather than indications of the way in which trends are progressing. However, the general indications are as follows:

1. In the Beach Survey Studies, fairly high levels of correlation have been shown so far between reporting of diarrhoea and gastrointestinal symptoms in holidaymakers taking part in wading, swimming and all water activities combined and counts of total coliform bacteria and faecal streptococci. The number of beaches so far examined is not enough for the observations to be regarded as significant, although the observations are plausible.

2. In the Beach Survey Studies, there is a consistent tendency for the relative rates of reporting of one or more ('major') symptoms and, at most beaches, of diarrhoea and gastrointestinal symptoms, to be related to degree of water contact in the order: no activity < wading < swimming < surfing/diving. This observation is plausible.

3. The Cohort Studies have shown that there is little concordance between subjects' reporting and medical diagnosis of symptoms and clinical findings. Very few of the subject report buying medicine or visiting the doctor or hospital out-patients units after exposure and the infrequent discoveries of pathogens in faecal samples show no relationship with exposure to water.

4. The Cohort Studies have so far shown that there are significant individual correlations between water quality measured by various indicator bacteria at different depths in the water and various symptoms reported by bathers. Firmer conclusions upon the effect of water quality can be made when the data for the individual studies are combined and an analysis is made to determine the relative significance of microbiological quality of the water and confounding effects, such as food intake, upon relative rates of reporting symptoms.

5. The studies so far have obtained usable data from 9531 subjects at six beaches in the Beach Surveys and 906 subjects in three Cohort Studies.

6. The results obtained so far are in general agreement with the findings of epidemiological research elsewhere and are amplifying them.

# 7. RECOMMENDATIONS

The following recommendations are made for the final year of Phase III, 1992/93:

1. The four beaches selected for the Beach Survey studies should be located in eastern England and on the north coast of south-west England and should include two beaches with high quality water and two with poor quality.

2. When these studies are complete, individual analysis of health effects and water quality should be supplemented by analysis of data from all ten beaches studied, including Langland Bay.

3. The protocols for the Beach Survey and Cohort Studies should not be changed.

4. A fourth Cohort Study is recommended for 1992.

5. Work should proceed on amalgamating the data from the Cohort Studies carried out so far, and that of the fourth study when complete. The data should additionally be examined by logistic regression analysis or other appropriate statistical methods to enable the relationship between relative risks to health and counts of microbial indicators of water quality and of confounding factors to be measured differentially.

6. The protocols for quality control of microbiological analyses should be revised to permit of more efficient evaluation of errors arising from sampling of sea water and of analytical, within-laboratory errors not arising by chance. This will involve submitting counts of colonies on individual membrane and not calculated (derived) densities of bacteria. Because microbial decay occurs during inter-laboratory exchanges of samples, inter-laboratory comparisons should either involve analysis of exchanged samples simultaneously, or use of prepared samples supplied by a reference laboratory and analyzed simultaneously.

7. The current policies for handling enquiries from news media and environmental groups should be continued. This aims to preserve open-ness and a positive attitude to the studies and to foster recruitment for the Cohort Studies, while reducing, as far as possible, the influencing of subjects' perception in the Beach Survey studies.

8. A detailed Final Report is required under this contract to be submitted by 31 March 1992. This presents WRc and subcontractors with a tight time schedule. It is recognized by WRc that there is also a need for a well-written account of the studies aimed at the non-expert and the lay public and extension of the contract is requested to enable this to be produced.

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# APPENDIX A - HEALTH RISKS ASSOCIATED WITH BATHING IN THE SEA. RESULTS OF STUDIES IN PAIGNTON, LYME REGIS, RHYL AND MORECAMBE

Report to WRc, January 1992
By R. Balarajan
Institute of Public Health
University of Surrey

# HEALTH RISKS ASSOCIATED WITH BATHING IN THE SEA

# RESULTS OF STUDIES IN PAIGNTON, LYME REGIS, RHYL AND MORECAMBE

INSTITUTE OF PUBLIC HEALTH

UNIVERSITY OF SURREY

*January 1992*

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*Professor R Balarajan*

*January 1992*

# CONTENTS

## INTRODUCTION

The risk to health of bathing in seawater contaminated with sewage has attracted public concern in Britain (Eykin, 1988). European standards for bacteriological quality of bathing water are less rigorous than those in the United States and Canada; hence there is increasing pressure on the European Commission to revise its bathing water directive (CEC, 1976). The difficulty is in establishing rational mandatory standards based on scientific criteria (House of Commons Environment Committee, 1990).

An Advisory Committee was set up by the Departments of Environment and Health to address the issue of health risks from bathing in seawater. The committee recommended a pilot study to explore the feasibility and further develop the methodology for establishing health risks associated with bathing in the sea. The pilot study was conducted at Langland Bay, Wales in the summer of 1989. Based on the experience of that study, a definitive study was conducted at Ramsgate, Kent in the summer of 1990. The findings were significant and showed an increased and dose-related risk of self-reported illness from bathing in sea water, findings consistent with those of the first phase study at Langland Bay.

These studies confirm that the study design used by the United States Environmental Protection Agency, endorsed by the World Health Organisation and the United Nations environment programme, and developed further by us is suitable for application in the United Kingdom. The noteworthy difference between our findings for Ramsgate and those for Langland Bay was the significant association between bathing and gastrointestinal symptoms observed at Ramsgate, where the seawater contained higher levels of faecal pollution.

The Langland Bay and Ramsgate studies reinforced the case for studying levels of illness in relation to the microbiological environment over a series of beaches selected for their varying levels of pollution. Accordingly, the Department of the Environment approved the study of eight further beaches in 1991 and 1992. We present here the findings for the four beaches studied in 1991.

## AIMS OF THE STUDY

- To investigate the risks to health of bathing in British seawaters, through a prospective cohort study of bathers and non-bathers at four beaches: Paignton, Lyme Regis, Rhyl and Morecambe, conducted in the month of August 1991, as the penultimate phase of a study starting at Langland Bay (1989) and Ramsgate (1990).

- To simultaneously monitor the microbiological quality of the seawaters at these beaches at selected locations and times over this period.

- To establish associations, if any, between levels of morbidity, exposure to seawaters, and the concentration of potential pathogens.

## STUDY DESIGN

### Choice of beaches

The study was conducted at four beaches identified by an expert group established by the Department of the Environment (DoE) and the Department of Health (DoH). The beaches were: Paignton (Devon), Lyme Regis (Dorset), Rhyl (Wales) and Morecambe (Lancashire). Rhyl replaced the original choice of Prestatyn, as parts of the Prestatyn beach were closed for marine engineering during the period of the study.

The study was conducted during the period 1-26 August 1991.

### Beach and telephone interviews

The study was designed according to the terms of reference set out by an Advisory Committee of the DoE. It took the form of a prospective cohort study, the study cohorts being obtained by interviews of beach users at the respective beaches during the month of August. Quota sampling was employed to obtain the necessary numbers in the various exposure categories (waders and swimmers/surfers/divers). Those not exposed to the water, ie, those who did not enter the sea, were used as a control group. The study was restricted to subjects aged 5-60 years. Subjects interviewed included holiday makers, day trippers and local residents.

Each beach was divided into three sections (Appendix 1) and the respondents were identified by these sections. All those interviewed were asked for a convenient time at which they could be contacted on the telephone a week after their intended day of departure from the resort. Respondents were then followed up at this time by telephone interviews using Computer Assisted Telephone Interviewing (CATI).

At the beach a pre-tested questionnaire (Appendix 2), refined on the basis of our previous studies (Langland Bay, August 1989 and Ramsgate, August 1990) was used to obtain information on socio-demographic characteristics, length of stay at the resort, visits to other resorts, type and duration of water activity, and food consumption. At the follow-up telephone interview a week later, information was obtained on symptoms in the preceding week, self-medication, and consultation with a general practitioner (Appendix 3).

A target of 2200 interviews was assigned for each beach. The number of beach interviews achieved (some of those interviewed were outside the study's age range) and the response rates for the telephone follow-up are given below:

| LOCATION | TOTAL NUMBER OF BEACH INTERVIEWS | BEACH INTERVIEWS AGES 5-60 YEARS | RESPONSE RATE FOR TELEPHONE INTERVIEWS |
|---|---|---|---|
| Paignton | 2203 | 2181 | 2038 (93.4%) |
| Lyme Regis | 2206 | 2159 | 2065 (95.6%) |
| Rhyl | 2183 | 2138 | 1964 (91.9%) |
| Morecambe | 927 | 908 | 790 (87.0%) |

The target for beach interviews was met in Paignton, Lyme Regis and Rhyl, and the respective response rates for the telephone interviews were satisfactory.

Recruitment proved much more difficult in Morecambe, for the reasons discussed below.

The quota sample defined that 30% of the sample were to consist of the control group, those who did not enter the sea. The remaining 70% were to consist of subjects who entered the sea in the three days preceding the interview. This sample was further stratified according to the degree of exposure (35% waders and 35% swimmers/divers). An attempt was made to maintain these quotas on a daily basis, irrespective of the weather, to avoid the situation whereby bathers were recruited predominantly in fine weather and non-bathers in poor weather. However, some adjustments in recruitment were inevitable given the composition of the beach population, the nature of the beach and seawaters, and other related factors. These problems arose in Rhyl, and were particularly serious in Morecambe. The quotas set for beach interviews and the results achieved were as follows:

| | NON-EXPOSED | WADERS | SWIMMERS/ SURFERS/DIVERS | TOTAL |
|---|---|---|---|---|
| QUOTA | 30% | 35% | 35% | 100% |
| RESULTS ACHIEVED | | | | |
| Paignton | 29% | 35% | 36% | 100% |
| Lyme Regis | 28% | 35% | 37% | 100% |
| Rhyl | 23% | 49% | 28% | 100% |
| Morecambe | 57% | 33% | 10% | 100% |

In Rhyl the quota of swimmers/surfers/divers was not achieved, and in Morecambe there was a significant shortfall in the number of interviews overall and in the quota of swimmers/surfers/divers. There were a number of reasons for this. In both Rhyl and Morecambe weather conditions were generally poor during the interviewing period, hence quotas for the exposed to risk groups were under-achieved. Both these beaches also had indoor/outdoor water leisure centres, which provided alternatives to sea bathing. At Rhyl the mean low water mark is 0.5 km from the promenade, severely limiting access for swimmers. At Morecambe the sea front is almost entirely mud flats rather than sandy beach, with very few people at the beach or in the water. At both Rhyl and Morecambe there was a general awareness of polluted seawaters, which deterred many people from entering the sea. Media reports about polluted Morecambe waters during the second week of the survey also contributed to the poor interviewing rate at this site. Overall, "site" problems seriously hampered the study in Morecambe and Rhyl.

**Bacteriological sampling**

Microbiological sampling of the seawaters was carried out on a daily basis at the three sections of each of the four beaches, from 1-26 August at Rhyl and Morecambe and from 1-21 August at Paignton and Lyme Regis. This included sampling and analysis for bacterial indicators, enteroviruses, rotaviruses, cryptosporidium and coliphages. All samples were collected from a standard depth (30 cm). Samples for bacterial and coliphage estimation were taken at 10, 12, 14 and 1600 hours daily at each designated site. On two occasions daily, 10 and 1600 hours, duplicate samples were taken for bacterial analysis.

Analytical facilities for bacteriological analysis were provided by the Public Health Laboratory Service (PHLS) Exeter and Preston Laboratories. Morecambe and Rhyl samples were processed by Preston PHLS, Paignton and Lyme Regis samples processed by Exeter PHLS. Routine bacteriological analyses included total coliforms, thermotolerant (faecal) coliforms and faecal streptococci. Coliphage analyses were undertaken on refrigerated samples that had been transferred to the Robens Institute, Guildford for subsequent analysis.

Quality control procedures involved within laboratory comparisons, interlaboratory comparisons and third party comparisons. Interlaboratory comparisons were achieved using split samples collected on a total of eight occasions. On four occasions samples from the Preston PHLS sites were relayed via courier to Exeter PHLS. The reverse process (ie split samples from Exeter PHLS sites couriered to Preston PHLS) took place on a further four occasions. The duplicated results could subsequently be compared between the laboratories. Third party comparisons were undertaken by the Newcastle PHLS quality control systems.

In addition, at each designated sample site at each beach on every third day samples were taken at the 10 hours sampling interval for virological and cryptosporidium estimations. These samples were relayed via a courier service to Severn Trent Laboratories at Coventry for determination of enterovirus, rotavirus and cryptosporidium. Samples from Rhyl and Morecambe were collected for such analyses on nine occasions (2, 5, 8, 11, 14, 17, 20, 23, 26 August) and from Paignton and Lyme Regis on seven occasions (1, 4, 7, 10, 13, 16, 19 August).

All sampling and analytical methods followed standard procedures. The results for bacterial indicators are expressed as geometric means, other determinands reported as simple arithmetic means. The results are compared against the EC bathing water standards, which are given in Appendix 4.

## METHOD OF ANALYSIS

Subjects who took part in water activities were treated as the exposed to risk group, and the others as the non-exposed or control group. The type of water activity was examined in a hierarchical manner graded from wading to swimming and surfing/diving. The latter category was grouped in view of the small numbers.

Information was collected by telephone on the occurrence of the following self-reported symptoms, which were grouped for analysis as shown:

| GROUP FOR ANALYSIS | SYMPTOM |
|---|---|
| Eye | sore or red eyes |
| Ear/nose/throat | ear infection |
| | runny nose |
| | sore throat |
| Respiratory | wheezing |
| | cough |
| Gastrointestinal | nausea |
| | vomiting |
| | stomach cramps |
| Diarrhoea* | diarrhoea |
| Fever** | fever |
| Skin | skin |

* Also included as part of gastrointestinal symptoms.

** Fever was not analysed separately.

Diarrhoea was analysed both as part of gastrointestinal illness and alone. All the above symptoms other than skin were also aggregated and analysed as "major symptoms". Skin-related symptoms are discussed separately rather than as part of "major symptoms" in order to maintain comparability with our previous studies at Langland Bay (1989) and Ramsgate (1990).

The relative risks (RR) of developing individual or grouped symptoms, adjusted for age and gender of the respondents, were calculated for the various exposure categories using standard logistic regression methods as described by, for example, Breslow and Day (1980). This allows 95% confidence intervals (CI) to be calculated for each RR. The non-exposed, males and the 5-14 years age group were used as the reference levels against which the RRs were calculated.

Data for each of the four beaches were first analysed separately and the results are presented separately. For the combined analysis of the four beaches Paignton was used as the reference for comparison.

In the Discussion we present a comparative analysis of symptoms and microbiological indicators at the four beaches.

## RESULTS

## PAIGNTON

### Age-sex distribution of respondents

The sexes were fairly equally represented in the sample of 2038 respondents. Subjects under 35 years of age constituted about two-thirds of the sample, and the age distributions of male and female respondents were similar (Figure P1, Table 1).

### Type of respondent

Holiday makers constituted 62% of the sample, day trippers 25%, and local residents 13% (Figure P2). The age composition of these groups is shown in Figure P3 (Table 2). While the proportion of children was broadly similar in the three groups, a higher proportion of local residents were aged 15-24.

### Type of water activity

Almost 82% of respondents entered the water (Figure P4), with swimmers and surfers/divers constituting 71% of the total sample. The type of water activity varied by type of respondent (Figure P5, Table 3), with a higher proportion of holiday makers entering the water than local residents or day trippers. On the other hand, the proportion of local residents who were surfers/divers was more than double that of surfers/divers among holiday makers and day trippers. The proportions of swimmers were similar across the three types of respondents.

The type of water activity was related to age (Figure P6, Table 4). Not surprisingly, the degree of exposure to water was greatest among the young. Over one-third of the swimmers and surfers/divers were under 15 years of age. Surfers/divers were over-represented among 15-24 year olds. Respondents who did not participate in water activities were generally older.

Fig P1. Percent distribution of respondents by age and sex : Paignton

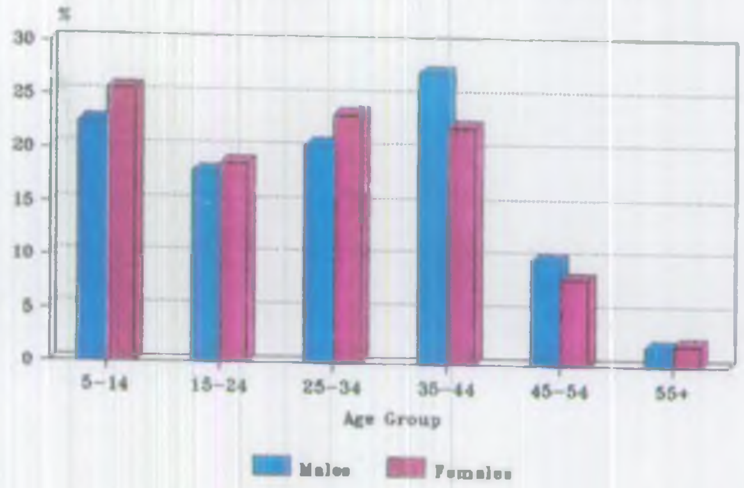



Fig P2. Percent distribution of respondents by type : Paignton

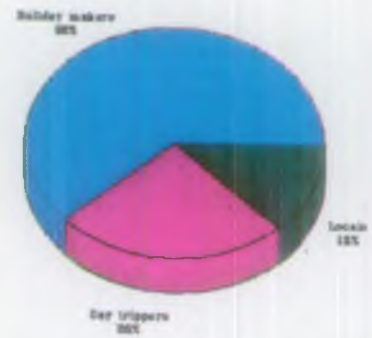



Fig P3. Percent distribution of type of respondents by age : Paignton

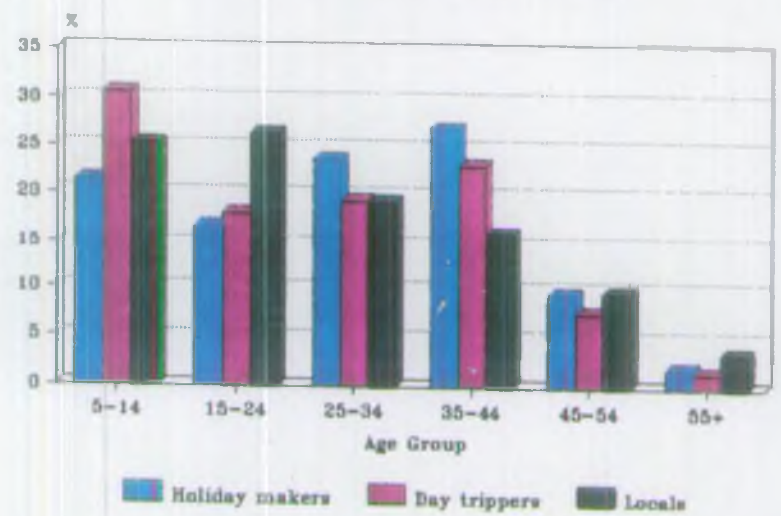


Fig P4. Percent distribution of respondents by water activity: Paignton

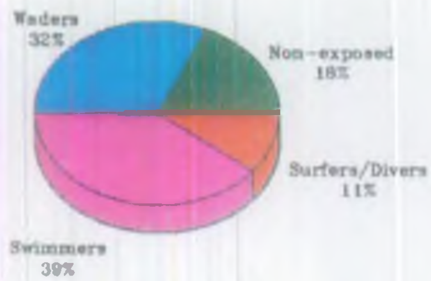



Fig P5. Percent distribution by type of respondents and water activity : Paignton

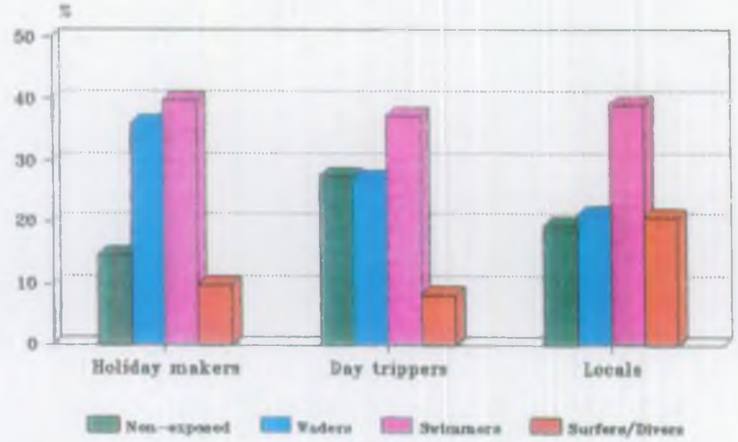
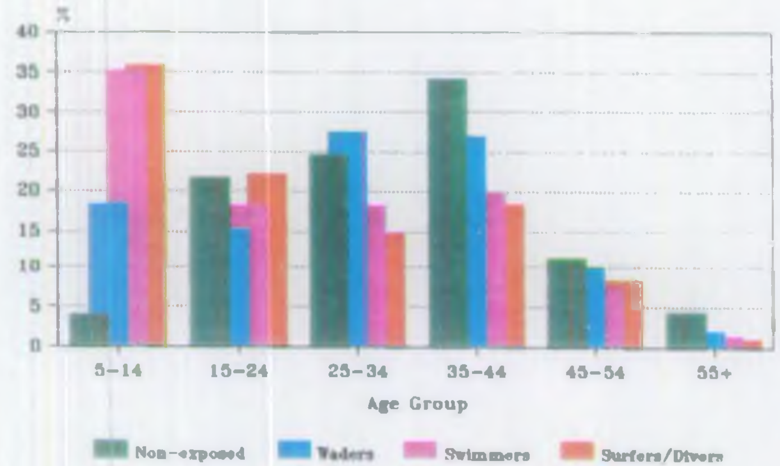



Fig P6. Percent distribution of respondents by age and water activity : Paignton



## Reported illness

About 23% of the respondents experienced one or more of the major symptoms (as described in Method of Analysis) in the week following the beach interview. Reported illness was higher in subjects exposed to water activity (23.9%) than in the non-exposed (19.5%). Reporting of major symptoms varied by type of water activity, with levels rising from 22.6% in waders to 31.7% in surfers/divers (Figure P7, Table 5). A dose-response type of relationship was therefore apparent for major symptoms.

Incidence rates for major symptoms are shown by age in Figure P8, Table 6. Levels among subjects exposed to water activity were highest at ages 15-24 followed by ages 5-14 and 25-34 years. Incidence among the non-exposed showed the reverse pattern, being highest at ages 5-14 followed by ages 15-24, with levels falling steadily up to ages 35-44.

Overall, the reported incidence of symptoms was highest for ear/nose/throat symptoms (13.5%) followed by gastrointestinal (7.5%), respiratory (7.2%), skin (4.4%), eye (3.3%) and diarrhoea (2.9%) symptoms. For all the individual symptoms except diarrhoea, the levels of reported illness were higher in subjects entering the sea than in those not exposed to risk (Figure P9, Tables 7-12). Moreover, risks for each of the symptoms examined were highest in surfers/divers, the group with the greatest exposure to seawater.

## Relative risk

The RR of major symptoms varied by age (Figure P10), and was highest at ages 15-24 (RR 1.13, 95% CI 0.83-1.54), the risks falling with age thereafter and being less than unity among people over 25 years of age. The risk associated with water activity was therefore accentuated in the young.

The risk of illness among subjects exposed to seawaters was compared with the non-exposed, after adjusting for age and sex (Figure P11, Table 13). Overall incidence of major symptoms, and of individual symptoms other than diarrhoea, Fig P7. Incidence of major symptoms by type of water activity : Paignton

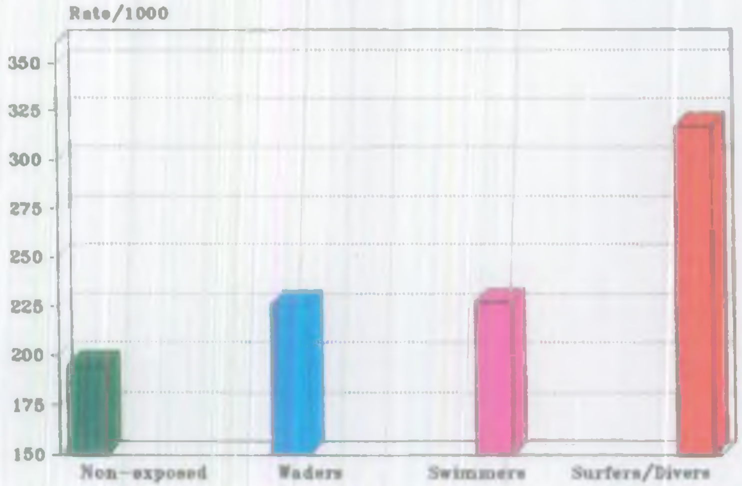



Fig P8. Incidence of major symptoms by water activity and age : Paignton

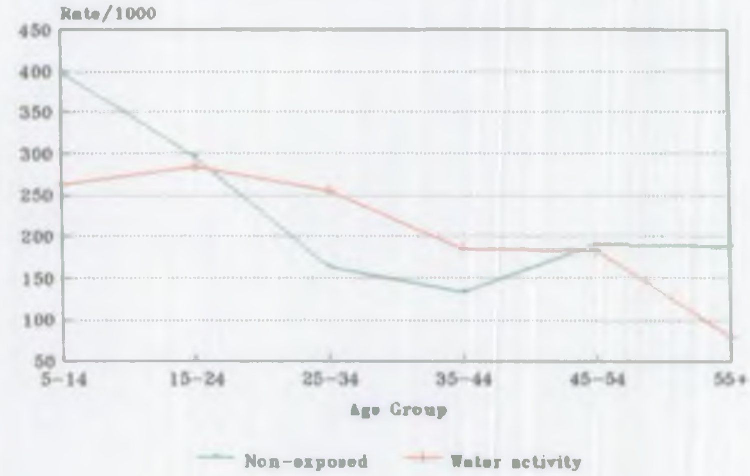



Fig P9. Incidence of individual symptoms by water activity : Paignton

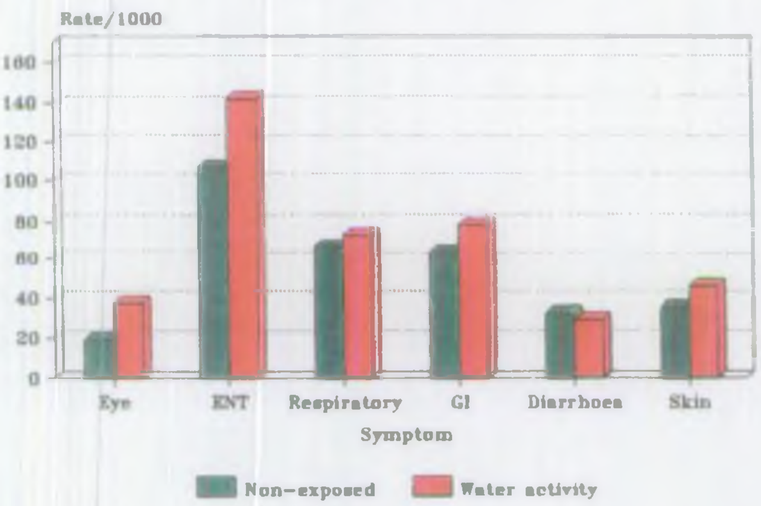


Fig P10. Relative risk of major symptoms by age : Paignton

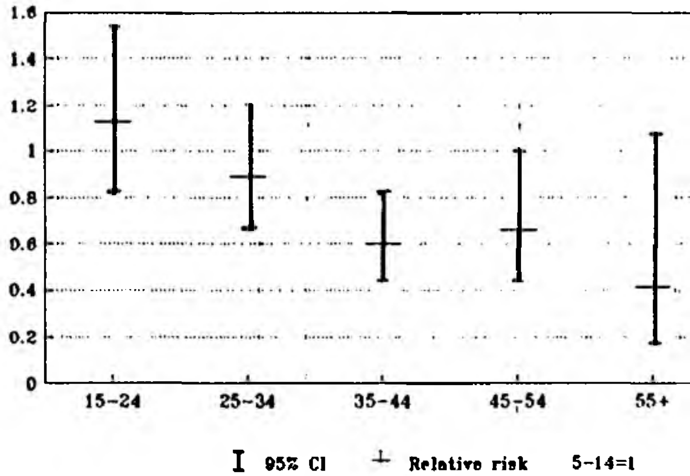
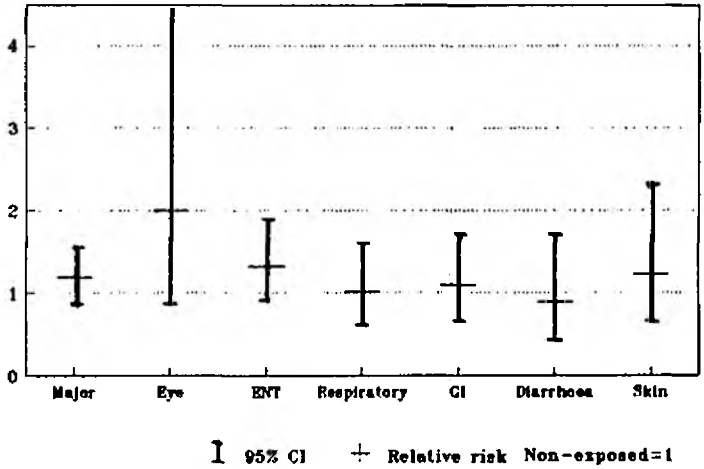


Fig P11. Relative risk of individual symptoms : Paignton



was elevated in subjects entering the sea, although the results did not reach formal statistical significance.

Relative risks (adjusted for age and sex) of symptoms associated with varying degrees of exposure to seawater are shown in Figures P12-P18 (Tables 14-20) for the following categories of symptoms respectively: major, eye, ear/nose/throat, respiratory, gastrointestinal, diarrhoea, and skin.

The risk of major symptoms was elevated in all categories of exposed subjects (Figure P12, Table 14), with surfers/divers showing an almost two-fold statistically significant excess (RR 1.75, 95% CI 1.17-2.61). A dose-response type of relationship was apparent for eye symptoms, with all exposed categories experiencing higher risk, the excess being statistically significant in surfers/divers (RR 3.72, 95% CI 1.41-9.77) (Figure P13, Table 15). Ear/nose/throat symptoms were also raised in all categories of exposed subjects, with a significant excess in surfers/divers (RR 1.74, 95% CI 1.06-2.86) (Figure P14, Table 16). Risks of respiratory symptoms were not significantly different in the exposed (Figure P15, Table 17).

Risks of gastrointestinal illness were significantly high in surfers/divers (RR 1.95, 95% CI 1.08-3.54) (Figure P16, Table 18). This group also experienced an elevated risk of diarrhoea (RR 1.54, 95% CI 0.62-3.79) (Figure P17, Table 19).

All categories of exposed subjects showed an elevated risk of skin symptoms, the two-fold excess in surfers/divers being statistically significant (RR 2.35, 95% CI 1.09-5.08) (Figure P18, Table 20).

**Microbiological monitoring**

No rotavirus or cryptosporidium samples proved positive. The range of enterovirus results for the three sampling sites at Paignton ranged between 0-1, overall arithmetic mean 0.1 per 10 litres (Table 21). Enterovirus were sparse, although 3 of 21 samples proved positive. This equates to 86% compliance and

Fig P12. Relative risk of major symptoms by water activity : Paignton

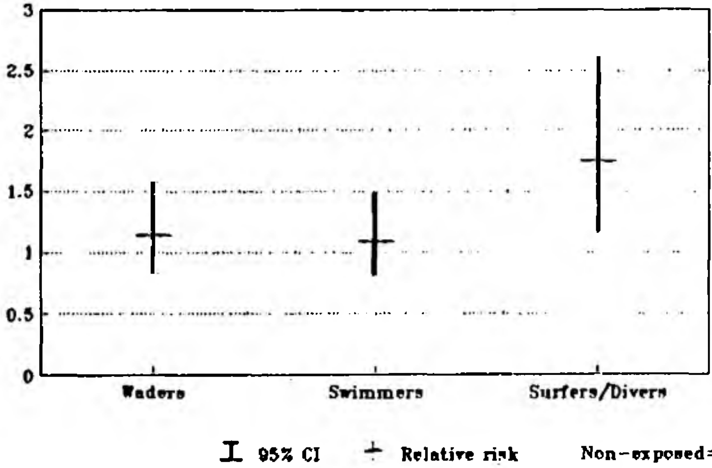



Fig P14 Relative risk of ear/nose/throat symptoms by water activity : Paignton

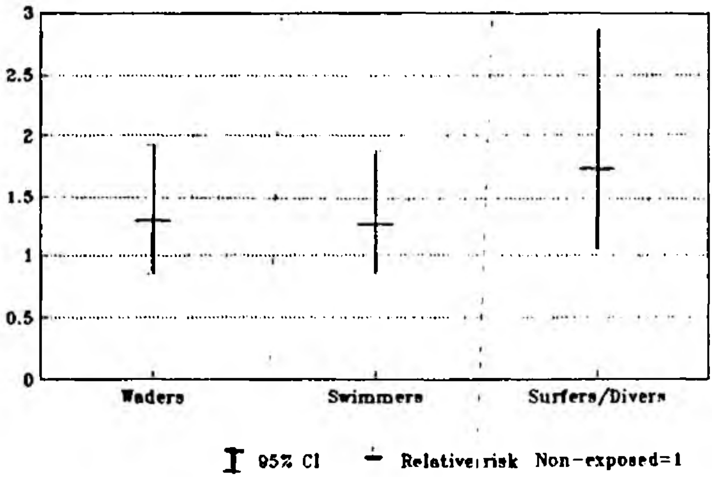


**Fig P13. Relative risk of eye symptoms by water activity : Paignton**

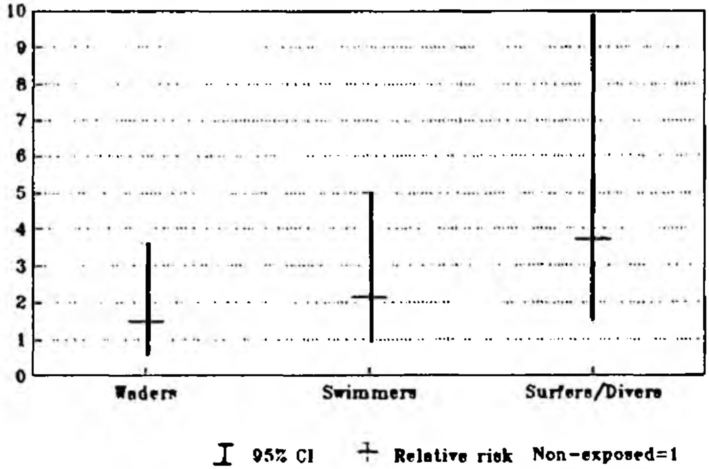
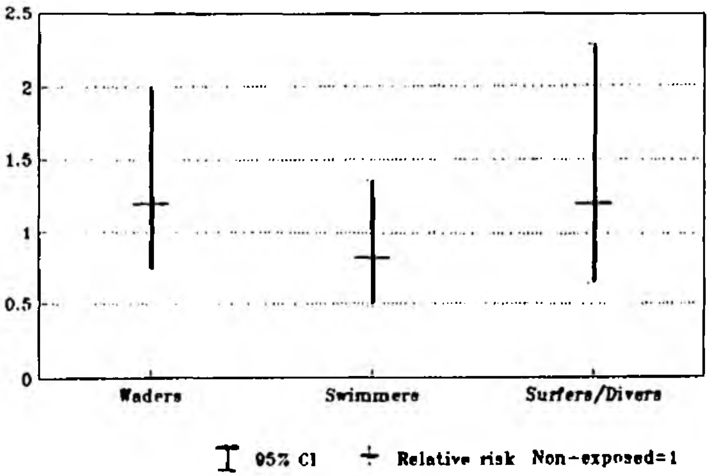



**Fig P15. Relative risk of respiratory symptoms by water activity : Paignton**



Fg P16 Relative risk of gastrointestinal symptoms by water activity : Paignton

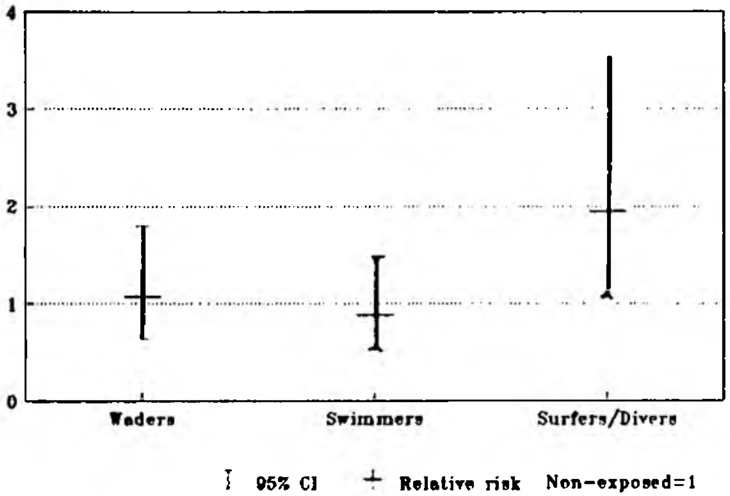



Fig P17. Relative risk of diarrhoea by water activity : Paignton

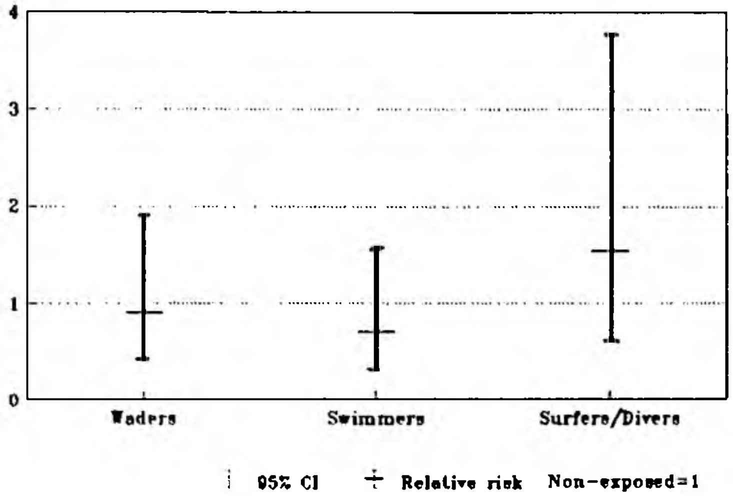
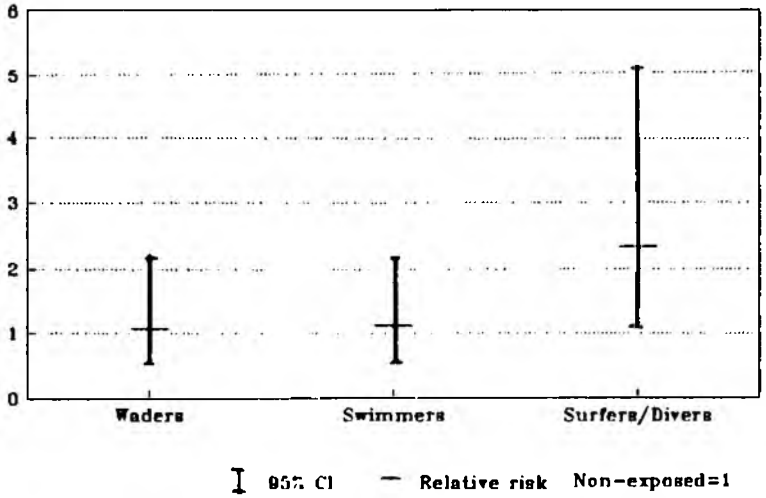



Fig P18. Relative risk of skin symptoms by water activity : Paignton



therefore fails the EC bathing water standard which stipulates zero enterovirus per 10 litres in 95% of samples.

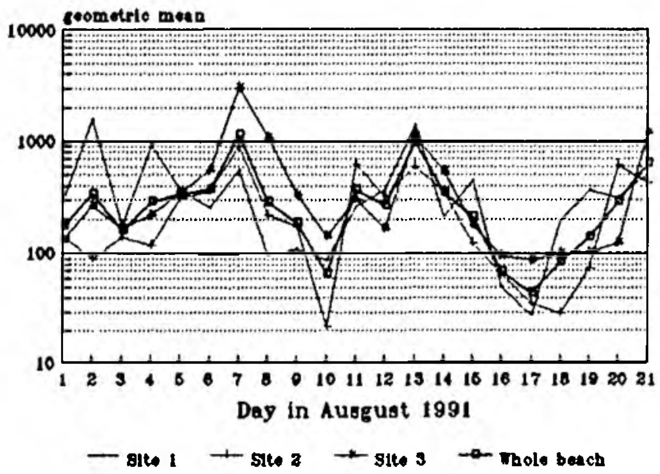
Results for coliphages were generally very low (Table 22), <6 per ml in all samples apart from two collected on the 6 August. In total, 48% of samples assayed for coliphage proved positive.

The overall geometric means for the three bacteriological indicators (Table 23) were well within EC mandatory standards, although sites 1 and 3 (and the beach as a whole) exceeded guide levels for thermotolerant coliforms. Examination of the data on a daily basis (Figure P19, Table 24) shows that total coliform compliance to the EC mandatory standard was consistently achieved, guide level compliance for the beach as a whole standing at 86%. However, guide levels were not met at sites 1 and 3, the respective compliance figures being 76% and 71%. Thermotolerant coliforms for the beach as a whole and individual sites showed compliance with EC mandatory levels, although guide levels were not met either for the whole beach (38% overall) or for the three individual sites. Faecal streptococcus levels for the beach as a whole and the individual sites were within guide level constraints.

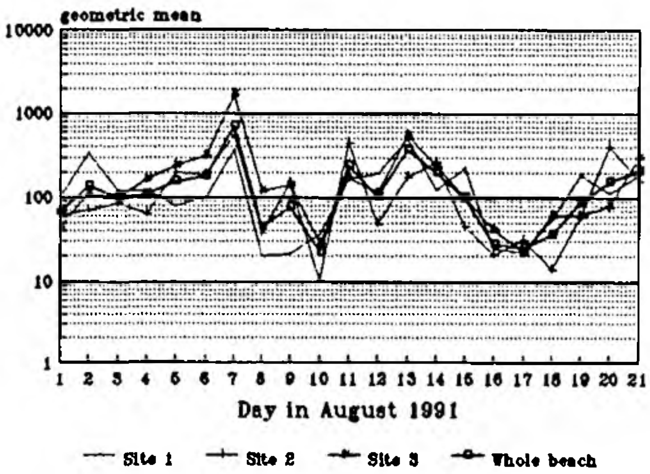
In summary, Paignton failed the enterovirus standard of the EC bathing water directive, but in terms of bacteriological standards the seawater may be considered of good quality over the study period.

## Fig P19 Variations in bacterial indicators by site : daily geometric mean levels (Paignton)

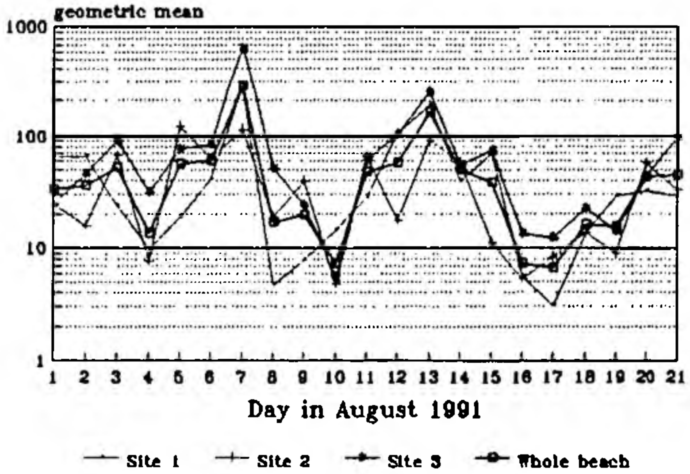
**Total coliforms**




**Thermotolerant coliforms**




**Faecal streptococci**



## LYME REGIS

### Age-sex distribution of respondents

The sample of 2065 respondents was fairly evenly distributed between males and females. Just over 60% of the subjects were under 35 years of age, with a somewhat higher proportion of males than females in the 5-14 years age group (Figure L1, Table 1).

### Type of respondent

The sample consisted predominantly of holiday makers (56%) and day trippers (38%), with local residents constituting only 5% (Figure L2). Holiday makers and day trippers also had a different age structure to local respondents (Figure L3, Table 2), with higher proportions of children aged 5-14. In contrast, almost half the local respondents were aged 15-24 years.

### Type of water activity

About 81% of respondents entered the water (Figure L4), the proportions of waders and swimmers being about one-third each. A higher proportion of holiday makers entered the water, compared with day trippers or local residents (Figure L5, Table 3). On the other hand, the proportion of local residents participating in surfing/diving was more than double that of holiday makers or day trippers participating in such activity. The proportion of swimmers and surfers/divers combined was similar in holiday makers and local residents, being just over half the respective samples.

The type of water activity undertaken was related to age, with the young having the greatest exposure (Figure L6, Table 4). Almost half the swimmers were children aged 5-14. Surfers/divers were also over-represented among the young, with 37% being 5-14 and 26% being 15-24 years. In contrast, the non-exposed had an older age distribution.

Fig L1. Percent distribution of respondents by age and sex : Lyme Regis

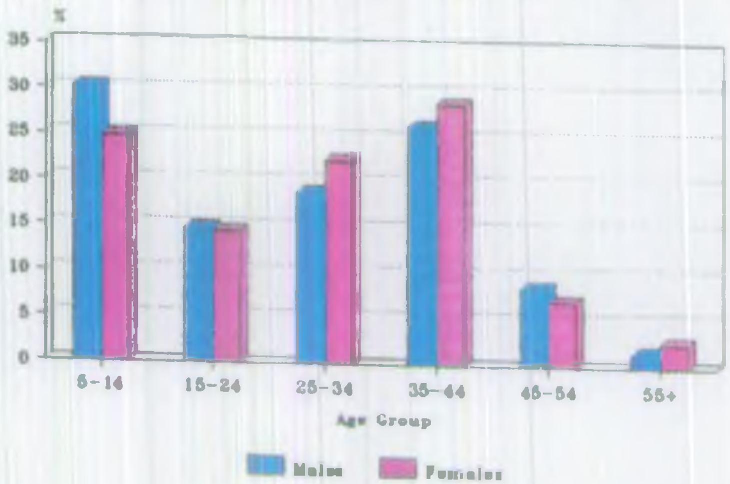



Fig L2. Percent distribution of respondents by type : Lyme Regis

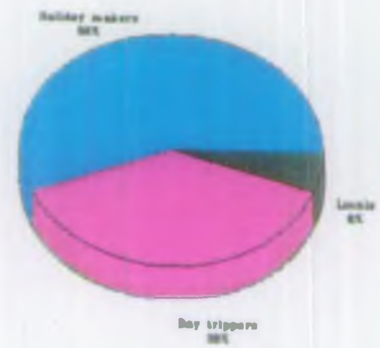



Fig L3. Percent distribution of type of respondents by age : Lyme Regis

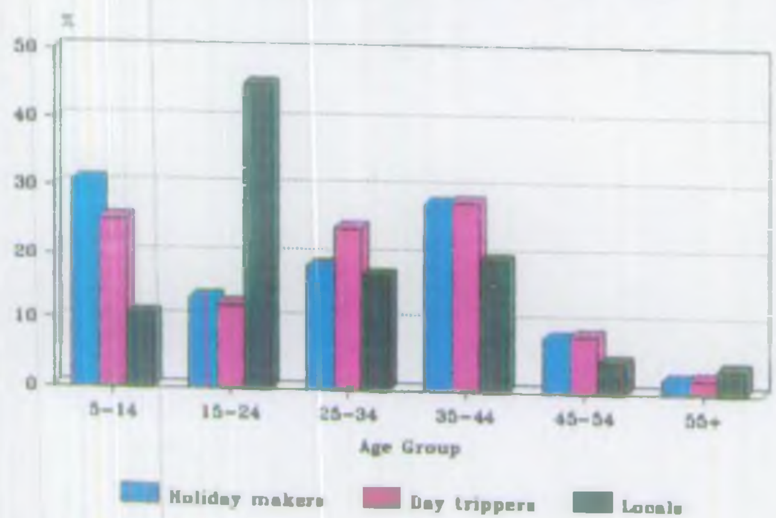


Fig L4. Percent distribution of respondents by water activity:Lyme Regis

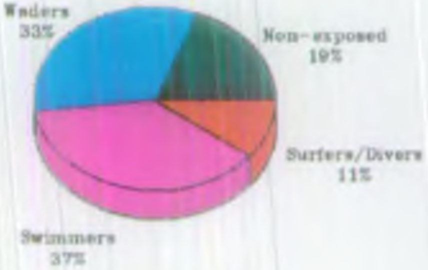



Fig L5. Percent distribution by type of respondents and water activity : Lyme Regis

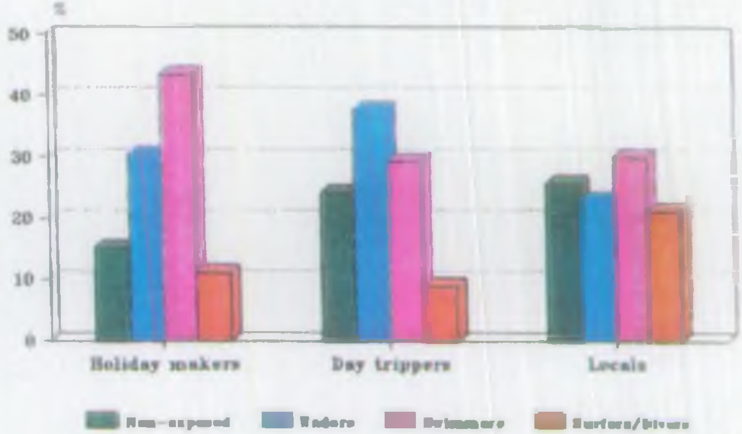
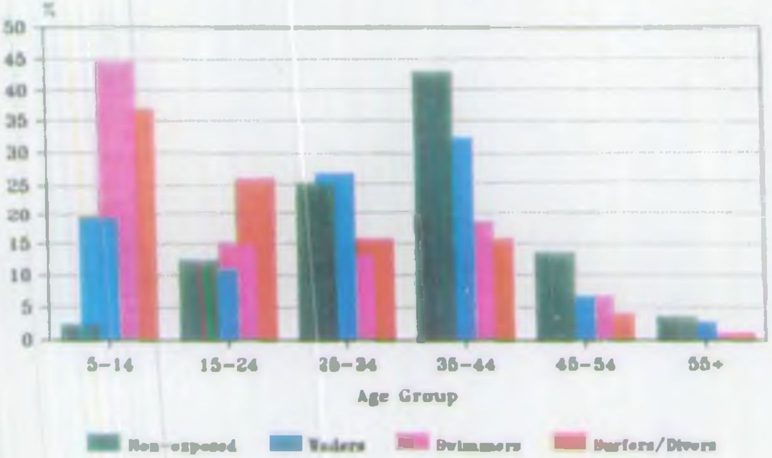



Fig L6. Percent distribution of respondents by age and water activity : Lyme Regis



**Reported illness**

About 23% of the sample population overall experienced one or more of the major symptoms (as described in Method of Analysis) in the week following the beach interview. Reported illness was higher in subjects exposed to water activity (23.4%) than in the non-exposed (20.5%), and varied by type of water activity, with 23.1% of waders, 21.8% of swimmers, and 29.4% of surfers/divers experiencing major symptoms (Figure L7, Table 5).

Incidence rates for major symptoms by age are shown in Figure L8, Table 6. Levels in subjects exposed to water activity were highest at ages 25-34, followed by 15-24 and 5-14. Thus, in young subjects exposed to risk, reported symptoms increased with age. The pattern was reversed in non-exposed subjects, with symptom levels being highest in children and falling with age thereafter.

Overall, the reported incidence was highest for ear/nose/throat symptoms (12.7%) followed by gastrointestinal (8%), respiratory (6.8%), eye (4.1%), skin (3.5%) and diarrhoea (3.5%) symptoms. For ear/nose/throat, gastrointestinal (and diarrhoea alone) and skin symptoms, levels of reported illness were higher in subjects entering the sea than in those not (Figure L9, Tables 7-12). Moreover, for each of the symptoms examined risks were highest in surfers/divers.

**Relative risk**

Reporting of major symptoms varied by age (Figure L10), the relative risk among bathers being raised at ages 15-24 and 25-34, with a risk of less than unity in exposed subjects over 35 years of age.

The risk of illness among subjects exposed to water was compared with the non-exposed, after adjusting for age and sex (Figure L11, Table 13). Risk levels were elevated for major, ear/nose/throat and gastrointestinal (and diarrhoea alone) symptoms, but these results did not reach formal statistical

Fig L7. Incidence of major symptoms by type of water activity : Lyme Regis


Fig L8. Incidence of major symptoms by water activity and age : Lyme Regis

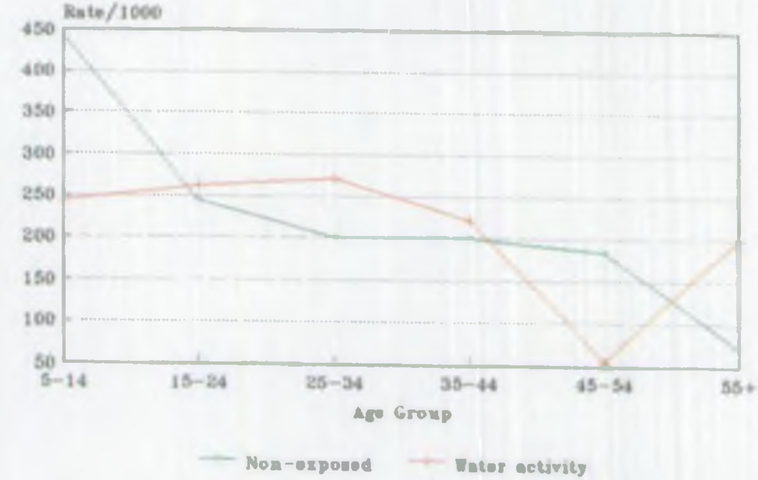



Fig L9. Incidence of individual symptoms by water activity : Lyme Regis

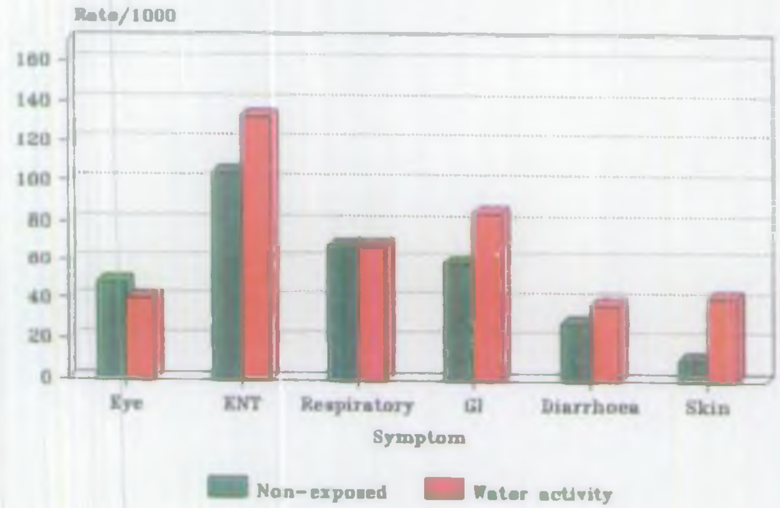


Fig L10. Relative risk of major symptoms
by age : Lyme Regis

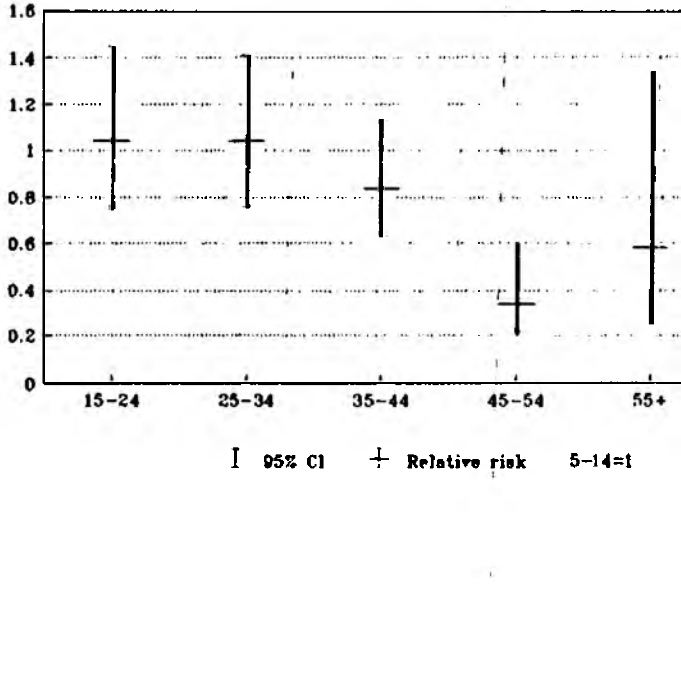
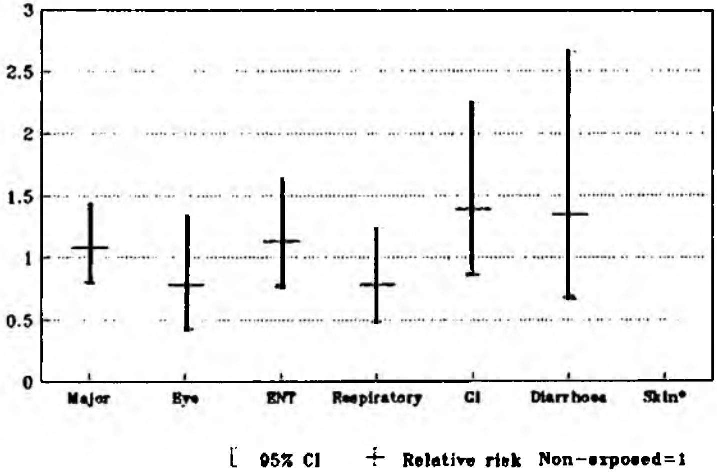


Fig L11. Relative risk of individual symptoms : Lyme Regis




* RR=3.88 (95% CI=1.36-10.65)

significance. A significant excess was noted for skin symptoms; however, this could be an artefact of the low reported levels among non-exposed subjects, who constitute the baseline for risk estimation in exposed subjects.

Relative risks (adjusted for age and sex) of symptoms associated with varying degrees of exposure to seawater are shown in Figures L12-L17 (Tables 14-20) for the following categories of symptoms respectively: major, eye, ear/nose/throat, respiratory, gastrointestinal, diarrhoea, and skin.

The risk of major symptoms was elevated in waders and surfers/divers (Figure L12, Table 14), but did not reach formal statistical significance. The exposed groups did not show any significant excess of eye symptoms (Figure L13, Table 15). Ear/nose/throat symptoms were raised in waders and surfers/divers (Figure L14, Table 16), although respiratory symptoms did not show an excess (Figure L15, Table 17).

Risks of gastrointestinal illness were raised in all categories of exposed subjects, the two-fold excess in surfers/divers being statistically significant (RR 2.02, 95% CI 1.09-3.76) (Figure L16, Table 18). This group also experienced a statistically significant excess of diarrhoea (RR 2.55, 95% CI 1.07-6.10) (Figure L17, Table 19).

Skin symptoms were significantly elevated in exposed subjects (Table 20). It should be noted that the proportion of such cases among the non-exposed group, which constitutes the baseline for risk estimation, was unduly low: 1% compared with 3.5-4.5% at the other beaches. This has the effect of inflating risk ratios for skin symptoms among the exposed group at this beach, hence we have not presented a graph depicting risks by exposure.

**Microbiological monitoring**

No rotavirus or cryptosporidium samples proved positive. The range of enterovirus results for the three sampling sites ranged between 0-5, with 3 of 21 samples proving positive. The overall arithmetic mean was 0.3 per 10 litres

**Fig L12. Relative risk of major symptoms by water activity : Lyme Regis**

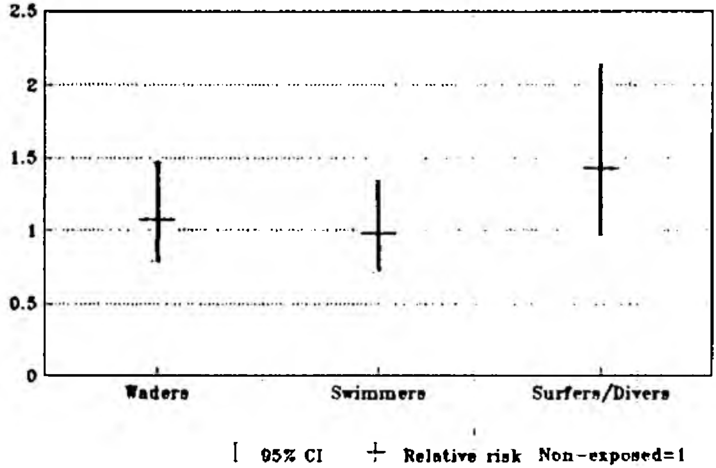



**Fig L14 Relative risk of ear/nose/throat symptoms by water activity : Lyme Regis**

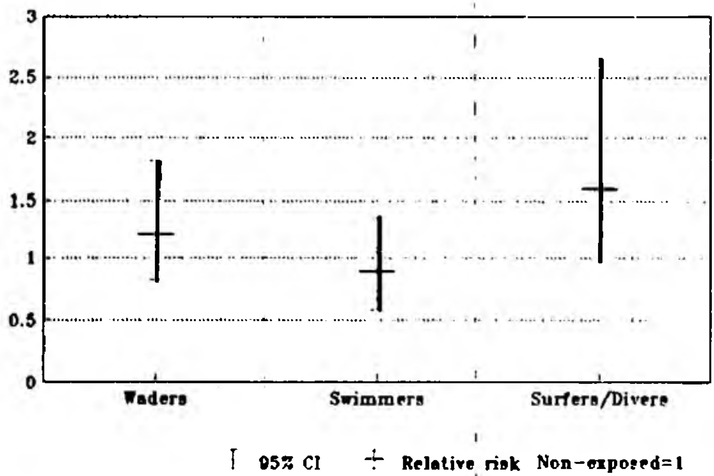


**Fig L13. Relative risk of eye symptoms by water activity : Lyme Regis**

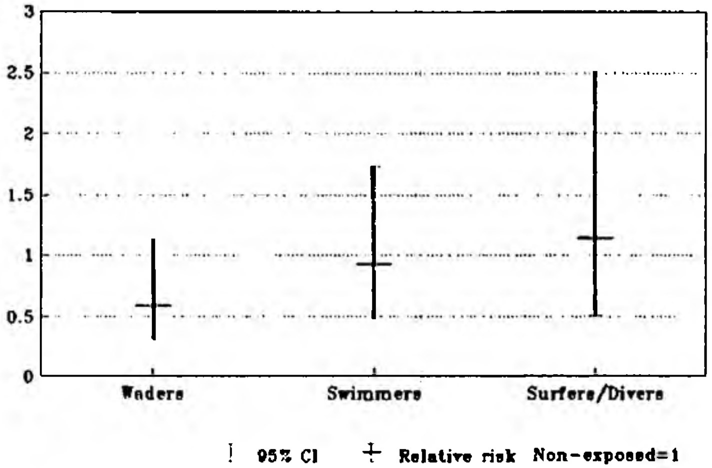
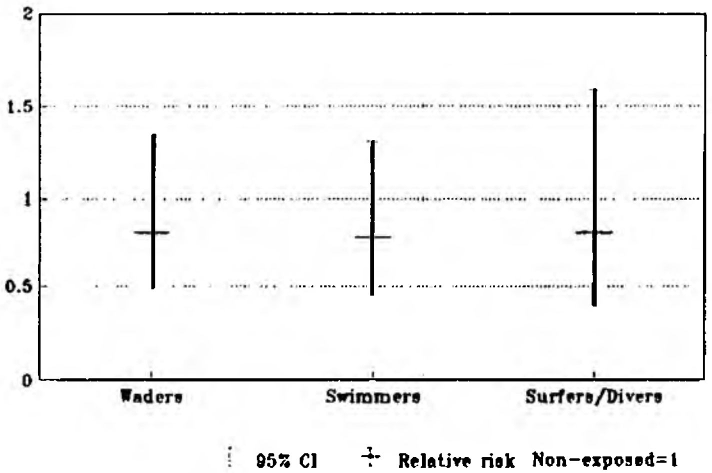



**Fig L15. Relative risk of respiratory symptoms by water activity : Lyme Regis**



**Fg L16 Relative risk of gastrointestinal symptoms by water activity : Lyme Regis**

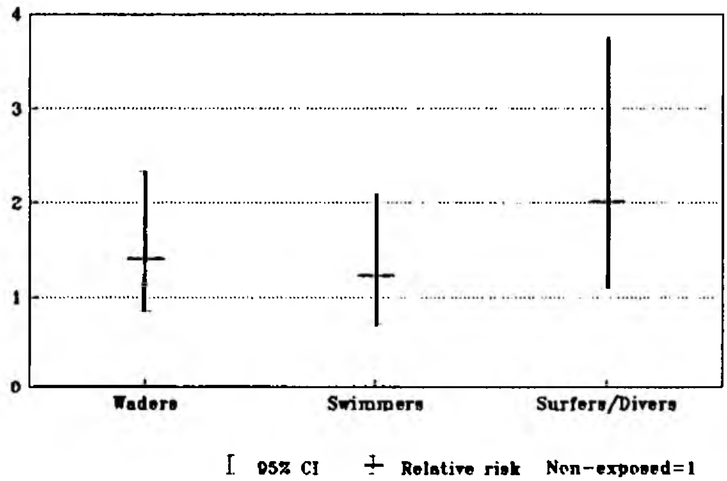
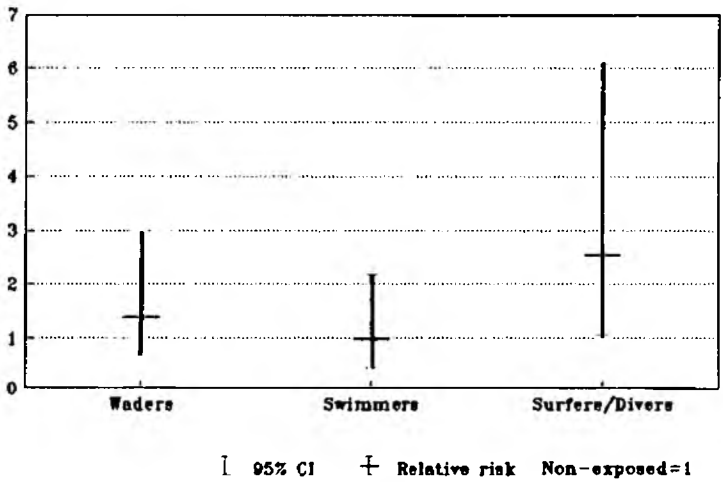


**Fig L17. Relative risk of diarrhoea by water activity : Lyme Regis**



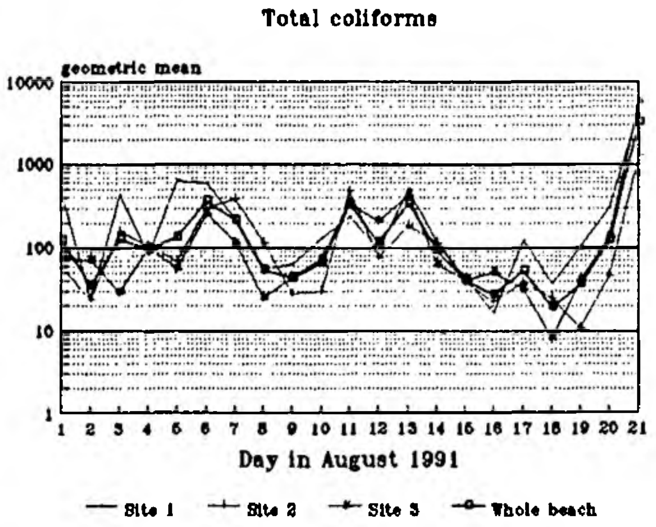
(Table 21). This equates to 86% compliance, and therefore fails the EC bathing water standard which stipulates zero enterovirus per 10 litres in 95% of samples.

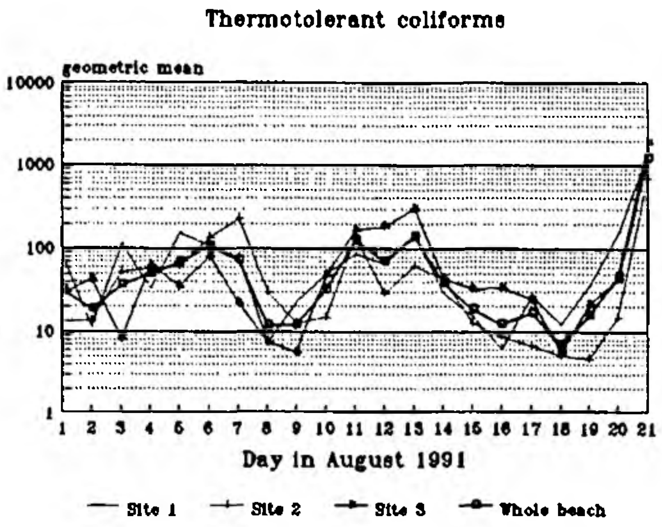
Results for coliphages from were generally very low (Table 22), <5 per ml in all samples apart from one on 6 August. In total, 52% of samples assayed for coliphage proved positive.

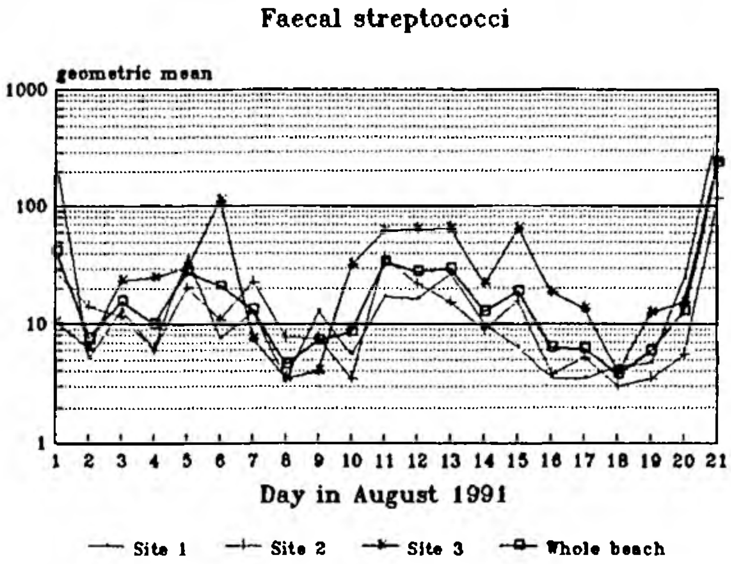
The overall geometric means for the three bacteriological indicators (Table 23) were well within EC mandatory and guide levels, with all sites meeting the required standards. Examination of the data on a daily basis (Figure L19, Table 25) shows that EC mandatory levels were not exceeded at any site for both total and thermotolerant coliforms. Similarly guide levels for all three indicators were maintained at above the required 80% compliance, the sole exception being site 1 recording 71% compliance for thermotolerant coliforms. The final sampling day (21 August) yielded extremely high results for all indicators; as yet no cause for this has been reported. On this one day EC guide levels were exceeded for all parameters at all sites, although mandatory levels were not exceeded.

In summary, Lyme Regis failed the enterovirus standard of the EC bathing water directive, but in terms of bacteriological standards the seawater may be considered of good quality over the study period.

Fig L19. Variations in bacterial indicators by site: daily geometric mean levels (Lyme Regis)



## RHYL

### Age-sex distribution of respondents

The sample of 1964 respondents consisted of somewhat more females than males (54% and 46% respectively). There was a disproportionately high number of 5-14 year olds (39%). About three-quarters of the sample was under 35 years of age (Figure R1, Table 1). Male respondents had a somewhat younger age distribution than female respondents.

### Type of respondent

The sample consisted predominantly of holiday makers (50%) and day trippers (46%), with local residents constituting only 5% (Figure R2). Children constituted a higher proportion of holiday makers and day trippers than of local residents, the latter group having a higher component of 15-24 year olds (Figure R3, Table 2).

### Type of water activity

Although about 80% of respondents entered the water, more than half of these only waded (Figure R4), as might be anticipated from the nature of the beach at Rhyl, which severely limited access to the sea for swimmers. Thus the proportion of respondents with a greater degree of exposure to seawaters was only 33%. The proportion of holiday makers and day trippers entering the water was much greater than that of local residents entering the water (Figure R5, Table 3). However, a higher proportion of local residents participated in surfing/diving.

Over half the swimmers and surfers/divers were aged 5-14 years (Figure R6, Table 4). About three-quarters of all swimmers and surfers/divers were under 25 years of age. Thus the young had the greatest exposure to seawater, with non-exposed respondents having an older age distribution.

Fig R1. Percent distribution of respondents by age and sex : Rhyl

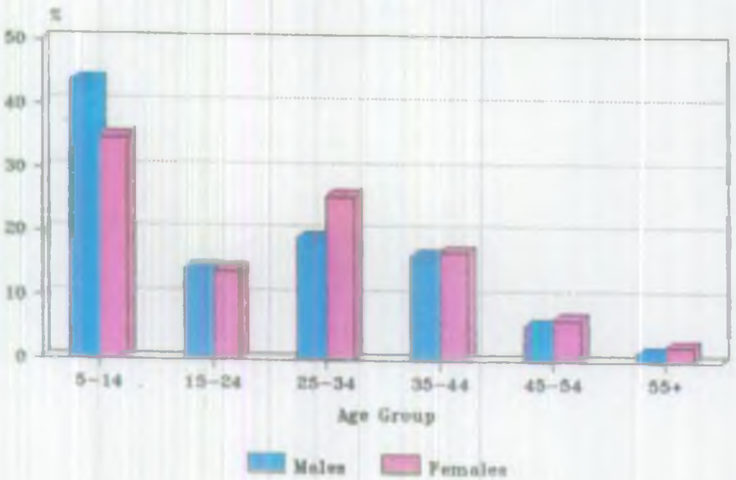



Fig R2. Percent distribution of respondents by type : Rhyl

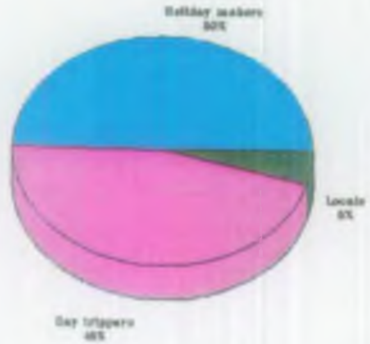



Fig R3. Percent distribution of type of respondents by age : Rhyl

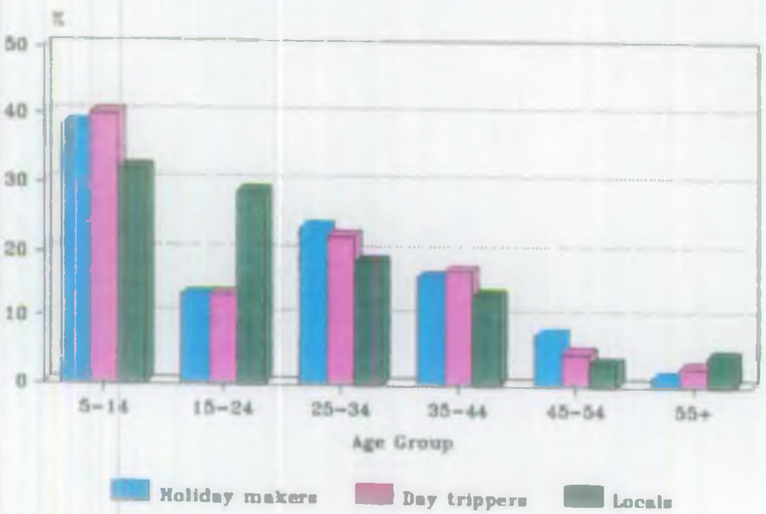


Fig R4. Percent distribution of respondents by water activity : Rhyl

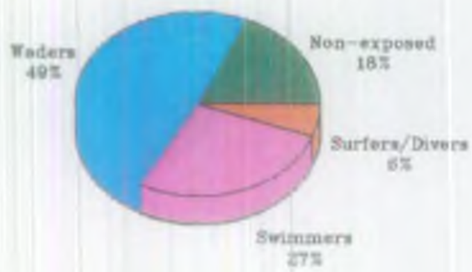



Fig R5. Percent distribution by type of respondents and water activity : Rhyl

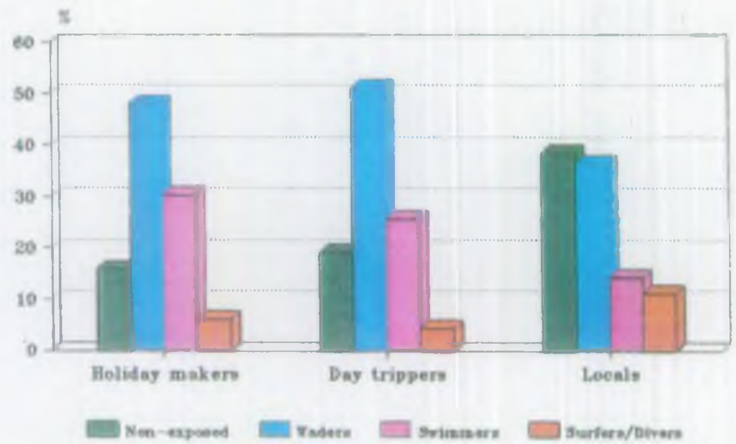
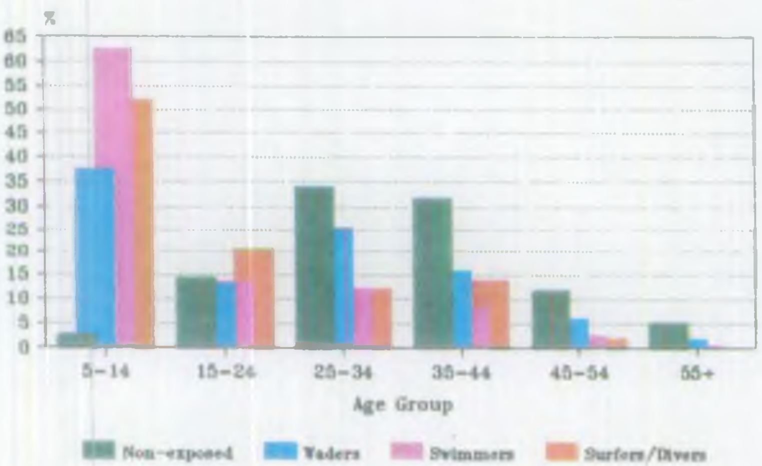



Fig R6. Percent distribution of respondents by age and water activity : Rhyl



## Reported illness

Almost 27% of the respondents experienced one or more of the major symptoms (as described in Method of Analysis) in the week following the beach interview. Levels of reported illness were similar in subjects exposed to water activity (26.6%) and the non-exposed (26.7%), with levels in waders being 25.9%, in swimmers 27.7%, and in surfers/divers 26.9% (Figure R7, Table 5).

Incidence rates for major symptoms are shown by age in Figure R8, Table 6. In non-exposed subjects the incidence of major symptoms was highest in children aged 5-14, with levels falling steadily up to ages 55 years. In subjects entering the sea, incidence rates were highest at ages 15-24.

Overall, the reported incidence of symptoms was highest for ear/nose/throat symptoms (15%) followed by gastrointestinal (9.8%), respiratory (9.2%), skin (4.7%), eye (4.5%) and diarrhoea (4.4%) symptoms. For gastrointestinal illness (and diarrhoea alone) and skin symptoms, the levels of reported illness were higher in subjects entering the sea than in those not exposed to risk (Figure R9, Tables 7-12). Levels of respiratory symptoms were highest in surfers/divers, and symptoms of the eye, ear/nose/throat and skin were highest in swimmers.

## Relative risk

Reporting of major symptoms varied by age (Figure R10). The relative risk of reporting symptoms was highest and statistically significant in exposed subjects aged 15-24 (RR 1.54, 95% CI 1.13-2.09), followed by ages 25-34 (RR 1.11, 95% CI 0.84-1.48). The risk associated with water activity was therefore greatest in young adults.

The risk of illness among subjects exposed to seawaters was compared with the non-exposed, after adjusting for age and sex (Figure R11, Table 13). The results show a statistically significant excess of gastrointestinal illness among respondents entering the sea (RR 1.76, 95% CI 1.10-2.82), with the risk of diarrhoea also being high and just failing to reach formal statistical significance

Fig R7. Incidence of major symptoms
by type of water activity : Rhyl

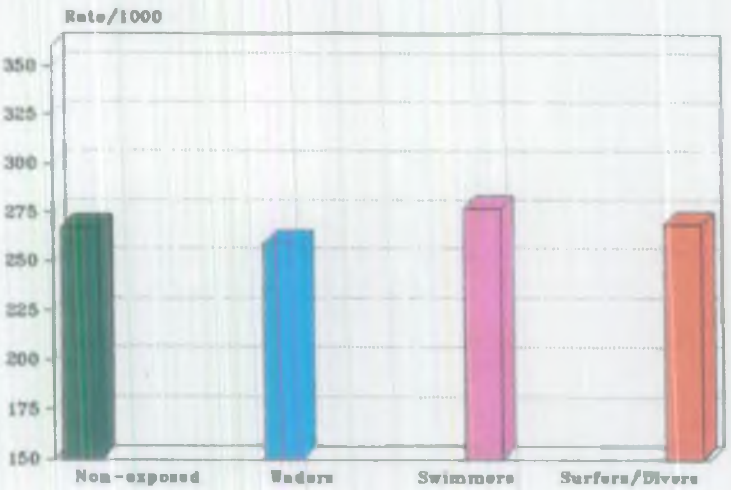



Fig R8. Incidence of major symptoms
by water activity and age : Rhyl

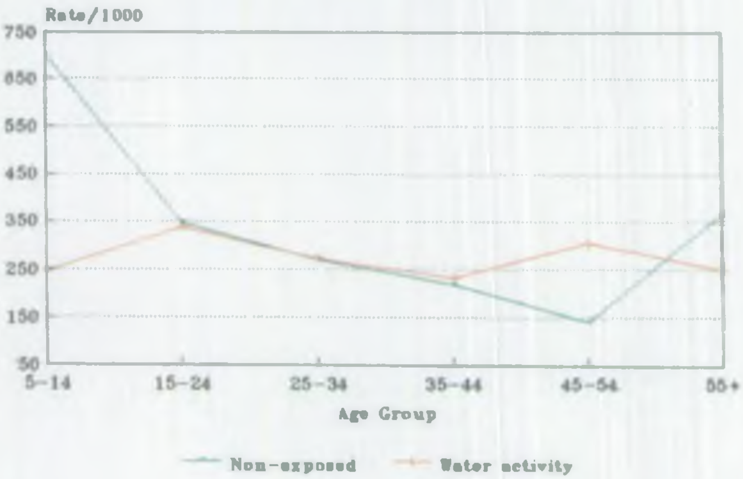



Fig R9. Incidence of individual symptoms
by water activity : Rhyl

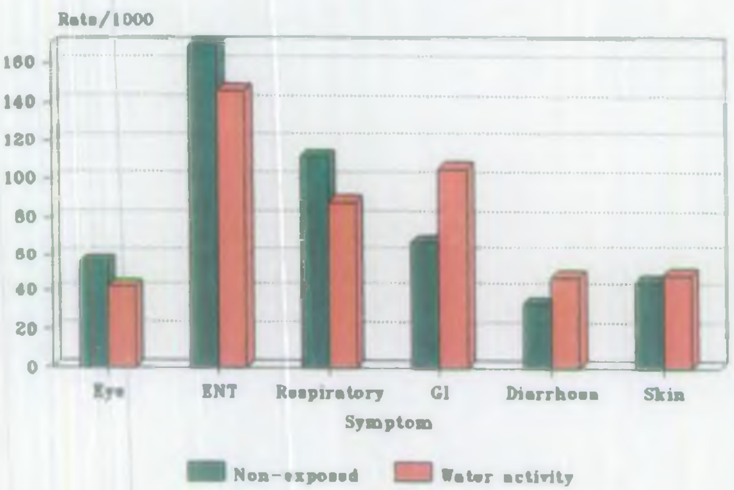


Fig R10. Relative risk of major symptoms
by age : Rhyl

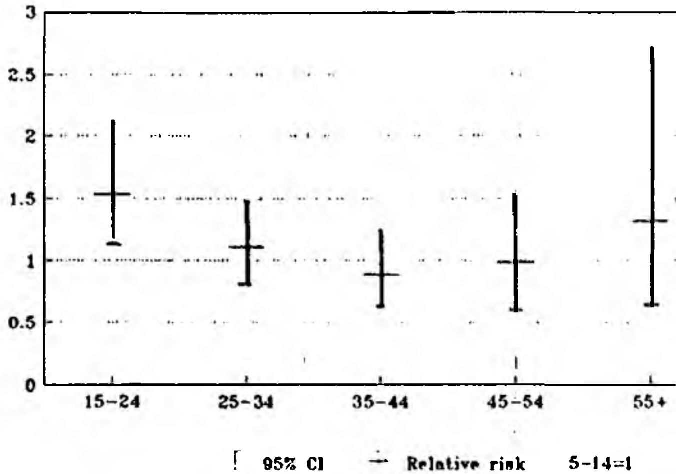
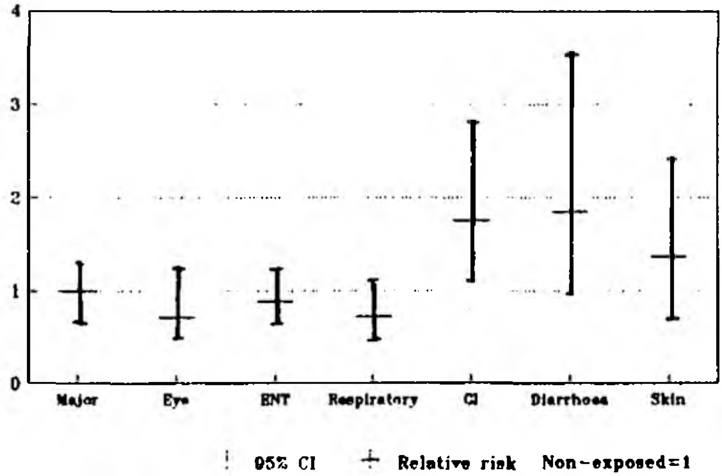


**Fig R11. Relative risk of individual symptoms : Rhyl**



(RR 1.85, 95% CI 0.97-3.55). Exposed subjects also experienced an elevated risk of skin symptoms.

Relative risks of symptoms associated with varying degrees of exposure to seawater are shown in Figures R12-R18 (Tables 14-20) for the following categories of symptoms respectively: major, eye, ear/nose/throat, respiratory, gastrointestinal, diarrhoea, and skin.

The risk of major, eye, ear/nose/throat and respiratory symptoms in bathers did not show any significant differences from the non-exposed (Figures R12-R15, Tables 14-17).

Gastrointestinal illness was raised in all categories of exposed subjects (Figure R16, Table 18), with an almost two-fold statistically significant excess in waders (RR 1.74, 95% CI 1.08-2.81) and swimmers (RR 1.85, 95% CI 1.07-3.20). These two groups also experienced an excess of diarrhoea (Figure R17, Table 19), the two-fold excess in waders being statistically significant (RR 2.07, 95% CI 1.07-3.99). Numbers of gastrointestinal and diarrhoea cases among surfers/divers (10 and 2 respectively) were too low for significant results to emerge.

All categories of bathers experienced an elevated risk of skin symptoms (Figure R18, Table 20).

**Microbiological monitoring**

No rotavirus or cryptosporidium samples proved positive. The range of enterovirus results for the three sampling sites varied from 0-18, overall arithmetic mean 2.4 per 10 litres (Table 21). In terms of the EC bathing water standard which stipulates zero enterovirus per 10 litres in 95% of samples, the compliance was 56% (12 of 27 samples positive). There was considerable variation in the incidence of positive enterovirus between sampling days.

Fig R12. Relative risk of major symptoms by water activity : Rhyl

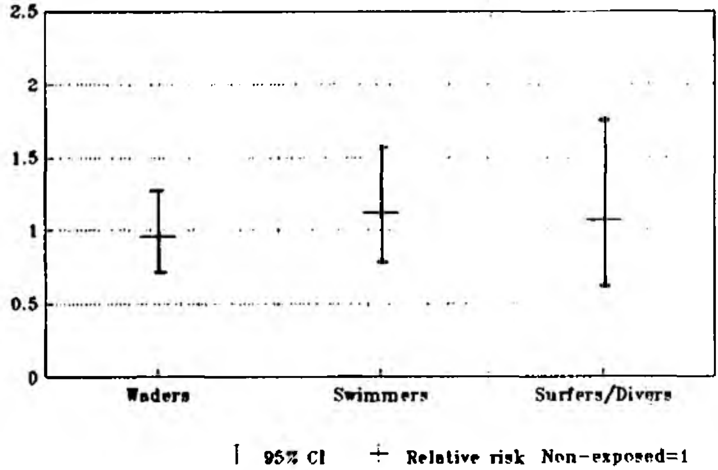



Fig R14 Relative risk of ear/nose/throat symptoms by water activity : Rhyl

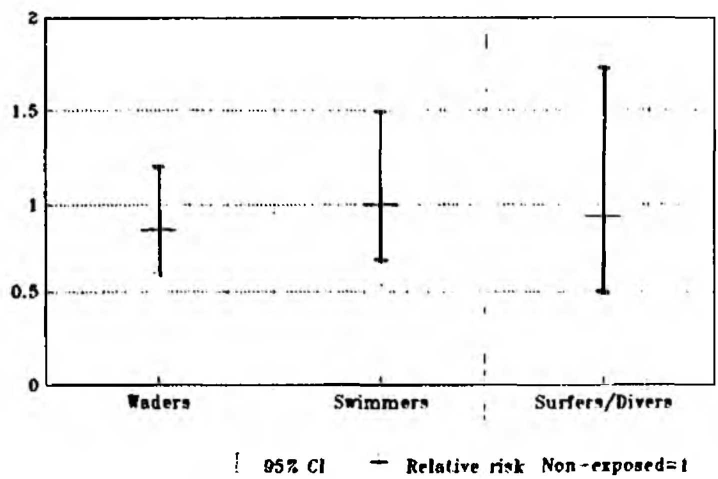


Fig R13. Relative risk of eye symptoms by water activity : Rhyl

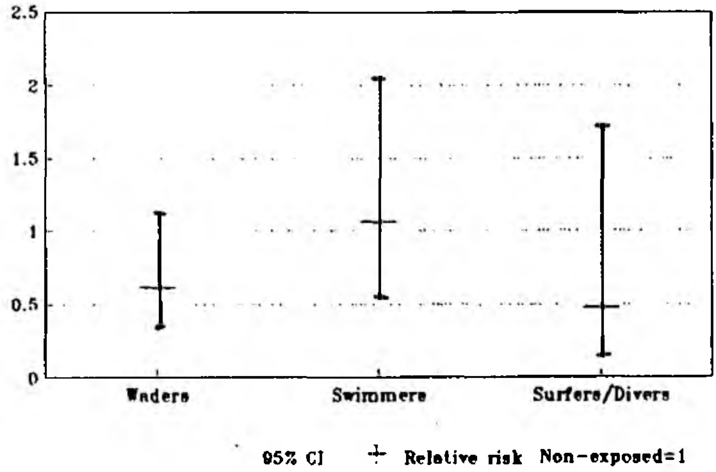
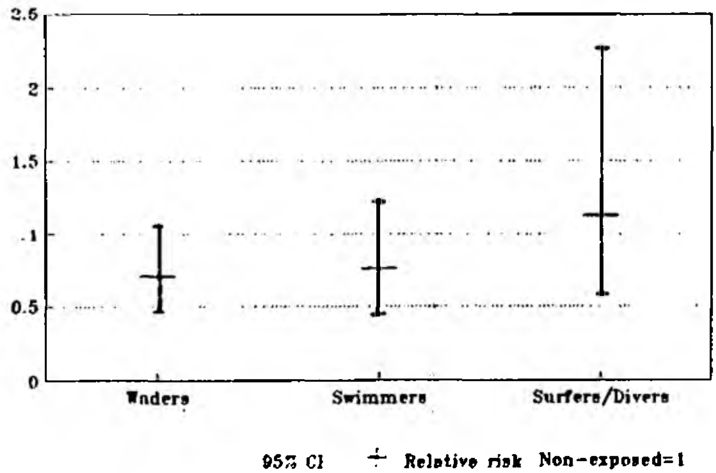



Fig R15. Relative risk of respiratory symptoms by water activity : Rhyl



Fg R16 Relative risk of gastrointestinal symptoms by water activity : Rhyl

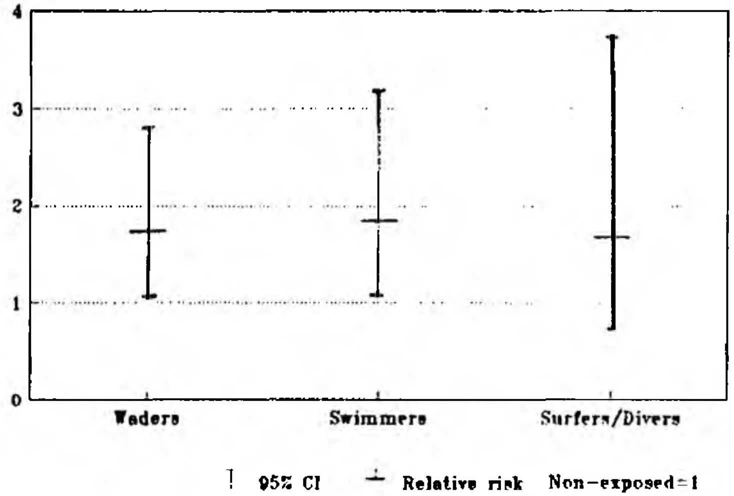



Fig R17. Relative risk of diarrhoea by water activity : Rhyl

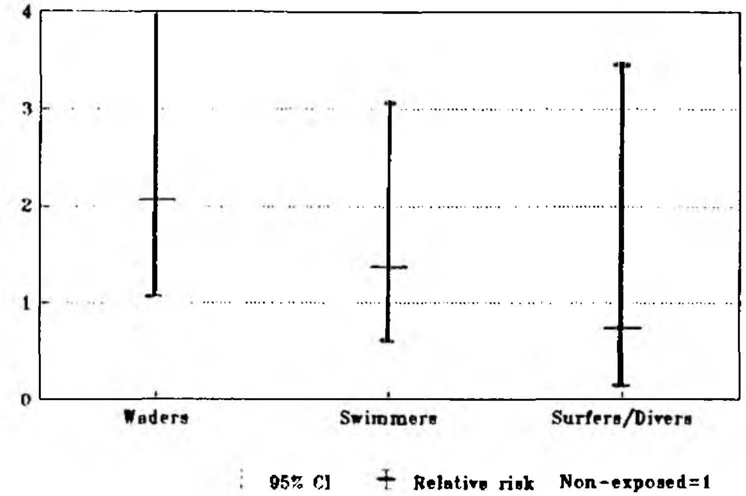
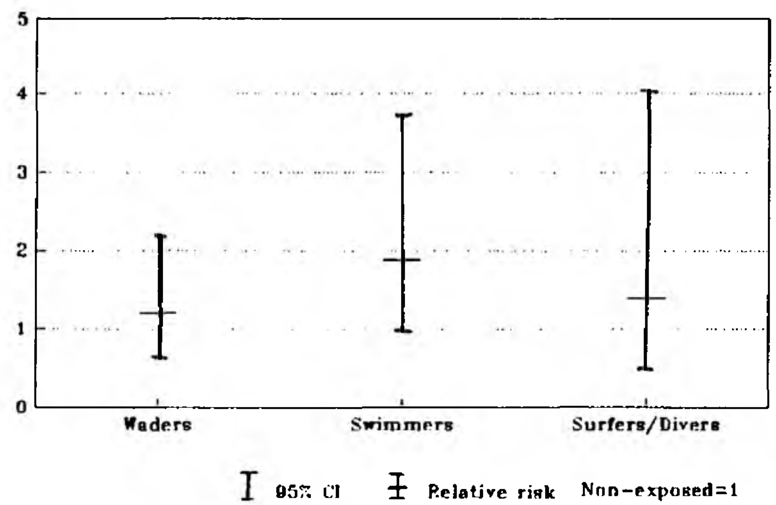



Fig R18. Relative risk of skin symptoms by water activity : Rhyl



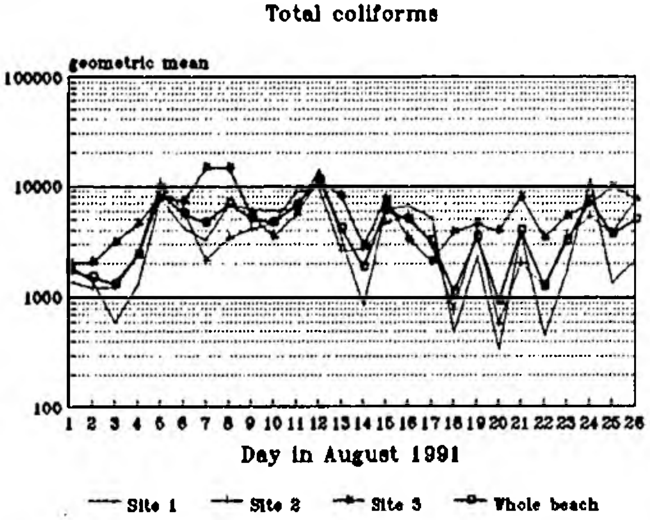
Results for coliphages were generally very low (Table 22), < 6 per ml in all samples apart from two collected on the 6 and 7 of August. In total, 60% of samples assayed for coliphage proved positive.

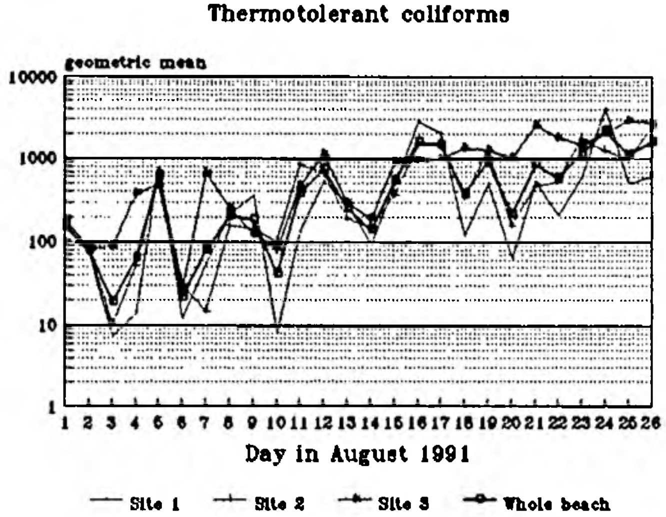
The overall geometric means for the three bacteriological indicators are given in Table 23. The beach complied with EC mandatory standards, but not with guide levels for total and thermotolerant coliforms, all three sites failing these requirements. In addition, site 3 failed the faecal streptococcus guide level standard. The individual daily and site specific samples are shown in Figure R19, Table 26. The data indicate that in terms of the EC mandatory standard for total coliforms, Rhyl may be considered to be a borderline pass on the overall geometric mean results, with a compliance for the whole beach of 96%. Sites 1 and 3 failed to achieve the necessary 95% compliance (92% and 88% respectively). Guide level compliance was zero for total coliforms at sites 2 and 3, and reached only 12% at site 1.

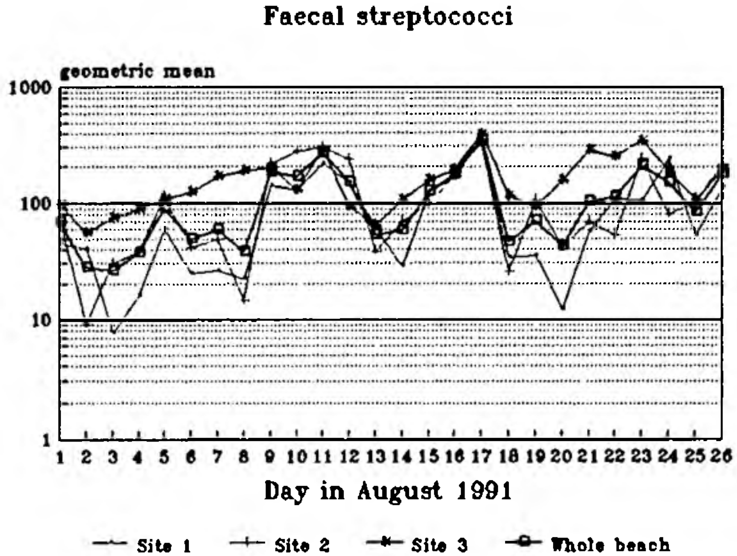
Thermotolerant coliforms similarly recorded 96% overall compliance with EC mandatory standards, once again sites 1 and 3 showing 'failure' compliance levels of less than 95%. Thermotolerant coliform guide level values showed a consistent failure across all sites, with site 3 achieving only 15% compliance. Faecal streptococcus counts for the beach as a whole exceeded guide level in 46% of samples, with all three sites failing to meet guide levels.

In summary, Rhyl failed the enterovirus standard of the EC bathing water directive. In terms of bacteriological standards, Rhyl achieved poor quality borderline passes on overall total coliform and thermotolerant coliform mandatory standards, but two of the three sites failed to meet these standards, and there was a consistent failure across all sites to meet guide levels for the three bacterial indicators. Rhyl can therefore be considered a poor water quality beach, performing poorly against the EC water standards.

## Fig R19. Variations in bacterial indicators by site: daily geometric mean levels (Rhyl)



## MORECAMBE

### Age-sex distribution of respondents

Females constituted 58% of the total sample of 790 subjects interviewed. The difficulties encountered in recruiting the target number of respondents at this beach have been referred to earlier. The proportion of children aged 5-14 years (18%) was low, and the proportion of respondents aged 45 years or more was comparatively high (13%) (Figure M1, Table 1). A higher proportion of the males than females were aged 5-14 years.

### Type of respondent

Half of the sample was holiday makers, 37% were day trippers, and 14% were local residents (Figure M2). Holiday makers and day trippers had a different age structure to local residents, with higher proportions of 5-14 year olds and lower proportions of 15-24 year olds (Figure M3, Table 2).

### Type of water activity

For the reasons discussed earlier, patterns of water activity were unusual at Morecambe in that over half the sample did not enter the water, and one-third only waded (Figure M4). Thus the proportion of respondents with any real exposure to seawaters was only 12%. The difficulties in recruiting both adequate numbers of respondents overall, and of those with exposure to seawaters, thus reduced the stability of the results for Morecambe.

The proportion of holiday makers and day trippers entering the water was higher than of local residents (Figure M5, Table 3), and the proportion participating in surfing/diving was higher among local residents than among holiday makers or day trippers. The type of bathing activity was related to age, with exposure being greatest among 5-14 and 15-24 year olds (Figure M6, Table 4). Respondents under 25 years of age constituted 69% of swimmers and 54% of surfers/divers, compared with 22% of the non-exposed.

Fig M1. Percent distribution of respondents by age and sex : Morecambe

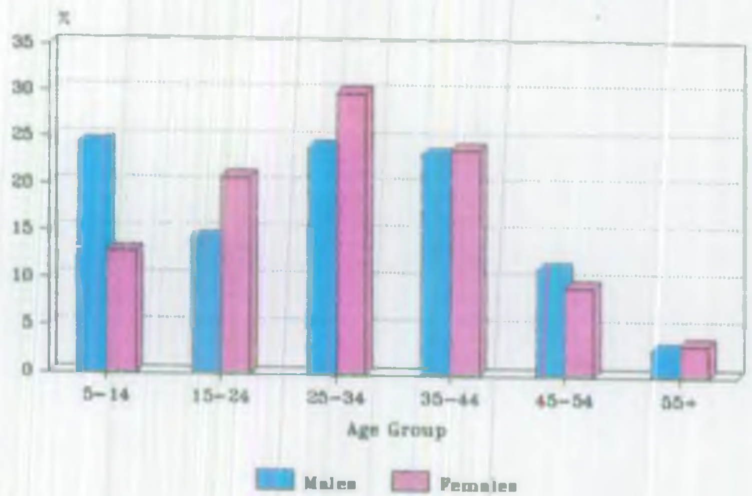



Fig M2. Percent distribution of respondents by type : Morecambe

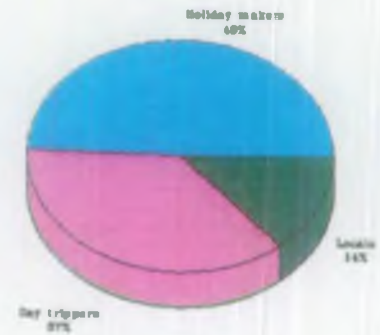



Fig M3. Percent distribution of type of respondents by age : Morecambe

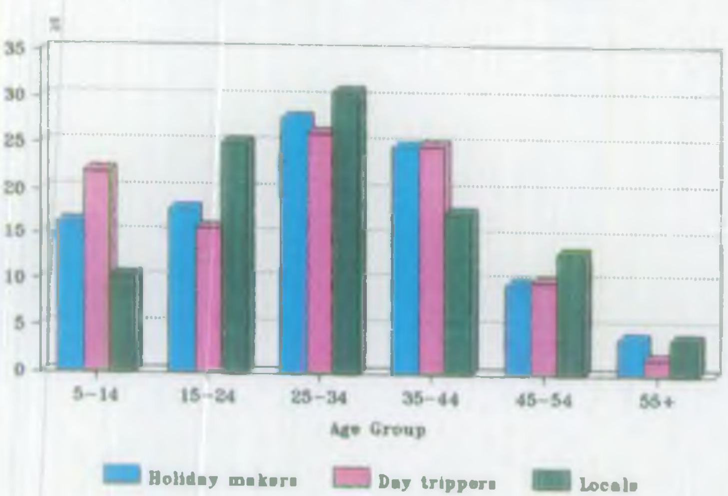


Fig M4. Percent distribution of respondents by water activity: Morecambe

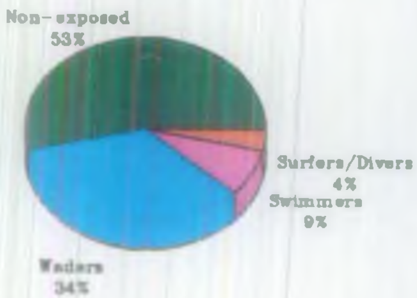



Fig M5. Percent distribution by type of respondents and water activity : Morecambe

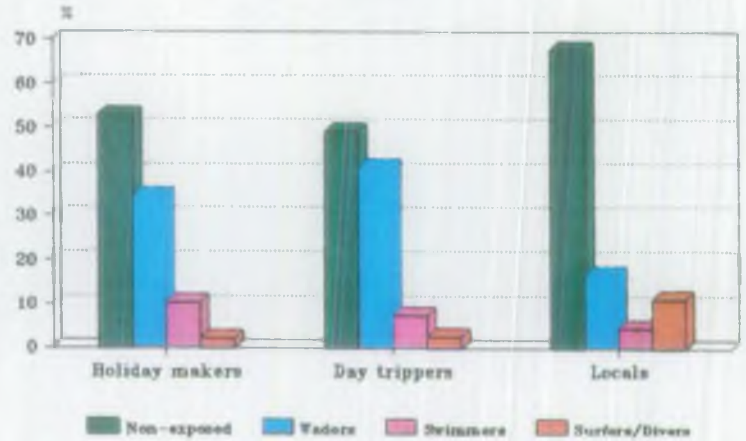
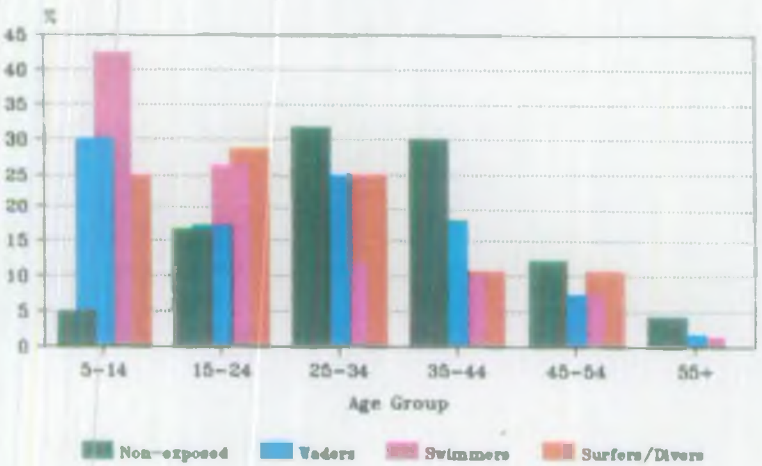



Fig M6. Percent distribution of respondents by age and water activity : Morecambe



**Reported illness**

About 26% of the respondents experienced one or more of the major symptoms (as described in Method of Analysis) in the week following the beach interview. Reported illness was higher in subjects exposed to water activity (29.3%) than in the non-exposed (23.5%). Reporting of major symptoms varied by type of water activity, with levels being 29% in waders, 27.9% in swimmers, and 35.7% in surfers/divers (Figure M7, Table 5).

Incidence rates for major symptoms by age varied between subjects entering the water and the non-exposed (Figure M8, Table 6). Levels among young exposed subjects increased with age, reaching a peak at ages 25-34. In the control group reported symptoms were highest in children aged 5-14 followed by ages 25-34 and 15-24.

Overall, the reported incidence of symptoms was highest for ear/nose/throat symptoms (15.2%) followed by gastrointestinal (9.1%), respiratory (8.3%), diarrhoea (4.6%), skin (4.4%), and eye (4.3%) symptoms. For all symptoms other than eye and skin, reported illness was higher in subjects entering the sea than in those not exposed to risk (Figure M9, Tables 7-12). Levels of eye, ear/nose/throat, respiratory and skin symptoms were highest in surfers/divers, the group with the greatest exposure. Gastrointestinal symptoms were highest in swimmers followed by surfers/divers.

**Relative risk**

Reporting of major symptoms varied by age (Figure M10), with levels being highest in exposed subjects aged 25-34 years (RR 1.33, 95% CI 0.80-2.19) followed by 15-24 year olds. Exposed subjects over 35 years of age had a reduced risk.

The risk of illness among subjects exposed to seawaters was compared with the non-exposed, after adjusting for age and sex (Figure M11, Table 13). The results show an elevated risk among subjects entering the sea of major and

Fig M7. Incidence of major symptoms
by type of water activity : Morecambe

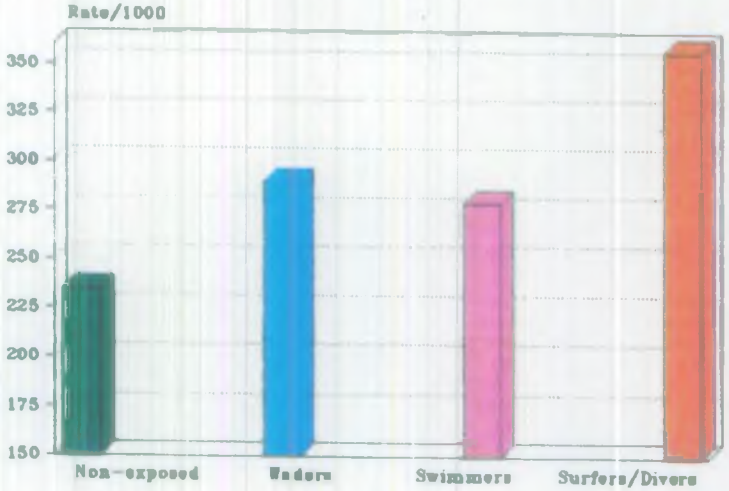



Fig M8. Incidence of major symptoms
by water activity and age : Morecambe

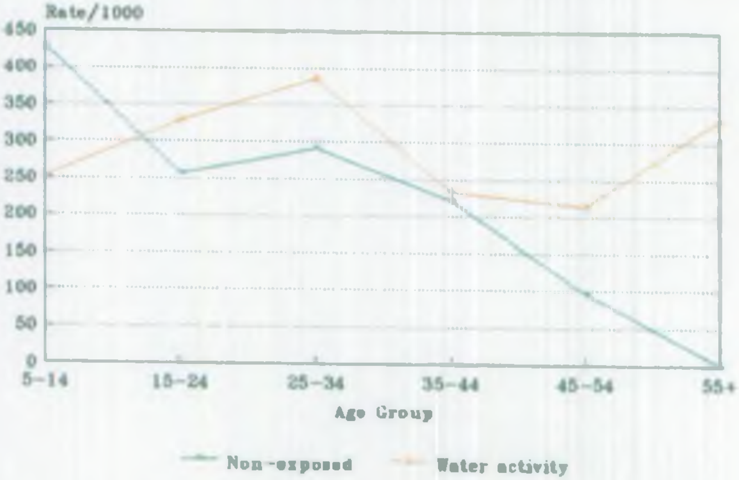





Fig M9. Incidence of individual symptoms
by water activity : Morecambe

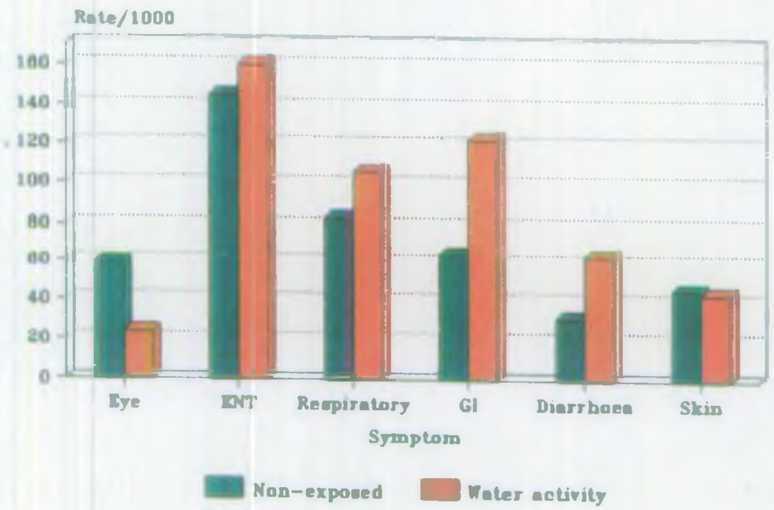


Fig M10. Relative risk of major symptoms
by age : Morecambe

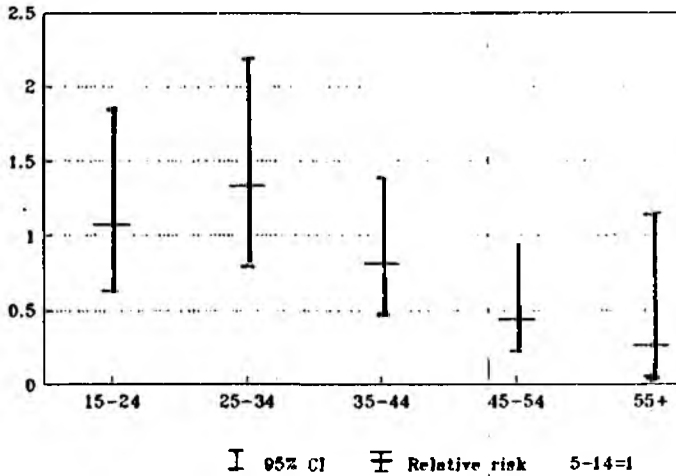
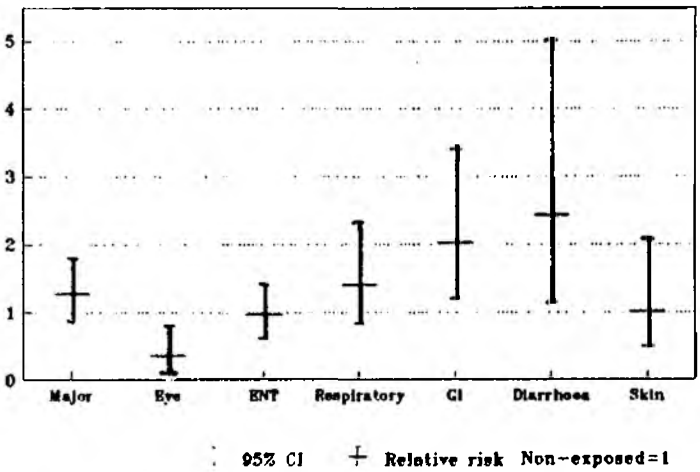


Fig M11. Relative risk of individual symptoms : Morecambe



respiratory symptoms. The exposed group experienced a statistically significant two-fold excess of gastrointestinal illness (RR 2.03, 95% CI 1.19-3.47). Risks for diarrhoea in exposed subjects showed a significant 2.4 fold excess (RR 2.43, 95% CI 1.17-5.05).

Relative risks of symptoms associated with varying degrees of exposure to seawater are shown in Figures M12-M18 (Tables 14-20) for the following categories of symptoms respectively: major, eye, ear/nose/throat, respiratory, gastrointestinal, diarrhoea, and skin.

The risk of major symptoms was elevated in all categories of exposed subjects, but the results did not reach statistical significance (Figure M12, Table 14). Surfers/divers experienced an elevated risk of eye symptoms (Figure M13, Table 15), and a statistically significant 2.4 fold excess of ear/nose/throat symptoms (RR 2.43, 95% CI 1.01-5.85) (Figure M14, Table 16). Respiratory symptoms were raised in all categories of exposed subjects (Figure M15, Table 17).

All categories of exposed subjects experienced higher gastrointestinal illness (Figure M16, Table 18), with a statistically significant two-fold excess in waders (RR 1.79, 95% CI 1.01-3.17) and a statistically significant three-fold excess in swimmers (RR 2.93, 95% CI 1.27-6.73). The three-fold excess in surfers/divers failed to reach statistical significance (RR 3.08, 95% CI 0.95-10.01). A dose-response type of relationship was apparent for gastrointestinal symptoms. The risk of diarrhoea was also raised in all categories of exposed subjects, with a 2.4 fold excess in waders (RR 2.40, 95% CI 1.12-5.14) and a three-fold excess in swimmers (RR 3.02, 95% CI 0.89-10.23) (Figure M17, Table 19). The excess in surfers/divers did not reach statistical significance. The stability of the results was compromised by the low numbers of gastrointestinal and diarrhoea cases among surfers/divers (4 and 1 respectively).

Surfers/divers showed a raised risk of skin symptoms (Figure M18, Table 20).

Fig M12. Relative risk of major symptoms by water activity : Morecambe

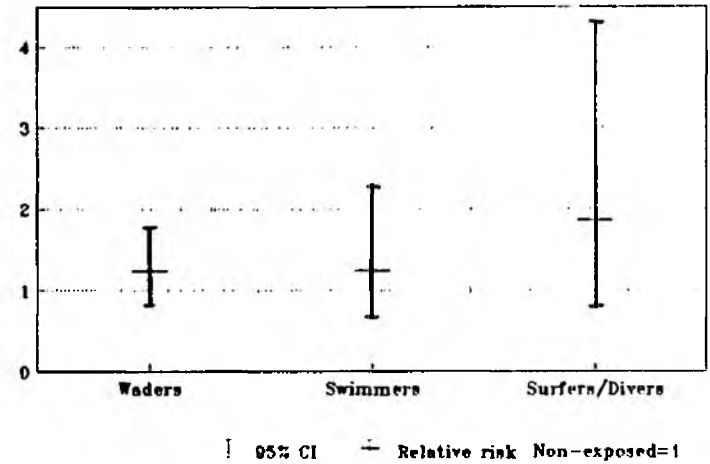



Fig M14 Relative risk of ear/nose/throat symptoms by water activity : Morecambe

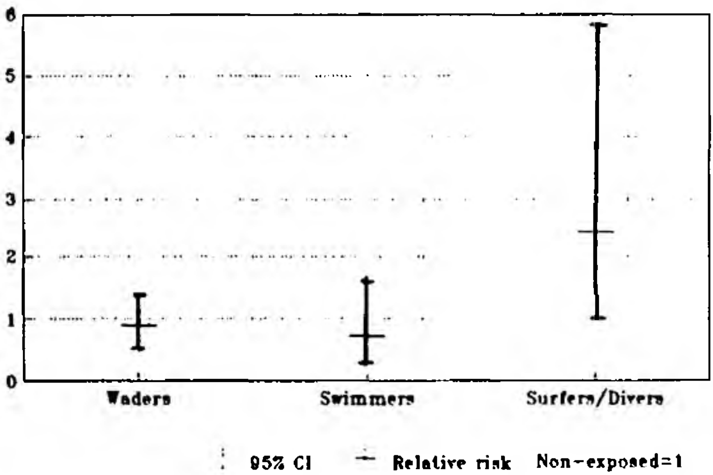


Fig M13. Relative risk of eye symptoms by water activity : Morecambe

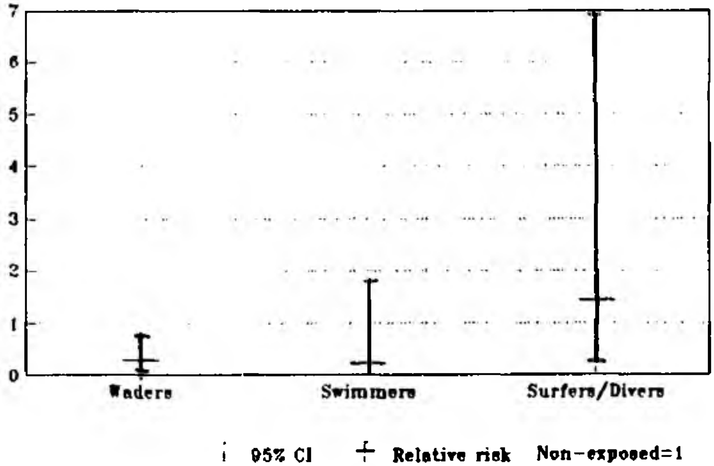
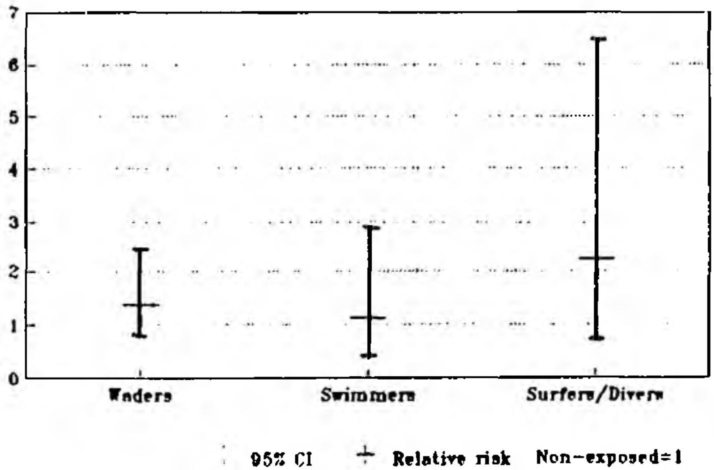



Fig M15. Relative risk of respiratory symptoms by water activity : Morecambe



Fg M16 Relative risk of gastrointestinal symptoms by water activity : Morecambe

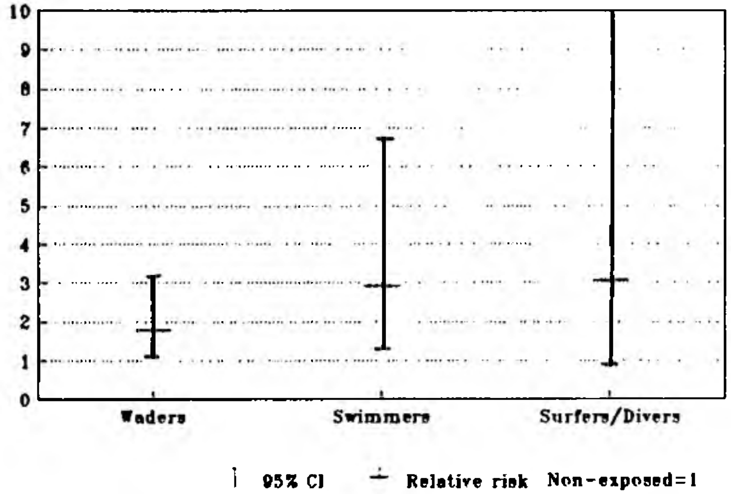



Fig M17. Relative risk of diarrhoea by water activity : Morecambe

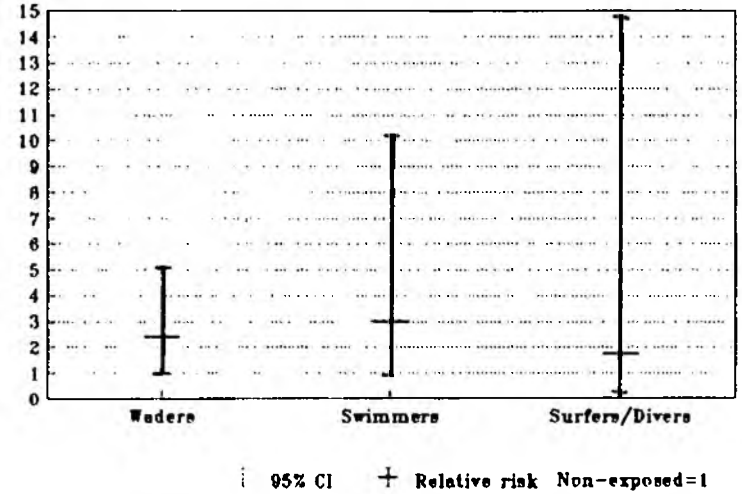
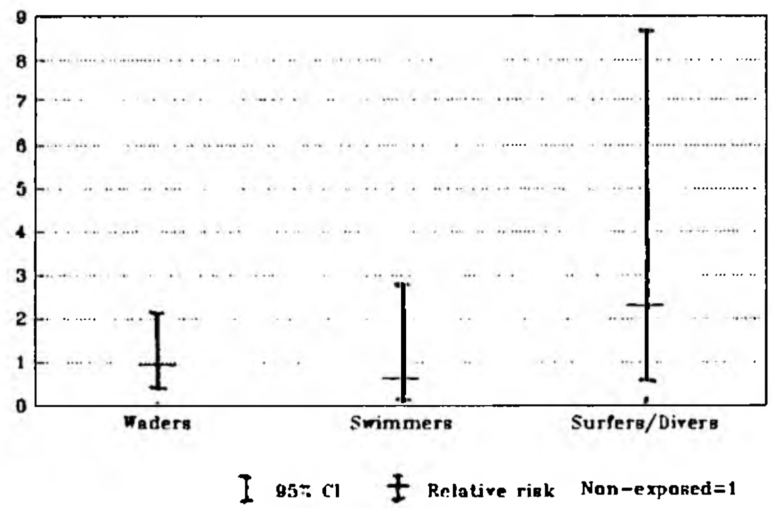



Fig M18. Relative risk of skin symptoms by water activity : Morecambe



**Microbiological monitoring**

No rotavirus or cryptosporidium samples proved positive. The enterovirus results for the three sampling sites at Morecambe ranged between 0-31, overall arithmetic mean 4.7 per 10 litres (Table 21). In comparison with the EC bathing water standard which stipulates zero enterovirus per 10 litres in 95% of samples, compliance was 56% (12 of 27 samples positive). There were considerable variations in the incidence of positive enterovirus between sampling days. This was most marked on 8 August where the daily mean of 25 per 10 litre was considerably higher than any other daily result.

Results for coliphages were generally low (Table 22), <10 per ml in all samples apart from two collected on 4 and 5 of August (10 and 13 per ml respectively). In total, 42% of samples assayed for coliphage proved positive.

The overall geometric means for the bacteriological indicators (Table 23) show that although Morecambe complied with EC mandatory standards, guide levels for total and thermotolerant coliforms were not met by any of the three sites. Guide levels for faecal streptococci were also exceeded at site 1 and overall.

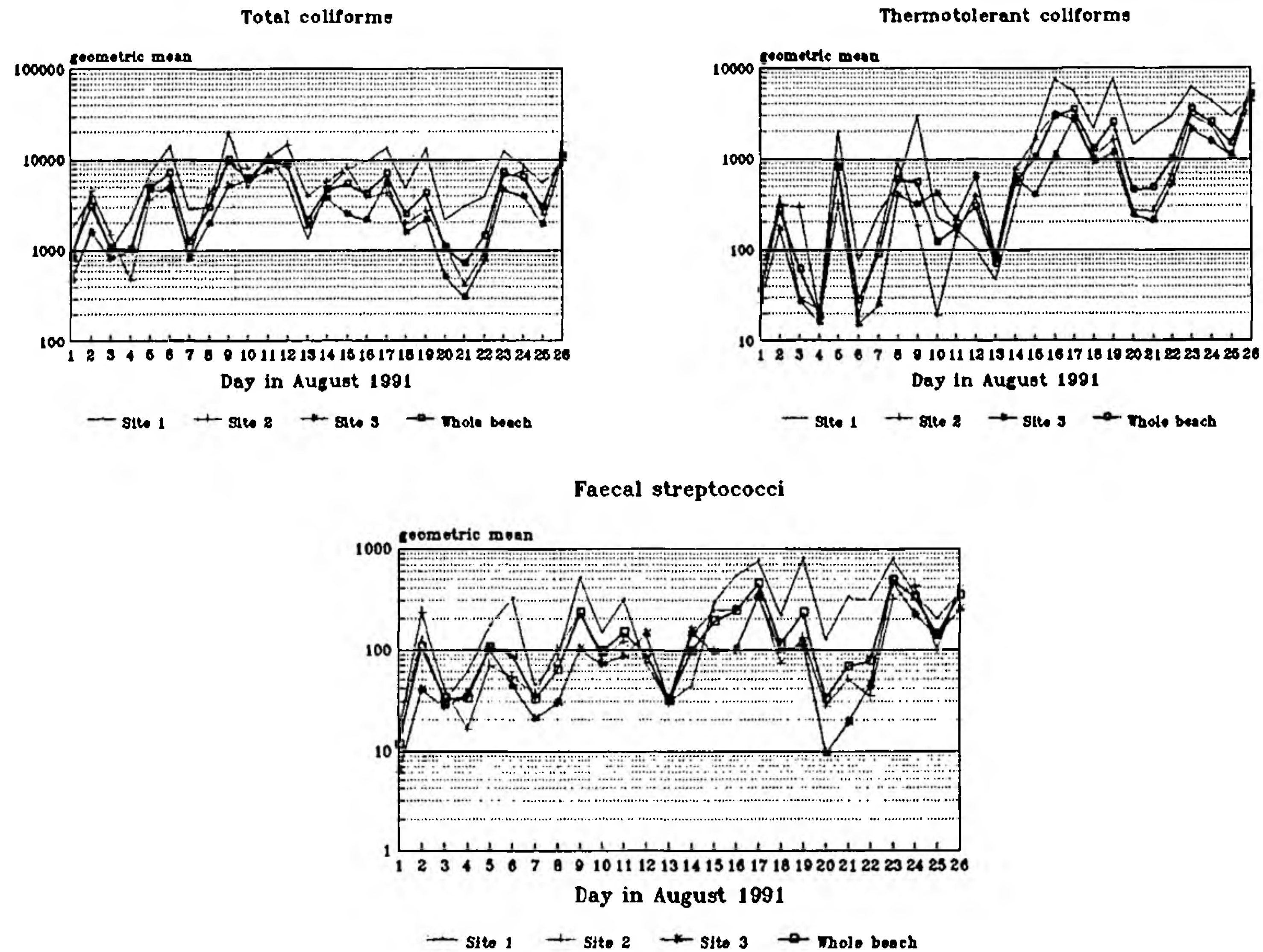
Examination of the daily samples (Figure M19, Table 27) indicates that the beach as a whole achieved the EC mandatory total coliform standard on 96% of samples. This compliance was not consistent at all sites - sites 1 and 2 achieved only 77% and 88% compliance. Virtually all samples (except 4 of the 78) failed to meet guideline levels for total coliforms.

The thermotolerant coliform compliance levels compared against the EC mandatory standard were considerably less, varying from 58-88% at the three designated sampling sites, overall compliance standing at 77%. Thus Morecambe may be considered to have failed the EC bathing water directive standard. Guide level compliance to the thermotolerant coliform standard was achieved in only 23% of samples. Similarly, compliance with the EC faecal streptococcus guide standard was only achieved on 50% of the total samples, varying from 31-58% in the three sampling sites.

Quality at Morecambe appeared to deteriorate in the second half of August. Sample site 1 was consistently poorer in quality than site 2, which was in turn poorer in quality than site 3.

In summary, Morecambe failed both the enterovirus and the bacteriological standards of the EC bathing water directive.

## Fig M19. Variations in bacterial indicators by site: daily geometric mean levels (Morecambe)



## ALL BEACHES

### Relative risk

As might be expected from the results of the individual beaches, the analysis including all the beaches into one model (with the Paignton non-exposed as the reference level) for major symptoms confirmed the gradation of increasing RR with increasing water activity, albeit the waders and swimmers had very similar risks. The RRs were of similar value in those who bathed at Rhyl and Morecambe, and higher than for those who bathed at Paignton and Lyme Regis, risks for the latter two sites being very similar. The RR estimates obtained for the 16 activity by beach groups are given below:

**RRs OF MAJOR SYMPTOMS BY SEAWATER EXPOSURE AND SITE**

| Location | Non-exposed | Waders | Swimmers | Surfers/divers |
|---|---|---|---|---|
| Paignton | 1 | 1.08 | 1.07 | 1.50 |
| Lyme Regis | 1.00 | 1.08 | 1.07 | 1.50 |
| Rhyl | 1.20 | 1.30 | 1.29 | 1.81 |
| Morecambe | 1.24 | 1.34 | 1.33 | 1.87 |

For gastrointestinal illness and individual symptoms other than eye-related symptoms in Lyme Regis, the RRs for Paignton and Lyme Regis were again very similar, and lower than the values at Rhyl and Morecambe, the latter two being similar (see below).

**RRs OF GASTROINTESTINAL SYMPTOMS BY SEAWATER EXPOSURE AND SITE**

| Location | Non-exposed | Waders | Swimmers | Surfers/divers |
|---|---|---|---|---|
| Paignton | 1 | 1.55 | 1.38 | 2.26 |
| Lyme Regis | 1.07 | 1.60 | 1.48 | 2.42 |
| Rhyl | 1.32 | 1.97 | 1.82 | 2.98 |
| Morecambe | 1.41 | 2.11 | 1.94 | 3.19 |

**RRs OF DIARRHOEA BY SEAWATER EXPOSURE AND SITE**

| Location | Non-exposed | Waders | Swimmers | Surfers/divers |
|---|---|---|---|---|
| Paignton | 1 | 1.66 | 1.16 | 2.14 |
| Lyme Regis | 1.19 | 1.96 | 1.37 | 2.54 |
| Rhyl | 1.50 | 2.49 | 1.74 | 3.22 |
| Morecambe | 1.66 | 2.74 | 1.92 | 3.55 |

These results are in line with the overall seawater quality at these resorts during August 1992.

## DISCUSSION

### Nature of beaches and type of respondents

The study went as planned in Paignton and Lyme Regis, but difficulties were encountered at Rhyl and Morecambe. The total numbers of completed interviews at each site were: Paignton 2038; Lyme Regis 2065; Rhyl 1964; and Morecambe 790, in comparison with the target for completed telephone interviews for each beach of 2000. The difficulty at Rhyl was that, although the target number of respondents was achieved, it was not possible to meet the quota requirements for exposure to seawater, as the proportions bathing were reduced by a tide which turned one-mile away from the shore line. At Morecambe the numbers visiting the beach were far fewer than expected, and of those that were there fewer entered the sea than was anticipated. As a consequence the sensitivity of the analysis and the stability of the results for Rhyl, and especially for Morecambe, are affected by inadequate numbers.

There were variations between the beaches in that subjects under 35 years of age constituted about two-thirds of those interviewed except in Rhyl (75%), where there was a disproportionately high number of 5-14 year olds, and the proportions of holiday makers (50-62%), day trippers (25-46%), and local residents (5-14%) varied quite substantially.

Patterns of water activity were broadly similar in Paignton and Lyme Regis where the study quotas by type of exposure were achieved, but at Rhyl and Morecambe, for reasons already described, the quotas for exposed groups could not be met.

However, the four beaches were similar in several respects. Thus, children aged 5-14 constituted a higher proportion of holiday makers and day trippers than of local residents, the latter group having a comparatively higher component of 15-24 year olds; higher proportions of holiday makers than of local residents entered the sea; a higher proportion of local residents than of holiday makers or day trippers participated in surfing/diving; and the degree of exposure to water was greatest among the 5-24 year age group.

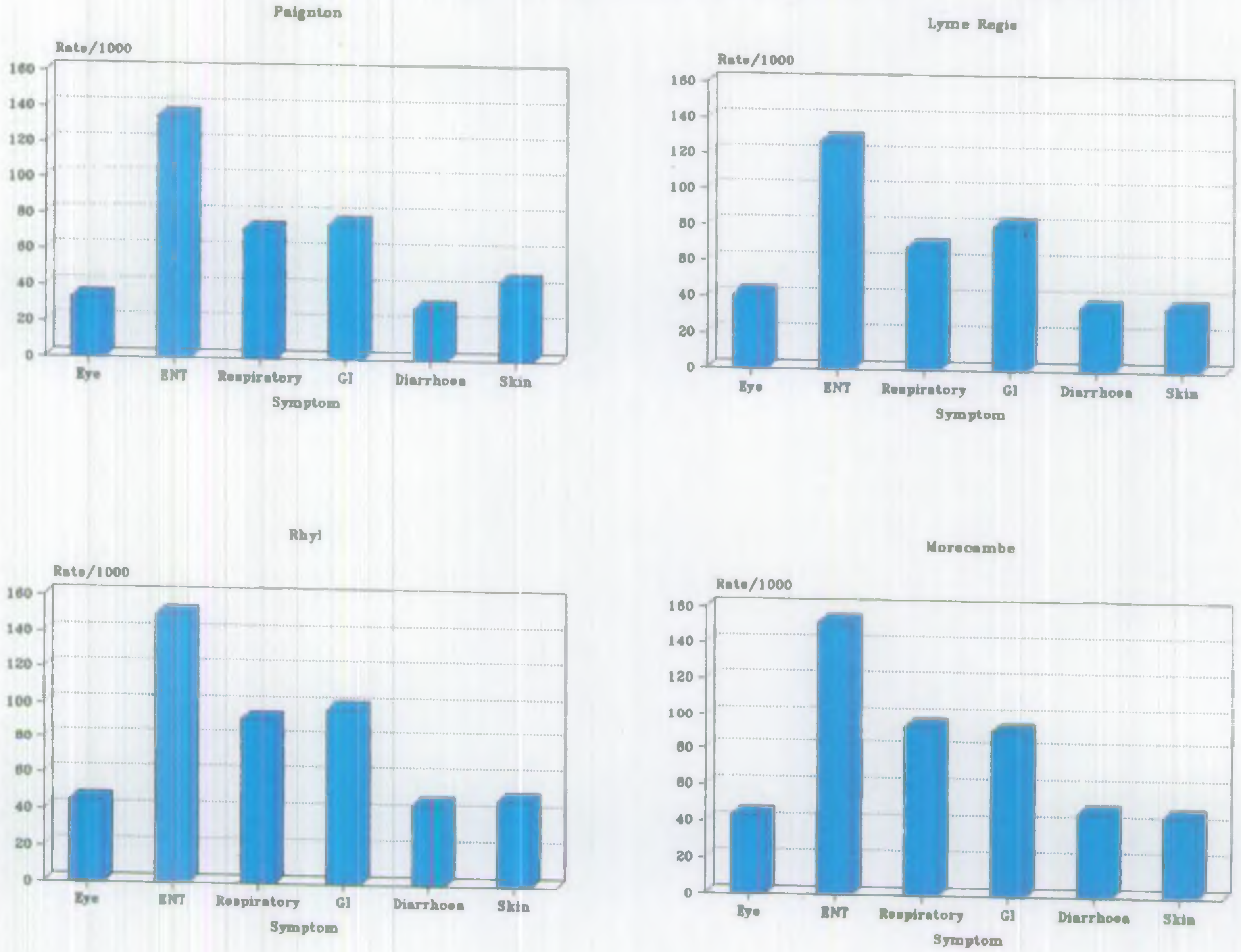
**Reporting of symptoms**

The basic study design recognised that the numbers reporting symptoms (particularly diarrhoea and the combined gastrointestinal symptoms) would be small, so that it was unlikely that each beach would consistently demonstrate the anticipated dose-response relation between levels of seawater exposure. Nevertheless, the numbers (2000) chosen for each beach were calculated as sufficient to provide a reliable estimate of the RR of bathers compared to non-bathers for gastrointestinal illness. It is of no surprise that some of the individual symptoms at some of the beaches fail to show a smoothly increasing RR with increasing exposure. However, in such situations the possibility of such a dose-response relation should not be discounted without careful examination of the CIs of each of the RRs concerned. Thus, although we have presented details of the RRs for each symptom and exposure level for each beach, it is the combined analysis of the subjects from the four beaches which provides the most reliable guide to the dose-response relations.

It was also recognised that the study is based on reported symptomatology but we assume that, although overall reporting levels may be affected, this should not distort the dose-response relationships. In the event, there was remarkable consistency in the reporting levels. Thus, about one-quarter of the respondents at each of the beaches reported one or more of the major symptoms in the week following the beach interview. Beaches with better water quality (Paignton 23.1%, Lyme Regis 22.8%) reported less symptoms than those of poorer quality (Rhyl 26.6%, Morecambe 26.2%).

Furthermore, there was consistency between the four beaches in that the reported incidence was highest for ear/nose/throat symptoms (range 12.7-15.2%), generally followed by gastrointestinal (7.5-9.8%), respiratory (6.8-9.2%), skin (3.5-4.7%), diarrhoea (2.9-4.6%) and eye symptoms (3.3-4.5%) (Figure 20).

Fig 20. Incidence of individual symptoms at 4 beaches



The incidence of major symptoms was higher in subjects exposed to water activity (Figure 21) and highest in surfers/divers at all beaches other than Rhyl (Figure 22). The incidence of gastrointestinal symptoms was higher in exposed subjects than in the non-exposed at all beaches (Figure 23). The incidence of diarrhoea was higher in exposed subjects compared with the non-exposed at all beaches other than Paignton (Figure 23).

At all beaches the risk of reporting major symptoms was highest among subjects aged 15-34 years and the risk associated with water activity was therefore accentuated in the young. The RR of major symptoms among exposed subjects was raised at the beaches other than Rhyl, although the results did not reach formal statistical significance (Figure 24). The surfers/divers at Paignton experienced a significant excess of major symptoms (RR 1.75, 95% CI 1.17-2.61).

RRs of eye symptoms (Figure 24) were elevated only in Paignton, with a significant excess in surfers/divers (RR 3.72, 95% CI 1.41-9.77). Ear/nose/throat symptoms among the exposed were raised at Paignton and Lyme Regis (Figure 24), with a significant excess among surfers/divers at Paignton (RR 1.74, 95% CI 1.06-2.86). Respiratory symptoms among subjects entering the sea were raised only at Morecambe (Figure 24).

As anticipated by the design, the RR of gastrointestinal illness among exposed subjects was raised at all beaches (Figure 24), with a statistically significant two-fold excess at Morecambe and Rhyl (RR 2.03, 95% CI 1.19-3.47 and RR 1.76, 95% CI 1.10-2.82 respectively). Risks of gastrointestinal illness by degree of exposure to water activity showed a statistically significant two-fold excess in surfers/divers at Paignton (RR 1.95) and Lyme Regis (RR 2.02), but the three-fold excess among surfers/divers at Morecambe narrowly failed to reach statistical significance (RR 3.08, 95% CI 0.95-10.01). Statistically significant effects in waders and swimmers at Rhyl (RRs 1.74 and 1.85 respectively) and Morecambe (RRs 1.79 and 2.93 respectively) were also demonstrated (Figure 25).

Fig 21. Incidence of major symptoms at 4 beaches by exposure

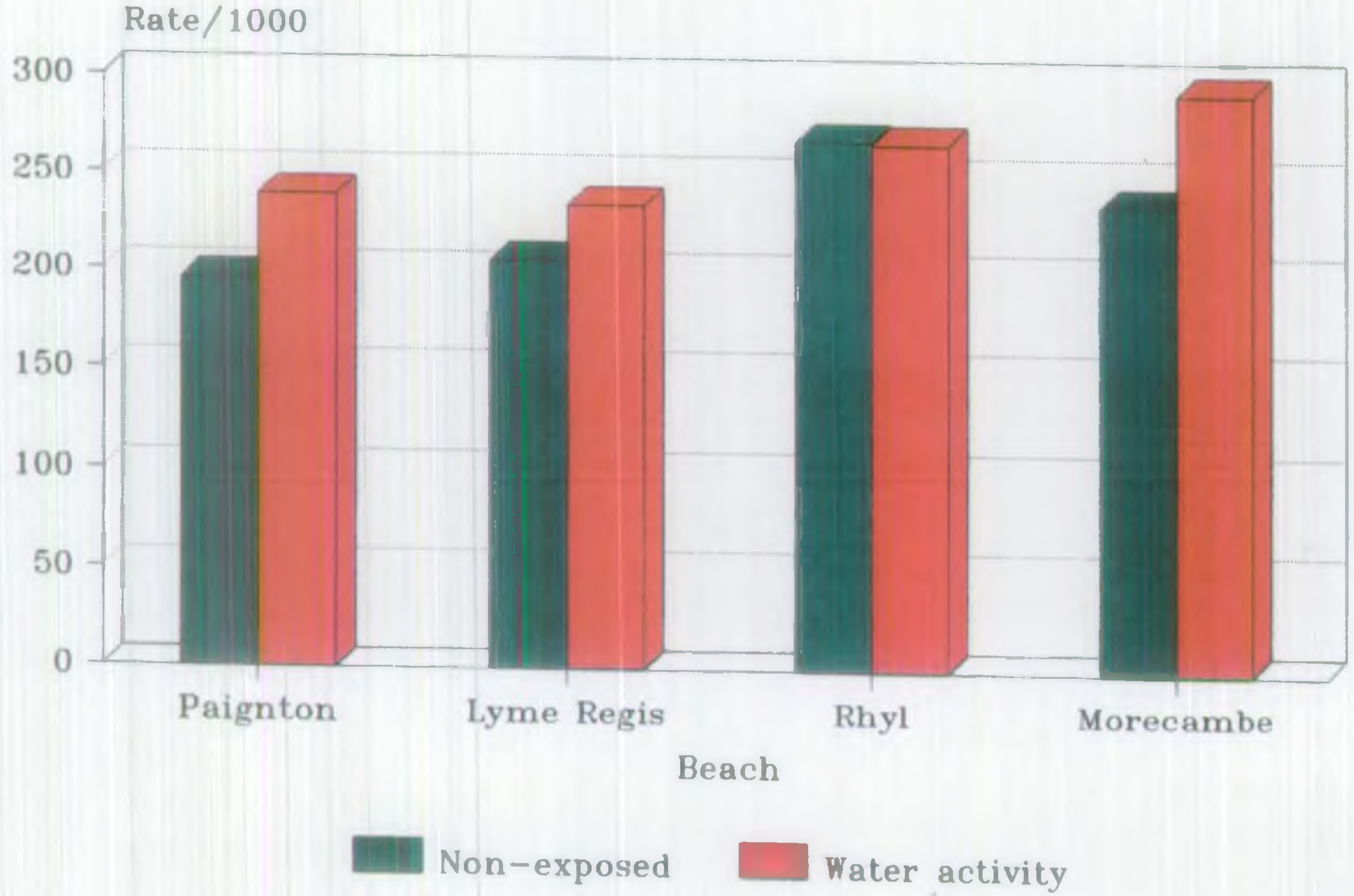


Fig 22. Incidence of major symptoms at 4 beaches by water activity

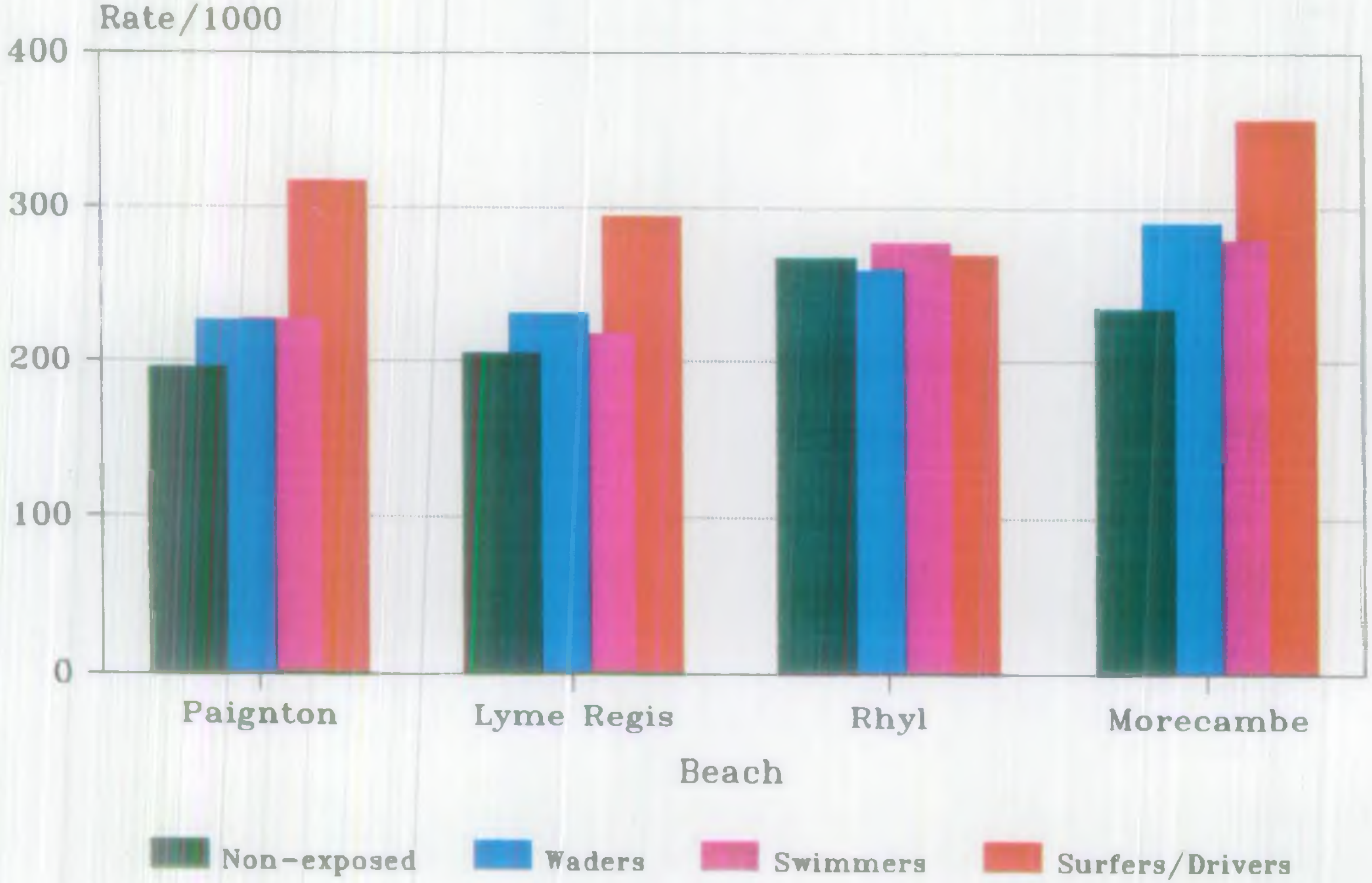
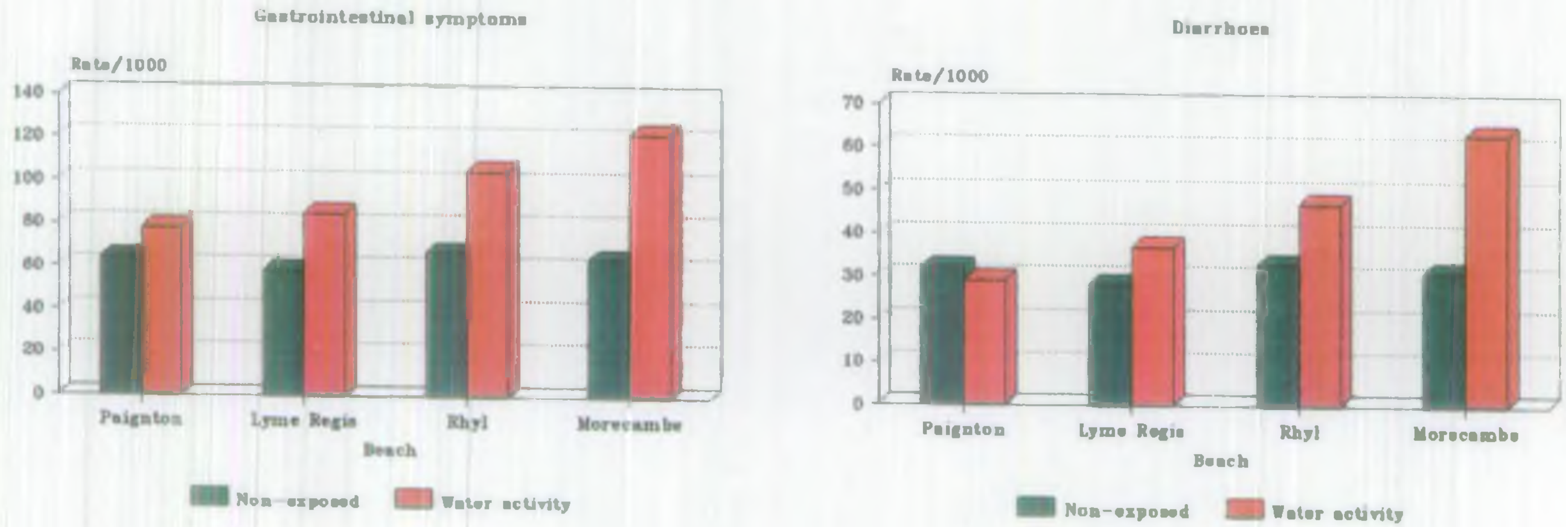
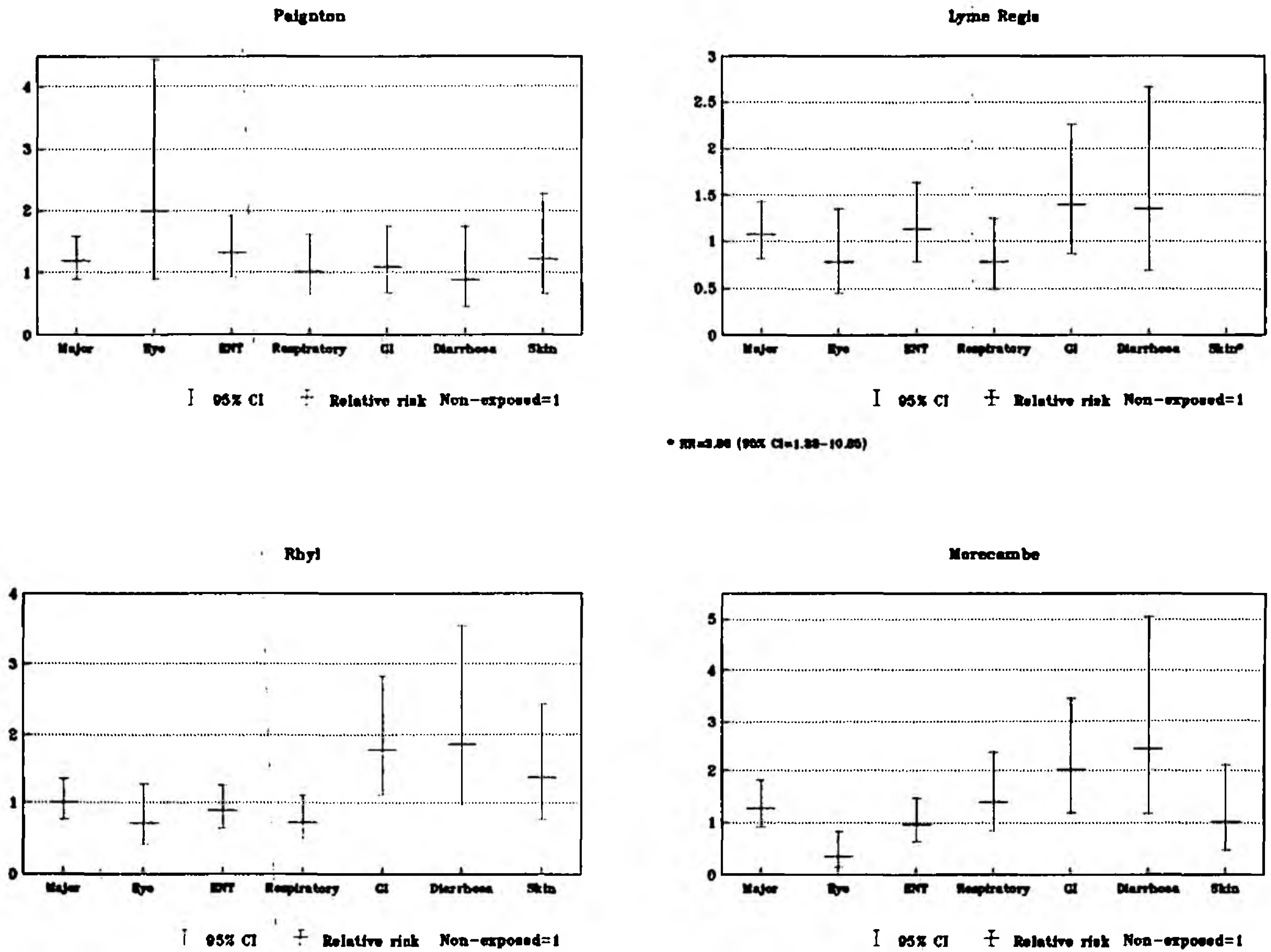


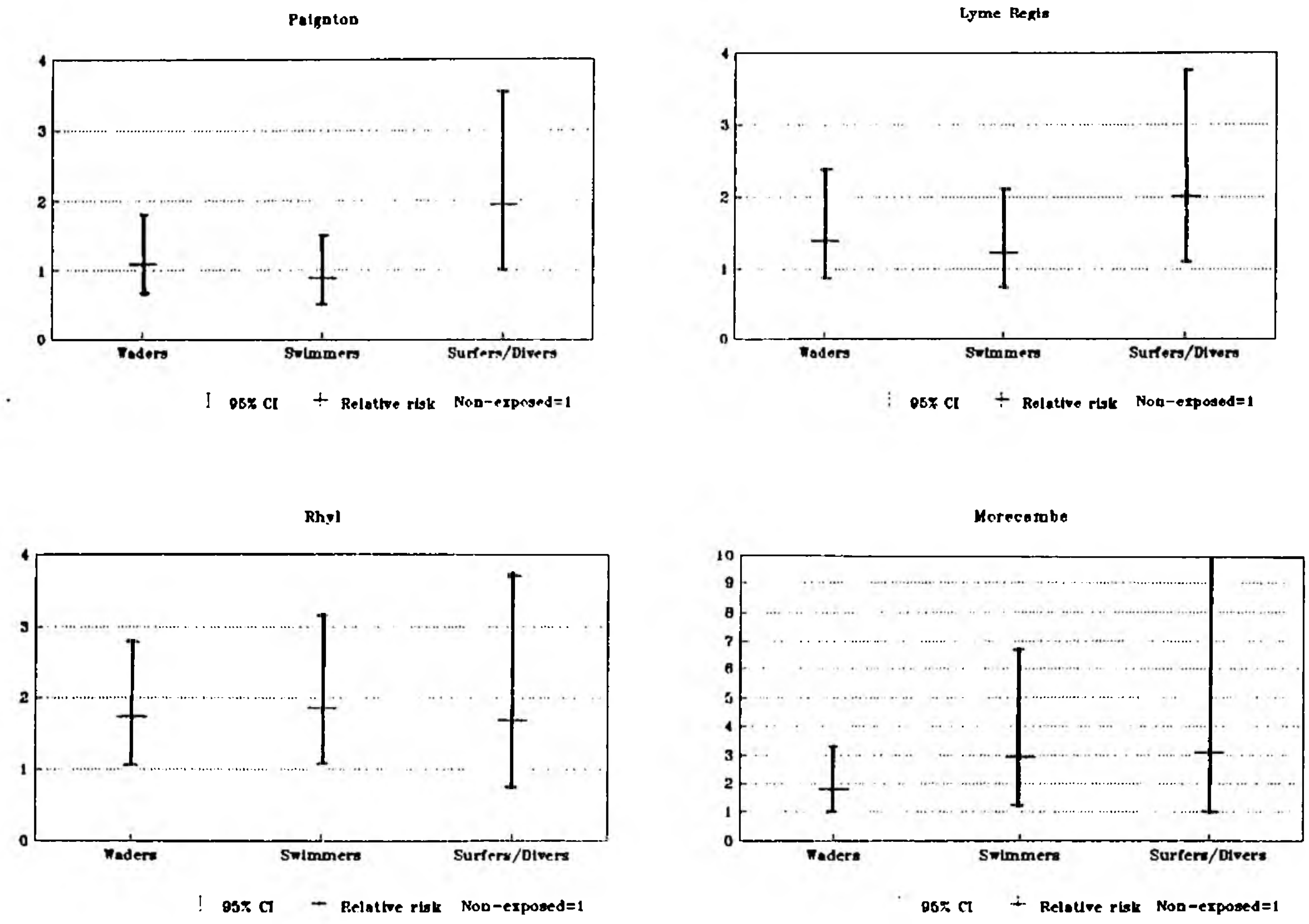
Fig 23. Incidence of gastrointestinal symptoms and and diarrhoea at 4 beaches by water activity



## Fig 24. Relative risk of symptoms at 4 beaches



## Fig 25. Relative risk of gastrointestinal symptoms at 4 beaches by water activity



Exposed subjects at all beaches other than Paignton experienced an elevated risk of diarrhoea, with a statistically significant 2.4 fold excess in Morecambe (RR 2.43, 95% CI 1.17-5.05), and an almost two-fold excess at Rhyl just failing to reach formal statistical significance (RR 1.85, 95% CI 0.97-3.55) (Figure 24). Analysis by degree of exposure to water activity showed a statistically significant and greater than two-fold excess of diarrhoea among surfers/divers in Lyme Regis (RR 2.55) and among waders in Rhyl and Morecambe (RRs 2.07 and 2.40 respectively) (Figure 26).

Skin symptoms were elevated among exposed subjects at all beaches other than Morecambe (Figure 24), with a significant excess among surfers/divers at Paignton (RR 2.35, 95% CI 1.09-2.27), although the observed increased risk at Lyme Regis may be an artefact of the low incidence in the control group.

## Microbiology

During the survey period all four bathing waters failed the enterovirus standard of the EC bathing water directive. Morecambe similarly failed the bacteriological standards. Rhyl was a poor water quality beach, performing poorly against EC water standards for all indicators. Paignton and Lyme Regis may be considered of good quality (Figures 27i-27iii). The results are summarised results below:

**BACTERIAL INDICATORS (GEOMETRIC MEANS PER 100 ML)**

| Location | Total coliforms | Thermotolerant coliforms | Faecal streptococci |
|---|---|---|---|
| Paignton | 235 | 103 | 32 |
| Lyme Regis | 104 | 40 | 14 |
| Rhyl | 3537 | 310 | 88 |
| Morecambe | 3380 | 447 | 100 |

Fig 26. Relative risk of diarrhoea at 4 beaches by water activity

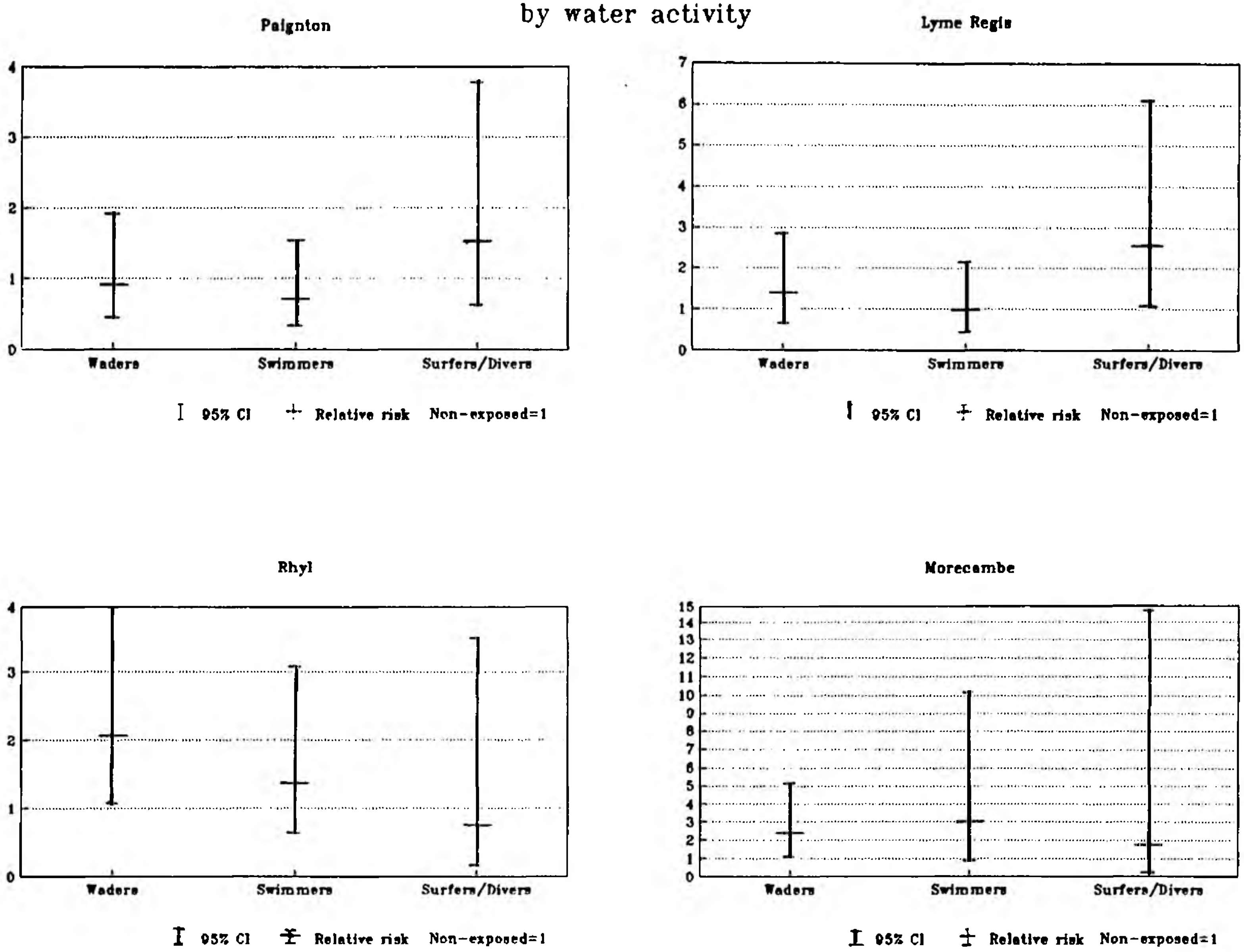


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Fig 27(i). Variations in bacterial indicators at 4 beaches:
daily geometric mean levels

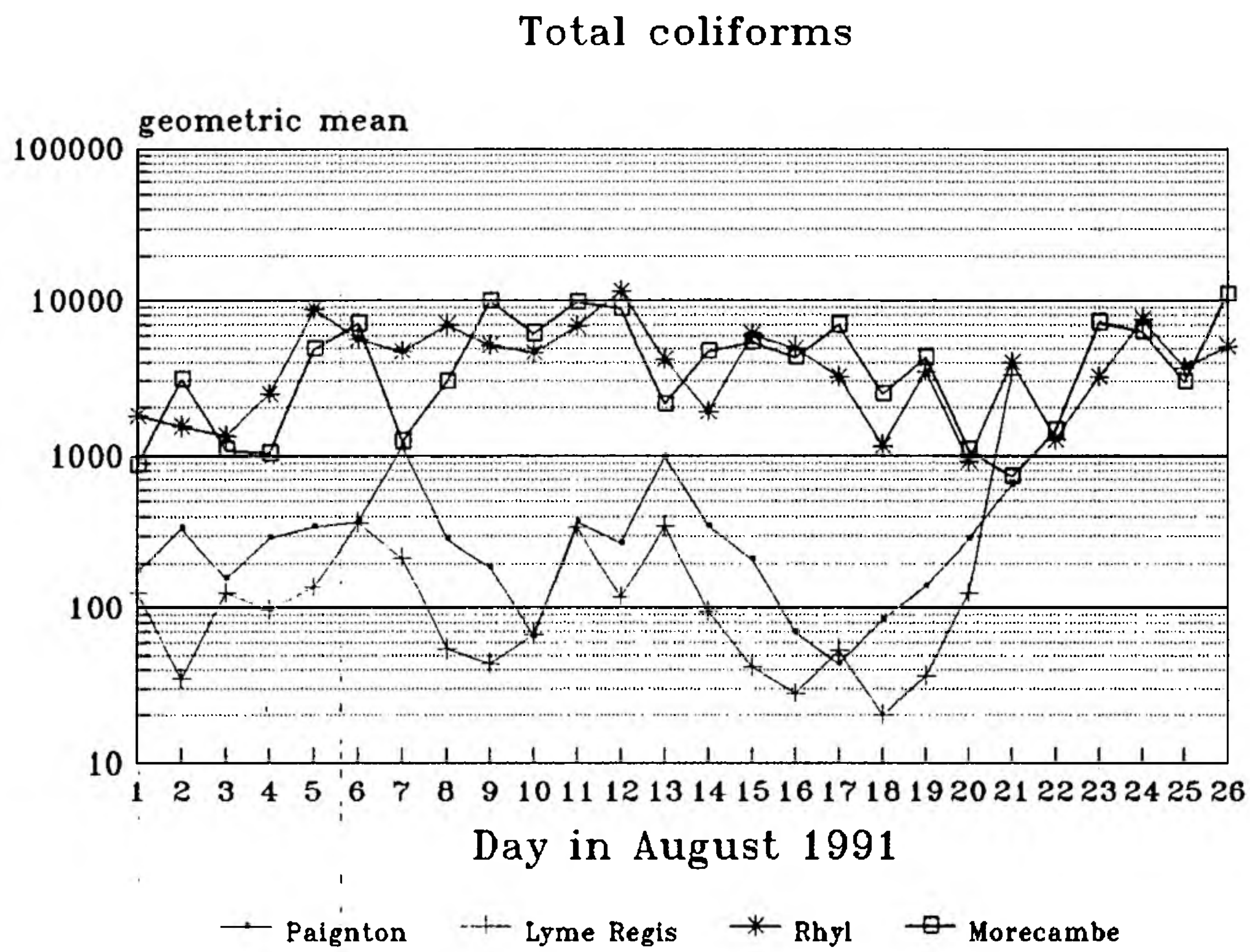


Fig 27(ii). Variations in bacterial indicators at 4 beaches:
daily geometric mean levels

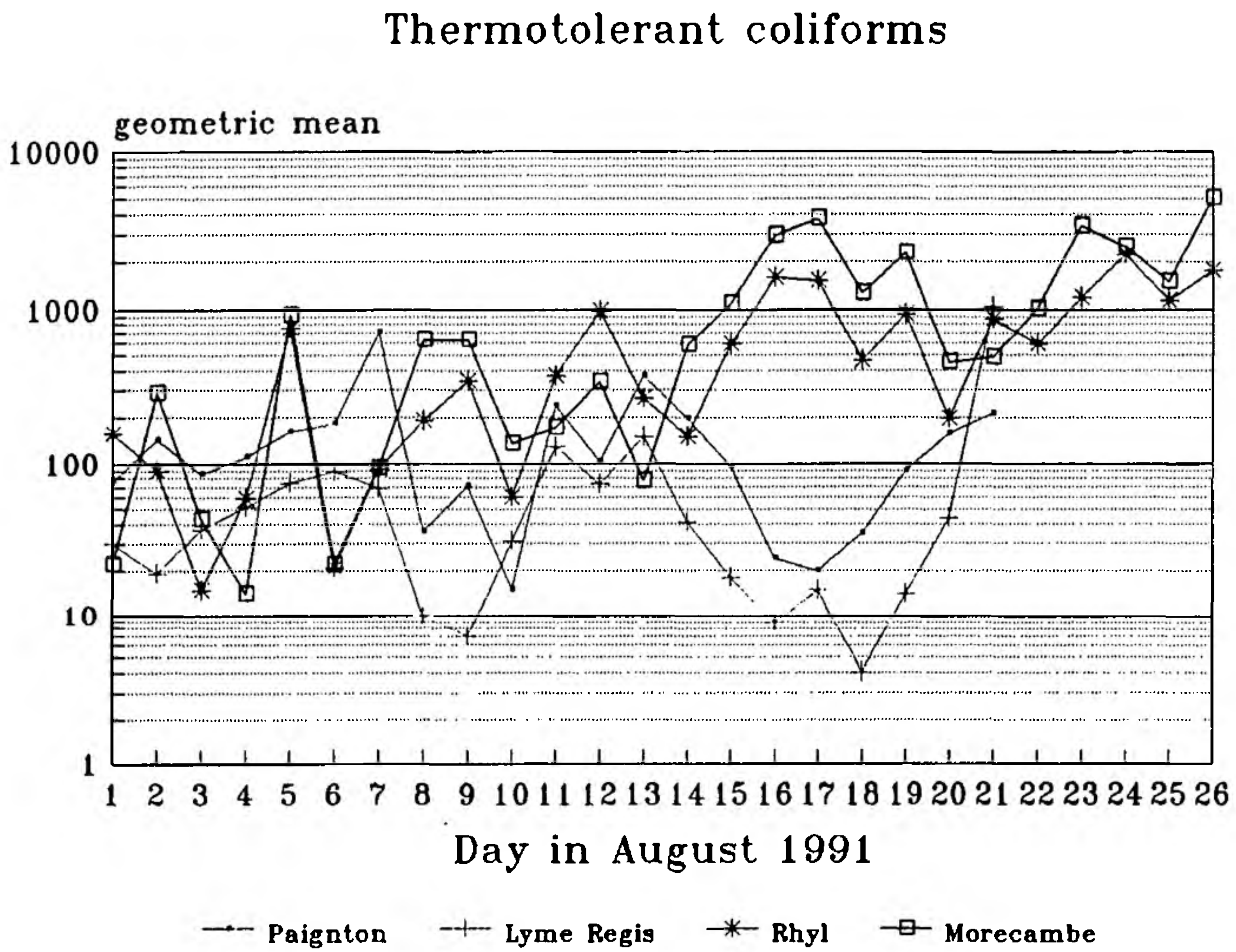
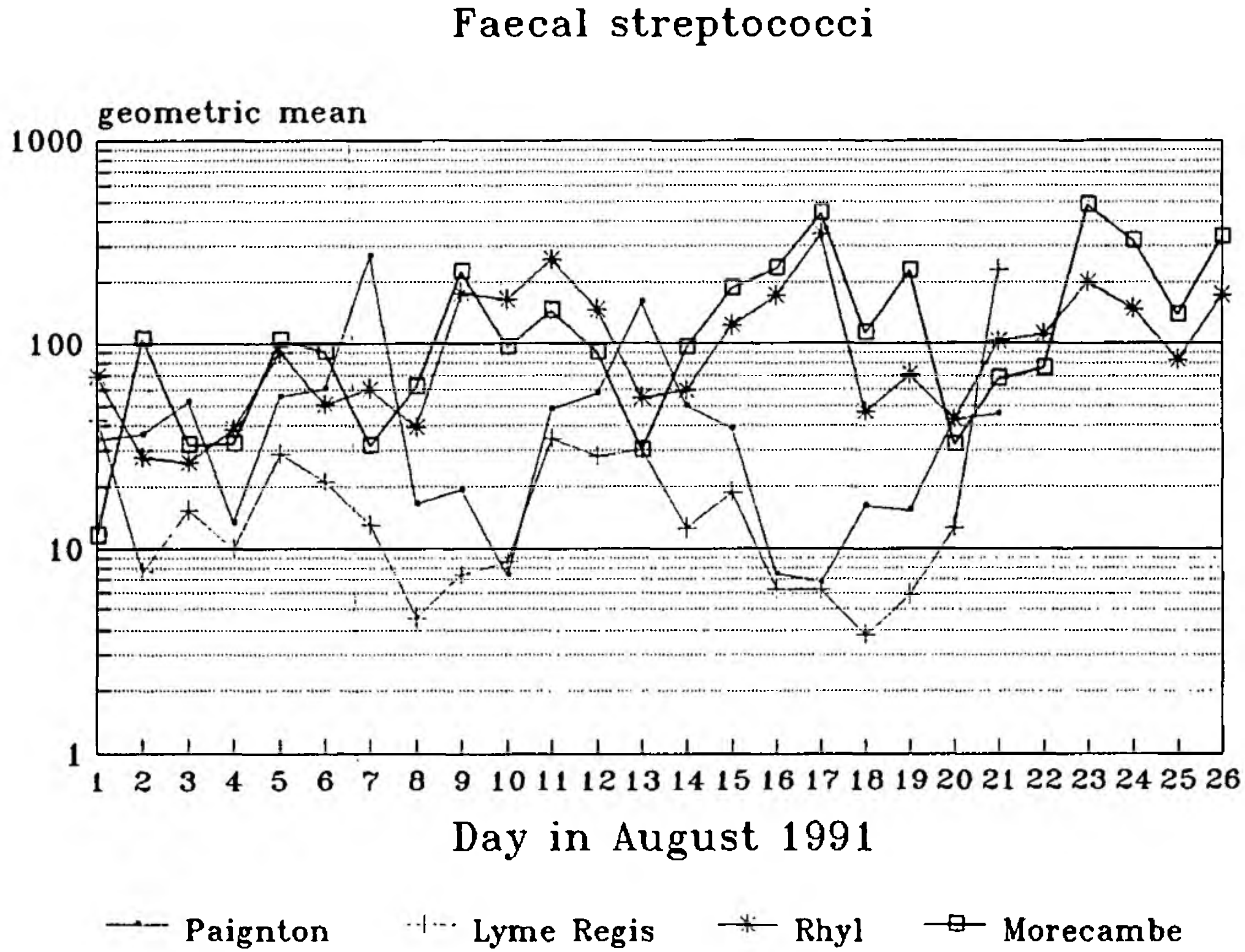


Fig 27(iii). Variations in bacterial indicators at 4 beaches daily geometric mean levels



**Reported symptoms and water quality**

Examination of the relationship between water quality at the four beaches and the risks of gastrointestinal illness and diarrhoea in exposed subjects suggested that there is an association between water quality and the incidence of symptoms, for all the three bacterial indicators examined (Figures 28-30). Incidence rates for gastrointestinal illness among bathers at the four beaches were plotted against the respective total coliform, thermotolerant coliform, and faecal streptococci levels (overall geometric means) (Figure 28). The beaches divide broadly into two quality groups as indicated, with a lower incidence of gastrointestinal illness among bathers at the beaches of better water quality. Gastrointestinal illness levels were highest in Morecambe, which also had the highest levels of thermotolerant coliforms and faecal streptococci.

A more formal analysis using the RR (adjusted for age and sex) confirmed this association (Figure 29).

Similar patterns were apparent also for diarrhoea (Figure 30).

The RRs calculated for all beaches combined (with the non-exposed in Paignton as the standard) confirmed the general trends observed by an examination of the symptoms beach by beach. In most circumstances the surfers/divers were at greatest risk; risks for waders and swimmers were elevated and similar. Those who visited beaches at Paignton and Lyme Regis had similar risks of reporting symptoms, which were lower than risks among those who visited Rhyl and Morecambe, the latter two sites carrying similar risks.

## Fig 28. Bacterial indicators and incidence of gastrointestinal symptoms at 4 beaches

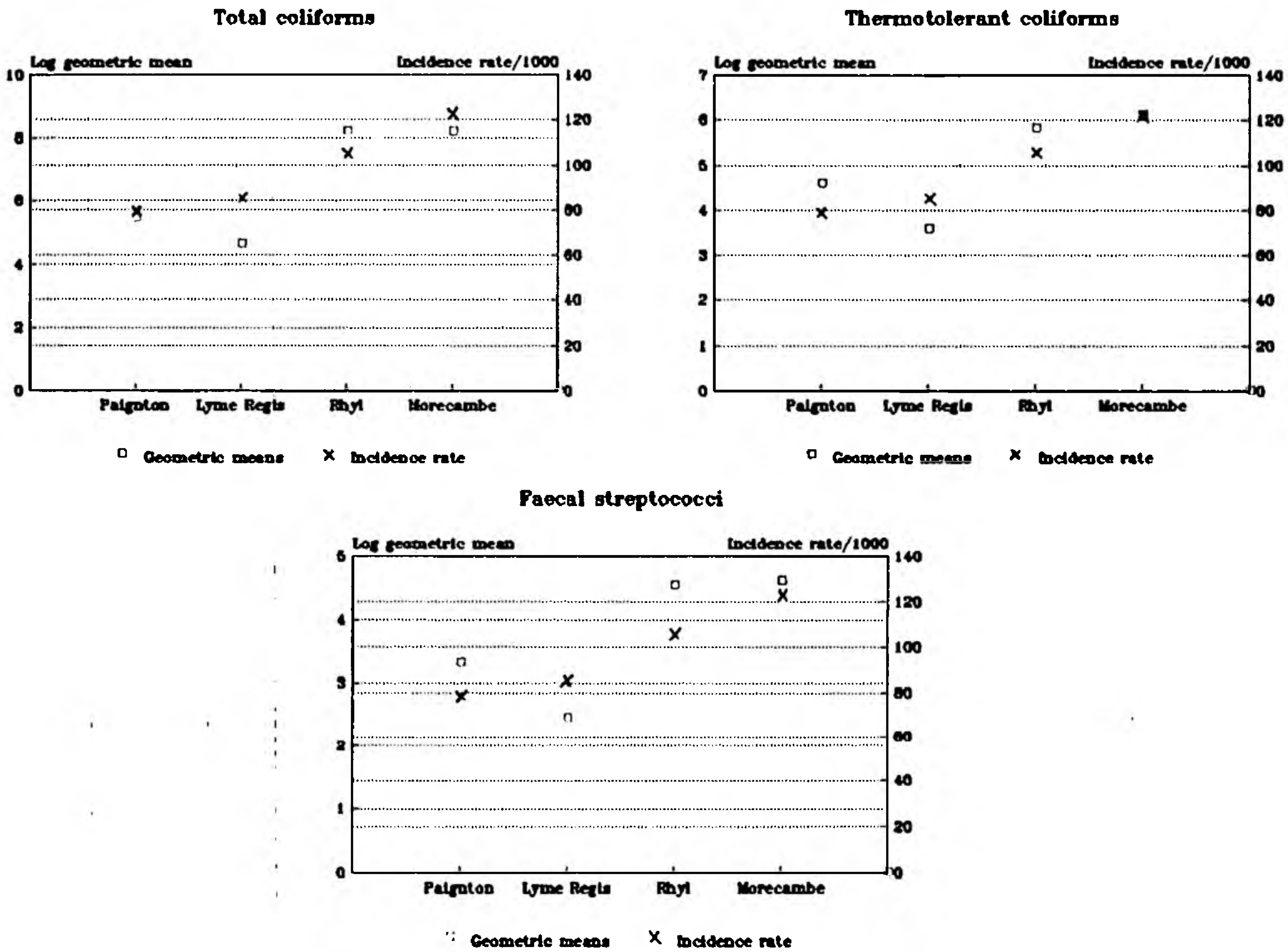


Fig 29. Bacterial indicators and relative risk of gastrointestinal symptoms at 4 beaches

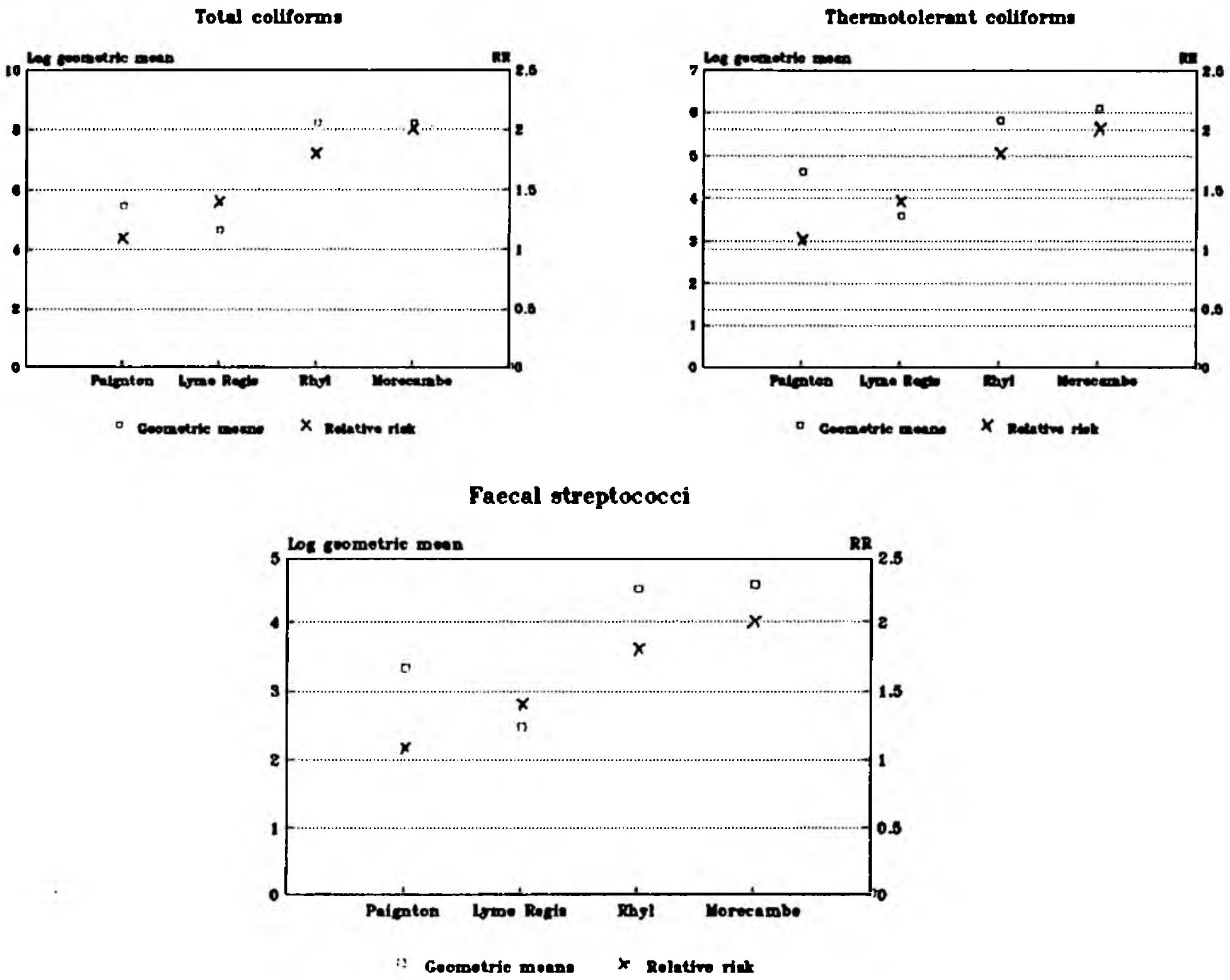
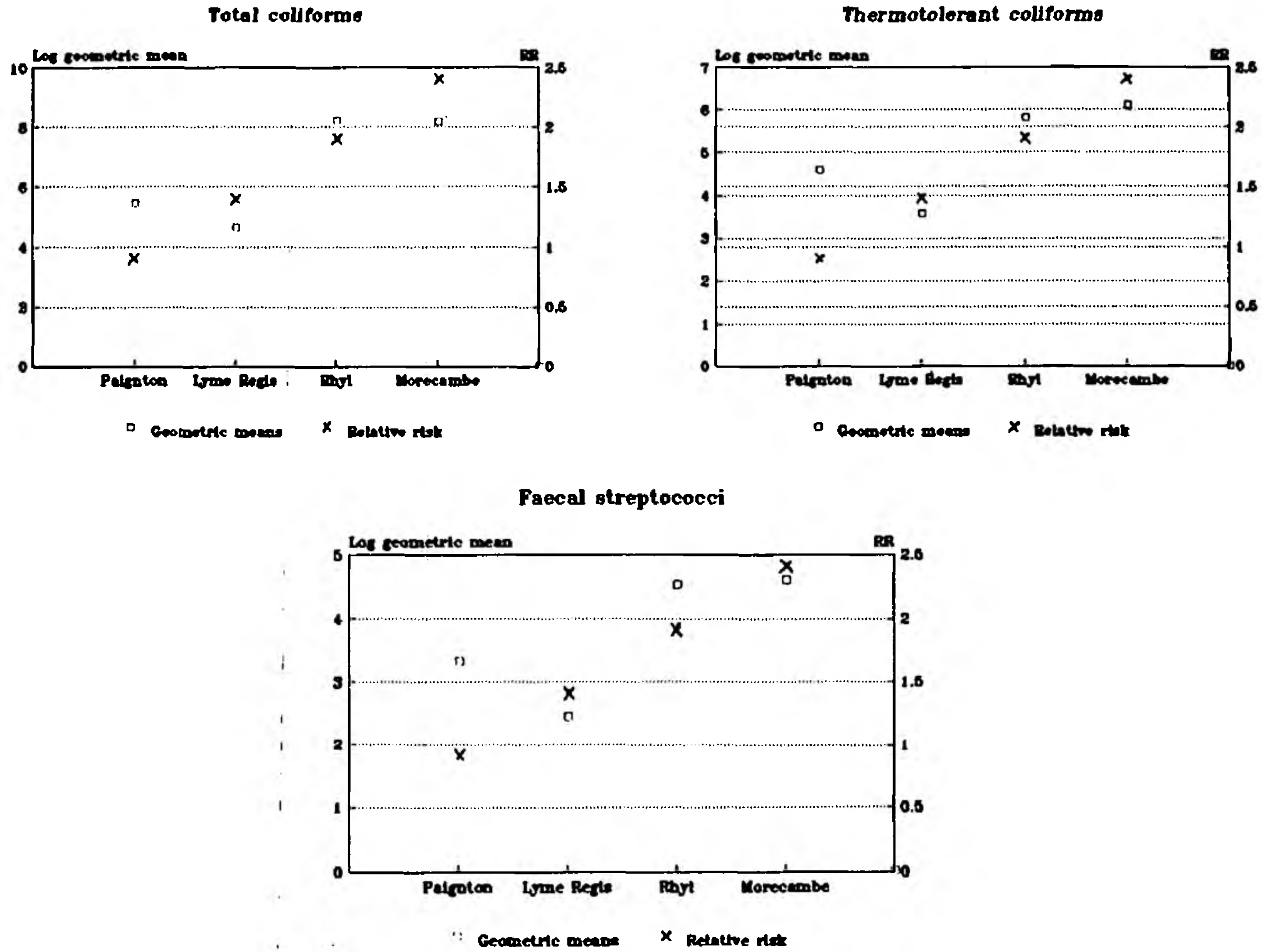


Fig 30. Bacterial indicators and relative risk of diarrhoea at 4 beaches



## CONCLUSIONS

1. There is a dose-response effect in the risk of reporting symptoms with increasing levels of seawater activity. Although the result is reasonably consistent for all major symptoms, it is also clear for gastrointestinal symptoms and diarrhoea which are felt to be of major importance.

2. For bathers a RR = 1.47 (95% CI 1.06-2.04) was reported at Ramsgate for gastrointestinal symptoms (Balarajan, Soni Raleigh, Yuen et al, 1991). In this study we obtain a very similar estimate of RR = 1.52 (95% CI 1.19-1.93) for the four beaches pooled together. For diarrhoea the comparative figures are RR = 1.88 (95% CI 1.18-2.99) for Ramsgate and RR = 1.55 (95% CI 1.10-2.19) for the four beaches of 1991.

3. The relative risk of reporting symptoms is raised in those beaches with the poorer seawater quality levels. RRs for the individual beaches studied in 1991 and for Ramsgate are given below. The findings indicate a dose-response relationship in terms of microbiological levels.

**RRs FOR GASTROINTESTINAL ILLNESS AND DIARRHOEA: RAMSGATE AND THE FOUR 1991 BEACHES**

| Location | RRs: gastrointestinal | RRs: diarrhoea |
|---|---|---|
| Ramsgate | 1.47 (1.06-2.04) | 1.88 (1.18-2.99) |
| Paignton | 1.09 (0.68-1.74) | 0.89 (0.46-1.74) |
| Lyme Regis | 1.40 (0.87-2.26) | 1.35 (0.69-2.66) |
| Rhyl | 1.76 (1.10-2.82) | 1.85 (0.97-3.55) |
| Morecambe | 2.03 (1.19-3.47) | 2.43 (1.17-5.05) |

4. The results of this prospective cohort study carried out at four beaches in 1991 are broadly in line with the results observed at Ramsgate in 1990. It is recognised for the less common symptoms that the establishment of associations (if they are indeed present) must await the final stage of this study to be conducted at four as yet unspecified beaches in 1992.

## RECOMMENDATIONS CONCERNING CHOICE OF 1992 BEACHES

1. Care should be taken to avoid the possibility of a substantially reduced sample size as occurred at Morecambe. It is important that at least two beaches should have poor water quality standards.

2. In terms of water quality, there is a north/south divide in the beaches chosen for 1991 and reported on here. It would be desirable to include at least one "good" beach from the north of England and one "poor" beach from the south to restore representativeness.

3. There are obvious areas of Britain that have not yet been studied, and these include Scotland and the eastern coast of England north of the Thames.

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# TABLES

**TABLE 1**
**PERCENT DISTRIBUTION OF RESPONDENTS BY AGE AND SEX**

**PAIGNTON**

| Age | Males | Females | Total |
|---|---|---|---|
| 5-14 | 22.5 | 25.6 | 24.1 |
| 15-24 | 17.9 | 18.7 | 18.3 |
| 25-34 | 20.5 | 23.3 | 22.0 |
| 35-44 | 27.3 | 22.2 | 24.6 |
| 45-54 | 9.9 | 8.1 | 9.0 |
| 55+ | 1.9 | 2.1 | 2.0 |
| Total | 956 (100%) | 1082 (100%) | 2038 (100%) |

**LYME REGIS**

| Age | Males | Females | Total |
|---|---|---|---|
| 5-14 | 30.2 | 24.8 | 27.5 |
| 15-24 | 14.7 | 14.4 | 14.5 |
| 25-34 | 18.7 | 22.4 | 20.6 |
| 35-44 | 26.2 | 28.7 | 27.5 |
| 45-54 | 8.6 | 7.1 | 7.8 |
| 55+ | 1.6 | 2.6 | 2.1 |
| Total | 1002 (100%) | 1063 (100%) | 2065 (100%) |

**RHYL**

| Age | Males | Females | Total |
|---|---|---|---|
| 5-14 | 43.7 | 34.8 | 38.8 |
| 15-24 | 14.0 | 13.8 | 13.9 |
| 25-34 | 19.1 | 25.7 | 22.7 |
| 35-44 | 16.3 | 16.9 | 16.6 |
| 45-54 | 5.5 | 6.5 | 6.0 |
| 55+ | 1.4 | 2.4 | 2.0 |
| Total | 897 (100%) | 1067 (100%) | 1964 (100%) |

**MORECAMBE**

| Age | Males | Females | Total |
|---|---|---|---|
| 5-14 | 24.3 | 12.8 | 17.6 |
| 15-24 | 14.3 | 20.8 | 18.1 |
| 25-34 | 24.0 | 29.9 | 27.5 |
| 35-44 | 23.4 | 23.9 | 23.7 |
| 45-54 | 11.2 | 9.3 | 10.1 |
| 55+ | 2.7 | 3.3 | 3.0 |
| Total | 329 (100%) | 461 (100%) | 790 (100%) |

**TABLE 2**
**PERCENT DISTRIBUTION OF TYPE OF RESPONDENTS BY AGE**

**PAIGNTON**

| Age | Holiday Makers | Day Trippers | Locals | Total |
|---|---|---|---|---|
| 5-14 | 21.3 | 30.6 | 25.3 | 24.1 |
| 15-24 | 16.7 | 18.0 | 26.4 | 18.3 |
| 25-34 | 23.7 | 19.3 | 19.2 | 22.0 |
| 35-44 | 27.0 | 23.0 | 16.1 | 24.6 |
| 45-54 | 9.4 | 7.5 | 9.6 | 9.0 |
| 55+ | 1.9 | 1.5 | 3.4 | 2.0 |
| Total | 1260 (100%) | 517 (100%) | 261 (100%) | 2038 (100%) |

**LYME REGIS**

| Age | Holiday Makers | Day Trippers | Locals | Total |
|---|---|---|---|---|
| 5-14 | 30.7 | 25.2 | 10.6 | 27.5 |
| 15-24 | 13.1 | 12.2 | 45.1 | 14.5 |
| 25-34 | 18.4 | 24.3 | 16.8 | 20.6 |
| 35-44 | 27.9 | 28.1 | 19.5 | 27.5 |
| 45-54 | 7.9 | 8.2 | 4.4 | 7.8 |
| 55+ | 2.0 | 2.1 | 3.5 | 2.1 |
| Total | 1157 (100%) | 795 (100%) | 113 (100%) | 2065 (100%) |

**RHYL**

| Age | Holiday Makers | Day Trippers | Locals | Total |
|---|---|---|---|---|
| 5-14 | 38.4 | 40.0 | 31.9 | 38.8 |
| 15-24 | 13.2 | 13.2 | 28.6 | 13.9 |
| 25-34 | 23.4 | 22.2 | 18.7 | 22.7 |
| 35-44 | 16.3 | 17.2 | 13.2 | 16.6 |
| 45-54 | 7.4 | 4.8 | 3.3 | 6.0 |
| 55+ | 1.2 | 2.6 | 4.4 | 2.0 |
| Total | 973 (100%) | 900 (100%) | 91 (100%) | 1964 (100%) |

**MORECAMBE**

| Age | Holiday Makers | Day Trippers | Locals | Total |
|---|---|---|---|---|
| 5-14 | 16.4 | 21.9 | 10.2 | 17.6 |
| 15-24 | 17.9 | 15.8 | 25.0 | 18.1 |
| 25-34 | 27.7 | 26.0 | 30.6 | 27.5 |
| 35-44 | 24.6 | 24.7 | 17.6 | 23.7 |
| 45-54 | 9.5 | 9.9 | 13.0 | 10.1 |
| 55+ | 3.8 | 1.7 | 3.7 | 3.0 |
| Total | 390 (100%) | 292 (100%) | 108 (100%) | 790 (100%) |

**TABLE 3**
**PERCENT DISTRIBUTION OF RESPONDENTS BY TYPE OF WATER ACTIVITY**

**PAIGNTON**

| Type of respondent | Non-exposed | Waders | Swimmers | Surfers/divers | Total |
|---|---|---|---|---|---|
| Holiday Makers | 14.4 | 36.1 | 39.8 | 9.7 | 1260 (100%) |
| Day Trippers | 27.5 | 27.1 | 37.3 | 8.1 | 517 (100%) |
| Locals | 19.2 | 21.1 | 39.1 | 20.7 | 261 (100%) |
| Total | 18.4 | 31.9 | 39.1 | 10.7 | 2038 (100%) |

**LYME REGIS**

| Type of respondent | Non-exposed | Waders | Swimmers | Surfers/divers | Total |
|---|---|---|---|---|---|
| Holiday Makers | 15.1 | 30.5 | 43.4 | 11.0 | 1157 (100%) |
| Day Trippers | 24.2 | 37.7 | 29.3 | 8.8 | 795 (100%) |
| Locals | 25.7 | 23.0 | 30.1 | 21.2 | 113 (100%) |
| Total | 19.2 | 32.9 | 37.2 | 10.7 | 2065 (100%) |

**RHYL**

| Type of respondent | Non-exposed | Waders | Swimmers | Surfers/divers | Total |
|---|---|---|---|---|---|
| Holiday Makers | 15.8 | 48.0 | 30.2 | 6.0 | 973 (100%) |
| Day Trippers | 19.0 | 51.0 | 25.6 | 4.4 | 900 (100%) |
| Locals | 38.5 | 36.3 | 14.3 | 11.0 | 91 (100%) |
| Total | 18.3 | 48.8 | 27.3 | 5.5 | 1964 (100%) |

**MORECAMBE**

| Type of respondent | Non-exposed | Waders | Swimmers | Surfers/divers | Total |
|---|---|---|---|---|---|
| Holiday Makers | 52.8 | 34.6 | 10.5 | 2.1 | 390 (100%) |
| Day Trippers | 49.0 | 40.8 | 7.5 | 2.7 | 292 (100%) |
| Locals | 67.6 | 16.7 | 4.6 | 11.1 | 108 (100%) |
| Total | 53.4 | 34.4 | 8.6 | 3.5 | 790 (100%) |

**TABLE 4**

**PERCENT DISTRIBUTION OF RESPONDENTS BY AGE & BY TYPE OF WATER ACTIVITY**

**PAIGNTON**

| Age | Non-exposed | Waders | Swimmers | Surfers/divers | Total |
|---|---|---|---|---|---|
| 5-14 | 4.0 | 18.3 | 35.2 | 35.8 | 24.1 |
| 15-24 | 21.7 | 15.2 | 18.2 | 22.0 | 18.3 |
| 25-34 | 24.6 | 27.5 | 18.2 | 14.7 | 22.0 |
| 35-44 | 34.2 | 26.9 | 19.8 | 18.3 | 24.6 |
| 45-54 | 11.2 | 10.0 | 7.3 | 8.3 | 9.0 |
| 55+ | 4.3 | 2.0 | 1.3 | 0.9 | 2.0 |
| Total | 374 (100%) | 650 (100%) | 796 (100%) | 218 (100%) | 2038 (100%) |

**LYME REGIS**

| Age | Non-exposed | Waders | Swimmers | Surfers/divers | Total |
|---|---|---|---|---|---|
| 5-14 | 2.3 | 19.6 | 44.6 | 37.1 | 27.5 |
| 15-24 | 12.4 | 11.0 | 15.3 | 26.2 | 14.5 |
| 25-34 | 25.3 | 27.1 | 13.8 | 15.8 | 20.6 |
| 35-44 | 42.9 | 32.5 | 18.5 | 15.8 | 27.5 |
| 45-54 | 13.6 | 6.8 | 6.8 | 4.1 | 7.8 |
| 55+ | 3.5 | 2.9 | 1.0 | 0.9 | 2.1 |
| Total | 396 (100%) | 679 (100%) | 769 (100%) | 221 (100%) | 2065 (100%) |

**RHYL**

| Age | Non-exposed | Waders | Swimmers | Surfers/divers | Total |
|---|---|---|---|---|---|
| 5-14 | 2.8 | 37.6 | 62.6 | 51.9 | 38.8 |
| 15-24 | 14.4 | 13.1 | 13.6 | 20.4 | 13.9 |
| 25-34 | 33.9 | 25.4 | 12.3 | 12.0 | 22.7 |
| 35-44 | 31.7 | 15.8 | 8.4 | 13.9 | 16.6 |
| 45-54 | 11.9 | 6.2 | 2.6 | 1.9 | 6.0 |
| 55+ | 5.3 | 1.8 | 0.6 | | 2.0 |
| Total | 360 (100%) | 959 (100%) | 537 (100%) | 108 (100%) | 1964 (100%) |

**MORECAMBE**

| Age | Non-exposed | Waders | Swimmers | Surfers/divers | Total |
|---|---|---|---|---|---|
| 5-14 | 5.0 | 30.1 | 42.6 | 25.0 | 17.6 |
| 15-24 | 16.6 | 17.3 | 26.5 | 28.6 | 18.1 |
| 25-34 | 31.8 | 25.0 | 11.8 | 25.0 | 27.5 |
| 35-44 | 30.1 | 18.4 | 10.3 | 10.7 | 23.7 |
| 45-54 | 12.3 | 7.4 | 7.4 | 10.7 | 10.1 |
| 55+ | 4.3 | 1.8 | 1.5 | | 3.0 |
| Total | 422 (100%) | 272 (100%) | 68 (100%) | 28 (100%) | 790 (100%) |

**TABLE 5**

**INCIDENCE OF MAJOR SYMPTOMS BY TYPE OF WATER ACTIVITY**

**PAIGNTON**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 147 | 503 | 226 |
| Swimmers | 181 | 615 | 227 |
| Surfers/divers | 69 | 149 | 317 |
| | | | |
| Water activity | 397 | 1267 | 239 |
| Non-exposed | 73 | 301 | 195 |
| TOTAL | 470 | 1568 | 231 |

**LYME REGIS**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 157 | 522 | 231 |
| Swimmers | 168 | 601 | 218 |
| Surfers/divers | 65 | 156 | 294 |
| | | | |
| Water activity | 390 | 1279 | 234 |
| Non-exposed | 81 | 315 | 205 |
| TOTAL | 471 | 1594 | 228 |

**RHYL**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 248 | 711 | 259 |
| Swimmers | 149 | 388 | 277 |
| Surfers/divers | 29 | 79 | 269 |
| | | | |
| Water activity | 426 | 1178 | 266 |
| Non-exposed | 96 | 264 | 267 |
| TOTAL | 522 | 1442 | 266 |

**MORECAMBE**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 79 | 193 | 290 |
| Swimmers | 19 | 49 | 279 |
| Surfers/divers | 10 | 18 | 357 |
| | | | |
| Water activity | 108 | 260 | 293 |
| Non-exposed | 99 | 323 | 235 |
| TOTAL | 207 | 583 | 262 |

TABLE 6

INCIDENCE OF MAJOR SYMPTOMS BY WATER ACTIVITY AND AGE

PAIGNTON

| Age | Non-exposed Rate per 1000 | Water activity Rate per 1000 |
|---|---|---|
| 5-14 | 400 | 264 |
| 15-24 | 296 | 284 |
| 25-34 | 163 | 256 |
| 35-44 | 133 | 185 |
| 45-54 | 190 | 184 |
| 55+ | 188 | 80 |
| Total | 195 | 239 |

LYME REGIS

| Age | Non-exposed Rate per 1000 | Water activity Rate per 1000 |
|---|---|---|
| 5-14 | 444 | 244 |
| 15-24 | 245 | 263 |
| 25-34 | 200 | 271 |
| 35-44 | 200 | 221 |
| 45-54 | 185 | 56 |
| 55+ | 71 | 200 |
| Total | 205 | 234 |

RHYL

| Age | Non-exposed Rate per 1000 | Water activity Rate per 1000 |
|---|---|---|
| 5-14 | 700 | 247 |
| 15-24 | 346 | 339 |
| 25-34 | 270 | 272 |
| 35-44 | 219 | 231 |
| 45-54 | 140 | 307 |
| 55+ | 368 | 250 |
| Total | 267 | 266 |

MORECAMBE

| Age | Non-exposed Rate per 1000 | Water activity Rate per 1000 |
|---|---|---|
| 5-14 | 429 | 254 |
| 15-24 | 257 | 329 |
| 25-34 | 291 | 386 |
| 35-44 | 220 | 233 |
| 45-54 | 96 | 214 |
| 55+ | - | 333 |
| Total | 235 | 293 |

**TABLE 7**

**INCIDENCE OF EYE SYMPTOMS BY TYPE OF WATER ACTIVITY**

**PAIGNTON**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 18 | 632 | 28 |
| Swimmers | 30 | 766 | 38 |
| Surfers/divers | 13 | 205 | 60 |
| | | | |
| Water activity | 61 | 1603 | 37 |
| Non-exposed | 7 | 367 | 19 |
| TOTAL | 68 | 1970 | 33 |

**LYME REGIS**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 20 | 659 | 29 |
| Swimmers | 34 | 735 | 44 |
| Surfers/divers | 12 | 209 | 54 |
| | | | |
| Water activity | 66 | 1603 | 40 |
| Non-exposed | 19 | 377 | 48 |
| TOTAL | 85 | 1980 | 41 |

**RHYL**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 34 | 925 | 35 |
| Swimmers | 31 | 506 | 58 |
| Surfers/divers | 3 | 105 | 28 |
| | | | |
| Water activity | 68 | 1536 | 42 |
| Non-exposed | 20 | 340 | 56 |
| TOTAL | 88 | 1876 | 45 |

**MORECAMBE**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 6 | 266 | 22 |
| Swimmers | 1 | 67 | 15 |
| Surfers/divers | 2 | 26 | 71 |
| | | | |
| Water activity | 9 | 359 | 24 |
| Non-exposed | 25 | 397 | 59 |
| TOTAL | 34 | 756 | 43 |

**TABLE 8**

**INCIDENCE OF EAR, NOSE AND THROAT SYMPTOMS BY TYPE OF WATER ACTIVITY**

**PAIGNTON**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 87 | 563 | 134 |
| Swimmers | 110 | 686 | 138 |
| Surfers/divers | 39 | 179 | 179 |
| Water activity | 236 | 1428 | 142 |
| Non-exposed | 40 | 334 | 107 |
| TOTAL | 276 | 1762 | 135 |

**LYME REGIS**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 93 | 586 | 137 |
| Swimmers | 87 | 682 | 113 |
| Surfers/divers | 42 | 179 | 190 |
| Water activity | 222 | 1447 | 133 |
| Non-exposed | 41 | 355 | 104 |
| TOTAL | 263 | 1802 | 127 |

**RHYL**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 136 | 823 | 142 |
| Swimmers | 82 | 455 | 153 |
| Surfers/divers | 16 | 92 | 148 |
| Water activity | 234 | 1370 | 146 |
| Non-exposed | 61 | 299 | 169 |
| TOTAL | 295 | 1669 | 150 |

**MORECAMBE**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 41 | 231 | 151 |
| Swimmers | 9 | 59 | 132 |
| Surfers/divers | 9 | 19 | 321 |
| Water activity | 59 | 309 | 160 |
| Non-exposed | 61 | 361 | 145 |
| TOTAL | 120 | 670 | 152 |

**TABLE 9**

**INCIDENCE OF RESPIRATORY SYMPTOMS BY TYPE OF WATER ACTIVITY**

**PAIGNTON**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 52 | 598 | 80 |
| Swimmers | 49 | 747 | 62 |
| Surfers/divers | 20 | 198 | 92 |
| | | | |
| Water activity | 121 | 1543 | 73 |
| Non-exposed | 25 | 349 | 67 |
| TOTAL | 146 | 1892 | 72 |

**LYME REGIS**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 43 | 636 | 63 |
| Swimmers | 55 | 714 | 72 |
| Surfers/divers | 16 | 205 | 72 |
| | | | |
| Water activity | 114 | 1555 | 68 |
| Non-exposed | 27 | 369 | 68 |
| TOTAL | 141 | 1924 | 68 |

**RHYL**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 80 | 879 | 83 |
| Swimmers | 47 | 490 | 88 |
| Surfers/divers | 14 | 94 | 130 |
| | | | |
| Water activity | 141 | 1463 | 88 |
| Non-exposed | 40 | 320 | 111 |
| TOTAL | 181 | 1783 | 92 |

**MORECAMBE**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 28 | 244 | 103 |
| Swimmers | 6 | 62 | 88 |
| Surfers/divers | 5 | 23 | 179 |
| | | | |
| Water activity | 39 | 329 | 106 |
| Non-exposed | 35 | 387 | 83 |
| TOTAL | 74 | 716 | 94 |

TABLE 10

INCIDENCE OF GASTROINTESTINAL SYMPTOMS BY TYPE OF WATER ACTIVITY

**PAIGNTON**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 48 | 602 | 74 |
| Swimmers | 52 | 744 | 65 |
| Surfers/divers | 29 | 189 | 133 |
| Water activity | 129 | 1535 | 78 |
| Non-exposed | 24 | 350 | 64 |
| TOTAL | 153 | 1885 | 75 |

**LYME REGIS**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 57 | 622 | 84 |
| Swimmers | 58 | 711 | 75 |
| Surfers/divers | 27 | 194 | 122 |
| Water activity | 142 | 1527 | 85 |
| Non-exposed | 23 | 373 | 58 |
| TOTAL | 165 | 1900 | 80 |

**RHYL**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 102 | 857 | 106 |
| Swimmers | 56 | 481 | 104 |
| Surfers/divers | 10 | 98 | 93 |
| Water activity | 168 | 1436 | 105 |
| Non-exposed | 24 | 336 | 67 |
| TOTAL | 192 | 1772 | 98 |

**MORECAMBE**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 31 | 241 | 114 |
| Swimmers | 10 | 58 | 147 |
| Surfers/divers | 4 | 24 | 143 |
| Water activity | 45 | 323 | 122 |
| Non-exposed | 27 | 395 | 64 |
| TOTAL | 72 | 718 | 91 |

**TABLE 11**

**INCIDENCE OF DIARRHOEA BY TYPE OF WATER ACTIVITY**

**PAIGNTON**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 20 | 630 | 31 |
| Swimmers | 18 | 778 | 23 |
| Surfers/divers | 10 | 208 | 46 |
| | | | |
| Water activity | 48 | 1616 | 29 |
| Non-exposed | 12 | 362 | 32 |
| TOTAL | 60 | 1978 | 29 |

**LYME REGIS**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 27 | 652 | 40 |
| Swimmers | 20 | 749 | 26 |
| Surfers/divers | 14 | 207 | 63 |
| | | | |
| Water activity | 61 | 1608 | 37 |
| Non-exposed | 11 | 385 | 28 |
| TOTAL | 72 | 1993 | 35 |

**RHYL**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 55 | 904 | 57 |
| Swimmers | 18 | 519 | 34 |
| Surfers/divers | 2 | 106 | 19 |
| | | | |
| Water activity | 75 | 1529 | 47 |
| Non-exposed | 12 | 348 | 33 |
| TOTAL | 87 | 1877 | 44 |

**MORECAMBE**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 18 | 254 | 66 |
| Swimmers | 4 | 64 | 59 |
| Surfers/divers | 1 | 27 | 36 |
| | | | |
| Water activity | 23 | 345 | 63 |
| Non-exposed | 13 | 409 | 31 |
| TOTAL | 36 | 754 | 46 |

**TABLE 12**
**INCIDENCE OF SKIN SYMPTOMS BY TYPE OF WATER ACTIVITY**

**PAIGNTON**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 25 | 625 | 38 |
| Swimmers | 34 | 762 | 43 |
| Surfers/divers | 18 | 200 | 83 |
| Water activity | 77 | 1587 | 46 |
| Non-exposed | 13 | 361 | 35 |
| TOTAL | 90 | 1948 | 44 |

**LYME REGIS**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 26 | 653 | 38 |
| Swimmers | 31 | 738 | 40 |
| Surfers/divers | 11 | 210 | 50 |
| Water activity | 68 | 1601 | 41 |
| Non-exposed | 4 | 392 | 10 |
| TOTAL | 72 | 1993 | 35 |

**RHYL**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 41 | 918 | 43 |
| Swimmers | 31 | 506 | 58 |
| Surfers/divers | 5 | 103 | 46 |
| Water activity | 77 | 1527 | 48 |
| Non-exposed | 16 | 344 | 44 |
| TOTAL | 93 | 1871 | 47 |

**MORECAMBE**

| Activity | Yes | No | Rate per 1000 |
|---|---|---|---|
| Waders | 11 | 261 | 40 |
| Swimmers | 2 | 66 | 29 |
| Surfers/divers | 3 | 25 | 107 |
| Water activity | 16 | 352 | 43 |
| Non-exposed | 19 | 403 | 45 |
| TOTAL | 35 | 755 | 44 |

**TABLE 13**

**LOGISTIC REGRESSION ANALYSIS USING DICHOTOMISED EXPOSURE AND AGE AND SEX***

**PAIGNTON**

| **Symptoms** | **Relative risk** |
|---|---|
| Major symptoms | 1.18 (0.89-1.58) |
| Eye | 2.00 (0.89-4.45) |
| Ear, nose & throat | 1.32 (0.92-1.91) |
| Respiratory | 1.02 (0.64-1.62) |
| Gastrointestinal | 1.09 (0.68-1.74) |
| Diarrhoea | 0.89 (0.46-1.74) |
| Skin | 1.22 (0.66-2.27) |

**LYME REGIS**

| **Symptoms** | **Relative risk** |
|---|---|
| Major symptoms | 1.08 (0.81-1.43) |
| Eye | 0.78 (0.45-1.35) |
| Ear, nose & throat | 1.13 (0.78-1.64) |
| Respiratory | 0.78 (0.49-1.25) |
| Gastrointestinal | 1.40 (0.87-2.26) |
| Diarrhoea | 1.35 (0.69-2.66) |
| Skin | 3.86 (1.38-10.85) |

**RHYL**

| **Symptoms** | **Relative risk** |
|---|---|
| Major symptoms | 1.00 (0.76-1.33) |
| Eye | 0.71 (0.41-1.26) |
| Ear, nose & throat | 0.89 (0.64-1.24) |
| Respiratory | 0.73 (0.49-1.10) |
| Gastrointestinal | 1.76 (1.10-2.82) |
| Diarrhoea | 1.85 (0.97-3.55) |
| Skin | 1.36 (0.76-2.43) |

**MORECAMBE**

| **Symptoms** | **Relative risk** |
|---|---|
| Major symptoms | 1.28 (0.91-1.82) |
| Eye | 0.35 (0.15-0.82) |
| Ear, nose & throat | 0.96 (0.63-1.47) |
| Respiratory | 1.40 (0.84-2.35) |
| Gastrointestinal | 2.03 (1.19-3.47) |
| Diarrhoea | 2.43 (1.17-5.05) |
| Skin | 1.01 (0.48-2.11) |

* Non-exposed = 1.00, 95% confidence intervals in parentheses.

**TABLE 14**

**LOGISTIC REGRESSION ANALYSIS INCLUDING ACTUAL EXPOSURE AND AGE AND SEX: MAJOR SYMPTOMS**

| **PAIGNTON** | | **Estimate** | **SE** | **RR** | **95% CI** | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | 0.14 | 0.16 | 1.14 | 0.83 | 1.58 |
| | Swimmers | 0.09 | 0.16 | 1.09 | 0.8 | 1.5 |
| | Surfers/Divers | 0.56 | 0.2 | 1.75 | 1.17 | 2.61 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | 0.13 | 0.16 | 1.13 | 0.83 | 1.54 |
| | 25-34 | -0.12 | 0.16 | 0.89 | 0.66 | 1.21 |
| | 35-44 | -0.51 | 0.16 | 0.6 | 0.44 | 0.83 |
| | 45-54 | -0.42 | 0.22 | 0.66 | 0.43 | 1.01 |
| | 55+ | -0.89 | 0.49 | 0.41 | 0.16 | 1.08 |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0.13 | 0.11 | 1.14 | 0.92 | 1.42 |

| **LYME REGIS** | | **Estimate** | **SE** | **RR** | **95% CI** | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | 0.08 | 0.16 | 1.08 | 0.79 | 1.47 |
| | Swimmers | -0.02 | 0.16 | 0.98 | 0.71 | 1.35 |
| | Surfers/Divers | 0.36 | 0.21 | 1.43 | 0.96 | 2.14 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | 0.04 | 0.17 | 1.04 | 0.75 | 1.45 |
| | 25-34 | 0.03 | 0.16 | 1.04 | 0.76 | 1.41 |
| | 35-44 | -0.17 | 0.15 | 0.84 | 0.63 | 1.13 |
| | 45-54 | -1.07 | 0.29 | 0.34 | 0.2 | 0.6 |
| | 55+ | -0.55 | 0.43 | 0.58 | 0.25 | 1.34 |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0.05 | 0.11 | 1.05 | 0.85 | 1.3 |

**TABLE 14 CONTINUED**

| **RHYL** | | **Estimate** | **SE** | **RR** | **95% CI** | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | -0.04 | 0.15 | 0.96 | 0.72 | 1.28 |
| | Swimmers | 0.12 | 0.17 | 1.12 | 0.8 | 1.57 |
| | Surfers/Divers | 0.06 | 0.26 | 1.07 | 0.64 | 1.77 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | 0.43 | 0.16 | 1.54 | 1.13 | 2.09 |
| | 25-34 | 0.11 | 0.14 | 1.11 | 0.84 | 1.48 |
| | 35-44 | -0.12 | 0.17 | 0.89 | 0.64 | 1.23 |
| | 45-54 | -0.02 | 0.24 | 0.98 | 0.62 | 1.56 |
| | 55+ | 0.28 | 0.37 | 1.32 | 0.64 | 2.7 |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0.24 | 0.11 | 1.27 | 1.03 | 1.56 |

| **MORECAMBE** | | **Estimate** | **SE** | **RR** | **95% CI** | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | 0.21 | 0.19 | 1.24 | 0.85 | 1.79 |
| | Swimmers | 0.22 | 0.31 | 1.25 | 0.68 | 2.3 |
| | Surfers/Divers | 0.62 | 0.43 | 1.87 | 0.81 | 4.31 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | 0.08 | 0.28 | 1.08 | 0.63 | 1.85 |
| | 25-34 | 0.28 | 0.26 | 1.33 | 0.8 | 2.19 |
| | 35-44 | -0.21 | 0.28 | 0.81 | 0.47 | 1.4 |
| | 45-54 | -0.81 | 0.39 | 0.44 | 0.21 | 0.95 |
| | 55+ | -1.35 | 0.77 | 0.26 | 0.06 | 1.17 |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0.23 | 0.18 | 1.25 | 0.89 | 1.77 |

**TABLE 15**

**LOGISTIC REGRESSION ANALYSIS INCLUDING ACTUAL EXPOSURE AND AGE AND SEX: EYE SYMPTOMS**

| **PAIGNTON** | | **Estimate** | **SE** | **RR** | **95% CI** | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | 0.39 | 0.45 | 1.48 | 0.61 | 3.59 |
| | Swimmers | 0.76 | 0.43 | 2.14 | 0.91 | 5.01 |
| | Surfers/Divers | 1.31 | 0.49 | 3.72 | 1.41 | 9.77 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | 0.44 | 0.36 | 1.56 | 0.78 | 3.12 |
| | 25-34 | 0.2 | 0.37 | 1.22 | 0.59 | 2.53 |
| | 35-44 | -0.28 | 0.42 | 0.75 | 0.33 | 1.7 |
| | 45-54 | 0.49 | 0.45 | 1.64 | 0.68 | 3.94 |
| | 55+ | -0.01 | 1.05 | 0.99 | 0.13 | 7.72 |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0.43 | 0.26 | 1.53 | 0.92 | 2.56 |

| **LYME REGIS** | | **Estimate** | **SE** | **RR** | **95% CI** | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | -0.53 | 0.33 | 0.59 | 0.31 | 1.13 |
| | Swimmers | -0.07 | 0.32 | 0.93 | 0.5 | 1.74 |
| | Surfers/Divers | 0.13 | 0.41 | 1.14 | 0.51 | 2.52 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | 0.2 | 0.35 | 1.22 | 0.62 | 2.41 |
| | 25-34 | -0.01 | 0.35 | 0.99 | 0.5 | 1.97 |
| | 35-44 | 0.22 | 0.31 | 1.25 | 0.67 | 2.31 |
| | 45-54 | -1.2 | 0.75 | 0.3 | 0.07 | 1.31 |
| | 55+ | 0.2 | 0.77 | 1.22 | 0.27 | 5.48 |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0.07 | 0.23 | 1.07 | 0.68 | 1.68 |

**TABLE 15 CONTINUED**

| **RHYL** | | **Estimate** | **SE** | **RR** | **95% CI** | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | -0.48 | 0.3 | 0.62 | 0.34 | 1.13 |
| | Swimmers | 0.06 | 0.34 | 1.06 | 0.55 | 2.06 |
| | Surfers/Divers | -0.72 | 0.65 | 0.48 | 0.14 | 1.72 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | 0.54 | 0.31 | 1.72 | 0.94 | 3.14 |
| | 25-34 | -0.03 | 0.32 | 0.97 | 0.51 | 1.83 |
| | 35-44 | -0.24 | 0.38 | 0.79 | 0.37 | 1.67 |
| | 45-54 | -0.00 | 0.51 | 1 | 0.36 | 2.72 |
| | 55+ | 0.58 | 0.65 | 1.78 | 0.49 | 6.4 |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0.16 | 0.23 | 1.17 | 0.75 | 1.83 |

| **MORECAMBE** | | **Estimate** | **SE** | **RR** | **95% CI** | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | -1.22 | 0.49 | 0.29 | 0.11 | 0.77 |
| | Swimmers | -1.49 | 1.06 | 0.23 | 0.03 | 1.81 |
| | Surfers/Divers | 0.36 | 0.8 | 1.43 | 0.3 | 6.93 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | -0.6 | 0.68 | 0.55 | 0.15 | 2.06 |
| | 25-34 | -0.05 | 0.58 | 0.95 | 0.3 | 2.99 |
| | 35-44 | -0.36 | 0.62 | 0.69 | 0.21 | 2.35 |
| | 45-54 | -1.74 | 1.13 | 0.18 | 0.02 | 1.61 |
| | 55+ | -8.51 | 30.67 | 0 | 0 | |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0.56 | 0.39 | 1.75 | 0.81 | 3.78 |

**TABLE 16**

**LOGISTIC REGRESSION ANALYSIS INCLUDING ACTUAL EXPOSURE AND AGE AND SEX: EAR, NOSE & THROAT**

| **PAIGNTON** | | **Estimate** | **SE** | **RR** | **95% CI** | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | 0.25 | 0.21 | 1.28 | 0.85 | 1.92 |
| | Swimmers | 0.23 | 0.2 | 1.26 | 0.84 | 1.88 |
| | Surfers/Divers | 0.55 | 0.25 | 1.74 | 1.06 | 2.86 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | 0.49 | 0.18 | 1.63 | 1.14 | 2.33 |
| | 25-34 | -0.09 | 0.2 | 0.91 | 0.62 | 1.34 |
| | 35-44 | -0.38 | 0.2 | 0.68 | 0.46 | 1.01 |
| | 45-54 | -0.67 | 0.31 | 0.51 | 0.28 | 0.94 |
| | 55+ | -0.68 | 0.62 | 0.51 | 0.15 | 1.7 |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0.19 | 0.13 | 1.21 | 0.93 | 1.57 |

| **LYME REGIS** | | **Estimate** | **SE** | **RR** | **95% CI** | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | 0.19 | 0.2 | 1.21 | 0.82 | 1.81 |
| | Swimmers | -0.12 | 0.22 | 0.89 | 0.58 | 1.36 |
| | Surfers/Divers | 0.47 | 0.25 | 1.59 | 0.97 | 2.62 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | -0.04 | 0.2 | 0.96 | 0.65 | 1.43 |
| | 25-34 | -0.09 | 0.19 | 0.91 | 0.63 | 1.33 |
| | 35-44 | -0.5 | 0.2 | 0.61 | 0.41 | 0.89 |
| | 45-54 | -1.23 | 0.39 | 0.29 | 0.14 | 0.63 |
| | 55+ | -0.62 | 0.54 | 0.54 | 0.19 | 1.56 |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0 | 0.14 | 1 | 0.77 | 1.31 |

**TABLE 16 CONTINUED**

| **RHYL** | | **Estimate** | **SE** | **RR** | **95% CI** | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | -0.16 | 0.18 | 0.85 | 0.6 | 1.2 |
| | Swimmers | -0.00 | 0.21 | 1 | 0.67 | 1.5 |
| | Surfers/Divers | -0.07 | 0.32 | 0.93 | 0.5 | 1.74 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | 0.62 | 0.19 | 1.86 | 1.29 | 2.67 |
| | 25-34 | 0.23 | 0.18 | 1.25 | 0.88 | 1.79 |
| | 35-44 | 0.02 | 0.21 | 1.02 | 0.68 | 1.53 |
| | 45-54 | 0.12 | 0.29 | 1.13 | 0.63 | 2 |
| | 55+ | 0.52 | 0.42 | 1.69 | 0.74 | 3.86 |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0.14 | 0.13 | 1.16 | 0.89 | 1.49 |

**MORECAMBE**

| | | **Estimate** | **SE** | **RR** | **95% CI** | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | -0.12 | 0.24 | 0.89 | 0.56 | 1.41 |
| | Swimmers | -0.33 | 0.4 | 0.72 | 0.33 | 1.59 |
| | Surfers/Divers | 0.89 | 0.45 | 2.43 | 1.01 | 5.85 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | 0.1 | 0.32 | 1.11 | 0.59 | 2.07 |
| | 25-34 | -0.19 | 0.31 | 0.83 | 0.45 | 1.53 |
| | 35-44 | -0.52 | 0.34 | 0.6 | 0.31 | 1.16 |
| | 45-54 | -1.08 | 0.49 | 0.34 | 0.13 | 0.89 |
| | 55+ | -8.86 | 21.45 | 0 | 0 | |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0.12 | 0.22 | 1.12 | 0.74 | 1.72 |

**TABLE 17**

**LOGISTIC REGRESSION ANALYSIS INCLUDING ACTUAL EXPOSURE AND AGE AND SEX: RESPIRATORY**

| PAIGNTON | | Estimate | SE | RR | 95% CI | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | 0.19 | 0.26 | 1.21 | 0.73 | 2 |
| | Swimmers | -0.21 | 0.27 | 0.81 | 0.48 | 1.36 |
| | Surfers/Divers | 0.18 | 0.33 | 1.2 | 0.63 | 2.28 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | 0.4 | 0.23 | 1.5 | 0.95 | 2.37 |
| | 25-34 | -0.35 | 0.26 | 0.71 | 0.42 | 1.19 |
| | 35-44 | -0.67 | 0.28 | 0.51 | 0.3 | 0.89 |
| | 45-54 | -0.86 | 0.42 | 0.42 | 0.18 | 0.97 |
| | 55+ | -0.17 | 0.63 | 0.84 | 0.25 | 2.9 |
| Sex: | Males | 0 | | 1 | | |
| | Females | -0.03 | 0.18 | 0.97 | 0.69 | 1.37 |

| LYME REGIS | | Estimate | SE | RR | 95% CI | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | -0.23 | 0.26 | 0.8 | 0.48 | 1.33 |
| | Swimmers | -0.27 | 0.27 | 0.77 | 0.45 | 1.3 |
| | Surfers/Divers | -0.23 | 0.35 | 0.8 | 0.4 | 1.59 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | -0.01 | 0.25 | 0.99 | 0.6 | 1.62 |
| | 25-34 | -0.59 | 0.27 | 0.55 | 0.33 | 0.94 |
| | 35-44 | -0.71 | 0.26 | 0.49 | 0.3 | 0.82 |
| | 45-54 | -0.87 | 0.42 | 0.42 | 0.18 | 0.97 |
| | 55+ | -0.86 | 0.75 | 0.42 | 0.1 | 1.82 |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0.22 | 0.18 | 1.25 | 0.88 | 1.78 |

TABLE 17 CONTINUED

| RHYL | | Estimate | SE | RR | 95% CI | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | -0.36 | 0.22 | 0.7 | 0.46 | 1.07 |
| | Swimmers | -0.29 | 0.26 | 0.75 | 0.45 | 1.23 |
| | Surfers/Divers | 0.13 | 0.35 | 1.14 | 0.57 | 2.27 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | 0.43 | 0.22 | 1.54 | 0.99 | 2.4 |
| | 25-34 | -0.13 | 0.23 | 0.88 | 0.56 | 1.38 |
| | 35-44 | -0.08 | 0.25 | 0.93 | 0.57 | 1.52 |
| | 45-54 | -0.24 | 0.38 | 0.79 | 0.37 | 1.67 |
| | 55+ | -0.29 | 0.63 | 0.75 | 0.22 | 2.58 |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0.22 | 0.16 | 1.25 | 0.91 | 1.72 |

| MORECAMBE | | Estimate | SE | RR | 95% CI | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | 0.32 | 0.28 | 1.37 | 0.79 | 2.39 |
| | Swimmers | 0.12 | 0.49 | 1.12 | 0.43 | 2.91 |
| | Surfers/Divers | 0.8 | 0.55 | 2.22 | 0.76 | 6.47 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | 0.45 | 0.42 | 1.56 | 0.69 | 3.56 |
| | 25-34 | 0.46 | 0.4 | 1.58 | 0.73 | 3.45 |
| | 35-44 | 0.32 | 0.42 | 1.38 | 0.61 | 3.14 |
| | 45-54 | -1.15 | 0.79 | 0.32 | 0.07 | 1.49 |
| | 55+ | 0.21 | 0.82 | 1.23 | 0.25 | 6.1 |
| Sex: | Males | 0 | | 1 | | |
| | Females | -0.31 | 0.26 | 0.74 | 0.44 | 1.23 |

**TABLE 18**

**LOGISTIC REGRESSION ANALYSIS INCLUDING ACTUAL EXPOSURE AND AGE AND SEX: GASTROINTESTINAL SYMPTOMS**

| PAIGNTON | | Estimate | SE | RR | 95% CI | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | 0.07 | 0.26 | 1.08 | 0.64 | 1.8 |
| | Swimmers | -0.11 | 0.27 | 0.89 | 0.53 | 1.5 |
| | Surfers/Divers | 0.67 | 0.3 | 1.95 | 1.08 | 3.54 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | -0.39 | 0.26 | 0.68 | 0.41 | 1.14 |
| | 25-34 | -0.1 | 0.24 | 0.91 | 0.57 | 1.45 |
| | 35-44 | -0.63 | 0.26 | 0.53 | 0.32 | 0.89 |
| | 45-54 | -0.23 | 0.32 | 0.79 | 0.42 | 1.5 |
| | 55+ | -0.24 | 0.63 | 0.79 | 0.23 | 2.69 |
| Sex: | Males | 0 | | 1 | | |
| | Females | -0.06 | 0.17 | 0.94 | 0.67 | 1.33 |

| LYME REGIS | | Estimate | SE | RR | 95% CI | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | 0.34 | 0.26 | 1.4 | 0.85 | 2.33 |
| | Swimmers | 0.21 | 0.27 | 1.23 | 0.72 | 2.1 |
| | Surfers/Divers | 0.7 | 0.32 | 2.02 | 1.09 | 3.76 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | 0.16 | 0.25 | 1.17 | 0.72 | 1.9 |
| | 25-34 | -0.00 | 0.24 | 1 | 0.62 | 1.6 |
| | 35-44 | -0.07 | 0.23 | 0.94 | 0.59 | 1.48 |
| | 45-54 | -1.21 | 0.53 | 0.3 | 0.1 | 0.85 |
| | 55+ | 0.14 | 0.55 | 1.15 | 0.39 | 3.4 |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0 | 0.17 | 1 | 0.72 | 1.39 |

**TABLE 18 CONTINUED**

| **RHYL** | | **Estimate** | **SE** | **RR** | **95% CI** | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | 0.55 | 0.24 | 1.74 | 1.08 | 2.81 |
| | Swimmers | 0.62 | 0.28 | 1.85 | 1.07 | 3.2 |
| | Surfers/Divers | 0.52 | 0.41 | 1.68 | 0.75 | 3.74 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | -0.15 | 0.25 | 0.86 | 0.53 | 1.41 |
| | 25-34 | -0.08 | 0.22 | 0.92 | 0.6 | 1.4 |
| | 35-44 | 0.06 | 0.24 | 1.07 | 0.67 | 1.69 |
| | 45-54 | 0.39 | 0.31 | 1.48 | 0.8 | 2.72 |
| | 55+ | 0.44 | 0.51 | 1.56 | 0.58 | 4.21 |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0.3 | 0.16 | 1.35 | 0.99 | 1.85 |

| **MORECAMBE** | | **Estimate** | **SE** | **RR** | **95% CI** | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | 0.58 | 0.29 | 1.79 | 1.01 | 3.17 |
| | Swimmers | 1.07 | 0.42 | 2.93 | 1.27 | 6.73 |
| | Surfers/Divers | 1.12 | 0.6 | 3.08 | 0.95 | 10.01 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | -0.04 | 0.42 | 0.96 | 0.42 | 2.2 |
| | 25-34 | 0.49 | 0.38 | 1.63 | 0.78 | 3.42 |
| | 35-44 | -0.02 | 0.42 | 0.98 | 0.43 | 2.24 |
| | 45-54 | -0.47 | 0.6 | 0.62 | 0.19 | 2.02 |
| | 55+ | -7.93 | 23.33 | 0 | 0 | |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0.51 | 0.28 | 1.66 | 0.95 | 2.9 |

**TABLE 19**

**LOGISTIC REGRESSION ANALYSIS INCLUDING ACTUAL EXPOSURE AND AGE AND SEX: DIARRHOEA**

| **PAIGNTON** | | **Estimate** | **SE** | **RR** | **95% CI** | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | -0.09 | 0.38 | 0.91 | 0.44 | 1.91 |
| | Swimmers | -0.34 | 0.4 | 0.71 | 0.33 | 1.55 |
| | Surfers/Divers | 0.43 | 0.46 | 1.54 | 0.62 | 3.79 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | -0.8 | 0.53 | 0.45 | 0.16 | 1.27 |
| | 25-34 | 0.35 | 0.38 | 1.41 | 0.67 | 2.96 |
| | 35-44 | -0.49 | 0.45 | 0.61 | 0.25 | 1.47 |
| | 45-54 | 0.85 | 0.42 | 2.33 | 1.03 | 5.28 |
| | 55+ | 0.53 | 0.79 | 1.69 | 0.36 | 7.97 |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0.05 | 0.27 | 1.05 | 0.62 | 1.79 |

| **LYME REGIS** | | **Estimate** | **SE** | **RR** | **95% CI** | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | 0.33 | 0.37 | 1.4 | 0.68 | 2.87 |
| | Swimmers | -0.02 | 0.41 | 0.98 | 0.44 | 2.17 |
| | Surfers/Divers | 0.94 | 0.44 | 2.55 | 1.07 | 6.1 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | 0.03 | 0.39 | 1.03 | 0.48 | 2.21 |
| | 25-34 | 0.11 | 0.36 | 1.12 | 0.55 | 2.27 |
| | 35-44 | 0.27 | 0.34 | 1.31 | 0.68 | 2.54 |
| | 45-54 | -9.25 | 27.3 | 0 | 0 | |
| | 55+ | 0.33 | 0.77 | 1.39 | 0.3 | 6.32 |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0.19 | 0.25 | 1.21 | 0.74 | 1.98 |

**TABLE 19 CONTINUED**

| RHYL | | Estimate | SE | RR | 95% CI | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | 0.73 | 0.34 | 2.07 | 1.07 | 3.99 |
| | Swimmers | 0.32 | 0.41 | 1.38 | 0.62 | 3.08 |
| | Surfers/Divers | -0.29 | 0.78 | 0.75 | 0.16 | 3.48 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | -0.19 | 0.41 | 0.82 | 0.37 | 1.84 |
| | 25-34 | 0.4 | 0.3 | 1.49 | 0.83 | 2.67 |
| | 35-44 | 0.55 | 0.32 | 1.73 | 0.92 | 3.25 |
| | 45-54 | 0.18 | 0.51 | 1.2 | 0.44 | 3.24 |
| | 55+ | 0.87 | 0.65 | 2.38 | 0.67 | 8.46 |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0.17 | 0.23 | 1.19 | 0.76 | 1.87 |

| MORECAMBE | | Estimate | SE | RR | 95% CI | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | 0.87 | 0.39 | 2.4 | 1.12 | 5.14 |
| | Swimmers | 1.11 | 0.62 | 3.02 | 0.89 | 10.23 |
| | Surfers/Divers | 0.57 | 1.09 | 1.76 | 0.21 | 14.79 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | -0.14 | 0.7 | 0.87 | 0.22 | 3.41 |
| | 25-34 | 1.12 | 0.55 | 3.05 | 1.03 | 9.01 |
| | 35-44 | 0.53 | 0.61 | 1.69 | 0.51 | 5.61 |
| | 45-54 | -0.02 | 0.87 | 0.98 | 0.18 | 5.33 |
| | 55+ | -6.79 | 23.52 | 0 | 0 | |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0.55 | 0.4 | 1.73 | 0.79 | 3.8 |

**TABLE 20**

**LOGISTIC REGRESSION ANALYSIS INCLUDING ACTUAL EXPOSURE AND AGE AND SEX: SKIN**

| **PAIGNTON** | | **Estimate** | **SE** | **RR** | **95% CI** | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | 0.06 | 0.35 | 1.06 | 0.53 | 2.12 |
| | Swimmers | 0.1 | 0.35 | 1.11 | 0.56 | 2.19 |
| | Surfers/Divers | 0.86 | 0.39 | 2.35 | 1.09 | 5.08 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | 0.19 | 0.29 | 1.21 | 0.68 | 2.16 |
| | 25-34 | -0.6 | 0.35 | 0.55 | 0.28 | 1.1 |
| | 35-44 | -0.29 | 0.32 | 0.75 | 0.4 | 1.4 |
| | 45-54 | -0.46 | 0.47 | 0.63 | 0.25 | 1.58 |
| | 55+ | -8.6 | 30.42 | 0 | 0 | |
| Sex: | Males | 0 | | 1 | | |
| | Females | 0.39 | 0.23 | 1.48 | 0.95 | 2.31 |

| **LYME REGIS** | | **Estimate** | **SE** | **RR** | **95% CI** | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | 1.31 | 0.54 | 3.7 | 1.27 | 10.75 |
| | Swimmers | 1.36 | 0.55 | 3.9 | 1.32 | 11.52 |
| | Surfers/Divers | 1.5 | 0.61 | 4.49 | 1.36 | 14.82 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | -0.03 | 0.38 | 0.97 | 0.47 | 2.03 |
| | 25-34 | 0.11 | 0.34 | 1.11 | 0.57 | 2.18 |
| | 35-44 | -0.08 | 0.34 | 0.93 | 0.48 | 1.79 |
| | 45-54 | -1.66 | 1.03 | 0.19 | 0.03 | 1.43 |
| | 55+ | 0.85 | 0.65 | 2.35 | 0.66 | 8.4 |
| Sex: | Males | 0 | | 1 | | |
| | Females | -0.25 | 0.25 | 0.78 | 0.48 | 1.27 |

**TABLE 20 CONTINUED**

| **RHYL** | | **Estimate** | **SE** | **RR** | **95% CI** | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | 0.18 | 0.31 | 1.2 | 0.65 | 2.2 |
| | Swimmers | 0.63 | 0.35 | 1.88 | 0.95 | 3.73 |
| | Surfers/Divers | 0.33 | 0.54 | 1.39 | 0.48 | 4.02 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | 0.6 | 0.33 | 1.82 | 0.96 | 3.46 |
| | 25-34 | 0.29 | 0.32 | 1.34 | 0.71 | 2.53 |
| | 35-44 | 0.75 | 0.32 | 2.11 | 1.13 | 3.95 |
| | 45-54 | 0.87 | 0.43 | 2.39 | 1.03 | 5.56 |
| | 55+ | 1.06 | 0.65 | 2.88 | 0.81 | 10.3 |
| Sex: | Males | 0 | | 1 | | |
| | Females | -0.02 | 0.22 | 0.98 | 0.64 | 1.51 |

| **MORECAMBE** | | **Estimate** | **SE** | **RR** | **95% CI** | |
|---|---|---|---|---|---|---|
| Exposure: | Non-exposed | 0 | | 1 | | |
| | Waders | -0.06 | 0.42 | 0.95 | 0.42 | 2.13 |
| | Swimmers | -0.49 | 0.78 | 0.62 | 0.13 | 2.85 |
| | Surfers/Divers | 0.82 | 0.68 | 2.28 | 0.6 | 8.71 |
| Age: | 5-14 | 0 | | 1 | | |
| | 15-24 | 0.16 | 0.6 | 1.18 | 0.37 | 3.79 |
| | 25-34 | -0.03 | 0.58 | 0.97 | 0.31 | 3 |
| | 35-44 | 0.13 | 0.58 | 1.14 | 0.36 | 3.57 |
| | 45-54 | -0.59 | 0.85 | 0.55 | 0.1 | 2.93 |
| | 55+ | 0.76 | 0.88 | 2.13 | 0.38 | 12.07 |
| Sex: | Males | 0 | | 1 | | |
| | Females | -0.38 | 0.36 | 0.69 | 0.34 | 1.4 |

Table 21

Levels of enterovirus (pfu per 10 litre) in seawater at three sites at Paignton, Lyme Regis, Rhyl and Morecambe, August 1991. Daily and monthly means are arithmetic means.

| | PAIGNTON | | | | LYME REGIS | | | |
|---|---|---|---|---|---|---|---|---|
| Date | Site 1 | Site 2 | Site 3 | Daily mean | Site 1 | Site 2 | Site 3 | Daily mean |
| 1 | ND | ND | ND | 0 | ND | ND | ND | 0 |
| 4 | ND | ND | ND | 0 | ND | ND | ND | 0 |
| 7 | ND | ND | ND | 0 | ND | ND | ND | 0 |
| 10 | ND | 1 | 1 | 0.7 | ND | ND | ND | 0 |
| 13 | ND | ND | ND | 0 | 5 | 1 | ND | 2 |
| 16 | ND | ND | 1 | 0.3 | ND | 1 | ND | 0.3 |
| 19 | ND | ND | ND | 0 | ND | ND | ND | 0 |
| August mean | 0 | 0.14 | 0.29 | 0.14 | 0.71 | 0.29 | 0 | 0.33 |

| | RHYL | | | | MORECAMBE | | | |
|---|---|---|---|---|---|---|---|---|
| Date | Site 1 | Site 2 | Site 3 | Daily mean | Site 1 | Site 2 | Site 3 | Daily mean |
| 2 | ND | ND | ND | 0 | ND | ND | ND | 0 |
| 5 | ND | ND | ND | 0 | ND | ND | ND | 0 |
| 8 | 1 | 7 | 18 | 8.66 | 31 | 15 | 29 | 25 |
| 11 | 4 | 4 | 3 | 3.67 | 4 | 2 | 25 | 10.3 |
| 14 | 1 | 1 | 2 | 1.33 | 2 | 1 | 2 | 1.7 |
| 17 | ND | ND | ND | 0 | ND | ND | ND | 0 |
| 20 | 3 | 9 | 11 | 7.66 | 1 | 5 | 9 | 5 |
| 23 | ND | ND | ND | 0 | ND | ND | ND | 0 |
| 26 | ND | ND | ND | 0 | ND | ND | ND | 0 |
| August mean | 1 | 2.3 | 3.77 | 2.37 | 4.22 | 2.55 | 7.22 | 4.66 |

Table 22
Levels of coliphage per ml at designated sampling sites at four bathing beaches

| | MORECAMBE | | | | RHYL | | | | PAIGTON | | | | LYME REGIS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Site | | | Whole | Site | | | Whole | Site | | | Whole | Site | | | Whole |
| Date | 1 | 2 | 3 | Beach | 1 | 2 | 3 | Beach | 1 | 2 | 3 | Beach | 1 | 2 | 3 | Beach |
| 1 | ND | ND | ND | 0 | ND | ND | ND | 0 | ND | 1 | ND | 0.3 | 2 | ND | 1 | 1 |
| 2 | ND | ND | ND | 0 | ND | ND | 1 | 0.3 | ND | 5 | 2 | 2.3 | 4 | 2 | 2 | 2.7 |
| 3 | 1 | ND | 2 | 1 | 2 | 5 | 5 | 4 | 3 | 5 | 1 | 3 | ND | 2 | ND | 0.7 |
| 4 | 10 | ND | 1 | 3.7 | 5 | 2 | 4 | 3.7 | 1 | 3 | 1 | 1.7 | 4 | 3 | 2 | 3 |
| 5 | 2 | 13 | 8 | 7.7 | 3 | 2 | 2 | 2.3 | 1 | 3 | ND | 1.3 | 4 | ND | 1 | 2.3 |
| 6 | ND | 1 | 2 | 1 | ND | 1 | 6 | 2.3 | 6 | 6 | 5 | 6.3 | ND | 4 | 7 | 3.7 |
| 7 | 3 | 1 | 2 | 2 | 2 | 6 | 2 | 3.3 | 4 | 2 | 2 | 2.7 | 2 | 3 | 2 | 2.3 |
| 8 | 1 | 2 | 4 | 2.3 | 1 | 3 | 3 | 2.3 | ND | 3 | 2 | 1.7 | 3 | 2 | 3 | 2.7 |
| 9 | ND | 1 | 1 | 0.7 | ND | 1 | 2 | 1 | ND | ND | 1 | 0.3 | 1 | 1 | ND | 0.7 |
| 10 | ND | 1 | 2 | 1 | 2 | 1 | 2 | 1.7 | ND | ND | ND | 0 | 1 | ND | ND | 0.3 |
| 11 | ND | 1 | 1 | 0.7 | 1 | ND | ND | 0.3 | 1 | ND | 1 | 0.7 | 1 | ND | ND | 0.3 |
| 12 | 1 | 1 | ND | 0.7 | 1 | 5 | ND | 2 | ND | ND | ND | 0 | ND | 1 | ND | 0.3 |
| 13 | 2 | 2 | 1 | 1.7 | ND | ND | 2 | 0.7 | ND | ND | ND | 0 | ND | ND | ND | 0 |
| 14 | ND | ND | ND | 0 | 1 | ND | 2 | 1 | ND | 1 | ND | 0.3 | ND | ND | ND | 0 |
| 15 | ND | ND | ND | 0 | 1 | 2 | 2 | 1.7 | 1 | ND | 1 | 0.7 | 1 | ND | ND | 0.3 |
| 16 | ND | ND | ND | 0 | 1 | 2 | 1 | 1.3 | 1 | ND | ND | 0.3 | ND | 2 | ND | 0.7 |
| 17 | ND | ND | ND | 0 | 1 | ND | ND | 0.3 | ND | ND | ND | 0 | 1 | 2 | 1 | 1.3 |
| 18 | ND | ND | ND | 0 | ND | ND | 1 | 0.3 | 1 | ND | ND | 0.3 | 1 | 1 | ND | 0.7 |
| 19 | ND | ND | ND | 0 | ND | ND | ND | 0 | ND | ND | ND | 0 | ND | ND | ND | 0 |
| 20 | ND | ND | ND | 0 | ND | ND | ND | 0 | ND | ND | 1 | 0.3 | 1 | ND | ND | 0.3 |
| 21 | ND | ND | ND | 0 | ND | ND | ND | 0 | ND | 1 | 1 | 0.7 | 1 | ND | ND | 0.3 |
| 22 | ND | ND | 1 | 0.3 | 1 | 1 | ND | 0.7 | - | - | - | - | - | - | - | - |
| 23 | 1 | 1 | ND | 0.7 | 1 | 1 | ND | 0.7 | - | - | - | - | - | - | - | - |
| 24 | ND | 2 | ND | 0.7 | ND | 2 | 1 | 1.0 | - | - | - | - | - | - | - | - |
| 25 | ND | 3 | 1 | 1.3 | 1 | ND | 1 | 0.7 | - | - | - | - | - | - | - | - |
| 26 | 2 | ND | ND | 0.7 | ND | 3 | 2 | 1.7 | - | - | - | - | - | - | - | - |
| Overall | 0.9 | 1.1 | 1 | 1 | 0.9 | 1.4 | 1.5 | 1.3 | 0.9 | 1.4 | 0.9 | 1.1 | 1.3 | 1.1 | 0.9 | 1.1 |

Table 23

Summary data on bacterial indicators (overall geometric means, and mean and standard deviation (SD) in logarithm scale), August 1991

Total coliforms

| | Site 1 | | | Site 2 | | | Site 3 | | | Whole beach | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Log scale | | | Log scale | | | Log scale | | | Log scale | |
| | Mean | Mean | SD | Mean | Mean | SD | Mean | Mean | SD | Mean | Mean | SD |
| Paignton | 264 | 5.58 | 1.01 | 174 | 5.16 | 1.06 | 282 | 5.64 | 0.99 | 235 | 5.46 | 0.84 |
| Lyme Regis | 156 | 5.05 | 1.31 | 81 | 4.39 | 1.20 | 89 | 4.49 | 1.34 | 104 | 4.64 | 1.15 |
| Rhyl | 2678 | 7.89 | 1.04 | 3109 | 8.04 | 0.76 | 5314 | 8.58 | 0.57 | 3537 | 8.17 | 0.68 |
| Morecambe | 5186 | 8.55 | 0.89 | 3310 | 8.10 | 1.02 | 2250 | 7.72 | 0.96 | 3380 | 8.13 | 0.85 |

Thermotolerant coliforms

| | Site 1 | | | Site 2 | | | Site 3 | | | Whole beach | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Log scale | | | Log scale | | | Log scale | | | Log scale | |
| | Mean | Mean | SD | Mean | Mean | SD | Mean | Mean | SD | Mean | Mean | SD |
| Paignton | 101 | 4.62 | 0.96 | 86 | 4.46 | 1.11 | 125 | 4.83 | 1.01 | 103 | 4.64 | 0.89 |
| Lyme Regis | 49 | 3.89 | 1.26 | 30 | 3.41 | 1.32 | 42 | 3.73 | 1.39 | 40 | 3.68 | 1.16 |
| Rhyl | 201 | 5.3 | 1.7 | 281 | 5.64 | 1.49 | 529 | 6.27 | 1.27 | 310 | 5.74 | 1.36 |
| Morecambe | 704 | 6.56 | 1.91 | 397 | 5.98 | 1.65 | 319 | 5.76 | 1.62 | 447 | 6.1 | 1.62 |

Faecal streptococci

| | Site 1 | | | Site 2 | | | Site 3 | | | Whole beach | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Log scale | | | Log scale | | | Log scale | | | Log scale | |
| | Mean | Mean | SD | Mean | Mean | SD | Mean | Mean | SD | Mean | Mean | SD |
| Paignton | 27 | 3.28 | 1.18 | 26 | 3.25 | 1.03 | 47 | 3.85 | 1.07 | 32 | 3.46 | 0.96 |
| Lyme Regis | 13 | 2.53 | 1.30 | 11 | 2.39 | 0.92 | 21 | 3.06 | 1.15 | 14 | 2.66 | 0.95 |
| Rhyl | 61 | 4.10 | 0.98 | 80 | 4.38 | 0.94 | 142 | 4.96 | 0.49 | 88 | 4.48 | 0.70 |
| Morecambe | 167 | 5.12 | 1.10 | 91 | 4.51 | 0.98 | 66 | 4.19 | 1.05 | 100 | 4.61 | 0.94 |

TABLE 24. DAILY GEOMETRIC MEAN LEVELS (PER 100 ML) FOR BACTERIAL INDICATORS PAIGNTON, AUGUST 1991

| | Total coliforms | | | | Thermotolerant coliforms | | | | Faecal streptococci | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Site | | | Whole | Site | | | Whole | Site | | | Whole |
| Day | 1 | 2 | 3 | beach | 1 | 2 | 3 | beach | 1 | 2 | 3 | beach |
| 1 | 292 | 139 | 132 | 175 | 98 | 62 | 46 | 66 | 65 | 24 | 25 | 34 |
| 2 | 1585 | 89 | 267 | 335 | 338 | 71 | 108 | 137 | 65 | 16 | 45 | 36 |
| 3 | 175 | 138 | 167 | 159 | 120 | 84 | 101 | 101 | 24 | 66 | 92 | 52 |
| 4 | 929 | 118 | 222 | 290 | 119 | 65 | 163 | 108 | 10 | 8 | 32 | 13 |
| 5 | 371 | 306 | 348 | 340 | 80 | 197 | 238 | 155 | 18 | 121 | 76 | 55 |
| 6 | 253 | 354 | 555 | 368 | 99 | 183 | 316 | 179 | 41 | 63 | 84 | 60 |
| 7 | 547 | 903 | 3046 | 1146 | 365 | 558 | 1729 | 706 | 266 | 113 | 647 | 269 |
| 8 | 95 | 224 | 1084 | 285 | 20 | 38 | 120 | 45 | 5 | 19 | 51 | 16 |
| 9 | 110 | 177 | 339 | 187 | 22 | 148 | 141 | 77 | 8 | 39 | 24 | 19 |
| 10 | 88 | 22 | 143 | 65 | 37 | 10 | 29 | 22 | 14 | 5 | 6 | 7 |
| 11 | 259 | 623 | 310 | 368 | 171 | 448 | 174 | 237 | 28 | 66 | 61 | 48 |
| 12 | 368 | 323 | 166 | 270 | 194 | 49 | 114 | 103 | 106 | 17 | 103 | 57 |
| 13 | 1418 | 595 | 1120 | 981 | 500 | 174 | 557 | 364 | 186 | 91 | 240 | 160 |
| 14 | 214 | 354 | 545 | 345 | 125 | 265 | 237 | 199 | 39 | 57 | 56 | 50 |
| 15 | 446 | 123 | 179 | 214 | 227 | 46 | 98 | 101 | 69 | 11 | 74 | 38 |
| 16 | 51 | 66 | 97 | 69 | 24 | 21 | 42 | 28 | 6 | 5 | 13 | 7 |
| 17 | 28 | 36 | 86 | 44 | 22 | 32 | 22 | 25 | 3 | 8 | 12 | 7 |
| 18 | 199 | 29 | 100 | 83 | 56 | 14 | 63 | 37 | 13 | 14 | 22 | 16 |
| 19 | 362 | 74 | 104 | 140 | 189 | 59 | 62 | 88 | 29 | 9 | 14 | 15 |
| 20 | 317 | 603 | 124 | 287 | 114 | 401 | 80 | 154 | 32 | 57 | 43 | 43 |
| 21 | 510 | 423 | 1208 | 639 | 185 | 161 | 302 | 208 | 29 | 33 | 98 | 45 |
| Overall mean | 264 | 174 | 282 | 235 | 101 | 86 | 125 | 103 | 27 | 26 | 47 | 32 |

TABLE 25. DAILY GEOMETRIC MEAN LEVELS (PER 100 ML) FOR BACTERIAL INDICATORS
LYME REGIS, AUGUST 1991

| | Total coliforms | | | | Thermotolerant coliforms | | | | Faecal streptococci | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Site | | | Whole | Site | | | Whole | Site | | | Whole |
| Day | 1 | 2 | 3 | beach | 1 | 2 | 3 | beach | 1 | 2 | 3 | beach |
| 1 | 447 | 59 | 75 | 126 | 85 | 13 | 29 | 32 | 246 | 29 | 10 | 42 |
| 2 | 24 | 24 | 73 | 35 | 11 | 13 | 42 | 19 | 5 | 14 | 6 | 8 |
| 3 | 425 | 161 | 29 | 126 | 114 | 53 | 8 | 37 | 13 | 12 | 24 | 15 |
| 4 | 82 | 105 | 103 | 96 | 34 | 58 | 63 | 50 | 6 | 6 | 26 | 10 |
| 5 | 653 | 70 | 57 | 138 | 153 | 60 | 35 | 69 | 37 | 20 | 31 | 29 |
| 6 | 601 | 302 | 265 | 364 | 110 | 137 | 82 | 107 | 8 | 11 | 111 | 21 |
| 7 | 224 | 397 | 115 | 217 | 77 | 233 | 23 | 74 | 13 | 23 | 8 | 13 |
| 8 | 56 | 116 | 25 | 55 | 8 | 31 | 7 | 12 | 3 | 8 | 3 | 5 |
| 9 | 64 | 28 | 46 | 44 | 23 | 13 | 6 | 12 | 13 | 8 | 4 | 7 |
| 10 | 132 | 31 | 73 | 67 | 50 | 15 | 48 | 33 | 5 | 3 | 33 | 9 |
| 11 | 236 | 493 | 339 | 340 | 89 | 137 | 169 | 127 | 17 | 37 | 62 | 34 |
| 12 | 97 | 78 | 213 | 118 | 66 | 29 | 189 | 72 | 16 | 22 | 64 | 28 |
| 13 | 506 | 189 | 434 | 346 | 150 | 61 | 303 | 141 | 27 | 15 | 65 | 30 |
| 14 | 116 | 116 | 64 | 95 | 30 | 44 | 45 | 39 | 10 | 9 | 22 | 13 |
| 15 | 45 | 39 | 42 | 42 | 15 | 13 | 34 | 19 | 6 | 16 | 65 | 19 |
| 16 | 17 | 23 | 52 | 27 | 6 | 9 | 34 | 12 | 3 | 4 | 18 | 6 |
| 17 | 123 | 40 | 33 | 54 | 27 | 7 | 25 | 17 | 3 | 5 | 13 | 6 |
| 18 | 38 | 25 | 8 | 20 | 12 | 5 | 6 | 7 | 4 | 3 | 4 | 4 |
| 19 | 106 | 11 | 42 | 37 | 37 | 5 | 22 | 16 | 5 | 3 | 12 | 6 |
| 20 | 308 | 47 | 136 | 125 | 157 | 15 | 44 | 47 | 25 | 5 | 15 | 13 |
| 21 | 4670 | 1325 | 5977 | 3332 | 1400 | 711 | 1954 | 1248 | 445 | 116 | 235 | 230 |
| Overall mean | 156 | 81 | 89 | 104 | 49 | 30 | 42 | 40 | 13 | 11 | 21 | 14 |

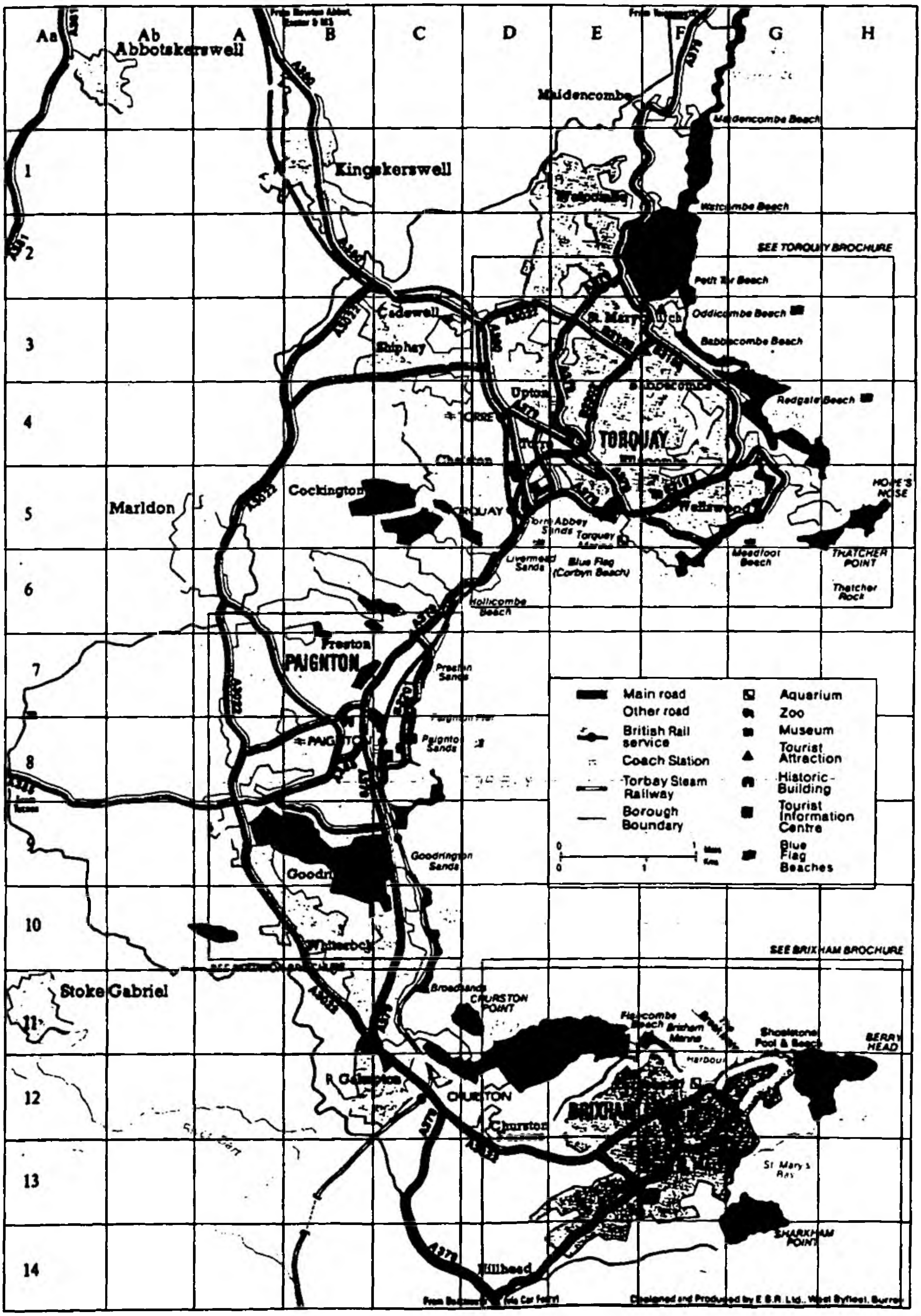
TABLE 26. DAILY GEOMETRIC MEAN LEVELS (PER 100 ML) FOR BACTERIAL INDICATORS
RHYL, AUGUST 1991

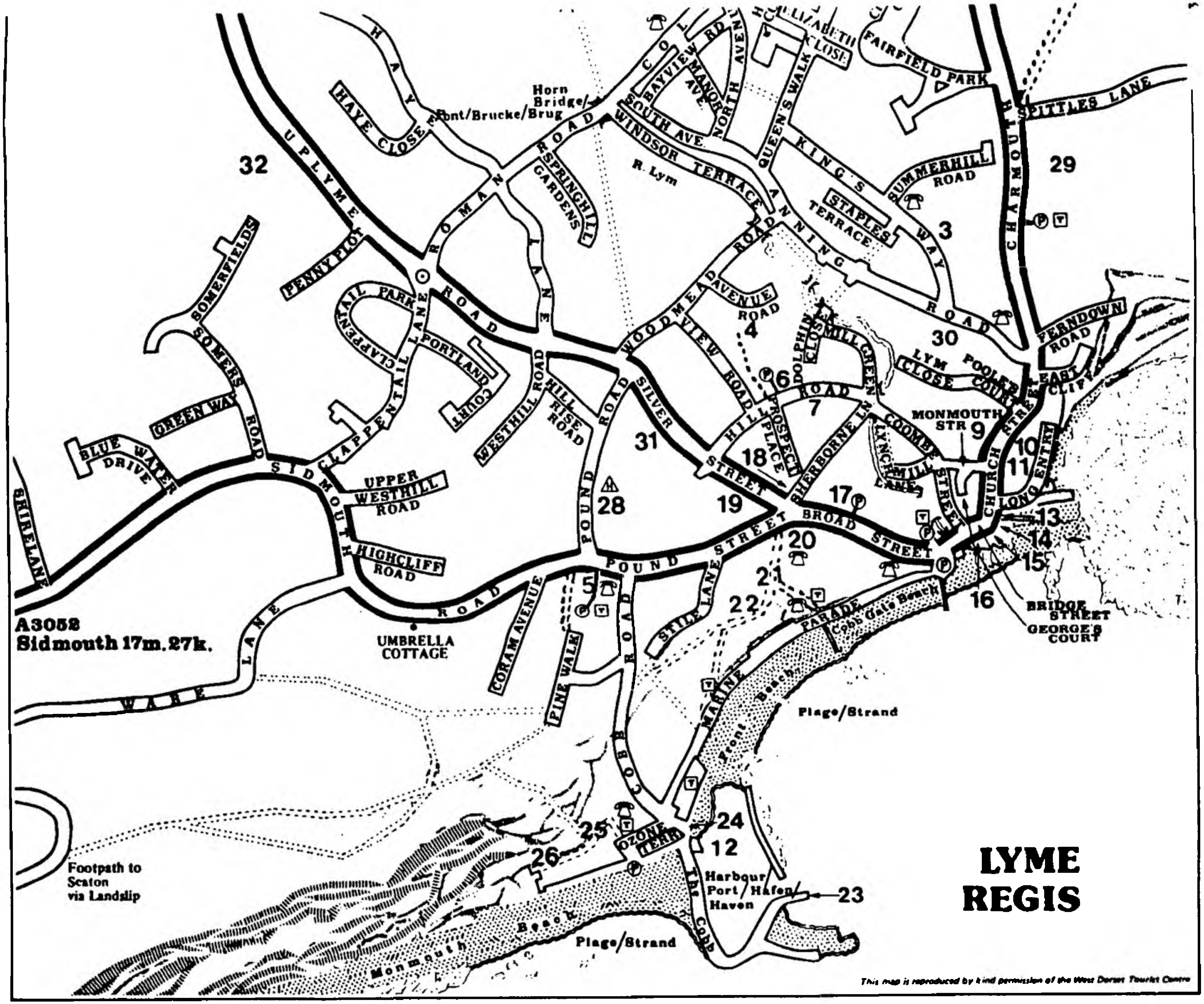
| | Total coliforms | | | | Thermotolerant coliforms | | | | Faecal streptococci | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Site | | | Whole | Site | | | Whole | Site | | | Whole |
| Day | 1 | 2 | 3 | beach | 1 | 2 | 3 | beach | 1 | 2 | 3 | beach |
| 1 | 1954 | 1388 | 2051 | 1772 | 166 | 109 | 185 | 149 | 46 | 73 | 97 | 69 |
| 2 | 1380 | 1249 | 2059 | 1525 | 71 | 85 | 83 | 80 | 41 | 9 | 57 | 28 |
| 3 | 600 | 1233 | 3150 | 1326 | 7 | 10 | 88 | 19 | 8 | 30 | 75 | 26 |
| 4 | 1316 | 2461 | 4539 | 2449 | 14 | 53 | 383 | 65 | 16 | 39 | 90 | 38 |
| 5 | 7778 | 10697 | 7960 | 8717 | 769 | 628 | 491 | 619 | 61 | 113 | 109 | 91 |
| 6 | 4158 | 6105 | 7248 | 5688 | 12 | 32 | 27 | 22 | 24 | 42 | 123 | 50 |
| 7 | 3270 | 2164 | 14719 | 4705 | 54 | 15 | 663 | 81 | 26 | 50 | 166 | 60 |
| 8 | 6895 | 3432 | 14821 | 7052 | 215 | 159 | 255 | 206 | 22 | 15 | 183 | 39 |
| 9 | 6262 | 4168 | 5367 | 5194 | 361 | 143 | 124 | 186 | 139 | 207 | 193 | 177 |
| 10 | 6067 | 4739 | 3570 | 4682 | 8 | 103 | 83 | 41 | 129 | 273 | 127 | 165 |
| 11 | 6300 | 9098 | 5682 | 6880 | 138 | 854 | 468 | 380 | 211 | 293 | 279 | 258 |
| 12 | 14025 | 9673 | 11319 | 11537 | 540 | 692 | 1128 | 750 | 149 | 229 | 94 | 147 |
| 13 | 3391 | 2647 | 8260 | 4201 | 298 | 191 | 300 | 257 | 63 | 39 | 66 | 54 |
| 14 | 843 | 2757 | 2918 | 1893 | 94 | 150 | 189 | 139 | 28 | 69 | 107 | 59 |
| 15 | 6283 | 4727 | 7760 | 6131 | 482 | 370 | 919 | 547 | 125 | 100 | 154 | 125 |
| 16 | 6639 | 5517 | 3408 | 4998 | 2769 | 1485 | 974 | 1588 | 161 | 169 | 187 | 172 |
| 17 | 5256 | 3019 | 2135 | 3236 | 2034 | 1531 | 1008 | 1464 | 333 | 322 | 390 | 347 |
| 18 | 485 | 785 | 3866 | 1137 | 121 | 345 | 1361 | 384 | 34 | 26 | 115 | 47 |
| 19 | 2320 | 3820 | 4617 | 3446 | 502 | 1270 | 1293 | 937 | 36 | 106 | 94 | 71 |
| 20 | 340 | 589 | 3976 | 927 | 64 | 159 | 1021 | 218 | 12 | 43 | 154 | 43 |
| 21 | 3807 | 2062 | 8030 | 3980 | 520 | 481 | 2571 | 863 | 58 | 70 | 270 | 103 |
| 22 | 456 | 1252 | 3468 | 1256 | 211 | 529 | 1835 | 589 | 107 | 55 | 240 | 112 |
| 23 | 1776 | 3523 | 5375 | 3227 | 618 | 1760 | 1495 | 1176 | 106 | 231 | 331 | 201 |
| 24 | 11464 | 5441 | 6987 | 7582 | 4096 | 1272 | 2034 | 2197 | 229 | 80 | 181 | 149 |
| 25 | 1346 | 3838 | 9858 | 3707 | 505 | 1000 | 2876 | 1133 | 53 | 102 | 107 | 83 |
| 26 | 2241 | 7529 | 7789 | 5085 | 636 | 2379 | 2688 | 1597 | 137 | 209 | 187 | 175 |
| Overall mean | 2678 | 3109 | 5314 | 3537 | 201 | 281 | 529 | 310 | 61 | 80 | 142 | 88 |

TABLE 27. DAILY GEOMETRIC MEAN LEVELS (PER 100 ML) FOR BACTERIAL INDICATORS MORECAMBE, AUGUST 1991

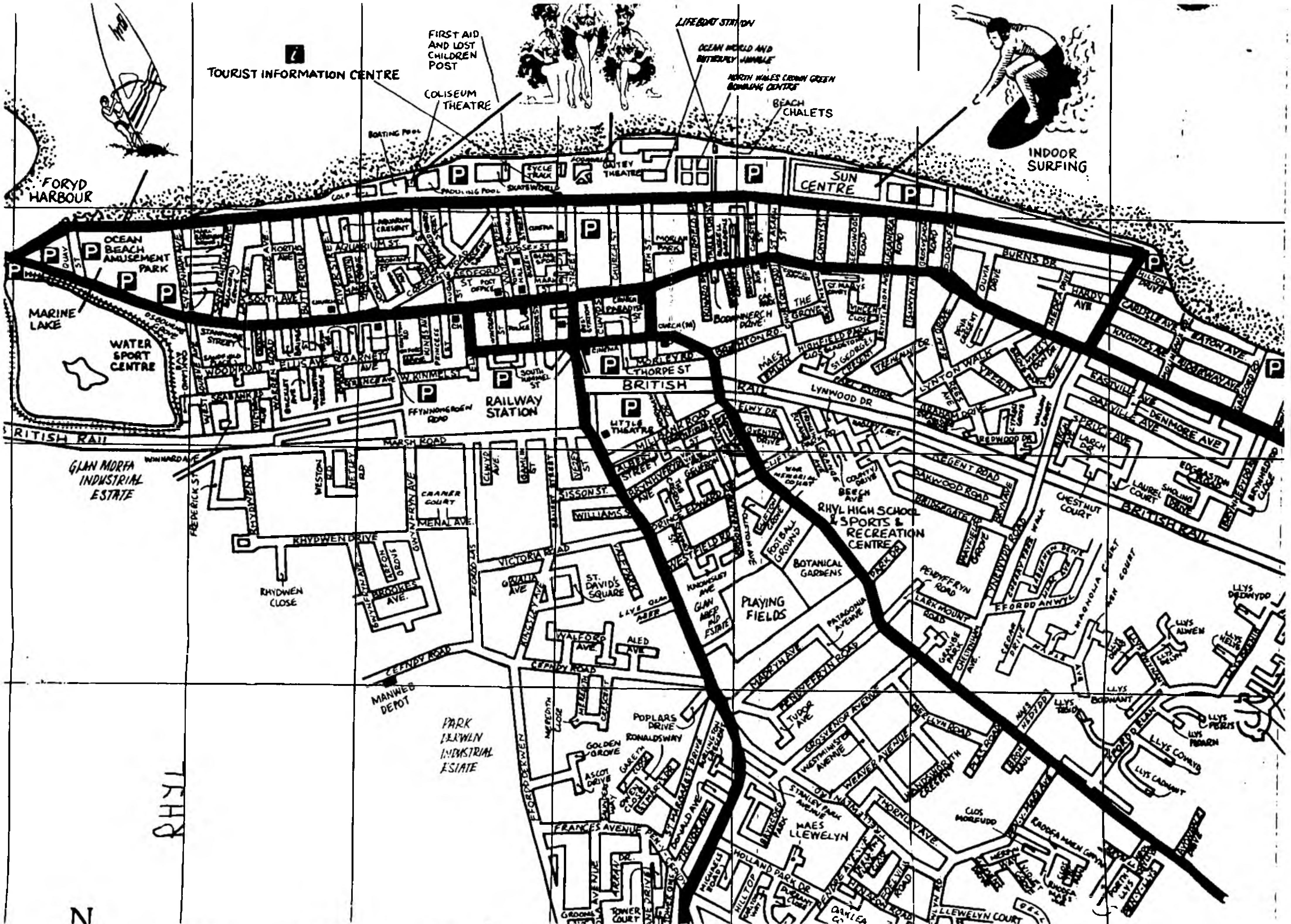
| | Total coliforms | | | | Thermotolerant coliforms | | | | Faecal streptococci | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Site | | | Whole | Site | | | Whole | Site | | | Whole |
| Day | 1 | 2 | 3 | beach | 1 | 2 | 3 | beach | 1 | 2 | 3 | beach |
| 1 | 1641 | 828 | 472 | 862 | 33 | 52 | 26 | 36 | 16 | 15 | 6 | 12 |
| 2 | 3735 | 4748 | 1600 | 3050 | 383 | 312 | 167 | 271 | 129 | 231 | 40 | 106 |
| 3 | 1010 | 1484 | 833 | 1077 | 29 | 292 | 27 | 61 | 30 | 40 | 27 | 32 |
| 4 | 2226 | 488 | 1007 | 1031 | 22 | 19 | 16 | 19 | 59 | 16 | 36 | 32 |
| 5 | 6943 | 3621 | 4600 | 4872 | 1980 | 320 | 816 | 802 | 167 | 68 | 101 | 105 |
| 6 | 13951 | 5295 | 4836 | 7096 | 76 | 19 | 15 | 28 | 316 | 53 | 44 | 90 |
| 7 | 2788 | 818 | 805 | 1224 | 242 | 120 | 25 | 90 | 43 | 36 | 20 | 32 |
| 8 | 3074 | 4280 | 1992 | 2971 | 543 | 940 | 401 | 589 | 80 | 100 | 29 | 61 |
| 9 | 20000 | 9237 | 5173 | 9850 | 2941 | 186 | 317 | 558 | 512 | 220 | 101 | 225 |
| 10 | 4933 | 8028 | 5923 | 6167 | 225 | 19 | 415 | 121 | 144 | 86 | 71 | 96 |
| 11 | 11416 | 10606 | 7733 | 9783 | 173 | 140 | 210 | 172 | 301 | 121 | 86 | 146 |
| 12 | 5595 | 14407 | 8797 | 8917 | 105 | 381 | 651 | 297 | 73 | 73 | 141 | 91 |
| 13 | 1313 | 4024 | 1796 | 2117 | 47 | 83 | 87 | 70 | 30 | 28 | 32 | 30 |
| 14 | 4698 | 5855 | 3827 | 4722 | 307 | 775 | 659 | 539 | 43 | 135 | 152 | 96 |
| 15 | 7929 | 8159 | 2501 | 5449 | 1746 | 1622 | 395 | 1038 | 282 | 242 | 96 | 187 |
| 16 | 9641 | 3836 | 2161 | 4307 | 7673 | 3018 | 1102 | 2945 | 529 | 239 | 100 | 233 |
| 17 | 13395 | 4419 | 5688 | 6957 | 5547 | 2697 | 2717 | 3438 | 754 | 342 | 329 | 439 |
| 18 | 4913 | 1977 | 1561 | 2475 | 2162 | 1032 | 928 | 1275 | 210 | 72 | 96 | 113 |
| 19 | 13127 | 2764 | 2180 | 4293 | 7789 | 1641 | 1158 | 2456 | 795 | 129 | 113 | 227 |
| 20 | 2169 | 1128 | 519 | 1083 | 1432 | 271 | 238 | 452 | 126 | 27 | 10 | 32 |
| 21 | 3003 | 419 | 303 | 725 | 2146 | 259 | 206 | 486 | 323 | 50 | 19 | 67 |
| 22 | 3871 | 948 | 793 | 1427 | 2884 | 670 | 522 | 1003 | 300 | 34 | 43 | 76 |
| 23 | 12289 | 6514 | 4608 | 7172 | 6138 | 3009 | 2120 | 3396 | 781 | 308 | 462 | 481 |
| 24 | 8787 | 7455 | 3993 | 6395 | 4334 | 2313 | 1557 | 2499 | 351 | 423 | 219 | 319 |
| 25 | 5483 | 2490 | 1891 | 2955 | 2875 | 1047 | 1100 | 1490 | 200 | 99 | 137 | 139 |
| 26 | 8787 | 15651 | 9703 | 11009 | 4560 | 6681 | 4375 | 5108 | 359 | 425 | 244 | 334 |
| Overall mean | 5186 | 3310 | 2250 | 3380 | 704 | 397 | 319 | 447 | 167 | 91 | 66 | 100 |

# THE ENGLISH RIVIERA

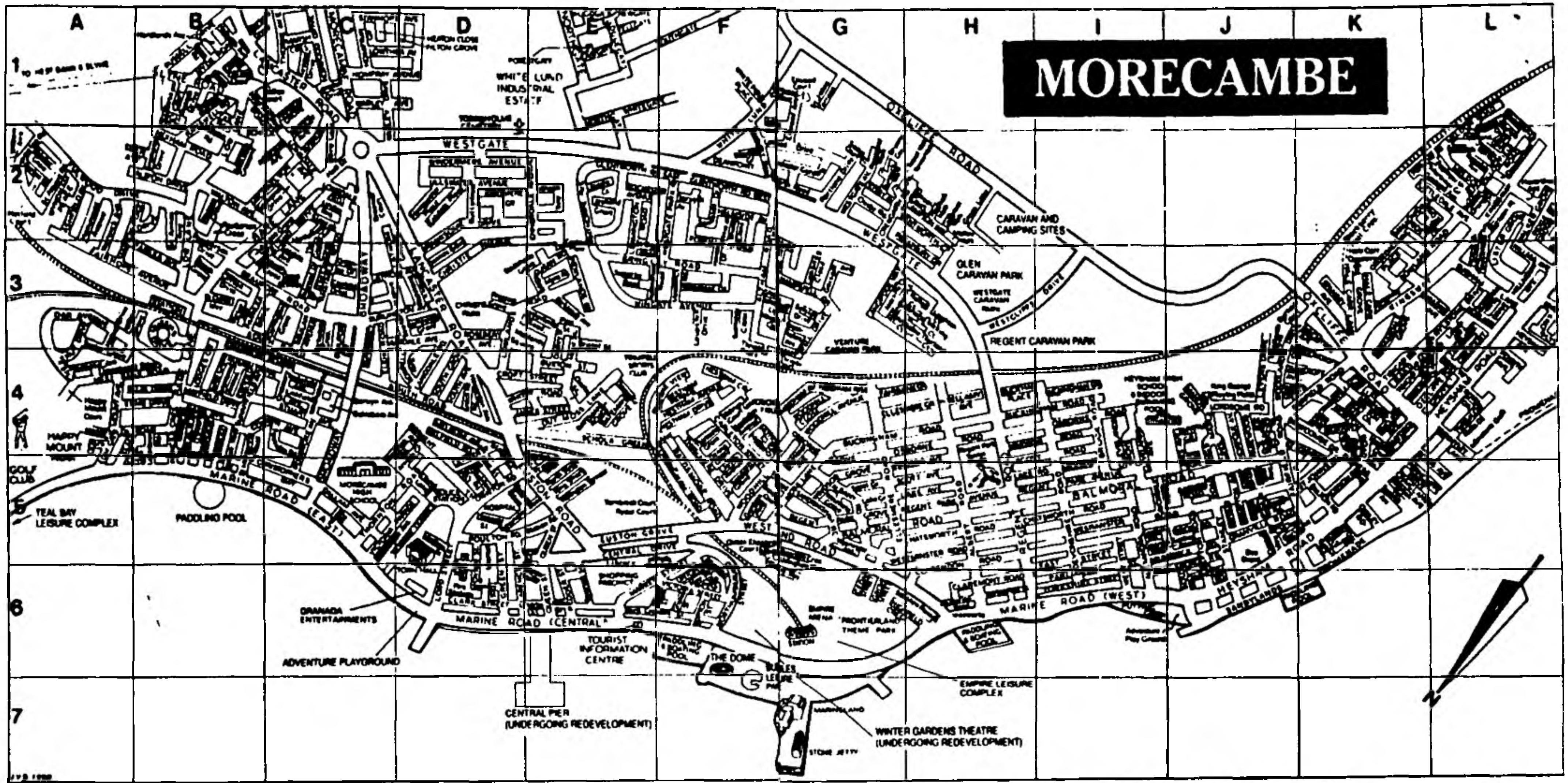




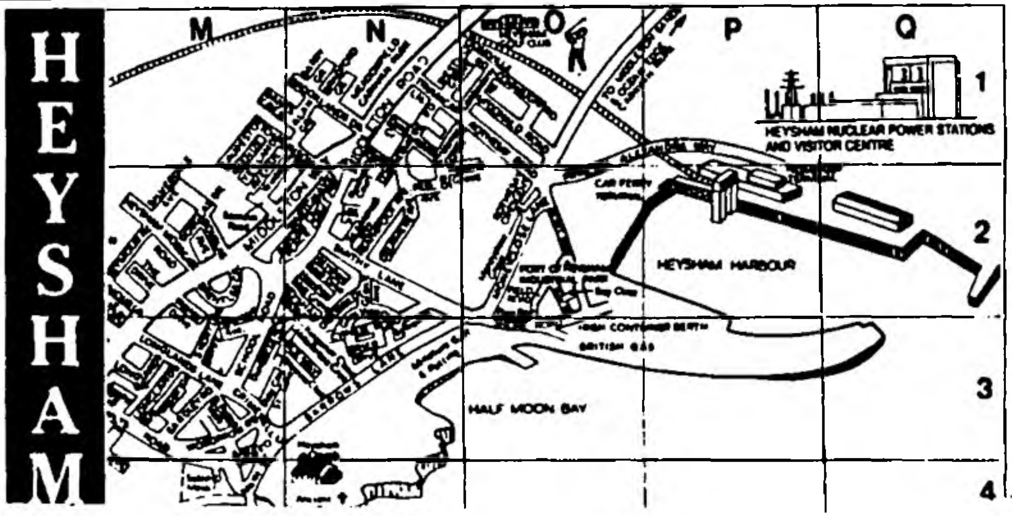
LYME REGIS
A3052
Sidmouth 17m. 27k.
Footpath to Seaton via Landslip
UMBRELLA COTTAGE
Horn Bridge/Pont/Brucke/Brug
R. Lym
HAYE LANE
HAYE CLOSE
UPLYME ROAD
ROMAN ROAD
COLWAY LANE
BAYVIEW RD.
MANOR AVE
NORTH AVENUE
SOUTH AVE.
WINDSOR TERRACE
QUEEN'S WALK
ELIZABETH CLOSE
FAIRFIELD PARK
SPITTLES LANE
CHARMOUTH ROAD
KING'S WAY
SUMMERHILL ROAD
STAPLES TERRACE
ANNING ROAD
SPRINGHILL GARDENS
PENNY PLOT
SOMERFIELDS
SOMERS ROAD
GREEN WAY
BLUE WATER DRIVE
SHIRE LANE
CLAPPENTAIL PARK
CLAPPENTAIL LANE
PORTLAND COURT
WESTHILL ROAD
HILL RISE ROAD
UPPER WESTHILL ROAD
SIDMOUTH ROAD
HIGHCLIFF ROAD
WARE LANE
POUND ROAD
POUND STREET
CORAM AVENUE
PINE WALK
COBB ROAD
SILVER STREET
WOODMEAD ROAD
VIEW ROAD
AVENUE ROAD
DOLPHIN CLOSE
MILL GREEN
HILL ROAD
PROSPECT PLACE
SHERBORNE LN
LYNCH
COOMBE STREET
MILL LANE
MONMOUTH STR
LYM CLOSE
POOLES COURT
FERNDOWN ROAD
EAST CLIFF
CHURCH STREET
LONG ENTRY
BROAD STREET
BRIDGE STREET
GEORGE'S COURT
STILE LANE
MARINE PARADE
Cobb Gate Beach
Front Beach
Plage/Strand
OZONE TERR
The Cobb
Harbour Port/Hafen Haven
Monmouth Beach
1 3 4 5 6 7 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 28 29 30 31 32
This map is reproduced by kind permission of the West Dorset Tourist Centre

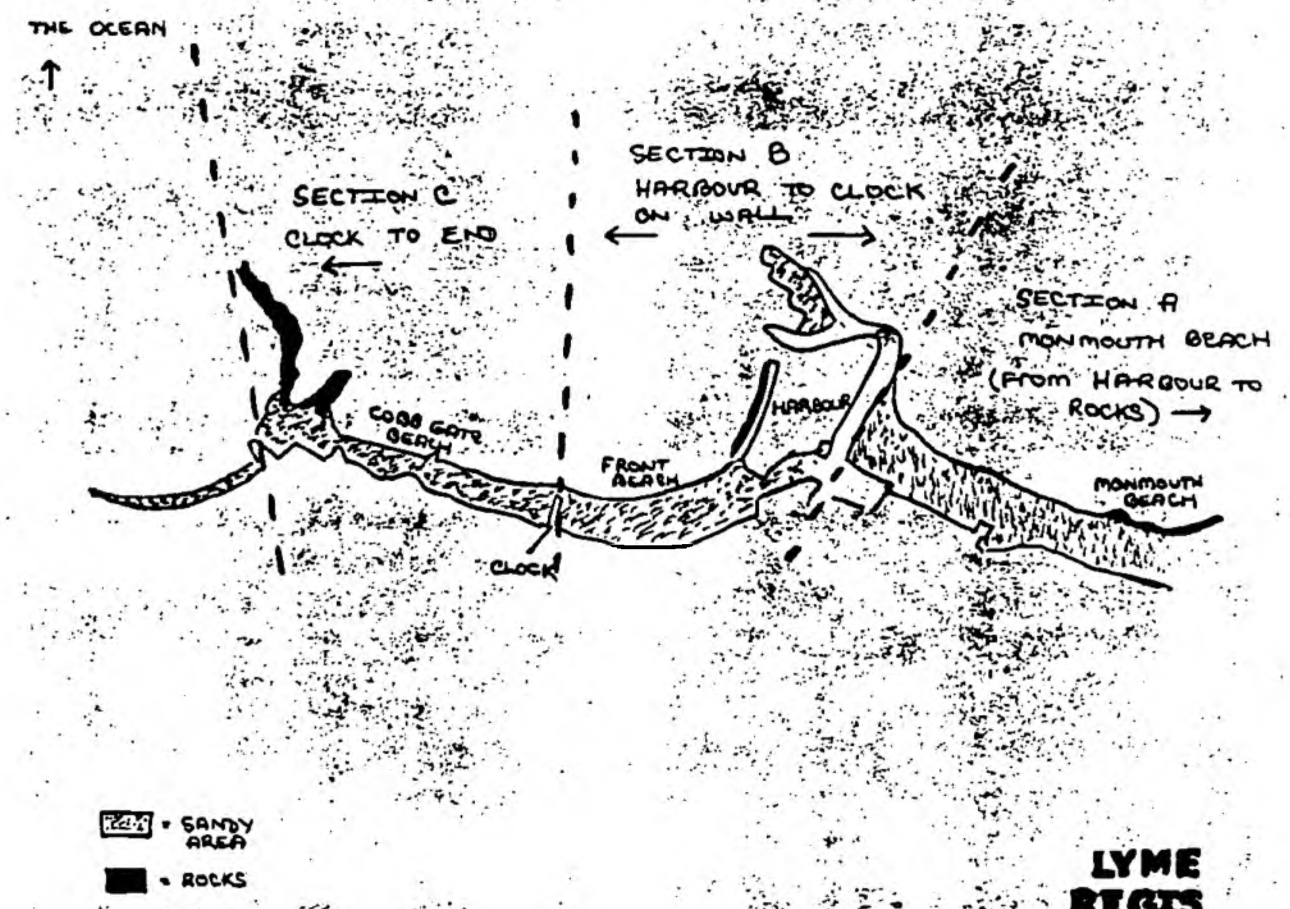


TOURIST INFORMATION CENTRE
FIRST AID AND LOST CHILDREN POST
COLISEUM THEATRE
BOATING POOL
LIFEBOAT STATION
OCEAN WORLD AND BUTTERFLY JUNGLE
NORTH WALES CROWN GREEN BOWLING CENTRE
BEACH CHALETS
INDOOR SURFING
SUN CENTRE
GATEY THEATRE
CYCLE TRACK
PADDLING POOL
SKATEWORLD
FORYD HARBOUR
OCEAN BEACH AMUSEMENT PARK
MARINE LAKE
WATER SPORT CENTRE
RAILWAY STATION
BRITISH RAIL
THORPE ST
MARSH ROAD
LITTLE THEATRE
GLAN MORFA INDUSTRIAL ESTATE
RHYDWEN DRIVE
RHYDWEN CLOSE
MENAI AVE.
VICTORIA ROAD
ST. DAVID'S SQUARE
WALFORD AVE.
ALED AVE.
CEFNDY ROAD
MANWEB DEPOT
PARK DERWEN INDUSTRIAL ESTATE
POPLARS DRIVE
RONALDSWAY
GOLDEN GROVE
ASCOT DRIVE
FRANCES AVENUE
TOWER COURT
RHYL HIGH SCHOOL & SPORTS & RECREATION CENTRE
BOTANICAL GARDENS
FOOTBALL GROUND
PLAYING FIELDS
GLAN ABER ESTATE
PATAGONIA AVENUE
GROSVENOR AVENUE
MAES LLEWELYN
HOLLAND PARK DR
LLEWELYN COURT
CLOS MORFUDD
REGENT ROAD
OAKWOOD ROAD
BRIDGEGATE RD
LYNWOOD DR
LYNTON WALK
BURNS DR
HARDY AVE
CARLISLE AVE
KNOWLES AVE
EATON AVE
DENMORE AVE
EASTVILLE AVE
SPRUCE AVE
CHESTNUT COURT
EDGBASTON ROAD
LAUREL COURT
MAGNOLIA COURT
FFORDD ANWYL
LLYS DEDWYDD
LLYS ALWEN
LLYS HELYG
LLYS BODNANT
LLYS PERIS
LLYS COWRYG
LLYS CADWGAN
RHYL
N

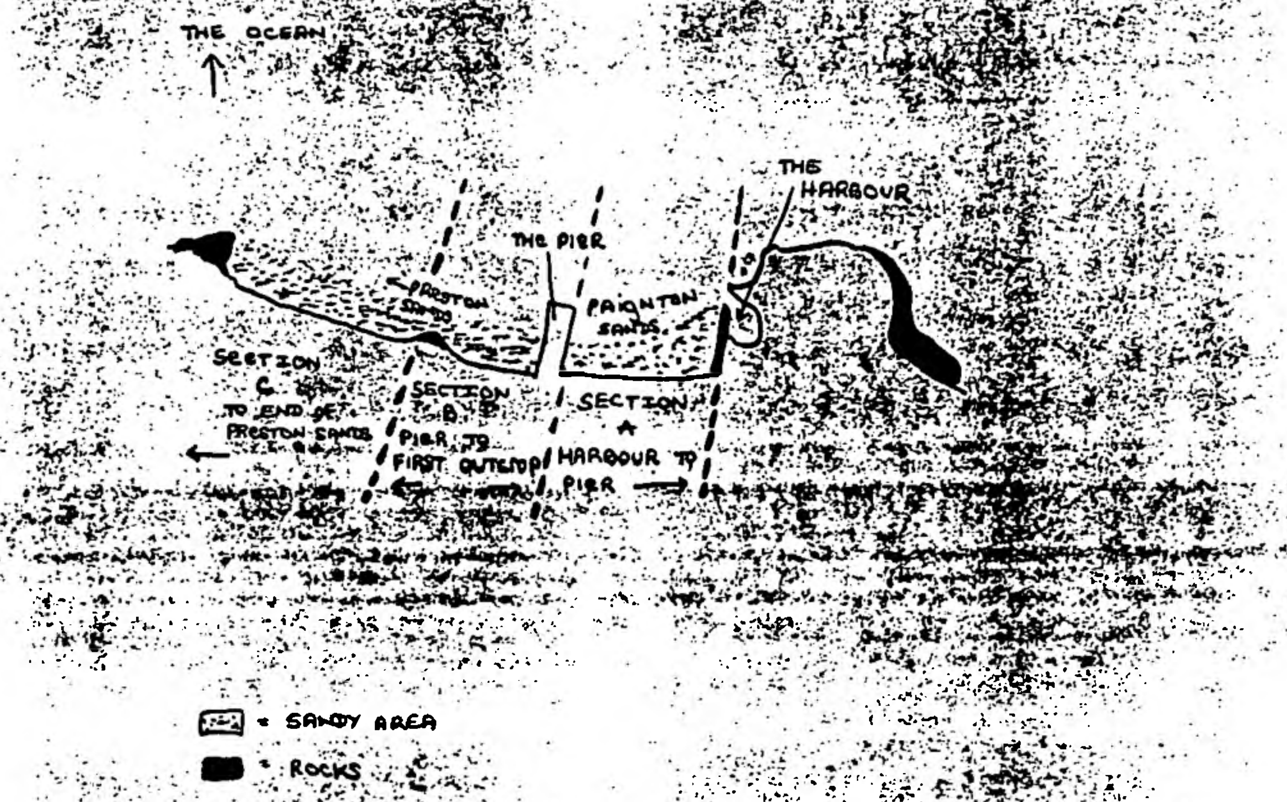



| CAR PARKS | | COACH PARKS |
|---|---|---|
| * Half Moon Bay, O3 | * Poulton Hall, D5 | * Poulton Hall, Coach Station, D5 |
| * Heysham Village, N3 | * Coastal Road, A5 | * Coastal Road, A5 |
| * Promenade Station Forecourt, G6 | * Rear of Town Hall (entrance Matthias Street), D6 | * Empire Arena, G6 |
| * Rear of Frontierland, G6 | * Pedder Street, E6 | * Rear of Frontierland, G6 |
| * Library, F5 | * Northumberland Street, F6 | * Northumberland Street, F6 |
| * *Empire Arena, G6* | * Back Brighton Terrace, C5 | * Heysham Village, N3 |
| * Telephone Exchange, F5 | | |

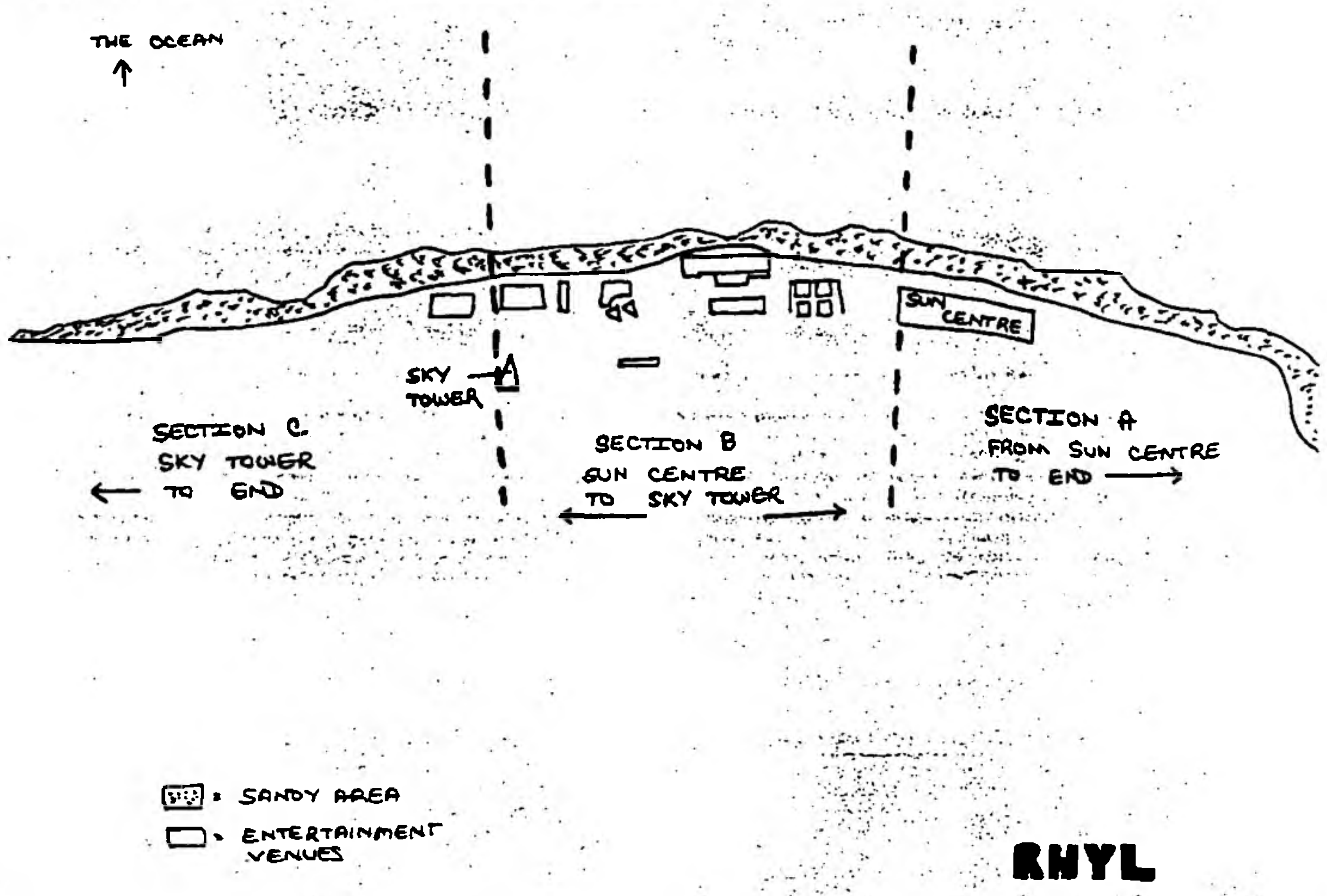


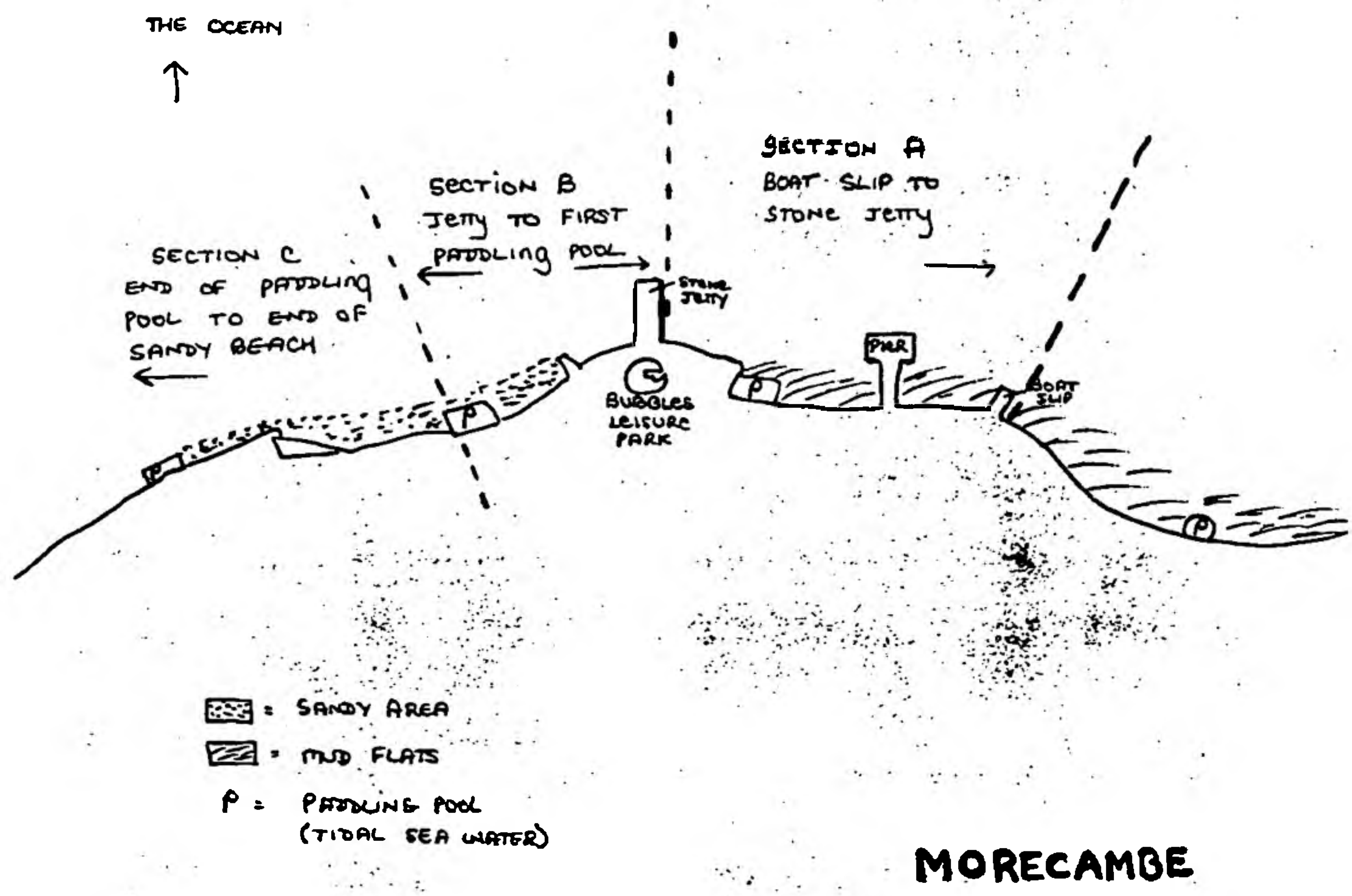



LYME REGIS




PAIGNTON


THE OCEAN
SKY TOWER
SUN CENTRE
SECTION C
SKY TOWER
TO END
SECTION B
SUN CENTRE
TO SKY TOWER
SECTION A
FROM SUN CENTRE
TO END
= SANDY AREA
= ENTERTAINMENT VENUES
RHYL


THE OCEAN
SECTION A
BOAT SLIP TO
STONE JETTY
SECTION B
JETTY TO FIRST
PADDLING POOL
SECTION C
END OF PADDLING
POOL TO END OF
SANDY BEACH
STONE JETTY
PIER
BOAT SLIP
BUBBLES
LEISURE
PARK
P
= SANDY AREA
= MUD FLATS
P = PADDLING POOL
(TIDAL SEA WATER)
MORECAMBE

# APPENDIX 2

# BEACH QUESTIONNAIRE

FTD690
BEACH QUESTIONNAIRE

CASE ID (1-4)
SERIAL NO (5-8)

NAME Miss/Mrs/Mr: ______________________ (9-28)

ADDRESS: ______________________ (29-58)

______________________ (59-88)

(89-118)

POSTCODE: ______________________

TELEPHONE NO. (STD Code): ______________________ (189-148)

Number: ______________________

INTERVIEWER DECLARATION:
I declare that this interview has been carried out according to all instructions and with a person previously unknown to me and within the rules of the MRS Code of Conduct.

INTERVIEWER SIGNATURE:

______________________

INTERVIEWER NAME:

______________________

SEX: (202)

| | | |
|---|---|---|
| Male | 1 | |
| Female | 2 | |

AGE: WRITE IN
Exact age last birthday:

___ ___ (203-205)

___ ___

DATE OF INTERVIEW:

_____/08/91 (206-211)

TIME INTERVIEW BEGAN:

___ ___ ___ ___ (212-2

___ ___ ___ ___

(USE 24 HOUR CLOCK)

LOCATION: (201)

| | |
|---|---|
| DEVON | 1 |
| DORSET | 2 |
| NORTHWEST | 3 |
| WALES | 4 |

INTRODUCTION:
READ OUT: Good morning/afternoon. We are carrying out a survey on behalf of the Department of the Environment and the University of Surrey. They are looking at what people do at this resort in order to improve facilities and the environment.

QA: Have you been interviewed on this subject before? (216)

| | | |
|---|---|---|
| Yes | 2 | CLOSE |
| No | 1 | CONTINUE |

QB: Are you resident in the UK? (217)

| | | |
|---|---|---|
| Yes | 1 | CONTINUE |
| No | 2 | CLOSE |

QC: We would appreciate if you could answer a few brief questions for us today and then make an appointment for one of our interviewers to contact you by telephone, at a later date. Will you be able to do this for us?

| | | | |
|---|---|---|---|
| Yes | 1 | CONTINUE | (218) |
| No | 2 | CLOSE | |

QD: Have you been into the sea at this beach in the last 3 days? That is since --------- for any of these activities? SHOW CARD A
IF YES: Which one(s)? Any others?
CHECK CALENDAR AND INCLUDE TODAY IN 3 DAY PERIOD

| | | | |
|---|---|---|---|
| NO | 1 | NONACTIVE QUOTA | (219) |
| YES | 2 | RECORD ACTIVITY QE | |

QE: RECORD HIGHEST LEVEL OF ACTIVITY ONLY:

| | | | |
|---|---|---|---|
| Paddling | 1 | LOW ACTIVITY QUOTA | (220) |
| Wading | 2 | | |
| Swimming | 3 | SWIMMER QUOTA | |
| Surfing/Windsurfing/ Waterskiing | 4 | | |
| Diving (without equipment) | 5 | | |
| Deep Sea Diving (with equipment) | 6 | | |

CHECK ELIGIBILITY

Q1. Are you: READ OUT
A. On holiday at this resort, that is, visiting the resort for longer than one day, staying overnight OR
B. A day tripper, visiting the resort for the day OR
C. A local, living in this area?

(221)

CODE ONE ONLY:

| | | | |
|---|---|---|---|
| A. | On holiday | 1 | |
| B. | Day tripper | 2 | |
| C. | A local | 3 | |

ASK ALL
Q2. How often in the past week, that is since last (STATE DAY) have you visited the beach at this resort, counting today?

WRITE IN: ____ ____ DAYS (222 - 223)

Q3. Have you been to any other resort within the past week?

| | | | |
|---|---|---|---|
| Yes | 1 | GO TO Q4 | (224) |
| No | 2 | SKIP TO Q6 | |

ASK IF OTHER RESORT VISITED:
Q4. Please can you tell me what resort that was? WRITE IN: (225-27)

______________________________________________
(RECORD MOST RECENT RESORT ONLY)

Q5a. How many days did you spend at that resort? (Including the day you arrived and the day you left.) WRITE IN:

____ (228)

____ Days

Q5b. IF RETURNING TO THAT RESORT TODAY, COUNT FROM DAY OF ARRIVAL AT THAT RESORT THROUGH AND INCLUDING TODAY AND CODE HERE:

Staying at other resort 1 (229)

ASK ALL:
Q6. I am going to read out some foods you may have bought from cafes, restaurants or food stalls here in (MENTION RESORT). For each type of food, please tell me if you have personally eaten it in the past three days here in (MENTION RESORT). Do not include any foods you have prepared yourselves.

INTERVIEWER: READ OUT EACH FOOD, ROTATING STARTING ORDER
CODE ONE ANSWER FOR EACH FOOD - REMIND THEM
NOT FOODS PREPARED THEMSELVES. SHOW CARD X

| TICK START | READ OUT: | CODE YES | CODE NO | |
|---|---|---|---|---|
| | Ice Cream | 1 | 2 | (230) |
| | Chicken | 1 | 2 | |
| | Eggs | 1 | 2 | |
| | Hot Dogs or Hamburgers | 1 | 2 | |
| | Sandwiches (ASK FOR INGREDIENTS) | 1 | 2 | |
| | Salad (ASK FOR INGREDIENTS) | 1 | 2 | |
| | Seafood | 1 | 2 | |
| | Mayonnaise/Salad Cream | 1 | 2 | |
| | Cold Meat or Pate | 1 | 2 | |
| | Meat Pasties or Pies | 1 | 2 | (239) |

INTERVIEWER: BE SURE YOU HAVE ONE CODE FOR EACH FOOD
REMEMBER TO PROBE FOR ALL INGREDIENTS EATEN
ALSO CODE HERE: (240)

Any food eaten 1
None eaten 2

Q7. Now I would like you to consider this beach area. If we divide this beach up into sections, POINT OUT KEY LANDMARKS ON BEACH WHICH DESCRIBE SECTIONS, where would you say you spend most of your time? Please consider any time you may spend in the sea as well.

IF RESPONDENT CANNOT GIVE YOU ONE SECTION, CODE AREA YOU ARE RECRUITING FROM.
IF RESPONDENT SWIMS IN ONE AREA AND SITS IN ANOTHER TAKE AREA FOR SWIMMING.

(241)

| | |
|---|---|
| SECTION A: | 1 |
| SECTION B: | 2 |
| SECTION C: | 3 |

Q8. I would like to ask you more about any water activities you may have done in the sea at this beach in the past three days that is since ------- CHECK CALDENDAR AND INCLUDE TODAY IN 3 DAY PERIOD. SHOW CARD A AND READ OUT EACH IN TURN

a. Which if any of these have you done here today? Any others? IF NONE CODE 'NOT IN SEA' UNDER TODAY. IF IN SEA BE SURE TO CODE YES OR NO AGAINST EACH ACTIVITY.

b. Which, if any, of these have you done yesterday, in the sea at this beach? Any others? IF NOT HERE OR NOT IN SEA YESTERDAY USE APPROPRIATE CODE UNDER YESTERDAY. IF IN SEA AT THIS RESORT YESTERDAY BE SURE TO CODE YES OR NO AGAINST EACH ACTIVITY.

c. And which, if any, of these have you done the day before yesterday, in the sea at this beach? Any others? IF NOT HERE OR NOT IN SEA DAY BEFORE YESTERDAY USE APPROPRIATE CODE UNDER DAY BEFORE. IF IN SEA AT THIS RESORT DAY BEFORE YESTERDAY BE SURE TO CODE YES OR NO AGAINST EACH ACTIVITY.

| ACTIVITY | 8A. TODAY | | 8B. YESTERDAY | | 8C. DAY BEFORE YESTERDAY | |
|---|---|---|---|---|---|---|
| Not at the Resort that Day | 1 (242) | | 1 (250) | | 1 (258) | |
| Not in Sea that day | 1 (243) | | 1 (251) | | 1 (259) | |
| IF IN SEA AT RESORT CODE ONE ANSWER FOR EACH ACTIVITY: | TODAY | | YEST. | | BEFORE | |
| | YES | NO | YES | NO | YES | NO |
| Paddling | 1 | 2 (244) | 1 | 2 (252) | 1 | 2 (260 |
| Wading | 1 | 2 | 1 | 2 | 1 | 2 |
| Swimming | 1 | 2 | 1 | 2 | 1 | 2 |
| Surfing/Wind surfing/ Waterskiing | 1 | 2 | 1 | 2 | 1 | 2 |
| Diving (diving into the sea without a mask/equipment) | 1 | 2 | 1 | 2 | 1 | 2 |
| Deep Sea Diving (diving such as scuba-diving or snorkelling where a mask/ equipment is used) | 1 | 2 (249) | 1 | 2 (257) | 1 | 2 (265 |

ASK Q9 FOR EACH DAY RESPONDENT WAS IN THE SEA.

IF IN SEA TODAY:
Q9a. Approximately, overall, how many hours/minutes have you spent in the sea on this beach TODAY? (266 ⟷ 269)
WRITE IN NO. OF HOURS AND MINUTES. --- --- --- ---

--- ---HRS. --- --- MINS.

IF IN SEA YESTERDAY:
Q9b. And how many hours/minutes did you spend in the sea on this beach YESTERDAY? (270 ⟷ 273)
WRITE IN NO. OF HOURS AND MINUTES. --- --- --- ---

--- ---HRS. --- --- MINS.

IF IN SEA DAY BEFORE YESTERDAY:
Q9c. And how many hours/minutes did you spend in the sea on this beach THE DAY BEFORE YESTERDAY? (274 ⟶ 277)
WRITE IN NO. OF HOURS AND MINUTES. --- --- --- ---

--- ---HRS. --- --- MINS.

ASK ALL
Q10. Generally speaking, when you go into the sea would you say: you are careful not to get your face or hair wet; your hair or face gets splashed with water but doesn't really go under; or do you put your head or face under the water? (278)

| | |
|---|---|
| Do not get face or hair wet | 1 |
| Face or hair gets splashed | 2 |
| Head goes under water | 3 |
| Never go into the sea (not even paddling) | 4 |

IF RESPONDENT DOES NOT REMEMBER PRESS FOR THE 'MOST LIKELY' OCCURRENCE. IF MORE THAN ONE MENTIONED, CODE HIGHEST LEVEL ONLY.

Q11. Have you been into the sea at any beach other than this particular beach since CHECK CALENDAR AND INCLUDE TODAY IN 3 DAY PERIOD.

Yes ........ 1 ........ Go to Q11b (279)

No ......... 2 ........ Go to Q14

Not sure ... 3 ........ Go to Q14

Q11b. Where was that? (280)

| | |
|---|---|
| At another beach in this area | 1 |
| At the other resort I stayed in (at Q4) | 2 |
| Abroad | 3 |
| At another UK resort | 4 |

WRITE IN ______________________ (308-310)

If more than one, probe where most time spent.

Q12. And on which days were you in the sea there?
Were you there: READ OUT AND CODE:

| | YES | NO | |
|---|---|---|---|
| Day before yesterday | 1 | 2 | (281) |
| Yesterday | 1 | 2 | (282) |
| Today | 1 | 2 | (283) |

FOR EACH DAY THERE ASK Q.13a

Q13a. Which of these activities did you do at that beach ... MENTION DAY . Any others?
SHOW CARD A. CODE HIGHEST LEVEL OF ACTIVITY ONLY FOR EACH DAY IN SEA AT ANOTHER BEACH.

| | (284) DAY BEFORE YESTERDAY | (285) YESTERDAY | (286) TODAY |
|---|---|---|---|
| Paddling | 1 | 1 | 1 |
| Wading | 2 | 2 | 2 |
| Swimming | 3 | 3 | 3 |
| Surfing/windsurfing/ waterskiing | 4 | 4 | 4 |
| Diving (without a mask or equipment) | 5 | 5 | 5 |
| Deep sea diving (such as scuba diving or snorkelling where a mask or equipment is used) | 6 | 6 | 6 |

Q13b. Approximately, overall how many hours/minutes have you spent in the sea on that other beach since ... CHECK CALENDAR AND INCLUDE TODAY IN 3 DAY PERIOD. 287 – 8 289 – 290

--- --- HRS. --- --- MINS.

Q14. ASK ALL:

SAY: Thank you for your help today. We would like to speak with you again briefly approximately one week after you leave this resort, or one week from today if you are a day tripper or local.

ASK HOLIDAY MAKERS ONLY:

Q14a. When will you be leaving this resort?

Day_______________and Date_____/_____/91 (291 – 296)

IF HOLIDAY MAKER OR CURRENTLY STAYING AT ANOTHER RESORT (Q5b)

Q14b. Can I just check first, are you going straight home after visiting this resort or will you be staying at another resort as part of your trip?

| | | | |
|---|---|---|---|
| Going straight home | 1 | GO TO 15 | (297 |
| Going to another resort | 2 | GO TO 14b | |

Q14c. Which resort are you going to:

WRITE IN: ______________________ (298 – 300)

Q14d. When will you be returning home?

Day ______________ and Date ____/______/91 (301 – 306)

> **NOW COMPLETE ATTACHED CONTACT SHEET WITH RECALL DETAILS. IT IT IMPORTANT TO WRITE IN NAME AND TEL. NO.**

SAY: If for any reason this time becomes inconvenient for you please telephone us at the number on the card to arrange another time or day.

THANK RESPONDENT. CHECK THAT TELEPHONE NUMBER IS ACCURATE AND ALL DETAILS HAVE BEEN COLLECTED. FOR CHILDREN COLLECT PARENTS SIGNATURE.

I ---------------- hereby agree that you may telephone my child --------------- in the near future about his/her holiday/ visit to this beach resort.

Signature ______________________________

DATE: ______________________________

Institute of Public Health

The University of Surrey

Guildford, Surrey

Analytica Research
The Heathers
Fairfield Road
Goring on Thames
Reading

FACTS CHECKED

| | Sup | Date |
|---|---|---|
| 1st interview checked | | |
| Back check | | |
| Edited | | |
| Entered | | |

Serial No.______________
O.U.O.

FTD690
"Bucket & Spade"

Name________________________________________________

Tel No.(STD)__________/____________

ASK ALL:
Q15. What time of day would be most convenient for us to phone you?
NOTE: IF CHILD AGED 5-13 BOTH CHILD AND PARENT MUST BE AVAILABLE DURING TELEPHONE RECALL

MAKE APPOINTMENT IN ACCORDANCE WITH INSTRUCTIONS.
HAND RESPONDENT APPOINTMENT CARD WITH DAY, DATE AND TIME.
WRITE DETAILS HERE:

DAY OF RECALL: ____________

DATE OF RECALL: ____________

TIME TO CALL: ____________

OFFICE USE ONLY

| Call | Result of Contact | Notes | Time | Date | No. of units | Inter-viewer |
|---|---|---|---|---|---|---|
| 1. | | | | | | |
| 2. | | | | | | |
| 3. | | | | | | |
| 4. | | | | | | |
| 5. | | | | | | |

(307)

FINAL OUTCOME

Interview completed..........................1
Refused all survey research..................2
Refused - will take part in another survey...3
Not available during fieldwork period........4
Moved away/wrong address.....................5
Number unobtainable..........................6
Other (write in)__________________________.7

RECRUITMENT INTERVIEW PUNCHED
Name.................
Date.................

# APPENDIX 3

# TELEPHONE INTERVIEW

311 - 314

SERIAL NO.

BEACHES TELEPHONE RECALL

1 2 3 4 5 6 7 8

NAME OF RESPONDENT: ______________________

TELEPHONE NO: ______________________

DATE OF TELEPHONE INTERVIEW: (452-453) DAY (454-455) MONTH

---- ---- ---- ----

---- ---- ---- ----

TIME OF TELEPHONE INTERVIEW: (USE 24 HOUR CLOCK)

(456-457) (458-459)

---- ---- ---- ----

DATE OF BEACHES INTERVIEW: ____/August/91

DAY: ______________

RESORT: ______________

INTRODUCTION:
Good morning/afternoon/evening, we are telephoning to follow up on the interview you did on <u>STATE DAY AND DATE</u> for us in. <u>STATE RESORT</u>
SAY: We have only a few short questions for you.

Q1. First can you tell me on how many days did you visit the beach where you were interviewed after our interviewer spoke with you. DO NOT COUNT THE DAY OF THE INTERVIEW

WRITE IN: ____ ____ DAYS (315-316)

IF NONE WRITE IN 0 0

Q2. I am going to read out the list of foods again which you might have eaten at the resort. I would like you to tell me if you have eaten any of these at the resort <u>after you were interviewed</u> . Remember we are talking about foods which were bought at the resort, not including any you prepared yourselves.

INTERVIEWER: READ OUT EACH FOOD, ROTATING STARTING ORDER
CODE ONE ANSWER FOR EACH FOOD

| TICK START | READ OUT: | CODE YES | NO | |
|---|---|---|---|---|
| | Ice Cream | 1 | 2 | (325) |
| | Chicken | 1 | 2 | (326) |
| | Eggs | 1 | 2 | (327) |
| | Hot Dogs or Hamburgers | 1 | 2 | (328) |
| | Sandwiches (ASK FOR INGREDIENTS) | 1 | 2 | (317) |
| | Salad (ASK FOR INGREDIENTS) | 1 | 2 | (318) |
| | Seafood | 1 | 2 | (329) |
| | Mayonnaise/Salad Cream | 1 | 2 | (330) |
| | Cold Meat or Pate | 1 | 2 | (331) |
| | Meat Pasties or Pies | 1 | 2 | (332) |

INTERVIEWER: BE SURE YOU HAVE ONE CODE FOR EACH FOOD
PROBE FOR ALL INGREDIENTS EATEN.

(333)

| ALSO CODE HERE: | | |
|---|---|---|
| | Any food eaten | 1 |
| | None eaten | 2 |

ASK ALL:

Q3a Please think back to the time our interviewer spoke with you on the beach. Did you go into the sea after the interview on that day?

Q3b. And did you go into the sea at that beach on any day since the interview?

| | (334) 3a. On Day | (336) 3b. After |
|---|---|---|
| Yes, in sea | 1 | 1 |
| No, not in sea | 2 | 2 |

IF IN SEA AT 3A OR 3B ASK Q4. IF NOT IN SEA 3A AND 3B GO TO Q5.

Q3a(i). Can I just check, when you were in the sea did you get the upper half of your body wet?

| | (335) |
|---|---|
| Yes | 1 |
| No | 2 |

IF YES AT 3A OR 3B:
Q4a Which, of the following activities did you do in the sea on that beach since our interviewer spoke with you?
CODE YES OR NO BESIDE EACH ACTIVITY.

| | Yes | No | |
|---|---|---|---|
| Paddling | 1 | 2 | (337) |
| Wading | 1 | 2 | (338) |
| Swimming | 1 | 2 | (339) |
| Surfing/wind surfing/ water sking | 1 | 2 | (340) |
| Diving (without mask or equipment) | 1 | 2 | (341) |
| Deep sea diving (such as scuba-diving or snorkling where a mask is used) | 1 | 2 | (342) |

Q4b. Approximately how many hours/minutes have you spent in the sea on the beach where we interviewed you, since the ~~interviewer~~ spoke with you?

(343-344) (345-346)

WRITE IN: ___ ___ HRS. ___ ___ MINS.

Q4c. And over how many days was that?

(347-348)

WRITE IN: ________ Days

ASK ALL
Q5a. Did you go into the sea at any other beach since we interviewed you?

(349)

| | | |
|---|---|---|
| Yes | 1 | - GO TO Q5b. |
| No | 2 | - GO TO Q6 |
| Not Sure | 3 | - GO TO Q6 |

Q5b. Where was that:
IF MORE THAN ONE TAKE FIRST ONE GONE TO AFTER INTERVIEW.

(350)

| | |
|---|---|
| At another beach in the area | 1 |
| Abroad | 2 |
| At another UK beach | 3 |

WRITE IN: ____________________

Q5c. And what activites did you do at that beach?
READ OUT EACH ACTIVITY. CODE YES OR NO FOR EACH.

| | YES | NO | |
|---|---|---|---|
| Paddling | 1 | 2 | (352) |
| Wading | 1 | 2 | (353) |
| Swimming | 1 | 2 | (354) |
| Surfing/wing surfing/ water skiing | 1 | 2 | (355) |
| Diving (without mask or equipment) | 1 | 2 | (356) |
| Deep sea diving (such as scuba-diving or snorkling where a mask is used) | 1 | 2 | (357) |

Q5d. Approximately how many hours/minutes have you spent in the sea on that beach since we interviewed you?

(358-359) (360-361)

WRITE IN: ___ ___ HRS. ___ ___ MINS.

Q5e. And over how many days was that?

(362-363)

WRITE IN: ________ Days

IF RESPONDENT WAS ON HOLIDAY AT RESORT ASK Q6.
IF DAY TRIPPER OR LOCAL SKIP TO Q7.

Q5f. Were you on holiday at the resort at which you were interviewed, that is

(364)

1 Visiting the resort for longer than one day staying overnight

2 On holiday at another resort

OR/ 3 A day tripper visiting the resort for the day

4 A local, living in this area

HOLIDAY MAKERS ONLY:
Q6. Did you have any of the following illnesses or symptoms after your interview, but while you were still at the resort?

INTERVIEWER: READ OUT EACH ILLNESS WITH DESCRIPTION AND CODE
ROTATE STARTING ORDER

| TICK START | READ OUT: | CODE YES | CODE NO | |
|---|---|---|---|---|
| | Runny Nose | 1 | 2 | (371 |
| | Sore Throat | 1 | 2 | (372 |
| | Sore or Red Eyes | 1 | 2 | (373 |
| | Ear Infection, any soreness or discharge | 1 | 2 | (374 |
| | Nausea, that is feeling sick | 1 | 2 | (375 |
| | Vomiting, that is being sick | 1 | 2 | (376 |
| | Stomach cramps, that is pain in the lower abdomen/stomach | 1 | 2 | (377) |
| | Diarrhoea, that is 3 or more loose or runny stools within 24 hours | 1 | 2 | (378 |
| | Wheezing or shortness of breath | 1 | 2 | (379) |
| | Cough | 1 | 2 | 380 |
| | Fever, either high temperature or feeling hot and cold | 1 | 2 | 381 |
| | Any skin rash or irritation | 1 | 2 | (382) |

INTERVIEWER: BE SURE YOU HAVE ONE CODE FOR EACH ILLNESS (383)
ALSO CODE HERE:

| | |
|---|---|
| Any illness experienced | 1 |
| None experienced | 2 |

IF NONE OF THESE EXPERIENCED, GO TO Q7

FOR EACH SYMPTOM/ILLNESS EXPERIENCED AT Q6a ASK Q6b and Q6c

INTERVIEWER: FIRST TICK OFF EACH SYMPTOM/ILLNESS EXPERIENCED AT Q6a IN GRID BELOW. THEN ASK Q6b AND 6c FOR EACH TICKED

Q6b. Did you take any medicine for your <u>MENTION ILLNESS</u> which was <u>not</u> prescribed by a doctor? CODE UNDER 6B IN GRID

Q6c. Did you consult a doctor about this <u>MENTION ILLNESS</u>? CODE UNDER 6C IN GRID

| TICK IF YES AT Q6A. | | 6B NONPRESCRIPTION YES | NO | | 6C SEEN DOCTOR YES | NO | |
|---|---|---|---|---|---|---|---|
| | RUNNY NOSE | 1 | 2 | (384) | 1 | 2 | (385) |
| | SORE THROAT | 1 | 2 | (386) | 1 | 2 | (387) |
| | SORE/RED EYES | 1 | 2 | (388) | 1 | 2 | (389) |
| | EAR INFECTION | 1 | 2 | (390) | 1 | 2 | (391) |
| | NAUSEA | 1 | 2 | (392) | 1 | 2 | (393) |
| | VOMITING | 1 | 2 | (394) | 1 | 2 | (395) |
| | STOMACH CRAMPS | 1 | 2 | (396) | 1 | 2 | (397) |
| | DIARRHOEA | 1 | 2 | (398) | 1 | 2 | (399) |
| | WHEEZING/SHORT BREATH | 1 | 2 | (400) | 1 | 2 | (401) |
| | COUGH | 1 | 2 | (402) | 1 | 2 | (403) |
| | FEVER | 1 | 2 | (404) | 1 | 2 | (405) |
| | SKIN RASH/IRRITATION | 1 | 2 | (406) | 1 | 2 | (407) |

INTERVIEWER: BE SURE YOU HAVE ONE CODE AT Q6b AND ONE CODE AT Q6c FOR EACH ILLNESS MENTIONED AT Q6A.

ASK ALL:

Q7a Now I would like you to think about this past week, that is the week after returning from the resort. Did you have any of the following illnesses or symptoms during the week after returning from the resort?

INTERVIEWER: READ OUT EACH ILLNESS WITH DESCRIPTION AND CODE. ROTATE STARTING ORDER.

| TICK START | READ OUT: | CODE YES | NO | |
|---|---|---|---|---|
| | Runny Nose | 1 | 2 | (414) |
| | Sore Throat | 1 | 2 | (415) |
| | Sore or Red Eyes | 1 | 2 | (416) |
| | Ear Infection, any soreness or discharge | 1 | 2 | (417) |
| | Nausea, that is feeling sick | 1 | 2 | (418) |
| | Vomiting, that is being sick | 1 | 2 | (419) |
| | Stomach Cramps, any pain in the lower abdomen/stomach | 1 | 2 | (420) |
| | Diarrhoea, that is 3 or more loose or runny stools within 24 hours | 1 | 2 | (421) |
| | Wheezing or shortness of breath | 1 | 2 | (422) |
| | Cough | 1 | 2 | (423) |
| | Fever | 1 | 2 | (424) |
| | Skin Rash or Irritation | 1 | 2 | (425) |

INTERVIEWER: BE SURE YOU HAVE ONE CODE FOR EACH ILLNESS AT Q7a.

ALSO CODE HERE: (426)

| | |
|---|---|
| Any illness experienced | 1 |
| None experienced | 2 |

IF NONE EXPERIENCED AT Q7a GO TO INSTRUCTIONS BEFORE Q8.

FOR EACH SYMPTOM/ILLNESS EXPERIENCED AT Q7a ASK Q7b AND Q7c

INTERVIEWER: FIRST TICK OFF EACH SYMPTOM/ILLNESS EXPERIENCED AT Q7a IN GRID BELOW. THEN ASK Q7b AND Q7c FOR EACH TICKED

Q7b. Did you take any medicine for your MENTION ILLNESS which was not prescribed by a doctor? CODE UNDER 7B IN GRID

Q7c. Did you consult a doctor about this MENTION ILLNESS? CODE UNDER 7C IN GRID

| TICK IF YES AT Q7A. | | 7B NONPRESCRIPTION YES | NO | | 7C SEEN DOCTOR YES | NO | |
|---|---|---|---|---|---|---|---|
| | RUNNY NOSE | 1 | 2 | (427) | 1 | 2 | (428) |
| | SORE THROAT | 1 | 2 | (429) | 1 | 2 | (430) |
| | SORE/RED EYES | 1 | 2 | (431) | 1 | 2 | (432) |
| | EAR INFECTION | 1 | 2 | (433) | 1 | 2 | (434) |
| | NAUSEA | 1 | 2 | (435) | 1 | 2 | (436) |
| | VOMITING | 1 | 2 | (437) | 1 | 2 | (438) |
| | STOMACH CRAMPS | 1 | 2 | (439) | 1 | 2 | (440) |
| | DIARRHOEA | 1 | 2 | (441) | 1 | 2 | (442) |
| | WHEEZING/SHORT BREATH | 1 | 2 | (443) | 1 | 2 | (444) |
| | COUGH | 1 | 2 | (445) | 1 | 2 | (446) |
| | FEVER | 1 | 2 | (447) | 1 | 2 | (448) |
| | SKIN RASH/IRRITATION | 1 | 2 | (449) | 1 | 2 | (450) |

INTERVIEWER: BE SURE YOU HAVE ONE CODE AT 7B AND ONE CODE AT 7C FOR EACH ILLNESS MENTIONED AT Q7A.

IF ANY DOCTOR WAS CONSULTATED FOR ANY ILLNESS AT Q6C OR Q7C ASK Q8. OTHERS SKIP TO CLOSE.

Q8. If you have seen a doctor for any of the illnesses or symptoms mentioned we would like to contact your Doctor for more technical information about your symptoms. This information will help us determine whether or not the symptoms are related to your visit to the beach. Any information provided by your doctor will be kept strictly confidential. May we do this

(451)

| | | |
|---|---|---|
| Yes | 1 | - Read out statement |
| No | 2 | - Go to close |

IF YES: We will send you a letter and ask you to send it back with the details of your doctor. May I just check we have your correct mailing address.

THANK RESPONDENT. CHECK THAT ADDRESS AND POSTCODE FOR RESPONDENT IS ACCURATE AND COMPLETE. CLOSE INTERVIEW.

# APPENDIX 4

# EC BATHING WATER MICROBIOLOGICAL STANDARDS

**EC BATHING WATER QUALITY DIRECTIVE (CEC, 1976)**
**SUMMARY MICROBIOLOGICAL STANDARDS**

| Indicator | Mandatory | Guide |
|---|---|---|
| Total coliforms | 10000* | 500* |
| Thermotolerant coliforms | 2000* | 100* |
| Faecal streptococci | - | 100* |
| Enterovirus | 0** | |

* per 100 ml seawater
** per 10 litres seawater

Note: Mandatory level must not be exceeded in 95% of samples.
Guide level must not be exceeded in 80% of samples.

# APPENDIX B - THE SOUTHSEA CONTROLLED COHORT STUDY, FINAL REPORT

Interim Report to WRc
By F. Jones, D. Kay, R. Salmon, M.D. Wyer and A.F. Godfree
Centre for Research into Environment and Health
St. David's University college, Lampeter, Dyfed

# THE SOUTHSEA CONTROLLED COHORT STUDY

# FINAL REPORT

NOT TO BE QUOTED WITHOUT PERMISSION

**F. Jones*, D. Kay*, R. Salmon**, M. D. Wyer* and A. F. Godfree*****

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This report is submitted in completion of the Department of Environment Contract PECD 7/7/377 (Phase III) and Department of Health / Welsh Office / NRA project No. A11.1/128 between the Water Reseach Centre and the Centre for Research into Environment and Health, at St. David's University College, University of Wales, Lampeter.

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## 1. Summary

The 1991 controlled cohort investigation at Southsea was part of the second phase of UK studies designed to examine the possible health effects of bathing in UK coastal waters. The study was the third implementation of the controlled cohort design pioneered at Langland Bay in 1989. The methodology was broadly similar to that carried out at Moreton, Wirral, in 1990. The study site was chosen to (i) provide water quality within the *Imperative* criteria for total and faecal coliforms in bathing waters (Directive 76/160/EEC) and (ii) provide a catchment area for volunteer recruitment. The data from water quality monitoring for the bathing season met the requirements of the Directive.

Pre-exposure interviews provided information on (i) social and demographic details, (ii) general health and symptomatology in the previous three weeks, (iii) smoking, alcohol consumption and prescription drugs, (iv) recreational use of water and (v) conditions of the throats and ears of volunteers.

The exposure day was Saturday 6th July. Volunteers were randomly ascribed to one of two cohort groups, bathing or non-bathing. Analysis of the demographic and social variables showed no evidence of any bias in the two groups. A short interview on the exposure day concerned current symptomatology and recent diet. Those volunteers assigned to the bathing group took a supervised and recorded dip during which they were asked to immerse their heads three times. Volunteers received a packed lunch.

Conditions on the study day were calm and sunny with sea temperatures of 20.7 - 20.8°C. Samples were taken at half hourly intervals for three hours at three foreshore locations along a 60 m stretch of shore at three depths. The water quality on the study day conformed to the EC Directive *Imperative* values for total and faecal coliform but failed on the *Guide* criteria for faecal coliform and *Imperative* criteria for enterovirus. *Cryptosporidia* and *Salmonella* were not found in samples analysed. Geometric mean faecal coliform count for the 84 samples was 128 100 $ml^{-1}$.

Post-exposure follow-up interviews and medical examinations were held on the following Friday and Saturday. Ear and throat swabs were taken and volunteers presented faecal samples. From an initial recruitment of over 1000, 386 volunteers completed the project to this stage. Postal questionnaires and final faecal sample pots were sent to volunteers at three weeks after the study day. In total, 360 completed questionnaires were returned.

A significant difference in the isolation of faecal streptococci from the ear swabs of bathers compared to non-bathers was found at one week post-exposure (Relative risk 2.97, 95% Confidence interval 1.20 - 7.35). Such a result was not found in previous studies. Bathers with faecal streptococci on ear swabs also experienced significantly higher total coliform concentrations at chest depth and total staphylococci in the surf zone. Results of microbiological analyses of faecal samples were generally negative as were results of virus determinations on throat swabs.

At one week post-exposure significant elevations were found in the gastrointestinal symptom group amongst bathers compared to non-bathers (Relative risk 1.76, 95% Confidence interval 1.31 - 2.38). Significant individual symptoms were loose motions (Relative risk 1.56, 95% Confidence interval 1.01 - 1.78) and nausea (Relative risk 2.51, 95% Confidence interval 1.36 - 4.63). The former result is similar to that found in both previous studies. Significant results were not found for symptoms such as sore throats and ear infections which have been found significant in previous studies. Bathers reporting loose motions at one week

experienced significantly higher concentrations of total staphylococci in the surf zone as did those reporting nausea. Bathers reporting nausea also experienced significantly greater concentrations of total coliform and total staphylococci in the surf zone.

A significantly greater proportion of bathers consumed mayonnaise during the one week post exposure period. The influence of this factor on gastrointestinal symptom reporting was examined using stratified contingency table analysis. The inclusion of mayonnaise consumption as a possible confounding factor had no effect on nausea (Relative risk 2.58, 95% Confidence interval 1.38 - 4.81) or any symptom from the gastrointestinal group (Relative risk 1.77, 95% Confidence interval 1.31 - 2.39) . The symptom loose motions was barely significant prior to the inclusion of this confounder . The lower confidence interval for this symptom was reduced to 0.97 when the confounding factor mayonnaise was included.

At three weeks, significantly more gastrointestinal symptoms (Relative risk 2.97, 95% Confidence interval 1.11 - 2.06), nausea (Relative risk 3.70, 95% Confidence interval 1.65 - 8.32) and skin symptoms (Relative risk 1.97, 95% Confidence interval 1.02 - 3.84) were reported by bathers. In the previous cohort studies skin symptoms have not been significant.

Statistical comparisons of water quality in the three cohort studies are reported. Several significant differences were found. Water quality at Langland Bay was characterised by high faecal streptococci concentrations compared to total and faecal coliform concentrations. Both Moreton and Southsea had comparatively high total and faecal coliform and enterovirus levels.

The third controlled cohort study at Southsea has again demonstrated the feasibility of this method. The combination of data sets will provide a base for a powerful statistical analysis.

## 2. Introduction

The Southsea Beach study was part of the second phase of epidemiological studies designed to investigate the health effects of bathing in sewage polluted coastal waters. The study derives directly from research pioneered at Langland Bay, Swansea, in the summer of 1989 (Jones *et al.*, 1991; Pike, 1990) and refined at Moreton, Wirral, in the 1990 bathing season (Jones *et al.*, 1990). This controlled cohort approach was first suggested by the World Health Organisation (WHO, 1972). The Southsea study was contracted to the Centre for Research into Environment and Health at the University of Wales under the management of the Water Research Centre. The funding agencies included the Department of the Environment , The National Rivers Authority, The Welsh Office and The Department of Health.

## 3. Study Design and Methodology

The study site, Southsea (NRA location: 14100 16600) was selected by the NRA which provided excellent logistical support to the study team. The site was chosen with the recruitment task in mind and is close to the large naval city of Portsmouth. Water quality at Southsea also has a record of compliance with the Imperative standard defined in Directive 76/160/EEC (EEC, 1976) for total and faecal coliforms. A study date of 6th July, early in the bathing season, was chosen to allow for a repeat attempt should inclement weather have prevailed on the test date.

The Southsea study was designed to be directly comparable with the study undertaken at Moreton during the 1990 bathing season (Jones *et al.*, 1990). The methodology adopted is therefore virtually identical to that at the previous site apart from a few differences in minor details. The Department of the Environment had received ethical approval for the protocol from the Royal College of Physicians Committee for research on Healthy Volunteers in 1989. Information sheets detailing the aims and nature of the study for prospective volunteers plus guide-lines for recruiters were designed in accordance with recommendations of the Royal College of Physicians (RCP, 1986). Local ethical clearance for the study was obtained from the Portsmouth Consultant Community Physician.

As in both previous investigations, the Southsea study aimed to accommodate at least 400 volunteers to be randomised into two equal groups of bathers and non-bathers. The initial recruitment drive numbered 1044 adults (over 18 years old) to account for expected drop out rates. At this stage of the study, each of the volunteers had read the subject information sheet and signed an agreement to take part. They also gave details of their home address, telephone general practitioner (Appendix I).

The recruitment of volunteers was organised by the University of Wales CREH and Oxford Conferences. The team consisted of 8 selected recruiters. Clerical support and office space was given by Portsmouth City Council (PCC). The recruitment team was in the field for three weeks prior to the study. Local media coverage was handled by Dr David Kay and Mrs Cathy Pownall in conjunction with the PCC public relations officer Ms Alison Rawlins. Volunteers were recruited in and around the Cascade shopping centre in Portsmouth, at the shopping centre in Southsea and at the coast between Southsea pier and the Pyramids Leisure Centre. In the Cascade Centre, displays using large colour pictures from the previous studies were erected.

The volunteer details from the subject information sheets were input to a data base on a daily basis. Updated versions of this data base were sent to CREH on floppy disks at regular intervals. In the two weeks prior to the study each volunteer was contacted by telephone or letter. Each volunteer's general practitioner was sent notification of their patient's involvement in the study (Appendix I).

Interviews took place in two committee rooms at Portsmouth civic offices. One room was allocated to the questionnaire interviews and one to medical interviews (Green questionnaire, Appendix II). Screens were provided in the medical interview room. Volunteers were guided through from an entrance desk and received information on the next stages of the project at an exit desk. Interviews and medical examinations were carried out by teams assembled by CREH and PCC Environmental Health Department. Medical and statistical staff from the Communicable Disease Surveillance Centre (CDSC) (Welsh Region) of the Public Health Laboratory Service also provided an input to the interviews. The pre-exposure interviews were conducted on the 4th and 5th of July. In total, 449 volunteers completed this stage of the project. Ten of these were advised not to take part on either medical or other grounds (e.g. refusal to adhere to the randomly defined bathing status)

After the final pre-exposure interview (8.00pm 5th July) the list of volunteers was randomised. This list was then split into two groups; bathers and non-bathers and the volunteers were each allocated a supervisor number. Alphabetical lists of participants in each group were prepared for distribution to the volunteers. The list of bathers was printed on blue paper and the list for the control group, who would go on to the beach area only, on red paper .

### 3.1 Study site preparation

At the study site (Figures 3.1 and 3.2) two portakabins were provided for administration and pre-exposure interviews of volunteers who could not attend for interview at the town hall. The CREH mobile laboratory facility was set up at the site to handle environmental microbiological analysis of samples. Mains water and electricity were available at the site, plus a back-up generator. Entertainment for children was provided by a bouncy castle close to the site. Packed lunches were provided through an independent caterer recommended by PCC. The caterers provided their own refrigerated vehicle for lunch distribution. The marking of the non-bather area and the four sampling locations along a 60 m stretch of beach (Figure 3.2) was carried out to a high standard by PCC staff under CREH direction. The site was a steeply sloping sand and shingle beach with a short tidal range. This was found to be ideal for accurate marking with metal stakes and ropes. The St. Johns Ambulance Brigade and PCC lifeguards provided safety cover.

### 3.2 Cohort organisation and follow up

Volunteers reported to the study site from 12.00 noon onwards. They each received a blue and red list enabling them to find their supervisor in the designated areas of the beach. Marshals were available to give appropriate guidance to volunteers. After making their way to their supervisors each volunteer completed the second interview (Yellow questionnaire, Appendix II). Non-bathers then received their packed lunch whilst bathers took a closely monitored dip in the sea. The bathers were instructed to immerse their heads completely on at least three occasions and to remain in the sea for a minimum of ten minutes. The exact location and activities of bathers were monitored using diary sheets (Appendix II). After their dip bathers were asked if they had ingested any water and then received their packed lunch.

Follow-up questionnaire and medical interviews were held in the same location in the Civic Offices as the pre-exposure interviews on Friday and Saturday (12th and 13th of July) following the study day. In total, 339 volunteers completed this third interview (Pink questionnaire, Appendix II), had throat and ear swabs taken and presented faecal samples for analysis . A further 47 subjects completed the interview only, either by telephone or post, because they were unable to attend at the Civic Offices. Final postal questionnaires (blue, Appendix II) were sent, along with faecal sample pots, to arrive at the volunteers' addresses by Saturday the 27th of July, three weeks after the study day. The postal questionnaire response rate was high (93% of those followed up at the post-exposure interview) with 360 postal questionnaires completed and returned to the CREH office.

**3.3 Questionnaire design and analysis**

The study used a four part questionnaire set designed to obtain information on social, health and environmental factors in the volunteer group before and after the exposure day. Where appropriate, the questionnaire content was matched with questionnaires being used in prospective beach surveys at four other UK locations during the 1991 bathing season.

The range of social factors recorded included details of age, gender, social class and household size. Questions about general health focused upon a wide range of individual symptoms and symptom groups including 'flu / cold symptoms, chest / respiratory symptoms, gastrointestinal symptoms and skin symptoms. Onset date and duration of recent illness were recorded. The health part of the pre-exposure interview also enquired into chronic illness, drug therapy plus factors such as smoking and alcohol consumption. The environmental factors covered a range of exposures to fresh or marine waters that volunteers might have encountered either through their vocation or recreational activities. The questionnaires also covered other factors including dietary history before and after exposure. This centred on foods thought likely to increase rates of gastrointestinal illness in the cohort group such as; meat products (cold meats, pâté, meat pasties/ pies, hot dogs, hamburgers), raw milk, raw egg products such as fresh mayonnaise plus seafood (cockles, whelks and mussels etc.).

The questionnaire set for the pre-exposure (1-2 days), test day and one week post-exposure (6-7 days) phases of the study were administered by personal interview. The final questionnaire was completed by the volunteers and returned in a stamped addressed envelope. Both cohort groups received the same questionnaire set. The bathing status of the volunteers was not known by the volunteers or interviewers until the exposure day.

The questionnaire format was virtually identical to that used at Moreton with pre-coded option boxes to be ticked by the interviewer. In the right hand margin columns were provided for coding the information ready for data input to a computer. Data entry involved a system of overwriting a fixed format template. Data analysis used the SPSSx package (SPSS, 1989) to examine response frequencies. Epi Info Version 5 (Dean *et al.*, 1990) was used to calculate relative risk and associated 95% confidence intervals and to undertake stratified analysis.

**4. Methods - Microbial investigations and statistical techniques**

**4.1 Microbiological quality during the 1991 bathing season**

A statistical summary of 21 samples taken at Southsea by the NRA (Southern Region) during the 1991 bathing season (between 07.05.91 and 24.09.91) is shown in Table 4.1. Geometric mean counts of total coliform, faecal coliform and faecal streptococci were 166, 85 and 13 100 $ml^{-1}$ respectively. Table 4.2 details the levels of compliance with the Directive 76/160/EEC for these indicator organisms. Compliance was achieved with the *Imperative* (I) levels for total coliform and faecal coliform. The samples also complied with the total coliform and faecal streptococci *Guide* (G) concentrations. However, the data failed to comply (61.9% compliance) with the faecal coliform G level. *Salmonella spp.* were not present in two samples analysed. Two samples assayed for enterovirus contained 4 and 5 plaque forming units 10 $l^{-1}$ (pfu 10 $l^{-1}$) and indicated non-compliance with the EC I standard for enterovirus in bathing waters (95% of samples to have zero counts).

**4.2 Bacterial water quality on 06.07.91**

Intensive sea water sampling took place in the designated bathing area at Southsea between 14.00 and 17.00 BST on the afternoon of 06.07.91. The sampling and microbiological determinations were carried out by staff from Altwell Ltd. This aspect was directed by Mr Alan Godfree. Sampling took place at four points 20 m apart along a 60 m stretch of the shore. Samples were taken at half hourly intervals at three depths in the near shore zone; surf, mid (30 cm) and chest depth. Additional samples were taken from a boat off shore. Samples were analysed for concentrations (count 100 $ml^{-1}$) of the following indicator organisms total coliforms, faecal coliforms, faecal streptococci, *Pseudomonas aeruginosa*, and total staphylococci (Appendix III).

Two sets of duplicate samples were taken for quality control analysis. One set was analysed for all five determinands by the sub-contracted microbiologists and the other for three parameters (total and faecal coliforms and faecal streptococci) by the NRA (Southern Region) laboratory at Waterlooville. The latter group of samples were transported to the laboratory and analysed within 2.5 hours of collection (Appendix III).

Samples were also analysed for *Cryptosporidium spp.* and *Salmonellae spp.* (Appendix III).

**4.3 Viral water quality on 06.07.91**

The virological sampling and analysis of sea water during the bathing period was undertaken by Enviros Ltd under the supervision of Dr Helen Merrett. Virological sampling produced a total of 15 samples taken from the 30 cm sampling depth during the afternoon (20, 40, and 60 m sampling points at half hourly intervals from 14.00 to 16.00 BST) plus two off-shore boat samples. These were analysed for enterovirus (pfu 10 $l^{-1}$) and rotavirus (fluorescing foci (ff) 10 $l^{-1}$) using methods outlined in Appendix III.

**4.4 Clinical samples and examinations by physicians**

At the pre and post-exposure interviews each Volunteer's ears and throats were examined by a physician. Details of any redness or infection in the throat was recorded. Likewise, any evidence of ear infection or discharge was noted.

Ear and throat swabs were taken for bacteriological analysis at the one week post-exposure interview. Throat swabs were also taken for virological analysis. Faecal samples were presented at one week and three weeks after exposure. Analysis was carried out by Preston Public Health Laboratory under the direction of Dr David Hutchinson and Dr Peter Morgan-Capner. Samples were transported in insulated cold boxes by courier at the end of each of the two post-exposure interview days to reach the laboratory within twelve hours.

The bacterial parameters examined on ear and throat swabs were; haemolytic streptococci, faecal streptococci, coliforms, *Escherichia coli* and *Staphylococcus aureus*. Ear swabs were also cultured for *Pseudomonas aeruginosa*. The viral throat swabs were cultured for enterovirus and rotavirus.

Stool samples submitted at one week were analysed for *Salmonella spp.*, *Shigella spp.*, *Campylobacter spp.* and *Escherichia coli* 157. Samples of faeces from participants reporting gastrointestinal symptoms were analysed for *Cryptosporidia spp.* and for ova, cysts and parasites. The laboratory also provided a visual index of faecal consistency in three categories; solid, semi-solid and liquid.

Virological analysis, using electron microscopy, was carried out on three week stool samples from the group of volunteers reporting gastrointestinal symptoms at both post-exposure stages.

Analytical details of human samples are given in Appendix III.

**4.5 Packed lunch analysis**

Packed lunches were provided for all volunteers on 6th of July. Five samples of cheese sandwiches randomly selected from the packed lunches were analysed for; coliforms, *salmonella spp.*, *Staphylococcus aureus*, *Enterococcus faecalis* and *Escherichia coli.* The analysis was carried out by Portsmouth District Pathology / Public Health Laboratory.

**4.6 Statistical methods**

The statistical significance of differences in symptom attack rates reported by the bathing group compared to the non-bathing group was examined using contingency table analysis. Relative risk values (RR), the risk of illness amongst bathers/risk of illness amongst non-bathers, and 95% confidence intervals (CI) were calculated based on algorithms used in Epi Info version 5 (Dean *et al.*, 1990; Greenland and Robins, 1985). The Epi Info contingency table analysis also reports significance values ($p$). The $p$ values examined were from Yates' corrected $\chi^2$ test or Fisher's exact test, where an expected cell count was less than five. In the latter case the $p$ value was calculated as twice the one tailed value. This approximates the Yates' corrected $\chi^2$ value most closely (Dupont, 1986).

Stratified contingency table analysis was used to provide an initial examination of food intake as a confounding factor at one week post exposure. The analysis allows the effects of the exposure of interest, in this case sea bathing, to be assessed controlling for the effects of another exposure such as food intake. Significance was ascertained from Mantel - Haenszel summary $\chi^2$ values, weighted RR values and Greenland / Robins 95% CI (Dean *et al.*, 1990).

Relationships between bather morbidity and water quality were examined using t-tests. Knowing the time and location that each bather was in the water allowed the results of the closest microbiological samples to index the water quality experienced by an individual bather. Student's t-test analysis was applied to detect any statistically significant differences in geometric mean indicator concentration experienced by bathers reporting a particular symptom / symptom group and those not reporting a symptom / symptom group. The hypothesis tested was:

$H_0 : \mu_1 = \mu_2 \text{ v } H_1 : \mu_1 < \mu_2$
(i.e. t to be -ve) where:

$\mu_1$ is the geometric mean water quality experienced by bathers reporting no symptom and
$\mu_2$ is the geometric mean water quality experienced by bathers reporting a symptom

The test selected was therefore a single tail separate variance estimate t-test, with $\alpha = 0.05$ as the cut off point for significance. Relationships between clinical results from throat and ear swabs and water quality were investigated in a similar manner. In this case the geometric mean concentrations of an indicator organism experienced by bathers with a positive result on a swab was compared to the geometric mean experienced by bathers with a negative swab result.

## 5. Results

### 5.1 Site conditions on the study day

Wind conditions were a gentle to moderate breeze from an easterly direction. The sky was generally clear providing bright sunshine throughout the afternoon. The only cloud cover (one okta) occurred during the first half hour of the study period. No precipitation occured. Sea water temperature in the bathing area during the study afternoon was 20.7 to 20.8 °C. Salinity was measured at 34.7 ppth. The state of the sea varied from smooth (wavelets) to slight (30 - 60 cm waves). No evidence of colour, mineral oils, surface active substances or sewage was present at the sea surface. Bather density in the study area is shown in Figure 5.1

### 5.2 Environmental samples

Summary statistics for microbiological determinations on the 104 samples taken during the afternoon of the exposure day are shown in Table 5.1a and the 84 inshore samples (excluding samples taken by boat) in Table 5.1b. Tables 5.1c to 5.1f detail the results by sampling depth. No *Cryptosporidia spp.* or *Salmonella spp.* were detected. Plots of the change in geometric mean concentrations of parameters during the bathing period for each sampling depth are shown in Figures 5.2 to 5.6. These patterns of microbial concentration during the course of the afternoon show similar trends at each sampling depth. The indicator organism concentrations increase inshore from chest depth to the surf zone. Figure 5.7 shows concentrations for the off-shore samples which were lower than the inshore samples.

The results of statistical analysis (paired t-tests) of duplicate sample sets for quality control are given in Appendix III. No significant differences ($\alpha = 0.05$) in geometric means between the sub-contractors results and those provided by the NRA Southern Region laboratory were detected.

The compliance of the, Directive (76/160/EEC), 30 cm depth sample set is displayed in Table 5.2. Bacteriological samples on the afternoon of the exposure day complied with all EC criteria except the *Guide* level for faecal coliform (28.6% compliance). The rate of non-compliance for this element of the Directive was lower than that for the whole bathing season samples (Table 4.1).

The results of virological analysis of 15 samples collected from the 30 cm depth are shown in Table 5.3. Enterovirus density ranged from 0 to 26 pfu 10 $l^{-1}$. The results are illustrated in Figure 5.8. Enterovirus were present in one of the two off-shore samples at 2 pfu 10 $l^{-1}$. Rotavirus was not detected in any sample. The presence of enterovirus in 20% of the 30 cm samples indicates failure to comply with the EC Directive for this parameter on the study afternoon.

## 5.3 Microbial results from human and food samples

### 5.3.1 Ear and throat swabs

The RR and 95% CI values for comparisons of swab results obtained from the bather and non-bather groups are shown in Figure 5.9. This includes combinations of any determinand present on either or both swabs. Counts, significance (*p*) and attack rates are presented along with RR and 95% CI levels in Appendix IV.

The bathing group had a significantly higher incidence of faecal streptococci on ear swabs compared to the non-bathers (RR Lower CI > 1.0). Attack rates for this comparison were 103 ‰ in the bather group compared to 35 ‰ in the non-bather group (Appendix IV). A large proportion of the volunteers (65%) had positive determinations for faecal streptococci on their throat swabs. No other swab results were significant. Virus particles were not detected in any of the throat swabs analysed.

### 5.3.2 Faecal samples

Of 352 samples analysed from the one week post exposure set *Campylobacter jejuni* was isolated in one sample. The carrier was a non-bather. No other determinands (*Salmonella spp., Shigella spp.* and *Escherichia coli* 157) were detected in this sample set.

*Giardia lamblia* cysts were present in two of 108 samples analysed from the 3 week post-exposure set analysed for ova, cysts and parasites. These samples were from a bather and a non-bather.

Electron microscopy revealed no virus particles in 111 faecal samples examined from volunteers reporting gastrointestinal symptoms at either one or three weeks post exposure.

The low number of positive results precluded any further statistical analysis.

The results of the analysis of the consistency of faecal samples is given in Table 5.4. The frequencies in each category were virtually identical for the bather and non-bather groups, indicating that neither group produced significantly greater numbers of runny stool samples.

### 5.3.3 Packed lunch analysis

The microbiological analysis of five cheese sandwiches from packed lunches, as consumed by volunteers on the study afternoon, revealed no positive determinations with the exception of *Enterococcus faecalis*. In one case this organism was isolated with a count of over 500 $gm^{-1}$. The same sample had a coliform count of zero. The source of *Enterococcus faecalis* in food is often unrelated to direct faecal contamination. If this result is correct it could partially explain the large number of positive faecal streptococci results found on throat swabs, as these methods utilise similar enumerations of the streptococci organism group.

## 5.4 Questionnaire Results

The results of frequency analysis for social and demographic variables, such as the gender and age structure, as well as the general health and chronic illness are given in Appendix V. This Appendix also details recreational water use and activities of the cohort. From these data the two randomly selected groups appeared to have broadly similar characteristics.

This report is concerned with results of symptoms and illnesses. Analysis of the effects of confounding factors, such as previous illness, frequency of recreational water use and travel will be undertaken at a later stage. Calculated RR and associated 95% CI's for 26 symptoms and eight symptom groups at each of the four stages of the project are show in Figures 5.10 to 5.13. Additional details of cell counts, significance and crude attack rates are given in Appendix IV.

At the pre-exposure stage, before the bathing status of each volunteer had been defined, the non-bather group exhibited significantly more (upper 95% CI < 1) chest symptoms, runny noses, ear / eye symptoms and the "any" symptom group in the three weeks prior to the study (Figure 5.10). The exposure day interview results show no significant differences between the bather and non-bather groups (Figure 5.11). At one week post-exposure the following symptoms / symptom groups were reported significantly more often in the bathing group than the non-bathing group; gastrointestinal (GI) symptoms, loose motions and nausea (Figure 5.12). During the three weeks post-exposure period the bathing group again reported significantly more gastrointestinal symptoms and nausea plus skin symptoms. Significant differences for the groups "any symptom" and "any bathing symptom" (excluding the "other" symptom group) were also found on the postal questionnaire set (Figure 5.13).

No significant differences were found in either post-exposure questionnaire for incidence of gastrointestinal symptoms and whether bathers swallowed water or not (Figures 5.14 and 5.15). Further details are listed in Appendix IV. Of the 13 food categories used to examine volunteers' dietary habits only fresh mayonnaise consumption differed significantly between the bather and non-bather groups in the one week post-exposure period (Appendix IV). Stratified contingency table analyses were performed to examine the effects of sea bathing on gastrointestinal symptoms controlling for fresh mayonnaise intake. The results are shown in Figure 5.16 and detailed further in Appendix IV. The results suggest that mayonnaise did not have a significant influence on the reporting of nausea and any gastrointestinal symptom as these symptoms remained significant in the stratified analysis. This was not the case for loose motions, however, which became non significant with the addition of mayonnaise as a factor.

Serious illness in the one and three week follow up periods was indexed through the number of subjects reporting; (i) GP consultations, (ii) illness interfering with normal daily cctivities and (iii) hospital consultation. The counts in each category were very low, especially for hospital consultations (Appendix IV). Bather vv non-bather differences were not significant .

The results of medical diagnoses of reported throat and ear conditions at the one week post-exposure examination are shown in Figure 5.17. No significant differences were detected between the bather and non-bather groups. Further detail is presented in Appendix IV.

### 5.5 Perceived symptoms and water quality - t-test results

A total of 510 t-test analyses for differences in geometric mean water quality experienced by bathers reporting symptoms and bathers not reporting symptoms were carried out for each of the post exposure questionnaires. The significant results for the hypothesis outlined in Section 4.6 are listed in Tables 5.5 and 5.6. In cases where the number of positive cases was small (<10 e.g. blurred vision at one week post-exposure, Table 5.5) the results of the analysis should be treated with caution as the calculation of a geometric mean value for limited number of results may be inappropriate. At one week post-exposure 64 tests were significant and at three weeks 38. It was noted that for 24 tests at one week and 22 tests at three weeks bathers reporting symptoms experienced significantly lower geometric mean indicator concentrations. A high proportion (72%) of these results were for *Pseudomonas aeruginosa* .

Taking the significant symptom groups as defined by RR, bathers reporting loose motions at one week post-exposure experienced significantly greater concentrations of total staphylococci in the surf zone. This variable was also significant for nausea reported at one week. Bathers reporting nausea at one week also experienced significantly higher total coliform and total staphylococci at the 30 cm depth. No significant water quality effect was evident for nausea during the three weeks post-exposure period.

### 5.6 Clinical results and water quality - t-test results

The t-test analysis for differences in water quality experienced by bathers with positive swab results at one week and those with negative swab results produced a total of 210 analyses. Ten percent of results were significant (Table 5.7) for the hypothesis tested. A similar percentage of tests showed significantly lower geometric mean indicator concentrations experienced by bathers with a positive swab result compared to those with a negative result. A comparatively high proportion (36%) of these results were for *Pseudomonas aeruginosa* concentrations. The single swab analysis producing a significant bather vv non-bather differential, i. e. faecal streptococci on the ear swab; revealed that bathers with a positive swab result experienced significantly higher geometric mean concentrations of total coliform at chest depth and total staphylococci in the surf zone.

### 5.7 Clinical results, perceived symptom and medical diagnosis relationships

The results from the one week post-exposure questionnaire for ear and throat symptoms and the clinical sample results from ear and throat swabs were combined to place volunteers into four symptom levels. These were; (i) those with both negative swab results and symptoms, (ii) those with positive swab results only, (iii) those with positive questionnaire responses only and (iv) those with both positive questionnaire response and swab results. Frequencies for these categories are shown in Tables 5.8 and 5.9.

Similar combinations of comparisons between (i) perceived symptoms and medical diagnoses and (ii) clinical swab results and medical diagnoses at one week post-exposure are detailed in Tables 5.10 and 5.11.

## 6. Comparisons with previous studies

### 6.1 Environmental microbiology

The Southsea study is the third study of this type to be successfully carried out. The geometric mean and ranges of microbial determinands for the three studies are shown in Figure 6.1 (Appendix IV gives further details). A statistical comparison of microbial indicator concentrations (count 100 $ml^{-1}$) is presented in Tables 6.1 to 6.4. With the exception of total staphylococci, the test used to compare the geometric mean for each indicator between the three studies was the Tukey Honest Significant Difference (HSD) multiple range variant of the analysis of variance procedure (Zar, 1984). Total staphylococci counts were not available from the study at Langland Bay so the t-test was used to examine differences in geometric mean concentrations of these organisms between the Moreton and Southsea studies. The results are broken down by sampling location.

With the exception of faecal streptococci, geometric mean concentrations were lowest at Langland Bay. Geometric mean total coliform concentration was highest at Moreton at all locations. This ranking was also true for faecal coliform at 30 cm and chest depth locations and for *Pseudomonas aeruginosa* at 30 cm depth. In the surf zone, Southsea had the highest geometric mean counts for faecal coliform and *Pseudomonas aeruginosa*. This was true for the latter indicator at chest depth. Geometric mean faecal streptococci count was highest at Langland Bay at 30 cm and chest depths and at Southsea in the surf zone samples. The lowest geometric mean concentrations of this determinand were found at Moreton (surf and 30 cm locations) and at Southsea (chest depth). Geometric mean total staphylococci values were higher at Southsea than Moreton.

All three studies have provided intensive monitoring of enterovirus in sea water samples yielding 15 samples from each study. Maximum enterovirus counts were found at Southsea (three positive results, maximum 26 pfu 10 $l^{-1}$ , arithmetic mean 2.8 pfu 10 $l^{-1}$ ) and the lowest at Langland Bay, where only one positive result was found, (maximum 2 pfu 10 $l^{-1}$, arithmetic mean 0.13 pfu 10 $l^{-1}$ ). Enterovirus results at Moreton showed five positive results (maximum 12 pfu 10 $l^{-1}$, 2 pfu arithmetic mean 10 $l^{-1}$ ).

Rotavirus results were as follows; the highest value was recorded at Langland Bay (three positive results, maximum 8 ff 10 $l^{-1}$, arithmetic mean 1.07 ff 10 $l^{-1}$). At Moreton only ten samples were viable for culture. Only one sample was positive at 2 ff 10 $l^{-1}$. No rotavirus was detected in samples from Southsea.

For the 30 cm and chest depths, the geometric mean total coliform counts from Southsea and Moreton were significantly different from Langland Bay. For these two locations the value from Moreton was also significantly different from Southsea. In the surf zone samples total coliform geometric means from Southsea and Moreton were significantly different from Langland Bay but were not significantly different from each other. This pattern of no significant difference between results from Moreton and Southsea and significant differences between these two studies and Langland Bay was repeated for faecal coliform and *Pseudomonas aeruginosa* at the surf and 30 cm sampling locations. In addition faecal coliform and *Pseudomonas aeruginosa* at chest depth had geometric mean values that were additionally significantly different between Moreton and Southsea, as with total coliform. Significant differences in geometric mean faecal streptococci concentrations were as follows; (i) in the surf zone; values from Langland Bay and Southsea were different from Moreton but were not different from each other, (ii) at 30 cm; values were different between Langland Bay and Moreton only and (iii) at chest depth no significant differences between studies were apparent. Geometric mean total staphylococci at Southsea was significantly different from results at Moreton at all depths.

The studies can also be compared in terms of compliance with EC Directives using the 30 cm depth location samples. All three studies passed the EC G and I criteria for total coliforms. Langland Bay passed the EC G criteria for faecal coliforms whilst the other two studies did not. Similarly, Langland Bay failed the G criteria for faecal streptococci whilst the latter two studies passed this criterion. Enterovirus was present in all three studies at frequencies above the EC I level (95%) for this parameter.

This demonstrates that whilst the three cohort studies have used beaches that comply with EC Directive Imperative criteria for total and faecal coliform, the bathing group at each site has been exposed to significant variation in water quality. The Langland Bay study was characterised by relatively high faecal streptococci concentrations in comparison to very low total and faecal coliform concentrations. Southsea and Moreton had comparatively greater total coliform, faecal coliform and enterovirus levels.

### 6.2 Clinical Results

The protocol for human sample collection has been altered on the advice of PHLS clinical microbiologists at the contracted laboratory. This is particularly evident between the first two studies at Langland Bay and Moreton. However, the results have shown some similarities. The analyses of stool samples from all three studies have yielded very low numbers of positive results for all parameters analysed. No virus particles were detected in faeces from Moreton and Southsea volunteers with positive gastrointestinal symptoms on their questionnaires. The Southsea study revealed the first significant Bather vv Non-bather differential for an individual swab determination, faecal streptococci on ear swabs. In contrast, no significant difference in individual determinands on swabs was detected at Langland Bay or Moreton. At Moreton a combination of any determinand on the throat swab was found to be significant, however. The examination of viruses on throat swabs undertaken for the Moreton and Southsea studies isolated just a single positive case.

### 6.3 Questionnaire results

The significant symptoms and symptom groups from bather vv non-bather comparisons in all three studies are shown in Figure 6.2 and listed in Appendix IV. Although the data reported to date are not wholly comparable due to the differences in the timing of post exposure interviews and slight differences in the questionnaires, the studies do show some similarities and differences. The Southsea study shows a significant result for loose motions at one week and any symptom in the gastrointestinal group. Similar results were found in the Moreton study at one week, whilst diarrhoea was significant during the three week post-exposure period for the Langland study. It should be noted that the symptom "diarrhoea" in the Langland study included "loose motions". The two symptoms were more specifically defined in the two subsequent studies. In addition, the post-exposure follow-up for the Langland study was completed at three days. The one week follow-up employed in subsequent studies has recorded significant gastrointestinal symptom reporting. Differences in other significant gastrointestinal symptoms reported at Moreton and Southsea are evident. At Moreton stomach pain was significant during the one week post-exposure period whilst at Southsea the symptom nausea was significant. Unlike the Langland Bay and Moreton studies the Southsea results found no significant differences for 'flu / cold and chest symptoms such as sore throats and coughs or ear infections.

The controlled cohort studies to date have demonstrated the feasibility of this study design and produced three data sets providing detailed information on almost 1000 individuals. The full potential of these data will be realised only when the data sets are combined.

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Finally, we thank all of the volunteers who took part in this study. Their commitment has demonstrated further that members of the public are willing to assist in scientific research which will assist objective environmental decision making.

# FIGURES

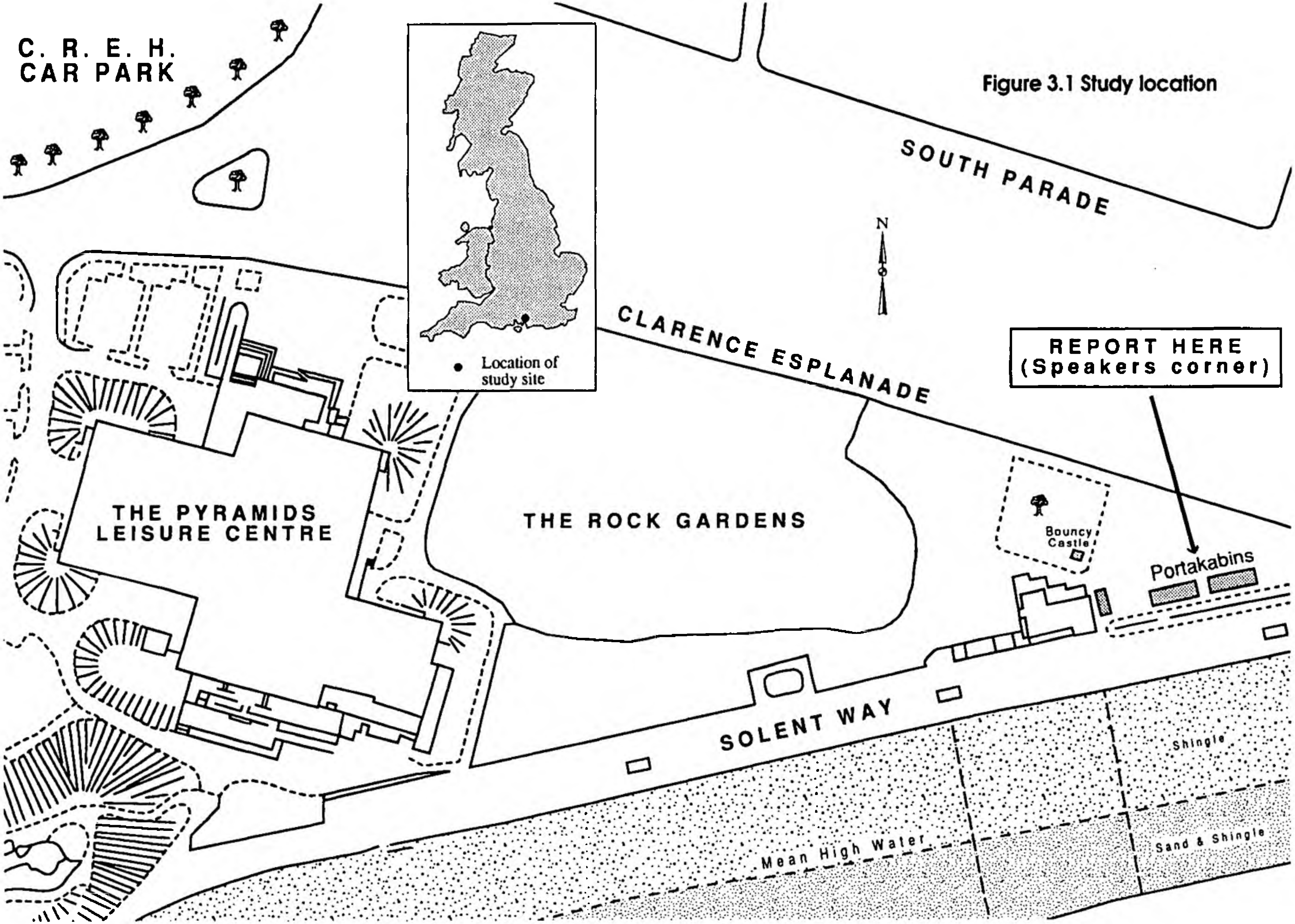



Figure 3.1 Study location

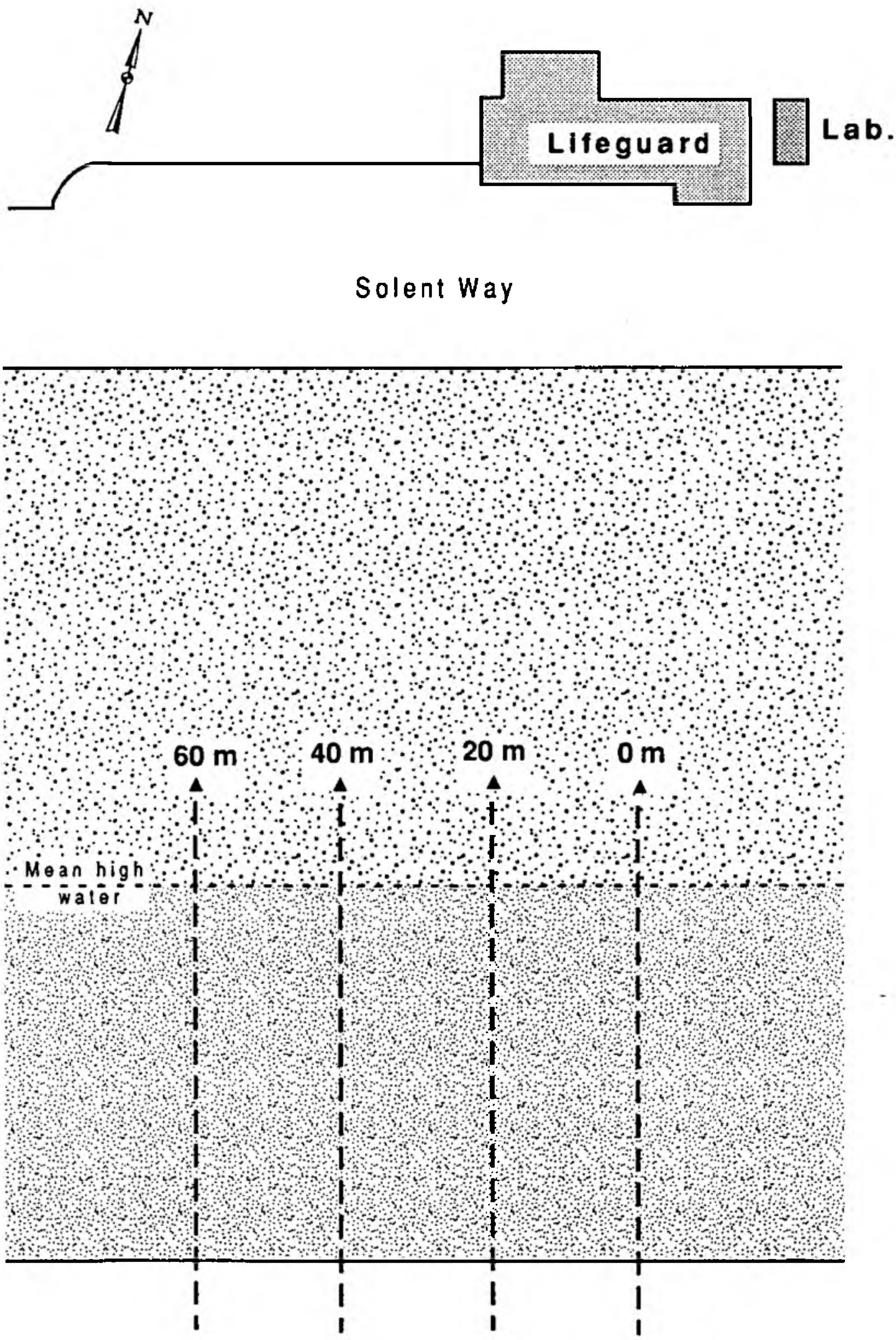



**Figure 3.2 Schematic map (not to scale) of sampling points**

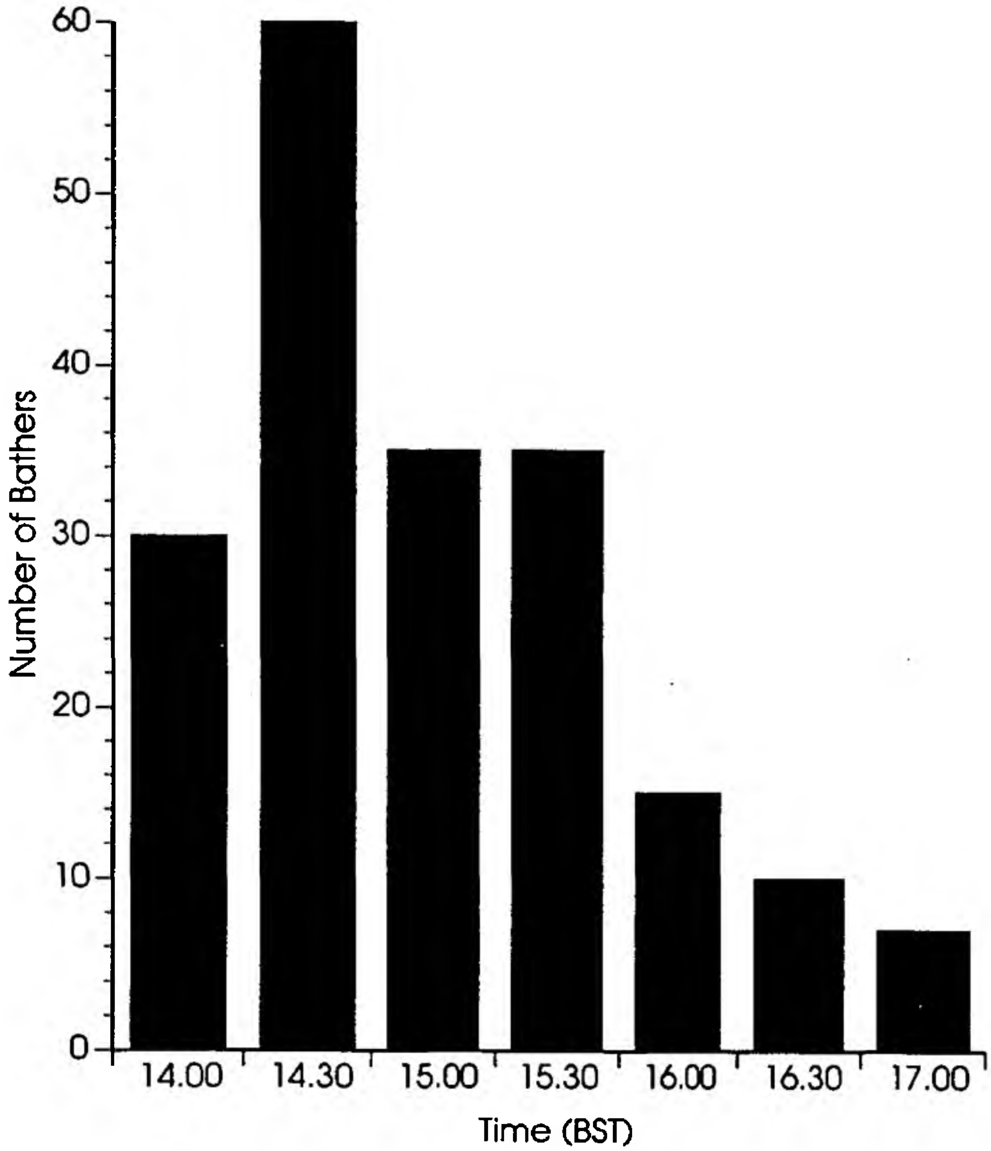



**Figure 5.1 Bather density in the bathing area, Southsea 06.07.91**

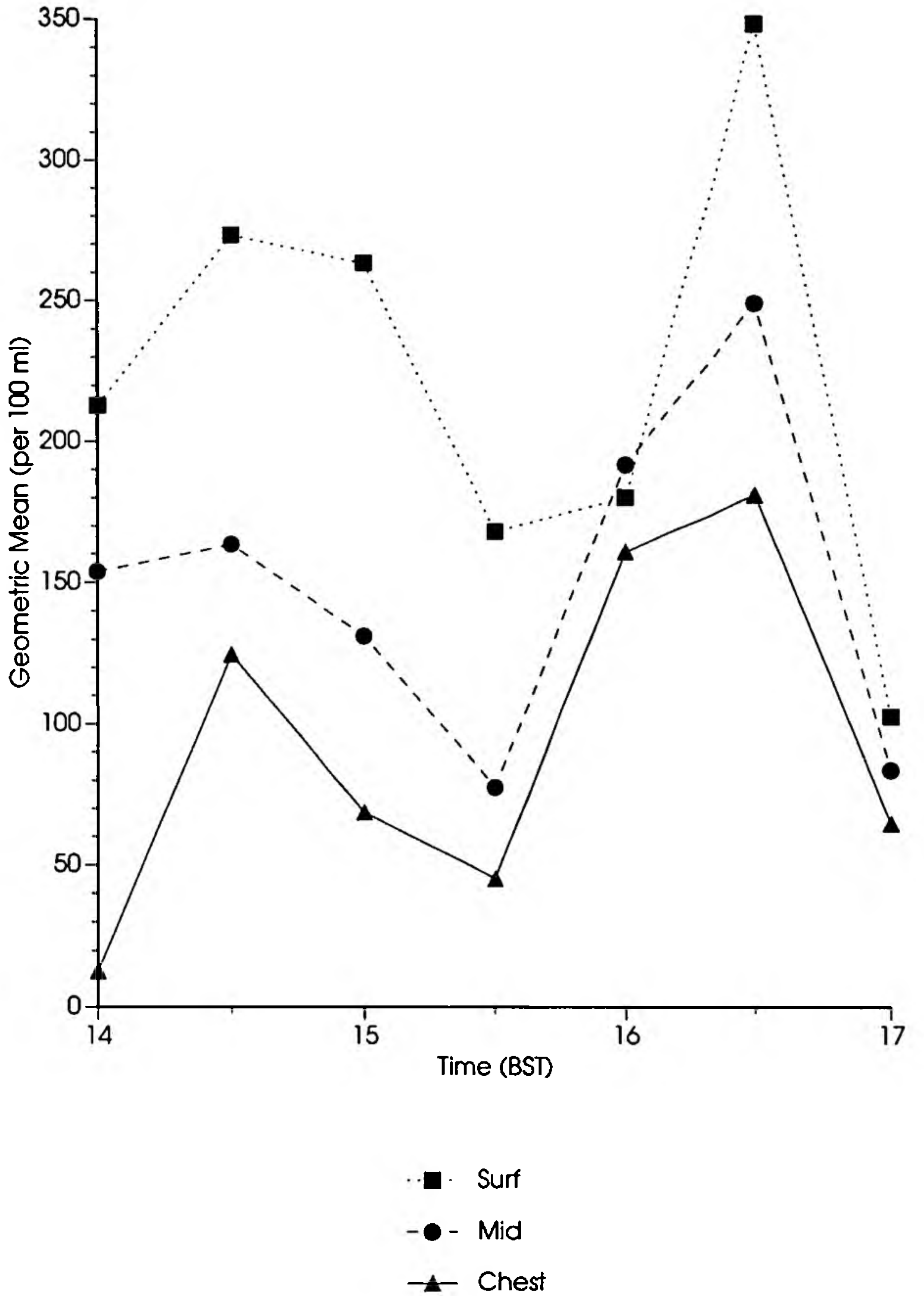



**Figure 5.2 Geometric mean total coliform (count per 100 ml) in seawater samples at Southsea, 06.07.91**

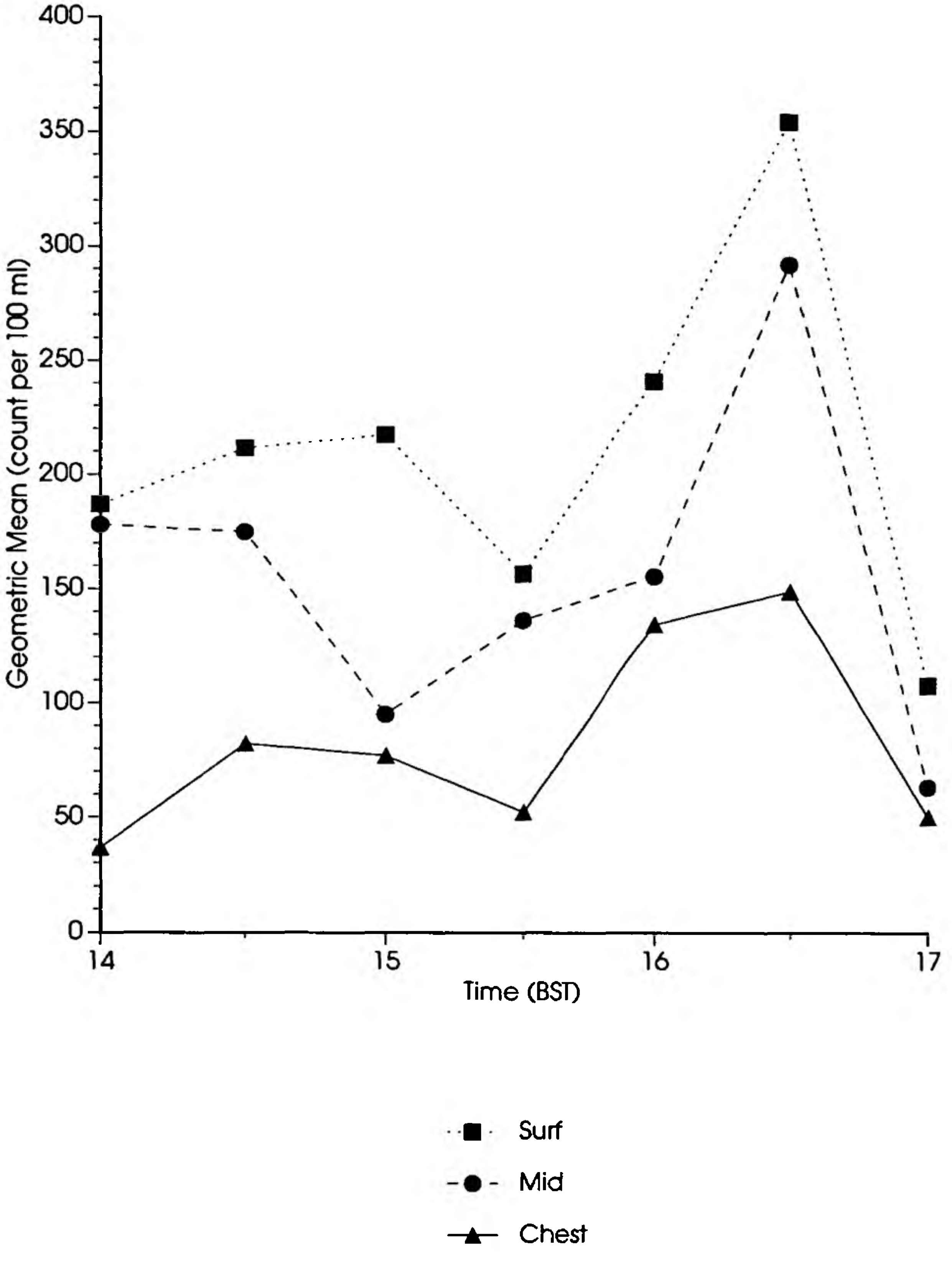



**Figure 5.3 Geometric mean faecal coliform (count per 100 ml) in seawater samples at Southsea, 06.07.91**

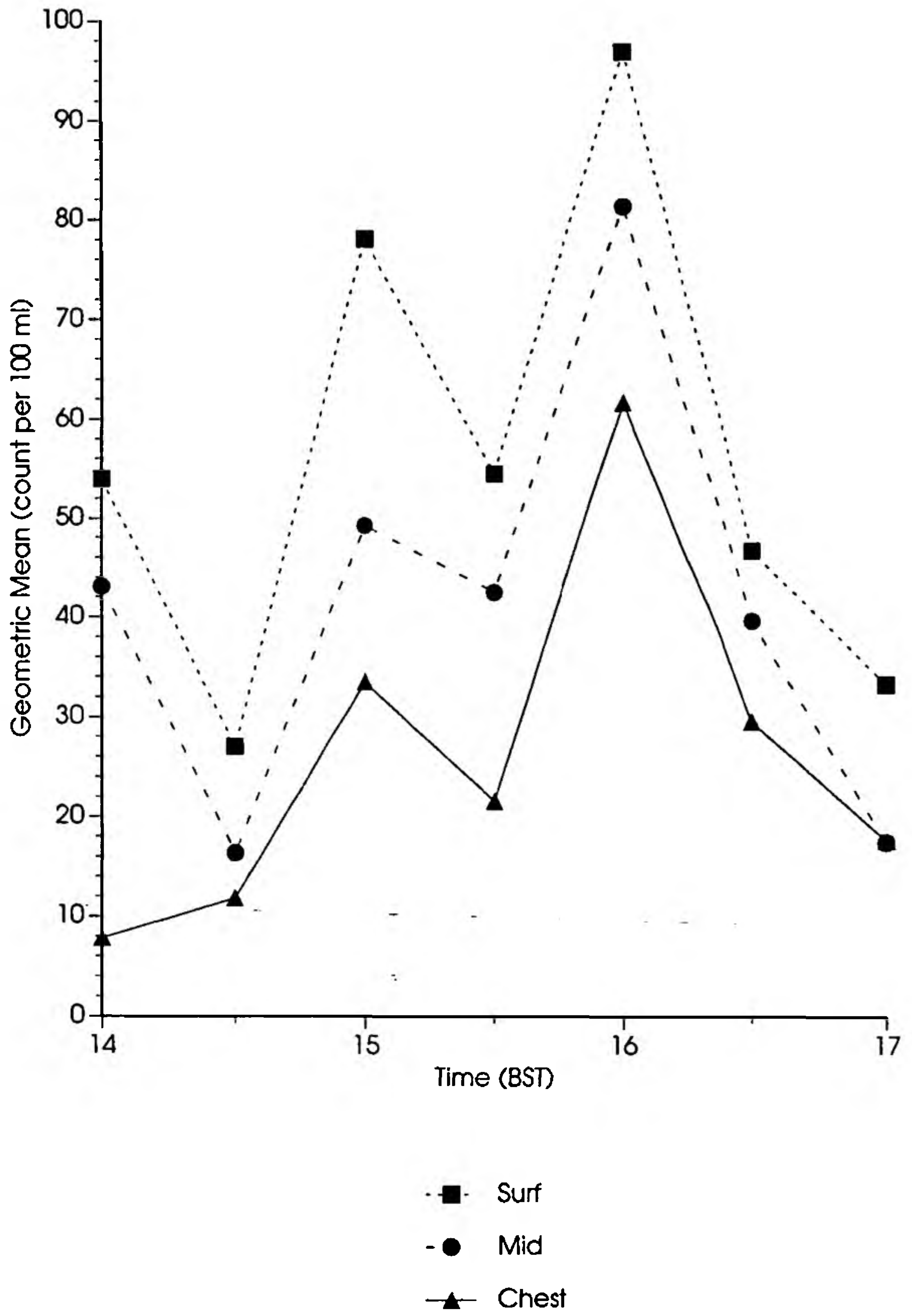



**Figure 5.4 Geometric mean faecal streptococci (count per 100 ml) in seawater samples at Southsea, 06.07.91**

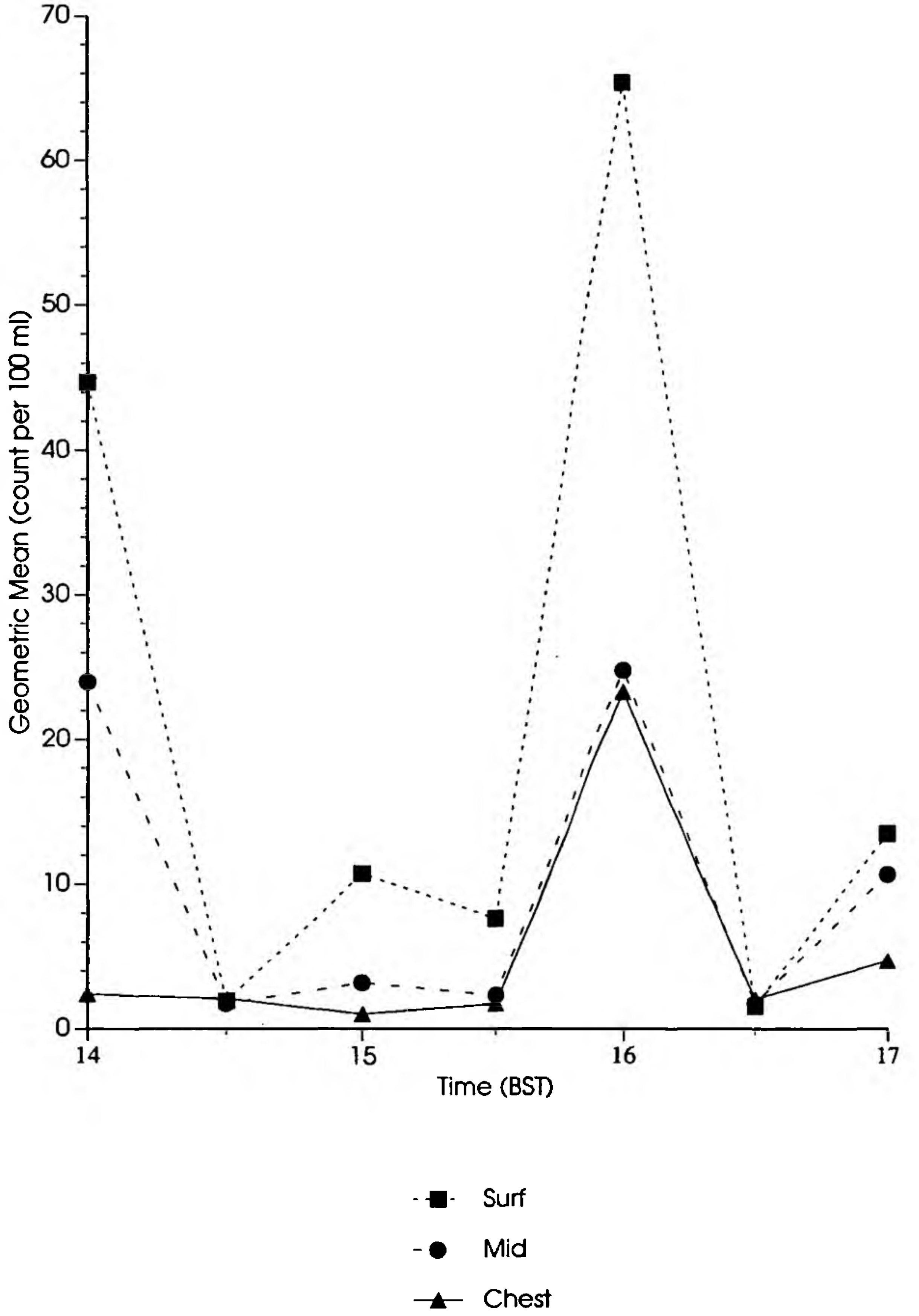



**Figure 5.5 Geometric mean *Pseudomonas aeruginosa* (count per 100 ml) in seawater samples at Southsea, 06.07.91**

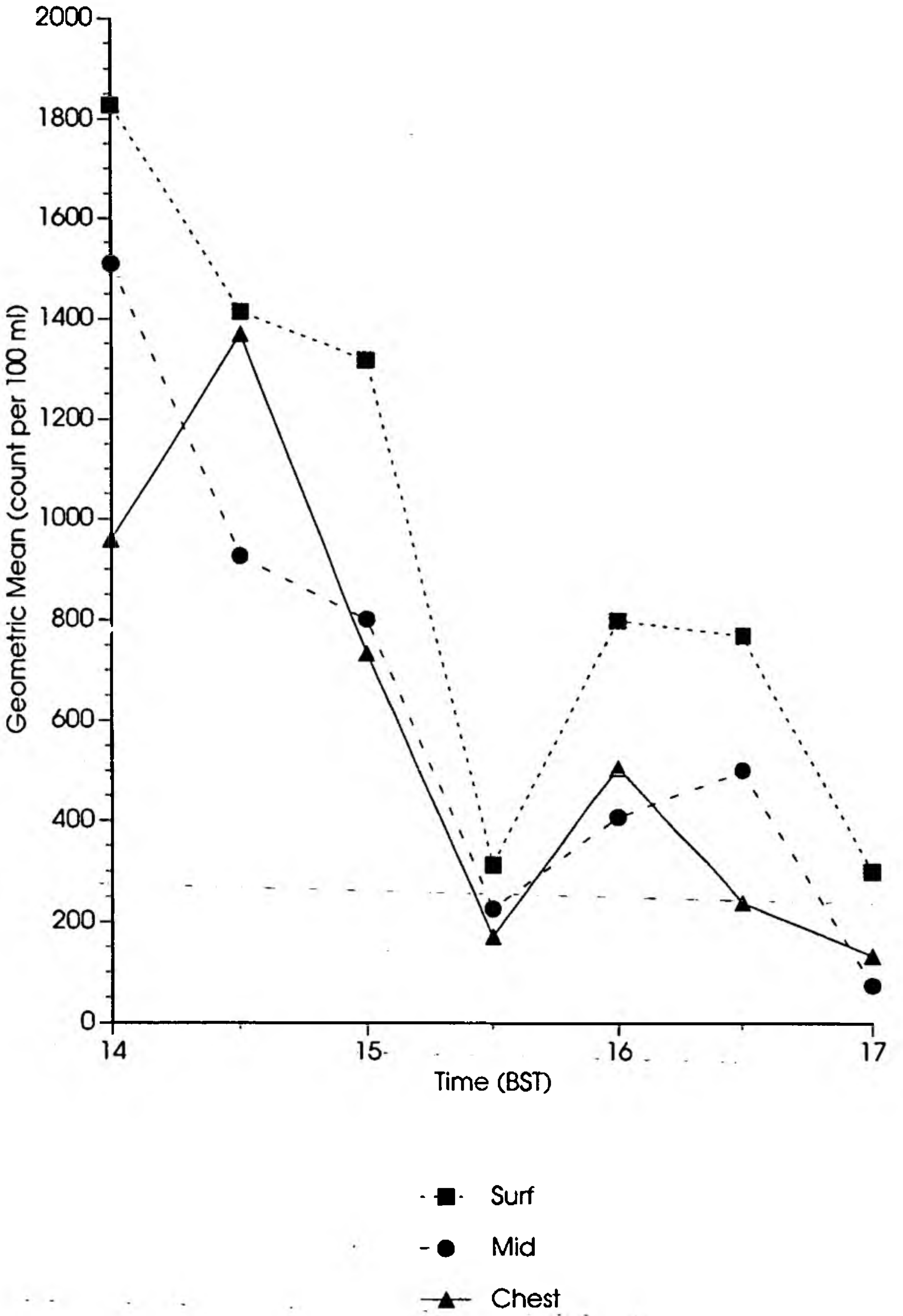



**Figure 5.6 Geometric mean total staphylococci (count per 100 ml) in seawater samples at Southsea, 06.07.91**

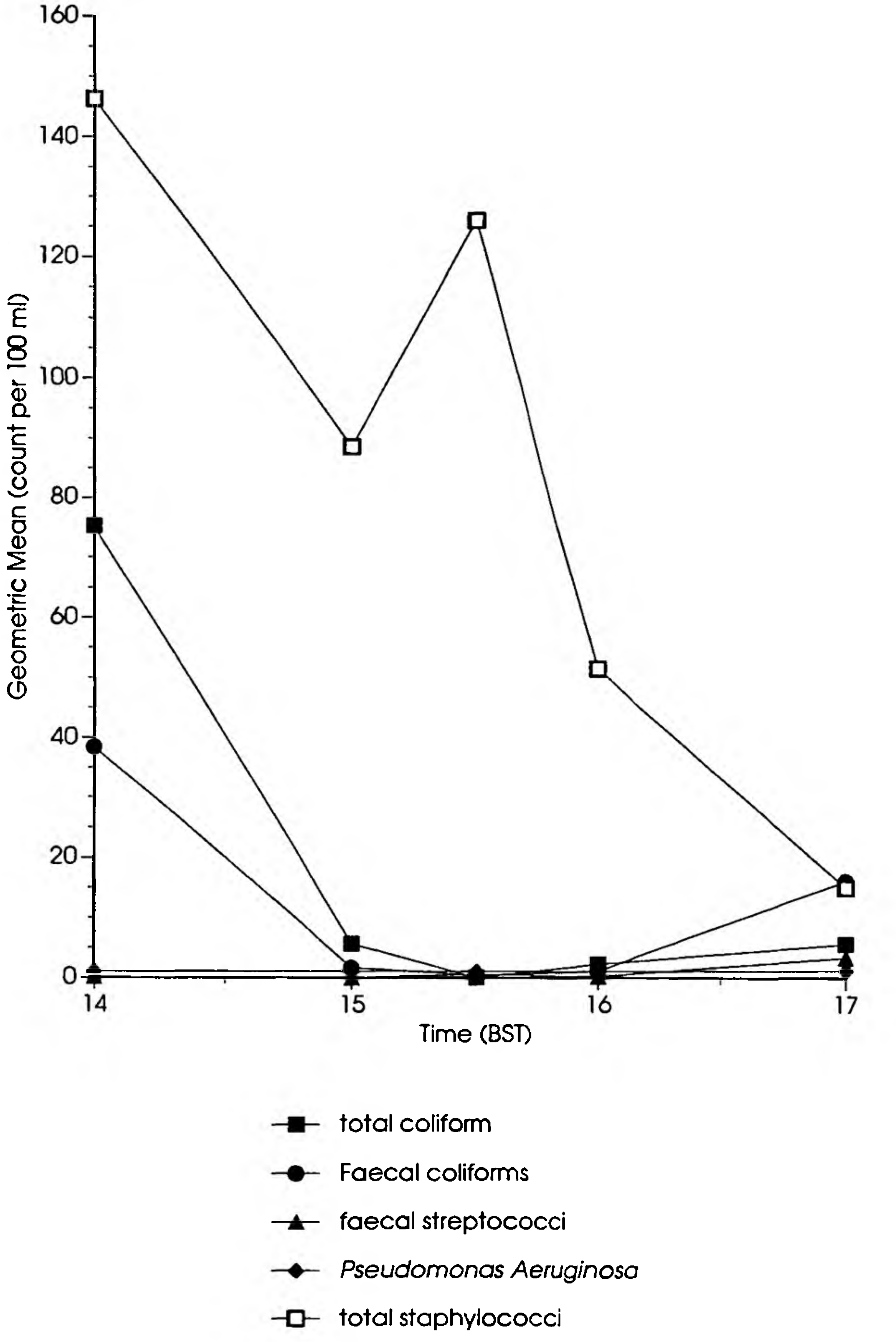



**Figure 5.7 Geometric mean indicator concentration (count per 100 ml) in offshore seawater samples at Southsea, 06.07.91**

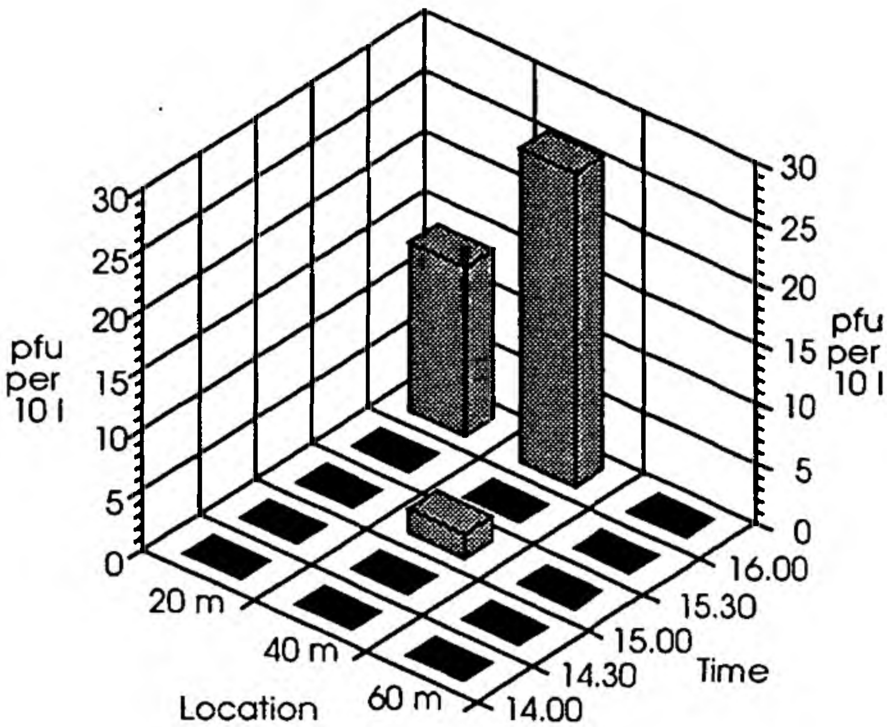



**Figure 5.8 Enterovirus counts (PFU per 10 l), Southsea 06.07.91**

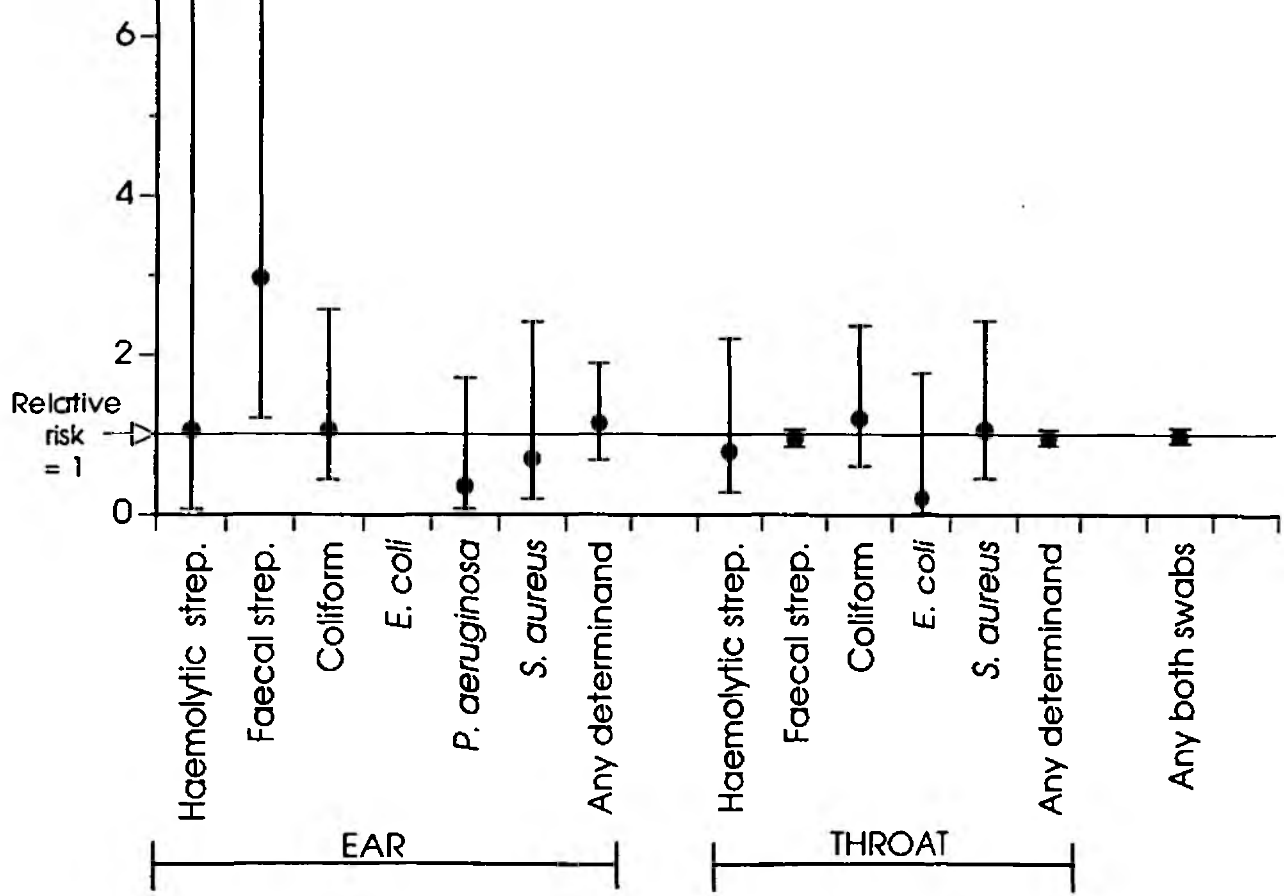
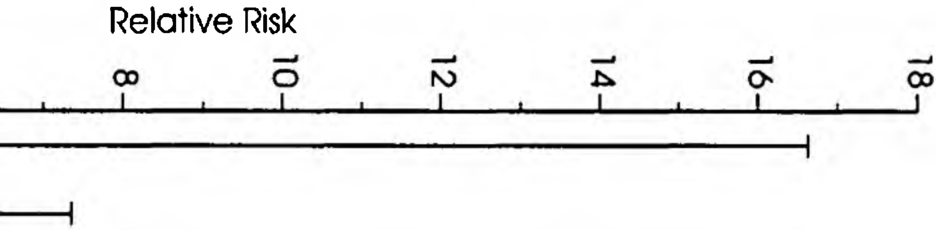



**Figure 5.9 Relative risk, swab results**


Relative Risk
8
10
12
14
16
18

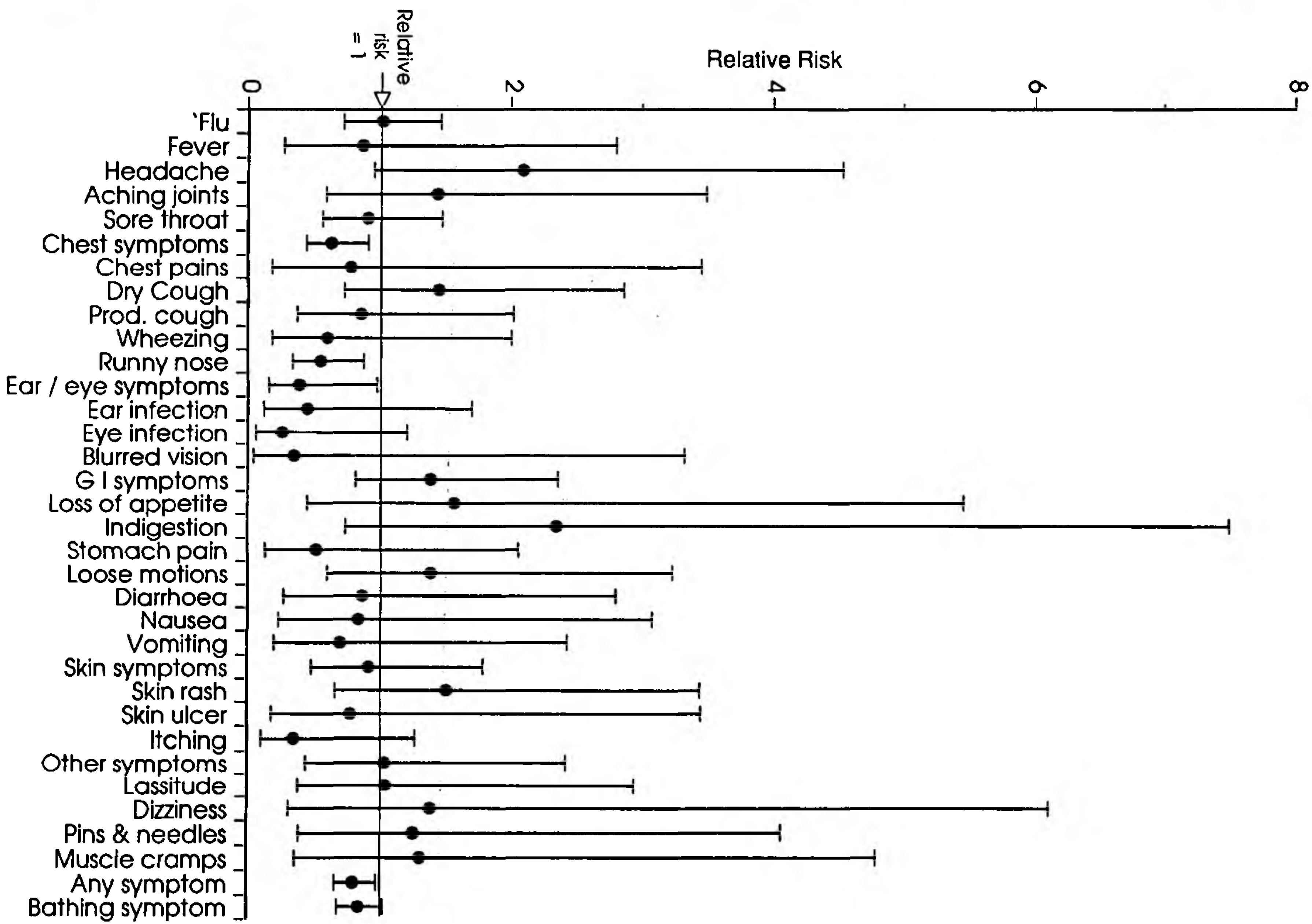



**Figure 5.10 Relative Risk pre-exposure interview**

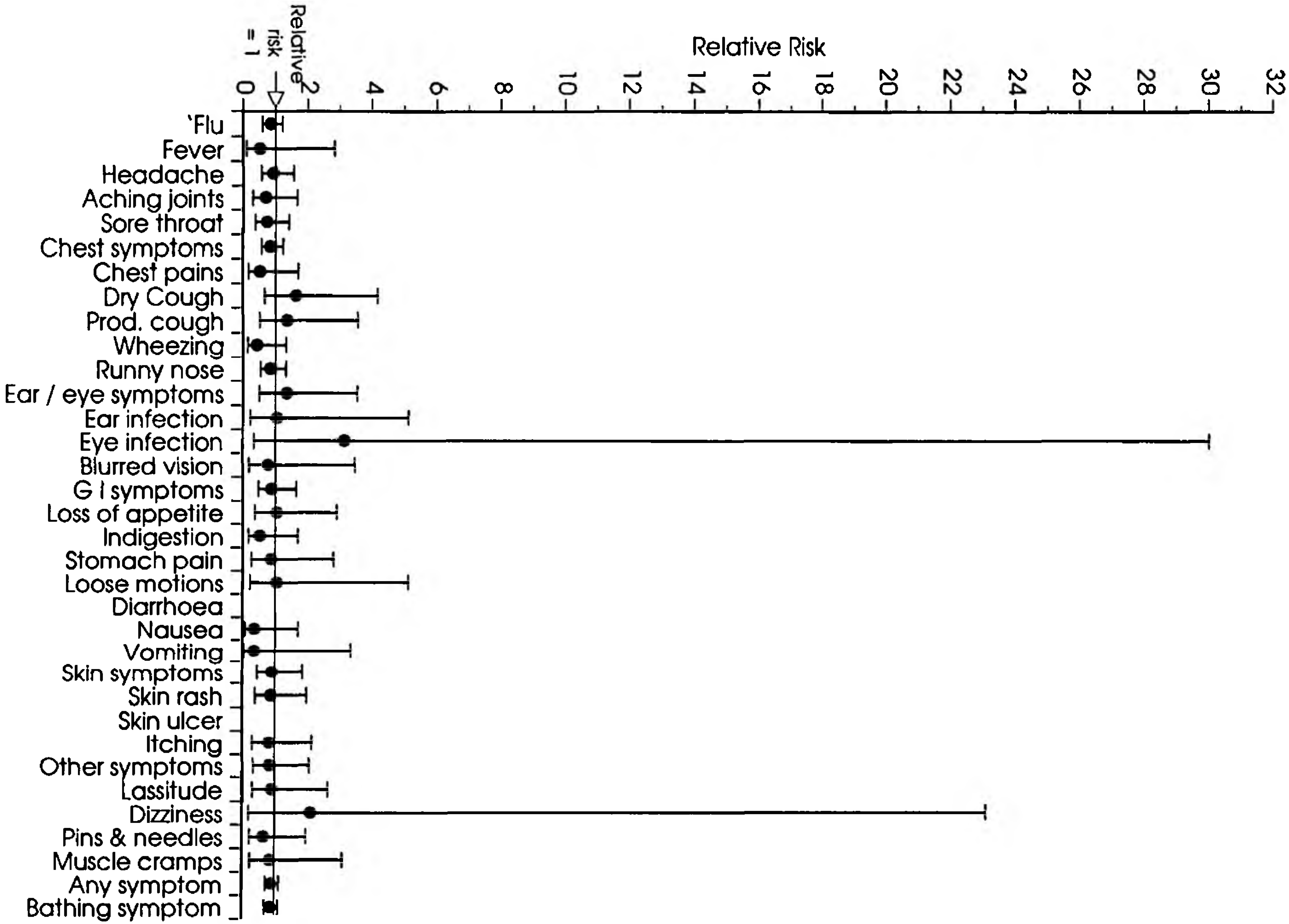



**Figure 5.11 Relative Risk at the exposure day interview**

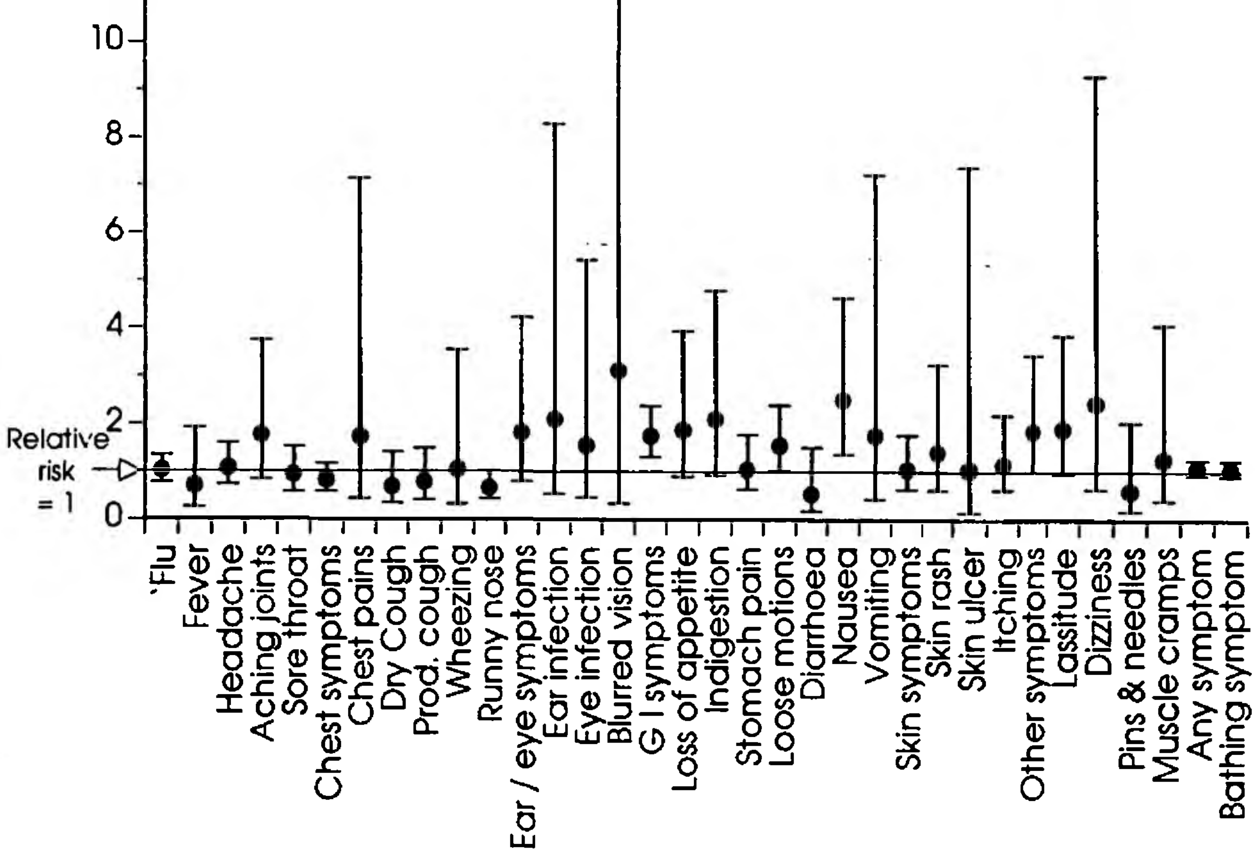
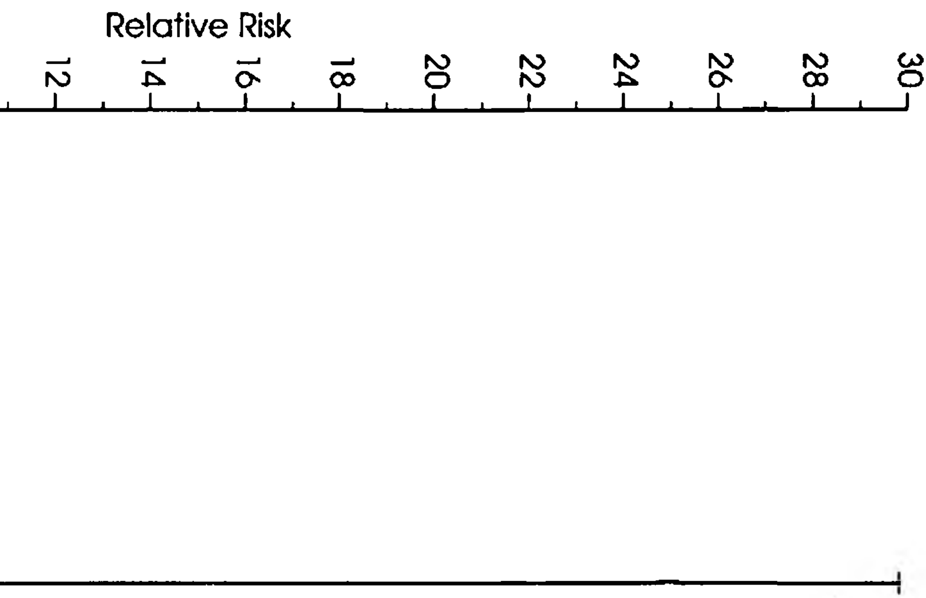



**Figure 5.12 Relative Risk at the one week post-exposure interview**


Relative Risk
12
14
16
18
20
22
24
26
28
30

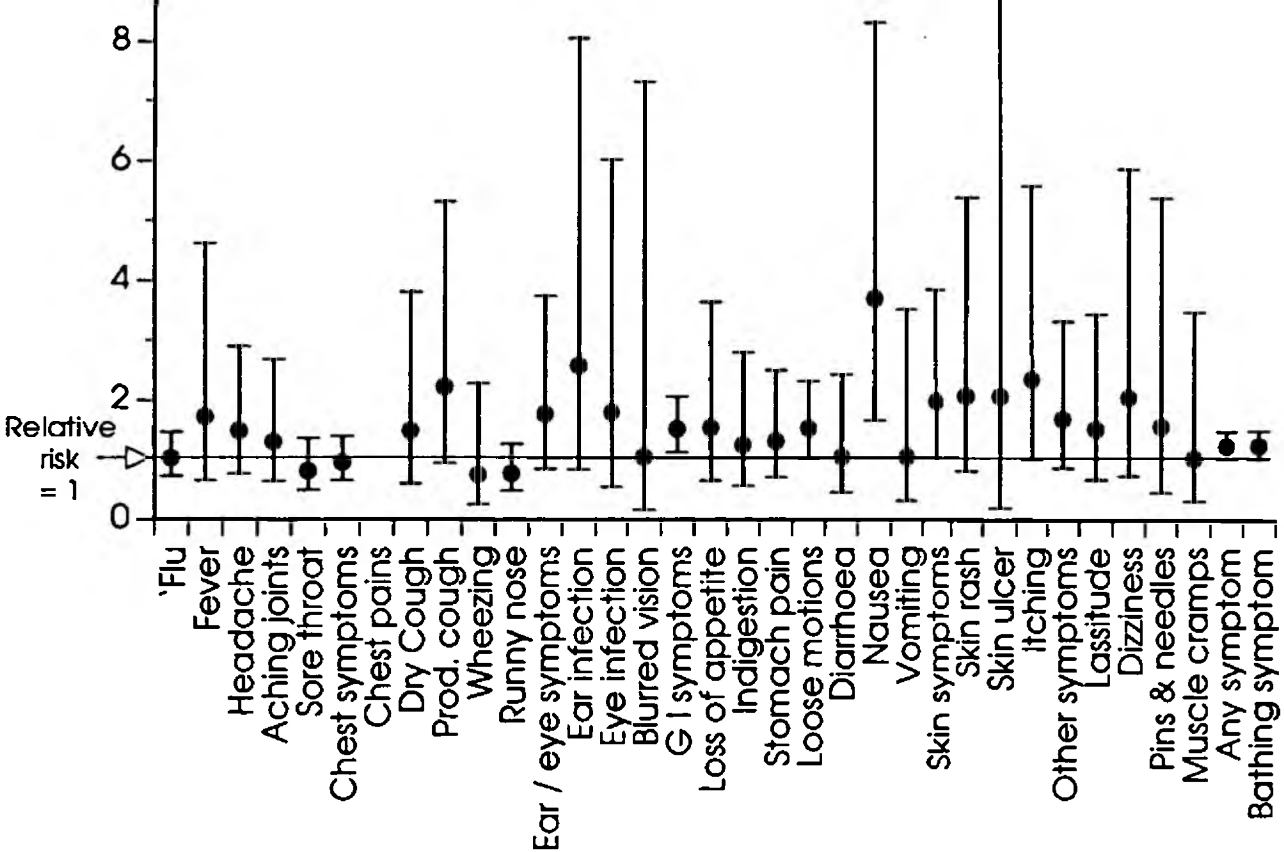
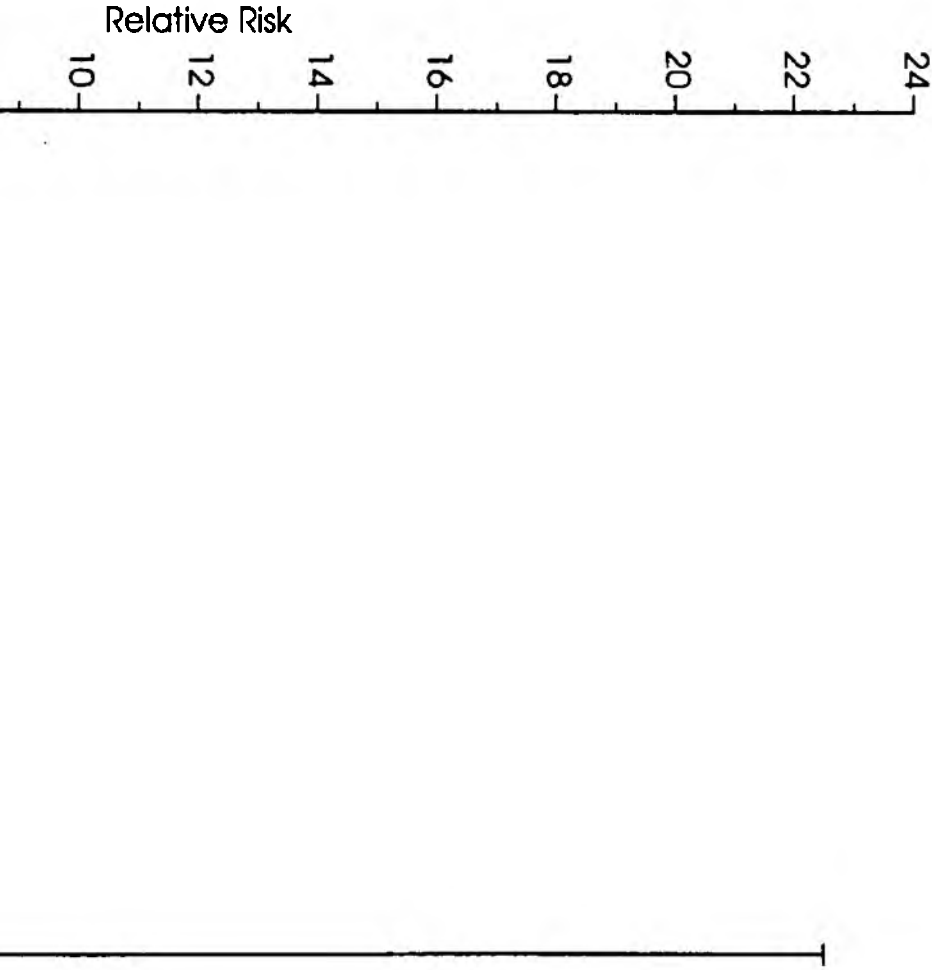



**Figure 5.13 Relative Risk at three weeks post-exposure**


Relative Risk
10
12
14
16
18
20
22
24

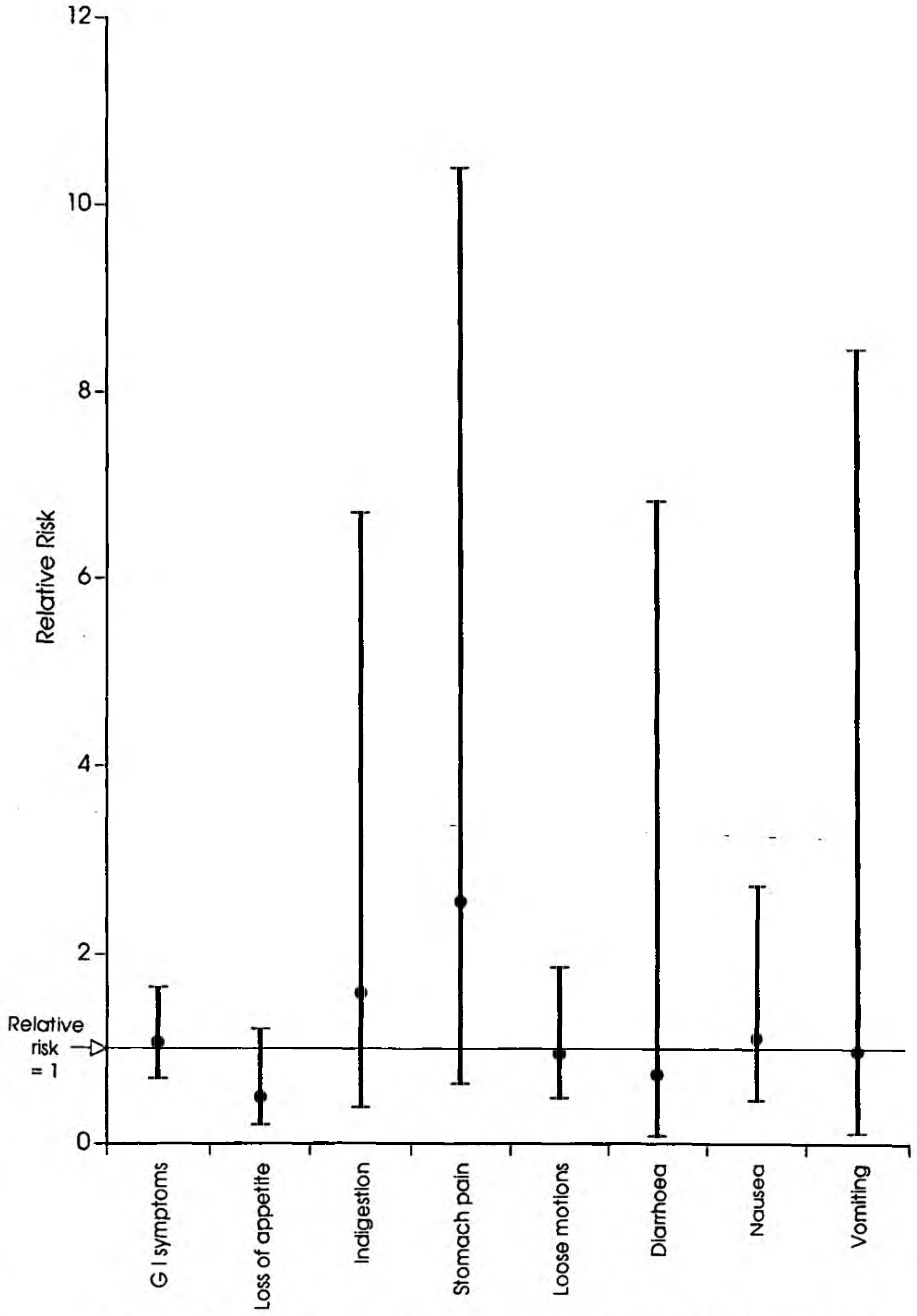



**Figure 5.14 Relative Risk - G I symptoms and water ingestion at one week**

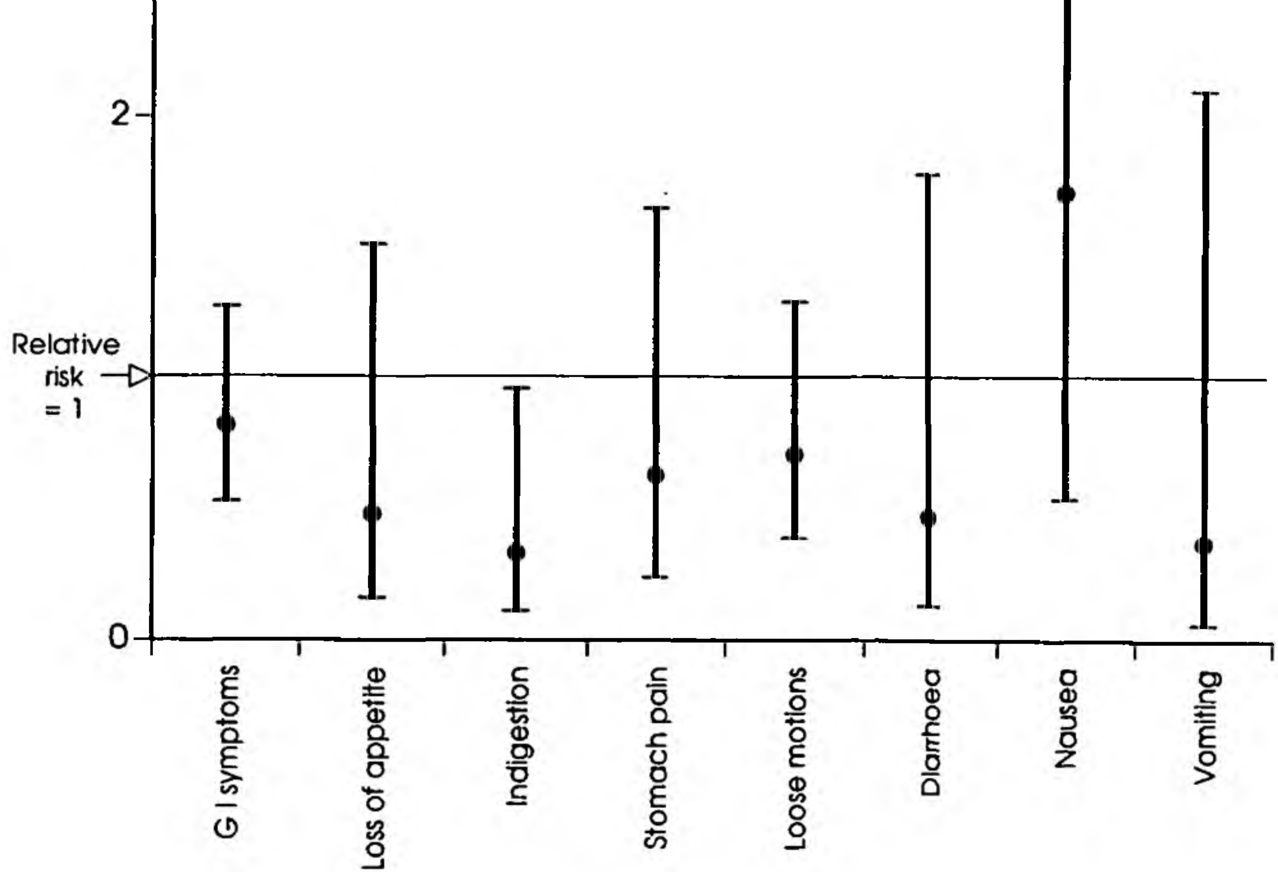
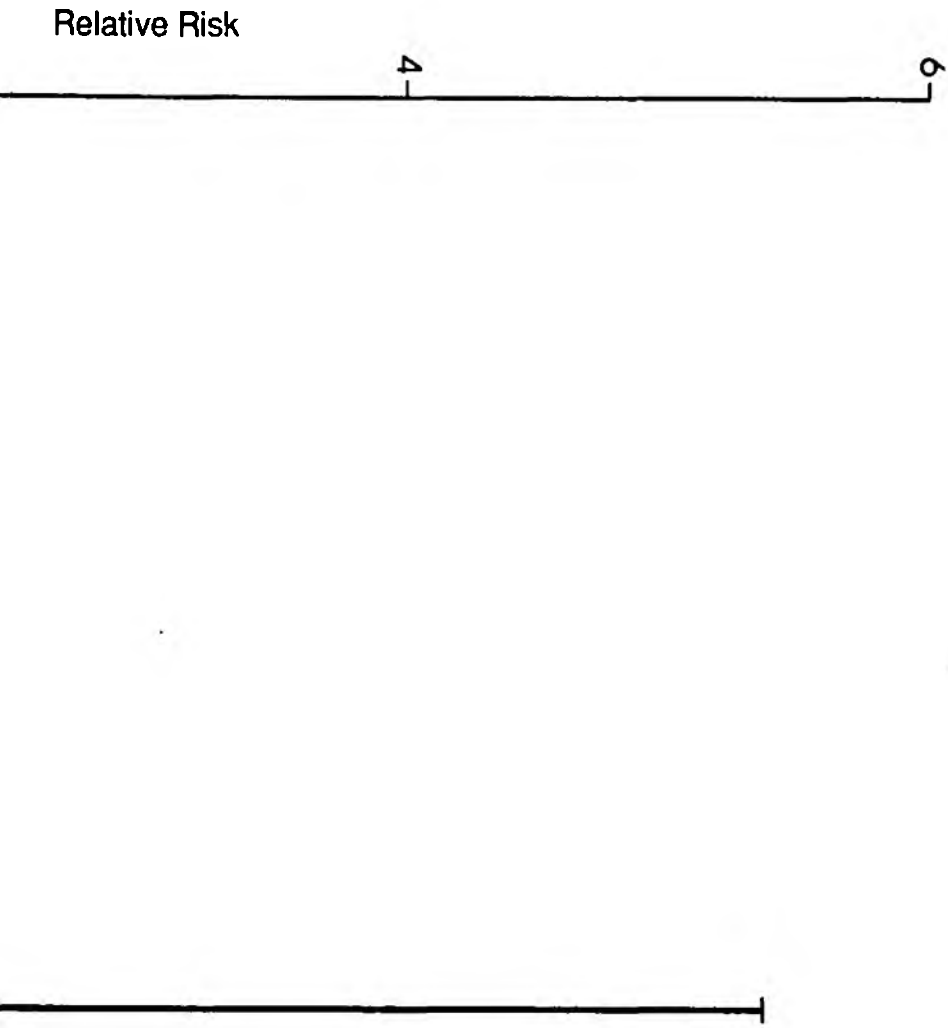



**Figure 5.15 Relative Risk- G I symptoms and water ingestion at three weeks**


Relative Risk
4
6

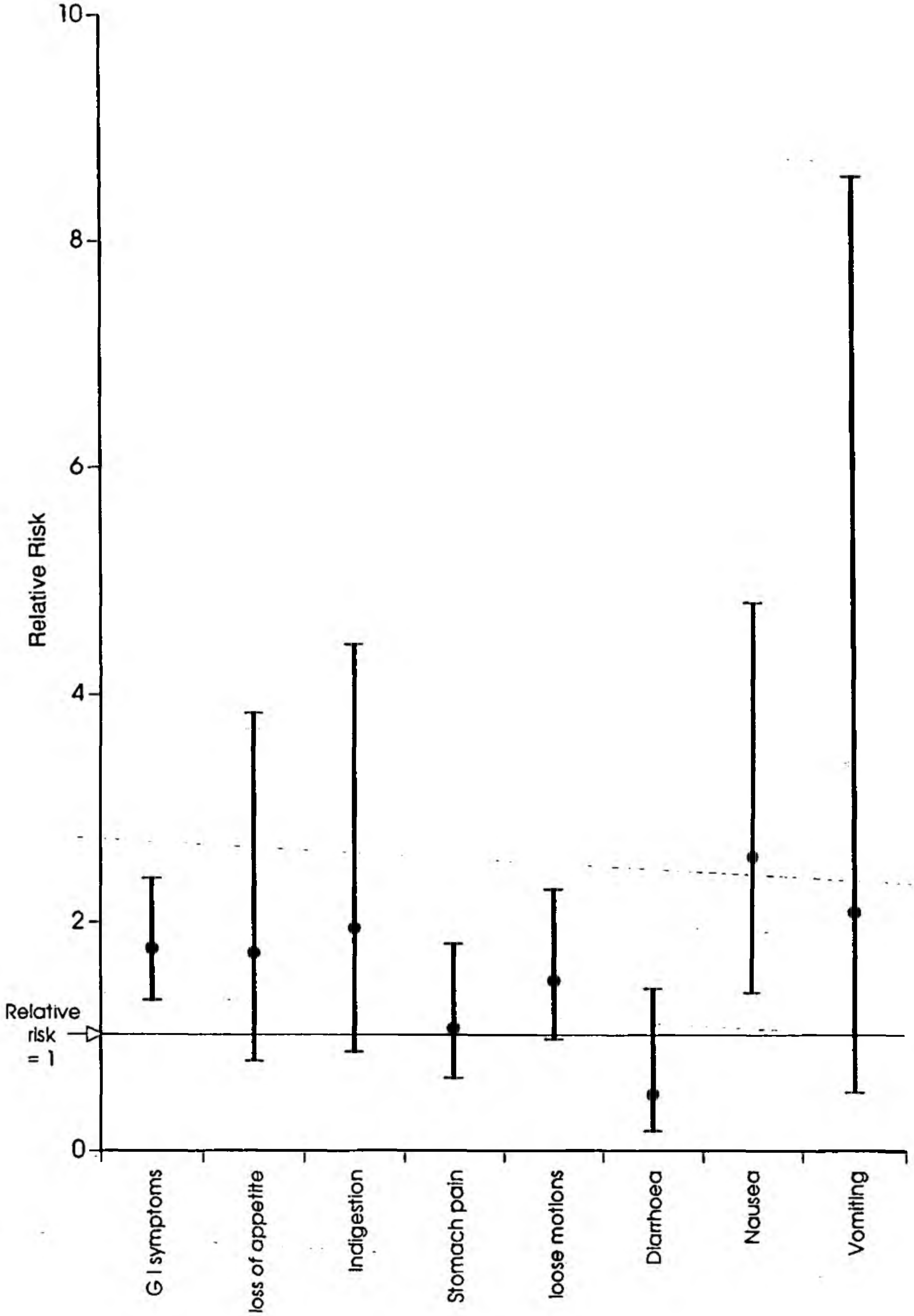



**Figure 5.16 Relative Risk - G I symptoms and sea bathing controlling for mayonnaise consumption at one week post exposure**

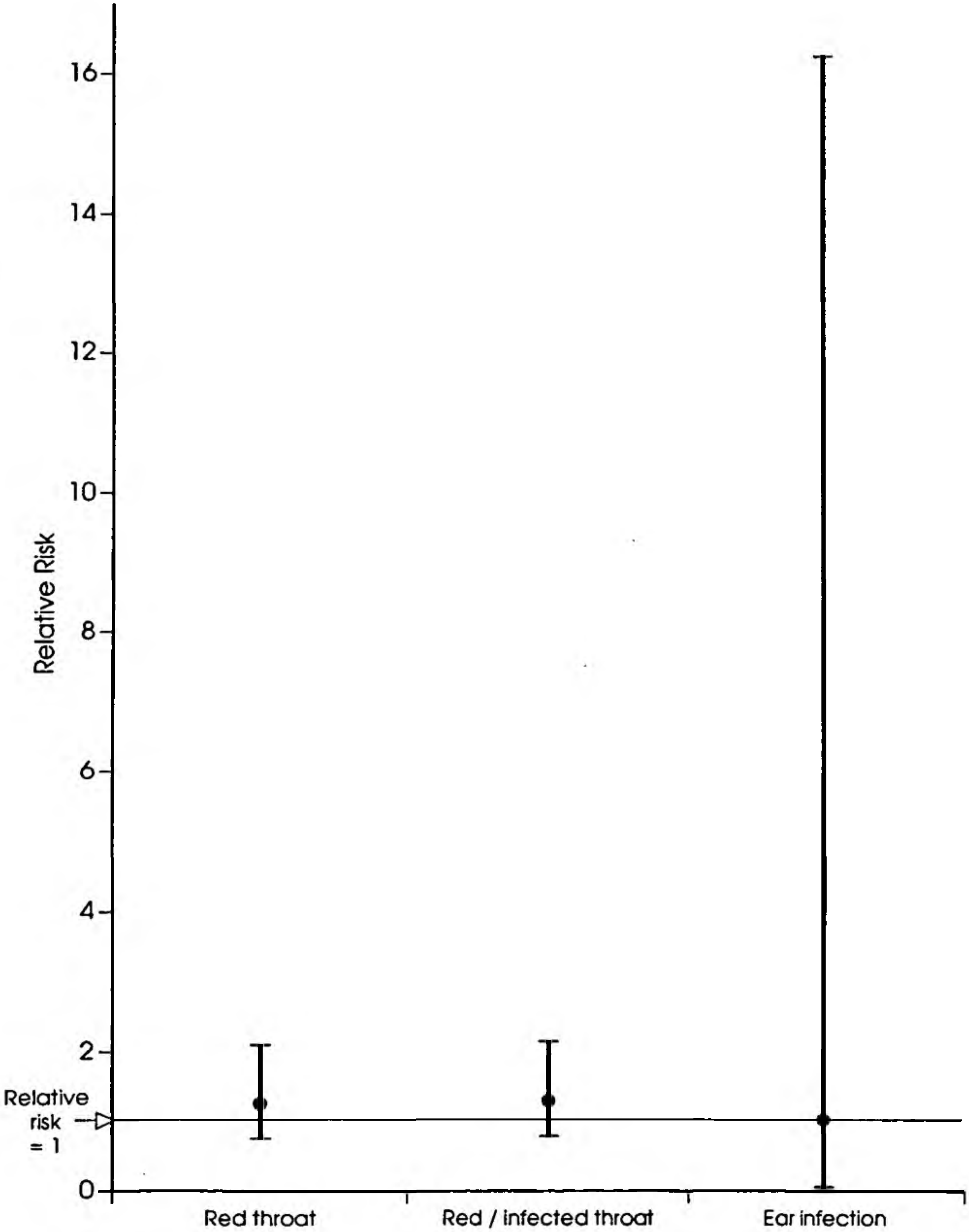



**Figure 5.17 Relative Risk- Medical diagnoses at one week**

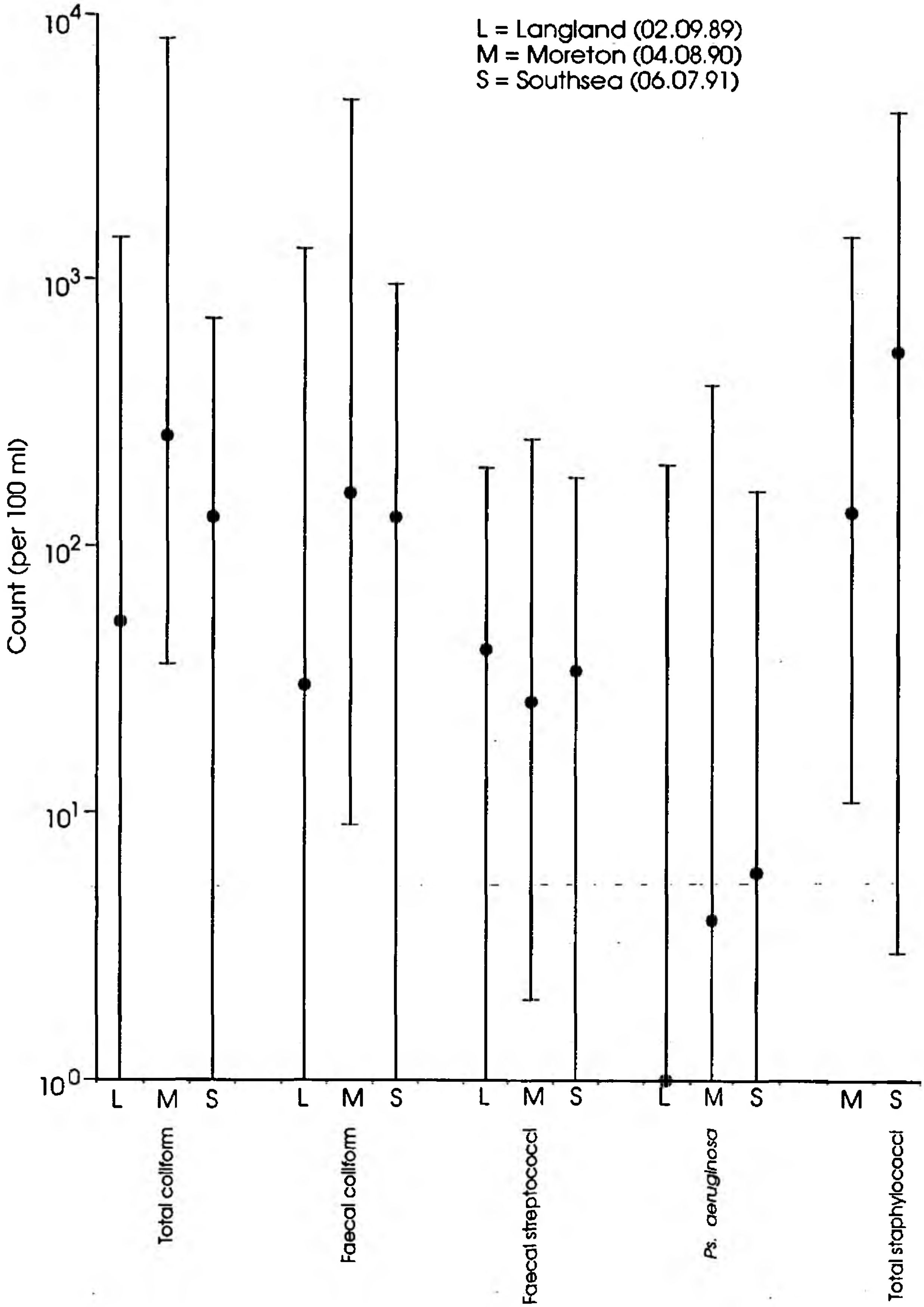



**Figure 6.1 Geometric mean and range values (count per 100 ml) for indicator organisms in in-shore samples from the cohort studies**

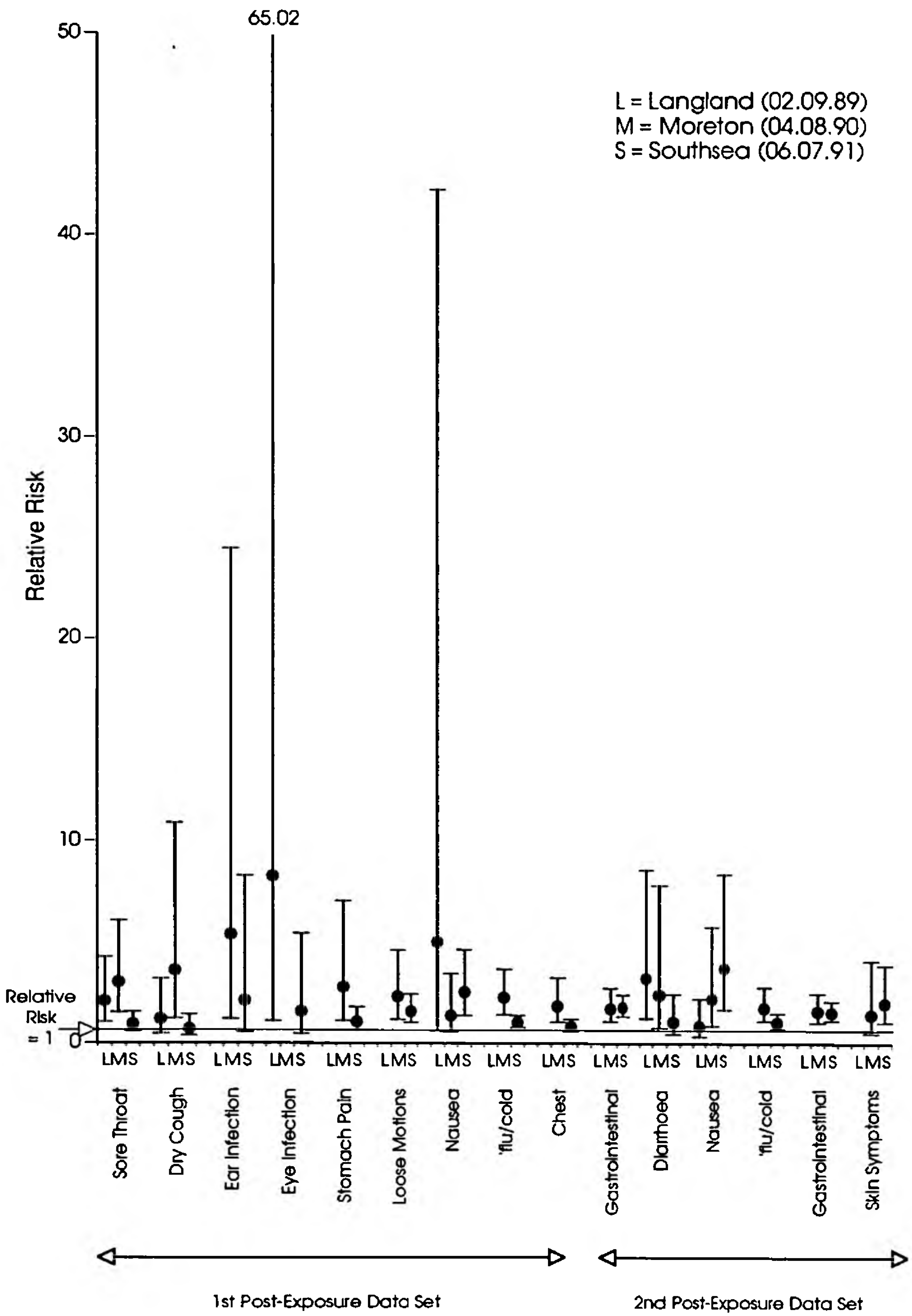



**Figure 6.2 Symptom comparison between cohort studies, RR and 95% CI**

# TABLES

**Table 4.1 Summary statistics for microbiological determinations (count 100 ml$^{-1}$) on samples taken at Southsea during the 1991 bathing season**

| Variable | Arith. Mean | Std. Dev. | Min. | Max. | Geo. Mean | $Log_{10}$ Std. Dev. | N |
|---|---|---|---|---|---|---|---|
| Total coliform | 418.619 | 811.301 | 20 | 3500 | 165.577 | 0.561 | 21 |
| Faecal coliform | 422.571 | 1337.228 | 9 | 6200 | 84.723 | 0.659 | 21 |
| Faecal streptococci | 157.571 | 608.141 | 1 | 2800 | 12.531 | 0.767 | 21 |

**Table 4.2 Compliance with EC bathing waters directives, Southsea 1991 bathing season**

| Indicator | Imperative | Guide | N |
|---|---|---|---|
| | No. samples not exceeding: 2000 100 ml$^{-1}$ (95% to comply) | No.samples not exceeding: 100 100 ml$^{-1}$ (80% to comply) | |
| Faecal coliform | 20 (95.2%) | 13 (61.9%) | 21 |
| | No. samples not exceeding: 10,000 100 ml$^{-1}$ (95% to comply) | No.samples not exceeding: 500 100 ml$^{-1}$ (80% to comply) | |
| Total coliform | 21(100%) | 18 (85.7%) | 21 |
| | - | No.samples not exceeding: 100 100 ml$^{-1}$ (90% to comply) | |
| Faecal streptococci | | 19 (90.5%) | 21 |

**Table 5.1** Summary statistics for microbiological determinations (count 100 $ml^{-1}$) on samples taken at Southsea, 06.07.91.

**(a) All samples**

| Variable | Arith. Mean | Std. Dev. | Min. | Max. | Geo. Mean | $Log_{10}$ Std. Dev. | N |
|---|---|---|---|---|---|---|---|
| Total coliform | 142.650 | 125.873 | 0 | 711 | 71.111 | 0.710 | 103 |
| Faecal coliform | 139.030 | 137.630 | 0 | 961 | 75.208 | 0.646 | 101 |
| Faecal streptococci | 37.462 | 33.936 | 0 | 180 | 18.454 | 0.656 | 104 |
| *Pseudomonas aer.* | 13.769 | 28.794 | 1 | 160 | 5.534 | 0.549 | 104 |
| Total staphylococci | 778.284 | 904.298 | 3 | 4320 | 359.749 | 0.660 | 104 |

**(b) All inshore samples (boat samples excluded)**

| Variable | Arith. Mean | Std. Dev. | Min. | Max. | Geo. Mean | $Log_{10}$ Std. Dev. | N |
|---|---|---|---|---|---|---|---|
| Total coliform | 168.917 | 119.962 | 0 | 711 | 127.529 | 0.392 | 84 |
| Faecal coliform | 161.131 | 135.110 | 21 | 961 | 128.122 | 0.292 | 84 |
| Faecal streptococci | 46.119 | 32.149 | 0 | 180 | 34.481 | 0.397 | 84 |
| *Pseudomonas aer.* | 16.798 | 31.315 | 1 | 160 | 6.031 | 0.563 | 84 |
| Total staphylococci | 924.032 | 946.904 | 16 | 4320 | 536.032 | 0.512 | 84 |

**(c) Surf samples**

| Variable | Arith. Mean | Std. Dev. | Min. | Max. | Geo. Mean | $Log_{10}$ Std. Dev. | N |
|---|---|---|---|---|---|---|---|
| Total coliform | 239.786 | 140.760 | 63 | 711 | 207.449 | 0.236 | 28 |
| Faecal coliform | 227.357 | 158.980 | 73 | 961 | 198.986 | 0.211 | 28 |
| Faecal streptococci | 64.786 | 37.643 | 0 | 180 | 51.360 | 0.395 | 28 |
| *Pseudomonas aer.* | 26.857 | 36.039 | 1 | 160 | 10.830 | 0.623 | 28 |
| Total staphylococci | 1341.611 | 1300.911 | 16 | 4320 | 791.501 | 0.535 | 28 |

**(d) 30cm samples**

| Variable | Arith. Mean | Std. Dev. | Min. | Max. | Geo. Mean | $Log_{10}$ Std. Dev. | N |
|---|---|---|---|---|---|---|---|
| Total coliform | 165.464 | 98.097 | 18 | 477 | 139.281 | 0.275 | 28 |
| Faecal coliform | 170.964 | 134.863 | 34 | 773 | 141.889 | 0.258 | 28 |
| Faecal streptococci | 45.036 | 24.784 | 0 | 125 | 36.411 | 0.371 | 28 |
| *Pseudomonas aer.* | 14.464 | 29.936 | 1 | 160 | 5.934 | 0.524 | 28 |
| Total staphylococci | 755.518 | 667.205 | 41 | 2520 | 452.942 | 0.510 | 28 |

**Table 5.1 Continued**

**(e) Chest samples**

| Variable | Arith. Mean | Std. Dev. | Min. | Max. | Geo. Mean | $Log_{10}$ Std. Dev. | N |
|---|---|---|---|---|---|---|---|
| Total coliform | 101.500 | 69.775 | 0 | 297 | 71.612 | 0.480 | 28 |
| Faecal coliform | 85.071 | 44.783 | 21 | 197 | 74.162 | 0.236 | 28 |
| Faecal streptococci | 28.536 | 21.512 | 1 | 99 | 21.751 | 0.349 | 28 |
| *Pseudomonas aer.* | 9.071 | 25.437 | 1 | 136 | 3.217 | 0.456 | 28 |
| Total staphylococci | 674.968 | 586.649 | 51 | 2520 | 428.536 | 0.463 | 28 |

**(f) Boat samples**

| Variable | Arith. Mean | Std. Dev. | Min. | Max. | Geo. Mean | $Log_{10}$ Std. Dev. | N |
|---|---|---|---|---|---|---|---|
| Total coliform | 26.526 | 77.274 | 0 | 342 | 4.598 | 0.743 | 19 |
| Faecal coliform | 29.824 | 91.957 | 0 | 385 | 4.610 | 0.727 | 17 |
| Faecal streptococci | 1.100 | 2.222 | 0 | 9 | 0.574 | 0.295 | 20 |
| *Pseudomonas aer.* | 1.050 | 0.224 | 1 | 2 | 1.042 | 0.039 | 20 |
| Total staphylococci | 166.140 | 167.015 | 3 | 495 | 67.453 | 0.727 | 20 |

Units : count 100 $ml^{-1}$

**Table 5.2 Compliance with EC bathing waters directives, Southsea 06.07.91**

| Indicator | Imperative | Guide | N |
|---|---|---|---|
| | No. samples not exceeding: 2000 100 $ml^{-1}$ (95% to comply) | No.samples not exceeding: 100 100 $ml^{-1}$ (80% to comply) | |
| Faecal coliform | 28 (100%) | 8 (28.6%) | 28 |
| | No. samples not exceeding: 10,000 100 $ml^{-1}$ (95% to comply) | No.samples not exceeding: 500 100 $ml^{-1}$ (80% to comply) | |
| Total coliform | 28 (100%) | 28 (100%) | 28 |
| | - | No.samples not exceeding: 100 100 $ml^{-1}$ (90% to comply) | |
| Faecal streptococci | | 27 (96.4%) | 28 |

**Table 5.3 Virological sample results, Southsea, 06.07.91**

| Time (BST) | Location | Enterovirus (PFU 10 $l^{-1}$) | Rotavirus (FF 10 $l^{-1}$) |
|---|---|---|---|
| 14.00 | 20 m | 0 | 0 |
| 14.00 | 40 m | 0 | 0 |
| 14.00 | 60 m | 0 | 0 |
| 14.30 | 20 m | 0 | 0 |
| 14.30 | 40 m | 0 | 0 |
| 14.30 | 60 m | 0 | 0 |
| 15.00 | 20 m | 0 | 0 |
| 15.00 | 40 m | 2 | 0 |
| 15.00 | 60 m | 0 | 0 |
| 15.30 | 20 m | 0 | 0 |
| 15.30 | 20 m* | 0 | 0 |
| 15.30 | 40 m | 0 | 0 |
| 15.30 | 40 m* | 2 | 0 |
| 15.30 | 60 m | 0 | 0 |
| 16.00 | 20 m | 14 | 0 |
| 16.00 | 40 m | 26 | 0 |
| 16.00 | 60 m | 0 | 0 |

* Boat samples

**Table 5.4 Consistency of faecal samples**

| | Bather | Non-bather |
|---|---|---|
| Liquid | 4 | 4 |
| Semi Solid | 118 | 118 |
| Solid | 44 | 41 |

**Table 5.5** One tailed separate variance estimate t-test results for Significantly greater ($\alpha=0.05$) geometric mean water quality (count 100 $ml^{-1}$) experienced by bathers reporting a symptom at 1 week compared with those not reporting a symptom at 1 week post exposure

| Indicator / depth | Symptom Presence | N§ | Geometric Mean | $Log_{10}$ Std. dev | t-value | D.F.¶ | 1 tail p |
|---|---|---|---|---|---|---|---|
| **Fever at 1 week:** | | | | | | | |
| Faecal streptococci | No | 166 | 32.713 | 0.512 | -3.20 | 38.97 | 0.002 |
| 30 cm | Yes | 6 | 47.328 | 0.070 | | | |
| Total staphylococci | No | 166 | 840.395 | 0.548 | -2.30 | 7.45 | 0.027 |
| Chest | Yes | 6 | 1426.250 | 0.221 | | | |
| **Aching limbs at 1 week:** | | | | | | | |
| Faecal streptococci | No | 156 | 50.369 | 0.604 | -2.43 | 65.63 | 0.009 |
| Surf | Yes | 16 | 72.858 | 0.173 | | | |
| Faecal streptococci | No | 156 | 32.037 | 0.526 | -3.18 | 133.96 | 0.001 |
| 30 cm | Yes | 16 | 46.044 | 0.094 | | | |
| **Sore throat at 1 week:** | | | | | | | |
| Faecal coliform | No | 146 | 58.676 | 0.315 | -2.61 | 70.81 | 0.006 |
| Chest | Yes | 26 | 74.736 | 0.152 | | | |
| **Chest pains at 1 week:** | | | | | | | |
| Faecal streptococci | No | 168 | 32.822 | 0.509 | -3.50 | 19.55 | 0.001 |
| 30 cm | Yes | 4 | 49.629 | 0.062 | | | |
| **Dry Cough 1 week:** | | | | | | | |
| Total coliform | No | 162 | 250.131 | 0.379 | -2.40 | 19.14 | 0.014 |
| Surf | Yes | 10 | 335.279 | 0.138 | | | |
| Total coliform | No | 162 | 144.445 | 0.375 | -3.28 | 23.45 | 0.002 |
| 30 cm | Yes | 10 | 207.113 | 0.117 | | | |
| Total coliform | No | 162 | 65.834 | 0.491 | -3.30 | 18.97 | 0.002 |
| Chest | Yes | 10 | 111.564 | 0.180 | | | |
| Total staphylococci | No | 162 | 736.564 | 0.512 | -3.53 | 33.60 | 0.001 |
| 30 cm | Yes | 10 | 1172.546 | 0.128 | | | |
| Total staphylococci | No | 162 | 822.569 | 0.551 | -3.63 | 17.25 | 0.001 |
| Chest | Yes | 10 | 1629.422 | 0.219 | | | |

§ N = number of cases, ¶ D. F. = degrees of freedom, all results significant at $\alpha < 0.05$

Table 5.5 continued

| Indicator / depth | Symptom Presence | N§ | Geometric Mean | $Log_{10}$ Std. dev | t-value | D.F.¶ | 1 tail p |
|---|---|---|---|---|---|---|---|
| **Breathing difficulty at 1 week:** | | | | | | | |
| Faecal streptococci | No | 167 | 51.143 | 0.585 | -3.43 | 8.23 | 0.005 |
| Surf | Yes | 5 | 98.678 | 0.153 | | | |
| Faecal streptococci | No | 167 | 32.682 | 0.510 | -5.11 | 169.29 | 0.000 |
| 30 cm | Yes | 5 | 52.970 | 0.010 | | | |
| Total staphylococci | No | 167 | 747.686 | 0.506 | -2.08 | 6.31 | 0.001 |
| 30 cm | Yes | 5 | 1131.922 | 0.172 | | | |
| Total staphylococci | No | 167 | 834.988 | 0.545 | -4.67 | 7.74 | 0.001 |
| Chest | Yes | 5 | 1961.456 | 0.150 | | | |
| **Runny nose at 1 week:** | | | | | | | |
| Total coliform | No | 148 | 143.477 | 0.384 | -1.74 | 45.55 | 0.044 |
| Surf | Yes | 23 | 180.009 | 0.223 | | | |
| Total coliform | No | 148 | 64.826 | 0.501 | -2.09 | 43.07 | 0.021 |
| 30 cm | Yes | 23 | 93.907 | 0.306 | | | |
| Faecal coliform | No | 148 | 207.737 | 0.370 | -2.16 | 53.56 | 0.018 |
| Surf | Yes | 23 | 266.055 | 0.188 | | | |
| Faecal coliform | No | 148 | 147.013 | 0.385 | -2.27 | 44.63 | 0.014 |
| 30 cm | Yes | 23 | 198.388 | 0.228 | | | |
| Faecal coliform | No | 148 | 59.242 | 0.316 | -2.09 | 67.78 | 0.021 |
| Chest | Yes | 23 | 71.427 | 0.135 | | | |
| Total staphylococci | No | 148 | 866.361 | 0.539 | -2.11 | 107.93 | 0.019 |
| Surf | Yes | 23 | 1139.775 | 0.167 | | | |
| Total staphylococci | No | 148 | 730.139 | 0.530 | -1.87 | 67.38 | 0.033 |
| 30 cm | Yes | 23 | 964.606 | 0.228 | | | |
| Total staphylococci | No | 148 | 800.863 | 0.566 | -2.63 | 49.71 | 0.006 |
| Chest | Yes | 23 | 1291.112 | 0.305 | | | |
| **Eye infection at 1 week:** | | | | | | | |
| Faecal streptococci | No | 166 | 51.578 | 0.588 | -1.79 | 13.02 | 0.049 |
| Surf | Yes | 6 | 70.187 | 0.142 | | | |
| Total staphylococci | No | 166 | 848.985 | 0.550 | -1.80 | 14.88 | 0.046 |
| Chest | Yes | 6 | 1113.038 | 0.122 | | | |

§ N = number of cases, ¶ D. F. = degrees of freedom, all results significant at $\alpha < 0.05$

Table 5.5 continued

| Indicator / depth | Symptom Presence | N§ | Geometric Mean | $Log_{10}$ Std. dev | t-value | D.F.¶ | 1 tail p |
|---|---|---|---|---|---|---|---|
| **Blurred vision at 1 week:** | | | | | | | |
| Faecal streptococci | No | 169 | 51.638 | 0.583 | -2.43 | 3.30 | 0.043 |
| Surf | Yes | 3 | 88.619 | 0.145 | | | |
| Faecal streptococci | No | 169 | 32.869 | 0.508 | -4.96 | 144.04 | 0.000 |
| 30 cm | Yes | 3 | 52.641 | 0.017 | | | |
| Total staphylococci | No | 169 | 845.642 | 0.544 | -3.02 | 2.96 | 0.029 |
| Chest | Yes | 3 | 1688.107 | 0.156 | | | |
| **Stomach pain at 1 week:** | | | | | | | |
| Total staphylococci | No | 148 | 727.283 | 0.527 | -1.91 | 54.92 | 0.031 |
| 30 cm | Yes | 23 | 989.148 | 0.263 | | | |
| **Loose motions at 1 week:** | | | | | | | |
| Total staphylococci | No | 131 | 848.376 | 0.562 | -1.74 | 153.40 | 0.042 |
| Surf | Yes | 40 | 1085.926 | 0.236 | | | |
| **Diarrhoea at 1 week:** | | | | | | | |
| Faecal coliform | No | 166 | 60.419 | 0.303 | -1.99 | 9.23 | 0.039 |
| Chest | Yes | 5 | 72.807 | 0.073 | | | |
| Faecal streptococci | No | 166 | 51.312 | 0.588 | -1.93 | 6.62 | 0.049 |
| Surf | Yes | 5 | 79.242 | 0.190 | | | |
| Faecal streptococci | No | 166 | 32.558 | 0.511 | -3.44 | 11.47 | 0.003 |
| 30 cm | Yes | 5 | 53.714 | 0.106 | | | |
| Faecal streptococci | No | 166 | 15.912 | 0.409 | -2.87 | 5.07 | 0.017 |
| Chest | Yes | 5 | 30.725 | 0.201 | | | |
| **Nausea 1 week:** | | | | | | | |
| Total coliform | No | 142 | 142.814 | 0.391 | -1.74 | 74.65 | 0.041 |
| 30 cm | Yes | 29 | 175.767 | 0.209 | | | |
| Total staphylococci | No | 142 | 857.420 | 0.542 | -1.82 | 86.65 | 0.036 |
| Surf | Yes | 29 | 1132.183 | 0.259 | | | |
| Total staphylococci | No | 142 | 725.440 | 0.536 | -1.69 | 84.38 | 0.048 |
| 30 cm | Yes | 29 | 938.940 | 0.261 | | | |
| **Vomiting at 1 week:** | | | | | | | |
| Faecal streptococci | No | 166 | 32.674 | 0.512 | -3.36 | 33.47 | 0.001 |
| 30 cm | Yes | 5 | 48.000 | 0.062 | | | |

§ N = number of cases, ¶ D. F. = degrees of freedom, all results significant at $\alpha < 0.05$

Table 5.5 continued

| Indicator / depth | Symptom Presence | N§ | Geometric Mean | $Log_{10}$ Std. dev | t-value | D.F.¶ | 1 tail p |
|---|---|---|---|---|---|---|---|
| **Skin rash at 1 week:** | | | | | | | |
| Total coliform | No | 159 | 65.881 | 0.493 | -2.84 | 21.57 | 0.005 |
| Chest | Yes | 12 | 106.498 | 0.212 | | | |
| **Lassitude 1 week:** | | | | | | | |
| Total coliform | No | 151 | 143.046 | 0.383 | -2.34 | 37.21 | 0.013 |
| 30 cm | Yes | 19 | 193.402 | 0.201 | | | |
| Total staphylococci | No | 151 | 721.437 | 0.521 | -2.39 | 36.49 | 0.011 |
| 30 cm | Yes | 19 | 1100.793 | 0.278 | | | |
| **Dizziness 1 week:** | | | | | | | |
| Faecal streptococci | No | 164 | 51.036 | 0.591 | -2.33 | 13.15 | 0.019 |
| Surf | Yes | 7 | 79.149 | 0.175 | | | |
| Faecal streptococci | No | 164 | 32.443 | 0.514 | -4.30 | 117.03 | 0.000 |
| 30 cm | Yes | 7 | 50.618 | 0.046 | | | |
| Total staphylococci | No | 164 | 834.026 | 0.551 | -2.39 | 10.90 | 0.006 |
| 30 cm | Yes | 7 | 1488.361 | 0.192 | | | |
| **Pins and needles 1 week:** | | | | | | | |
| Total coliform | No | 167 | 145.690 | 0.369 | -4.34 | 3.26 | 0.010 |
| 30 cm | Yes | 3 | 269.957 | 0.094 | | | |
| Faecal coliform | No | 167 | 213.783 | 0.357 | -2.07 | 4.71 | 0.049 |
| Surf | Yes | 3 | 267.287 | 0.065 | | | |
| Faecal coliform | No | 167 | 151.546 | 0.374 | -3.66 | 3.97 | 0.011 |
| 30 cm | Yes | 3 | 238.662 | 0.078 | | | |
| Faecal streptococci | No | 167 | 32.698 | 0.510 | -4.83 | 167.29 | 0.000 |
| 30 cm | Yes | 3 | 51.336 | 0.005 | | | |
| Total staphylococci | No | 167 | 738.946 | 0.502 | -5.03 | 3.02 | 0.007 |
| 30 cm | Yes | 3 | 2091.185 | 0.140 | | | |
| Total staphylococci | No | 167 | 840.814 | 0.547 | -3.86 | 3.52 | 0.012 |
| Chest | Yes | 3 | 1792.907 | 0.128 | | | |
| **Muscle cramps at 1 week:** | | | | | | | |
| Faecal streptococci | No | 166 | 32.744 | 0.512 | -2.19 | 12.98 | 0.024 |
| Chest | Yes | 5 | 44.509 | 0.098 | | | |
| Total staphylococci | No | 166 | 842.723 | 0.549 | -1.97 | 5.93 | 0.049 |
| Chest | Yes | 5 | 1330.067 | 0.204 | | | |

§ N = number of cases, ¶ D. F. = degrees of freedom, all results significant at $\alpha < 0.05$

**Table 5.5 continued**

| Indicator / depth | Symptom Presence | N§ | Geometric Mean | $Log_{10}$ Std. dev | t-value | D.F.¶ | 1 tail p |
|---|---|---|---|---|---|---|---|
| **Chest symptoms at 1 week:** | | | | | | | |
| Total coliform | No | 133 | 244.584 | 0.410 | -1.77 | 148.75 | 0.040 |
| Surf | Yes | 38 | 293.781 | 0.169 | | | |
| Total coliform | No | 133 | 139.540 | 0.400 | -2.38 | 123.10 | 0.010 |
| 30 cm | Yes | 38 | 181.432 | 0.202 | | | |
| Total coliform | No | 133 | 62.870 | 0.387 | -2.30 | 100.50 | 0.012 |
| 30 cm | Yes | 38 | 90.283 | 0.172 | | | |
| Faecal coliform | No | 133 | 205.110 | 0.387 | -2.05 | 139.50 | 0.021 |
| Surf | Yes | 38 | 252.396 | 0.172 | | | |
| Faecal coliform | No | 133 | 143.311 | 0.399 | -2.57 | 110.42 | 0.006 |
| 30 cm | Yes | 38 | 192.821 | 0.222 | | | |
| Total staphylococci | No | 133 | 848.572 | 0.564 | -1.98 | 167.71 | 0.025 |
| Surf | Yes | 38 | 1099.779 | 0.177 | | | |
| Total staphylococci | No | 133 | 710.541 | 0.550 | -2.03 | 139.29 | 0.023 |
| 30 cm | Yes | 38 | 950.043 | 0.245 | | | |
| Total staphylococci | No | 133 | 773.105 | 0.586 | -2.70 | 114.83 | 0.004 |
| Chest | Yes | 38 | 1211.435 | 0.315 | | | |
| **Other symptoms at 1 week:** | | | | | | | |
| Total coliform | No | 144 | 142.120 | 0.389 | -2.47 | 53.68 | 0.009 |
| 30 cm | Yes | 23 | 192.241 | 0.200 | | | |
| Faecal coliform | No | 144 | 148.108 | 0.395 | -1.78 | 66.99 | 0.040 |
| 30 cm | Yes | 23 | 181.054 | 0.173 | | | |
| Total staphylococci | No | 144 | 708.905 | 0.529 | -2.83 | 53.67 | 0.003 |
| 30 cm | Yes | 23 | 1135.842 | 0.272 | | | |
| Total staphylococci | No | 144 | 803.452 | 0.575 | -2.16 | 53.06 | 0.018 |
| Chest | Yes | 23 | 1188.596 | 0.298 | | | |

§ N = number of cases, ¶ D. F. = degrees of freedom, all results significant at $\alpha < 0.05$

**Table 5.6** One tailed separate variance estimate t-test results for significantly greater ($\alpha$=0.05) geometric mean water quality (count 100 $ml^{-1}$) experienced by bathers reporting a symptom at three weeks compared with those not reporting a symptom at three weeks post exposure

| Indicator / depth | Symptom Presence | N§ | Geometric Mean | $Log_{10}$ Std. dev | t-value | D.F.¶ | 1 tail p |
|---|---|---|---|---|---|---|---|
| **Headache 3 weeks:** | | | | | | | |
| *Pseudomonas aeruginosa* | No | 143 | 4.478 | 0.561 | -1.87 | 20.59 | 0.038 |
| Surf | Yes | 18 | 9.807 | 0.639 | | | |
| Aching limbs 3 weeks: | | | | | | | |
| Total coliform | No | 147 | 146.197 | 0.340 | -1.87 | 17.97 | 0.039 |
| 30 cm | Yes | 14 | 199.909 | 0.249 | | | |
| Total staphylococci | No | 147 | 745.105 | 0.466 | -2.35 | 18.81 | 0.015 |
| 30 cm | Yes | 14 | 1237.226 | 0.320 | | | |
| **Productive cough 3 weeks:** | | | | | | | |
| Total coliform | No | 147 | 66.842 | 0.486 | -2.08 | 24.91 | 0.024 |
| Chest | Yes | 14 | 96.364 | 0.239 | | | |
| Total staphylococci | No | 147 | 908.704 | 0.484 | -1.99 | 55.09 | 0.026 |
| Surf | Yes | 14 | 1167.154 | 0.139 | | | |
| **Breathing difficulties 3 weeks:** | | | | | | | |
| Faecal coliform | No | 157 | 63.077 | 0.268 | -1.96 | 7.10 | 0.045 |
| Chest | Yes | 5 | 76.732 | 0.083 | | | |
| Faecal streptococci | No | 157 | 32.705 | 0.510 | -3.29 | 12.11 | 0.003 |
| 30 cm | Yes | 5 | 52.939 | 0.105 | | | |
| Faecal streptococci | No | 157 | 16.326 | 0.403 | -2.80 | 5.06 | 0.019 |
| Chest | Yes | 5 | 31.248 | 0.203 | | | |
| **Eye infection 3 weeks:** | | | | | | | |
| Faecal coliform | No | 155 | 62.738 | 0.269 | -2.73 | 10.96 | 0.010 |
| Chest | Yes | 7 | 82.062 | 0.096 | | | |
| Total staphylococci | No | 155 | 916.065 | 0.472 | -2.85 | 12.10 | 0.008 |
| Surf | Yes | 7 | 1450.109 | 0.156 | | | |

§ N = number of cases, ¶ D. F. = degrees of freedom, all results significant at $\alpha < 0.05$

Table 5.6 continued

| Indicator / depth | Symptom Presence | N§ | Geometric Mean | $Log_{10}$ Std. dev | t-value | D.F.¶ | 1 tail p |
|---|---|---|---|---|---|---|---|
| **Loss of appetite 3 weeks:** | | | | | | | |
| Total staphylococci | No | 150 | 762.836 | 0.471 | -2.04 | 18.67 | 0.028 |
| 30 cm | Yes | 12 | 1109.708 | 0.242 | | | |
| Diarrhoea 3 weeks: | | | | | | | |
| Faecal streptococci | No | 150 | 50.689 | 0.596 | -3.83 | 45.74 | 0.000 |
| Surf | Yes | 10 | 89.908 | 0.131 | | | |
| Faecal streptococci | No | 150 | 35.348 | 0.520 | -2.76 | 42.13 | 0.005 |
| 30 cm | Yes | 10 | 46.973 | 0.119 | | | |
| Faecal streptococci | No | 150 | 16.302 | 0.411 | -1.87 | 15.64 | 0.041 |
| Chest | Yes | 10 | 22.174 | 0.187 | | | |
| **Vomiting 3 weeks:** | | | | | | | |
| Faecal streptococci | No | 156 | 51.481 | 0.586 | -4.83 | 26.20 | 0.000 |
| Surf | Yes | 5 | 100.719 | 0.082 | | | |
| Total staphylococci | No | 156 | 877.011 | 0.502 | -2.65 | 5.99 | 0.019 |
| Chest | Yes | 5 | 1563.228 | 0.191 | | | |
| Lassitude 3 weeks: | | | | | | | |
| Total coliform | No | 147 | 145.893 | 0.342 | -1.99 | 17.77 | 0.031 |
| 30 cm | Yes | 13 | 198.159 | 0.217 | | | |
| Faecal coliform | No | 147 | 215.671 | 0.325 | -2.53 | 64.29 | 0.007 |
| Surf | Yes | 13 | 263.789 | 0.078 | | | |
| *Pseudomonas aeruginosa* | No | 147 | 3.137 | 0.453 | -1.81 | 13.19 | 0.046 |
| 30 cm | Yes | 13 | 7.553 | 0.617 | | | |
| Total staphylococci | No | 147 | 749.758 | 0.470 | -1.88 | 18.66 | 0.038 |
| 30 cm | Yes | 13 | 1091.195 | 0.279 | | | |
| **Dizziness 3 weeks:** | | | | | | | |
| Faecal coliform | No | 152 | 152.886 | 0.342 | -2.30 | 15.02 | 0.018 |
| 30 cm | Yes | 10 | 208.411 | 0.161 | | | |
| Faecal streptococci | No | 152 | 50.618 | 0.592 | -4.03 | 43.47 | 0.000 |
| Surf | Yes | 10 | 92.368 | 0.133 | | | |
| Faecal streptococci | No | 152 | 32.189 | 0.516 | --4.02 | 58.55 | 0.000 |
| 30 cm | Yes | 10 | 52.889 | 0.099 | | | |
| Total staphylococci | No | 152 | 765.832 | 0.468 | -1.79 | 12.85 | 0.048 |
| 30 cm | Yes | 10 | 1128.276 | 0.271 | | | |
| Total staphylococci | No | 152 | 851.315 | 0.511 | -2.44 | 13.45 | 0.015 |
| Chest | Yes | 10 | 1468.265 | 0.276 | | | |

§ N = number of cases. ¶ D. F. = degrees of freedom. all results significant at $\alpha < 0.05$

Table 5.6 continued

| Indicator / depth | Symptom Presence | N§ | Geometric Mean | $Log_{10}$ Std. dev | t-value | D.F.¶ | 1 tail p |
|---|---|---|---|---|---|---|---|
| **Pins and needles 3 weeks:** | | | | | | | |
| Faecal streptococci | No | 156 | 51.602 | 0.587 | -2.76 | 13.39 | 0.008 |
| Surf | Yes | 6 | 83.684 | 0.143 | | | |
| Faecal streptococci | No | 156 | 32.628 | 0.511 | --4.78 | 158.65 | 0.000 |
| 30 cm | Yes | 6 | 51.979 | 0.012 | | | |
| Total staphylococci | No | 156 | 762.484 | 0.462 | -3.03 | 6.37 | 0.011 |
| 30 cm | Yes | 6 | 1635.440 | 0.252 | | | |
| Total staphylococci | No | 156 | 857.618 | 0.511 | -4.62 | 12.67 | 0.001 |
| Chest | Yes | 6 | 1739.203 | 0.128 | | | |
| **Muscle cramps 3 weeks:** | | | | | | | |
| Faecal streptococci | No | 158 | 51.796 | 0.583 | -3.16 | 7.21 | 0.008 |
| Surf | Yes | 4 | 91.939 | 0.125 | | | |
| Faecal streptococci | No | 158 | 32.861 | 0.583 | --2.04 | 4.93 | 0.049 |
| 30 cm | Yes | 4 | 49.711 | 0.125 | | | |
| **Ear / eye symptoms 3 weeks:** | | | | | | | |
| Total staphylococci | No | 144 | 905.985 | 0.487 | -2.21 | 47.03 | 0.016 |
| Surf | Yes | 17 | 1238.938 | 0.191 | | | |
| **Other symptoms 3 weeks:** | | | | | | | |
| Total coliform | No | 139 | 145.150 | 0.348 | -2.67 | 38.26 | 0.006 |
| 30 cm | Yes | 20 | 202.002 | 0.199 | | | |
| Faecal coliform | No | 139 | 214.080 | 0.332 | -2.42 | 103.62 | 0.009 |
| Surf | Yes | 20 | 260.517 | 0.094 | | | |
| Faecal coliform | No | 139 | 150.321 | 0.353 | -2.31 | 44.96 | 0.013 |
| 30 cm | Yes | 20 | 195.970 | 0.177 | | | |
| *Pseudomonas aeruginosa* | No | 139 | 3.054 | 0.435 | -1.99 | 21.55 | 0.030 |
| 30 cm | Yes | 20 | 7.022 | 0.646 | | | |
| Total staphylococci | No | 139 | 737.924 | 0.478 | -2.91 | 40.45 | 0.003 |
| 30 cm | Yes | 20 | 1188.871 | 0.261 | | | |
| Total staphylococci | No | 139 | 832.681 | 0.526 | -2.64 | 43.90 | 0.006 |
| Chest | Yes | 20 | 1314.528 | 0.269 | | | |

§ N = number of cases, ¶ D. F. = degrees of freedom, all results significant at $\alpha < 0.05$

**Table 5.7** One tailed separate variance estimate t-test results for Significantly greater ($\alpha$=0.05) geometric mean water quality (count 100 $ml^{-1}$) experienced by bathers with positive swab results at one week compared with those with negative results at one week post exposure

| Indicator / depth | Symptom Presence | N§ | Geometric Mean | $Log_{10}$ Std. dev | t-value | D.F.¶ | 1 tail p |
|---|---|---|---|---|---|---|---|
| **Faecal streptococci, ear swab:** | | | | | | | |
| Total coliform | No | 145 | 70.779 | 0.453 | -2.88 | 35.02 | 0.004 |
| Chest | Yes | 17 | 109.611 | 0.220 | | | |
| Total staphylococci | No | 145 | 1005.236 | 0.348 | -1.74 | 36.20 | 0.046 |
| Surf | Yes | 17 | 1223.898 | 0.164 | | | |
| **Coliform, ear swab:** | | | | | | | |
| Faecal streptococci | No | 153 | 33.882 | 0.501 | -2.15 | 35.82 | 0.019 |
| 30 cm | Yes | 9 | 45.814 | 0.111 | | | |
| ***Staphylococcus aureus*, ear swab:** | | | | | | | |
| Total coliform | No | 158 | 272.527 | 0.267 | -7.14 | 157.00 | 0.000 |
| Surf | Yes | 4 | 386.972 | 0.000 | | | |
| Total coliform | No | 158 | 155.495 | 0.287 | -5.69 | 157.00 | 0.000 |
| 30 cm | Yes | 4 | 211.009 | 0.000 | | | |
| Total coliform | No | 158 | 73.388 | 0.443 | -4.82 | 157.00 | 0.000 |
| Chest | Yes | 4 | 109.002 | 0.000 | | | |
| Faecal coliform | No | 158 | 229.409 | 0.250 | -7.11 | 157.00 | 0.000 |
| Surf | Yes | 4 | 319.007 | 0.000 | | | |
| Faecal coliform | No | 158 | 162.795 | 0.283 | -11.34 | 157.00 | 0.000 |
| 30 cm | Yes | 4 | 293.985 | 0.000 | | | |
| Faecal streptococci | No | 158 | 53.488 | 0.568 | -7.98 | 157.00 | 0.000 |
| Surf | Yes | 4 | 123.997 | 0.000 | | | |
| Faecal streptococci | No | 158 | 34.051 | 0.494 | -4.57 | 157.00 | 0.000 |
| 30 cm | Yes | 4 | 52.003 | 0.000 | | | |
| Total staphylococci | No | 158 | 788.587 | 0.357 | -9.19 | 157.00 | 0.000 |
| 30 cm | Yes | 4 | 1440.120 | 0.000 | | | |
| Total staphylococci | No | 158 | 892.100 | 0.430 | -13.17 | 157.00 | 0.000 |
| Chest | Yes | 4 | 2520.158 | 0.000 | | | |
| **Haemolytic streptococci, throat swab:** | | | | | | | |
| Total staphylococci | No | 154 | 872.172 | 0.442 | -2.97 | 7.47 | 0.010 |
| Chest | Yes | 6 | 1542.121 | 0.185 | | | |

§ N = number of cases, ¶ D. F. = degrees of freedom, all results significant at $\alpha < 0.05$

Table 5.7 continued

| Indicator / depth | Symptom Presence | N§ | Geometric Mean | $Log_{10}$ Std. dev | t-value | D.F.¶ | 1 tail p |
|---|---|---|---|---|---|---|---|
| ***Staphylococcus aureus*, throat swab:** | | | | | | | |
| Total coliform | No | 150 | 73.165 | 0.453 | -1.94 | 36.04 | 0.030 |
| Chest | Yes | 10 | 92.325 | 0.113 | | | |
| Faecal streptococci | No | 150 | 51.662 | 0.579 | -4.26 | 34.69 | 0.030 |
| Surf | Yes | 10 | 100.088 | 0.148 | | | |
| Faecal streptococci | No | 150 | 33.206 | 0.505 | -2.63 | 31.30 | 0.007 |
| 30 cm | Yes | 10 | 49.125 | 0.137 | | | |
| **Any determinand, ear swab:** | | | | | | | |
| Total coliform | No | 136 | 267.596 | 0.282 | -2.01 | 72.90 | 0.025 |
| Surf | Yes | 26 | 316.395 | 0.137 | | | |
| Total coliform | No | 136 | 70.417 | 0.466 | -2.30 | 73.83 | 0.012 |
| Chest | Yes | 26 | 96.791 | 0.224 | | | |
| Faecal coliform | No | 136 | 226.457 | 0.264 | -1.70 | 75.55 | 0.047 |
| Chest | Yes | 26 | 258.119 | 0.125 | | | |
| **Any determinand, throat swab:** | | | | | | | |
| *Pseudomonas aeruginosa* | No | 33 | 1.273 | 0.182 | -2.08 | 106.52 | 0.020 |
| Chest | Yes | 127 | 1.826 | 0.370 | | | |
| **Any determinand, either swab:** | | | | | | | |
| *Pseudomonas aeruginosa* | No | 27 | 1.195 | 0.220 | -2.57 | 101.28 | 0.006 |
| Chest | Yes | 132 | 1.826 | 0.367 | | | |

§ N = number of cases, ¶ D. F. = degrees of freedom, all results significant at $\alpha < 0.05$

**Table 5.8** **Relationships between swab results and perceived sore throats and ear infections at 1 week in the bather group**

| Symptom | Swab | Determinand | Both Positive | Both Negative | Symptom Positive Only | Swab Positive Only |
|---|---|---|---|---|---|---|
| Sore throat | Throat | Haemolytic strep. | 3 | 137 | 20 | 3 |
| Sore throat | Throat | Faecal strep. | 16 | 34 | 7 | 106 |
| Sore throat | Throat | Coliform | 1 | 125 | 22 | 15 |
| Sore throat | Throat | *E. coli* | 0 | 139 | 23 | 1 |
| Sore throat | Throat | *S. aureus* | 3 | 133 | 20 | 7 |
| Sore throat | Throat | Any | 17 | 27 | 6 | 113 |
| Ear infection | Ear | Haemolytic strep. | 0 | 157 | 6 | 1 |
| Ear infection | Ear | Faecal strep. | 1 | 142 | 5 | 16 |
| Ear infection | Ear | Coliform | 1 | 150 | 5 | 8 |
| Ear infection | Ear | *E. coli* | 0 | 158 | 6 | 0 |
| Ear infection | Ear | *P. aeruginosa* | 1 | 157 | 5 | 1 |
| Ear infection | Ear | *S. aureus* | 0 | 154 | 6 | 4 |
| Ear infection | Ear | Any | 1 | 133 | 5 | 25 |
| Sore throat or ear infection | Either | Haemolytic strep. | 3 | 130 | 23 | 4 |
| Sore throat or ear infection | Either | Faecal strep. | 19 | 27 | 7 | 108 |
| Sore throat or ear infection | Either | Coliform | 3 | 115 | 23 | 20 |
| Sore throat or ear infection | Either | *E. Coli* | 0 | 133 | 26 | 1 |
| Sore throat or ear infection | Either | *S. aureus* | 3 | 130 | 23 | 4 |
| Sore throat or ear infection | Either | Any | 20 | 21 | 6 | 114 |

**Table 5.9 Relationships between swab results and perceived sore throats and ear infections at 1 week in the non-bather group**

| Symptom | Swab | Determinand | Both Positive | Both Negative | Symptom Positive Only | Swab Positive Only |
|---|---|---|---|---|---|---|
| Sore throat | Throat | Haemolytic strep. | 1 | 135 | 27 | 7 |
| Sore throat | Throat | Faecal strep. | 23 | 29 | 5 | 113 |
| Sore throat | Throat | Coliform | 1 | 129 | 27 | 13 |
| Sore throat | Throat | *E. coli* | 2 | 139 | 26 | 3 |
| Sore throat | Throat | *S. aureus* | 1 | 133 | 27 | 9 |
| Sore throat | Throat | Any | 24 | 23 | 4 | 119 |
| Ear infection | Ear | Haemolytic strep. | 0 | 169 | 3 | 1 |
| Ear infection | Ear | Faecal strep. | 1 | 165 | 2 | 5 |
| Ear infection | Ear | Coliform | 0 | 161 | 3 | 9 |
| Ear infection | Ear | *E. coli* | 0 | 169 | 3 | 1 |
| Ear infection | Ear | *P. aeruginosa* | 0 | 164 | 3 | 6 |
| Ear infection | Ear | *S. aureus* | 0 | 164 | 3 | 6 |
| Ear infection | Ear | Any | 1 | 147 | 2 | 23 |
| Sore throat or ear infection | Either | Haemolytic strep. | 1 | 131 | 28 | 8 |
| Sore throat or ear infection | Either | Faecal strep. | 24 | 29 | 5 | 113 |
| Sore throat or ear infection | Either | Coliform | 2 | 120 | 27 | 19 |
| Sore throat or ear infection | Either | *E. Coli* | 2 | 135 | 27 | 4 |
| Sore throat or ear infection | Either | *S. aureus* | 1 | 131 | 28 | 8 |
| Sore throat or ear infection | Either | Any | 25 | 21 | 4 | 121 |

**Table 5.10 Relationships between medical diagnosis and volunteer perception of sore throats and ear infections at 1 week**

| Symptom | Diagnosis | Both Positive | Both Negative | Symptom Positive Only | Diagnosis Positive Only |
|---|---|---|---|---|---|
| **a. Bathers** | | | | | |
| Sore throat | Red throat | 6 | 120 | 17 | 22 |
| Sore throat | Throat Infection | 1 | 120 | 17 | 0 |
| Sore throat | Red / infected | 7 | 120 | 17 | 22 |
| Ear Infection | Ear Infection | 0 | 156 | 6 | 1 |
| **b. Non-bathers** | | | | | |
| Sore throat | Red throat | 8 | 126 | 20 | 15 |
| Sore throat | Throat Infection | 0 | 126 | 20 | 15 |
| Sore throat | Red / Infected | 8 | 126 | 20 | 15 |
| Ear infection | Ear Infection | 0 | 163 | 3 | 1 |

**Table 5.11 Relationships between swab results and diagnosed sore throats and ear infections at 1 week**

| Diagnosis | Swab | Determinand | Both Positive | Both Negative | Diagnosis Positive Only | Swab Positive Only |
|---|---|---|---|---|---|---|
| **a. Bathers** | | | | | | |
| Red throat | Throat | Haemolytic strep. | 0 | 125 | 27 | 6 |
| Red throat | Throat | Faecal strep. | 20 | 32 | 7 | 99 |
| Red throat | Throat | Coliform | 4 | 120 | 23 | 11 |
| Red throat | Throat | *E. coli* | 0 | 130 | 27 | 1 |
| Red throat | Throat | *S. aureus* | 3 | 124 | 24 | 7 |
| Red throat | Throat | Any | 23 | 27 | 4 | 104 |
| Infected throat | Throat | Haemolytic strep. | 0 | 125 | 1 | 6 |
| Infected throat | Throat | Faecal strep. | 0 | 32 | 1 | 99 |
| Infected throat | Throat | Coliform | 0 | 120 | 1 | 11 |
| Infected throat | Throat | *E. coli* | 0 | 130 | 1 | 1 |
| Infected throat | Throat | *S. aureus* | 0 | 124 | 1 | 7 |
| Infected throat | Throat | Any | 0 | 27 | 1 | 104 |
| Ear infection | Ear | Haemolytic strep. | 0 | 157 | 1 | 0 |
| Ear infection | Ear | Faecal strep. | 0 | 140 | 1 | 17 |
| Ear infection | Ear | Coliform | 0 | 148 | 1 | 9 |
| Ear infection | Ear | *E. coli* | 0 | 157 | 1 | 0 |
| Ear infection | Ear | *P. aeruginosa* | 0 | 155 | 2 | 0 |
| Ear infection | Ear | *S. aureus* | 0 | 154 | 1 | 3 |
| Ear infection | Ear | Any | 0 | 132 | 1 | 25 |
| **b. Non-bathers** | | | | | | |
| Red throat | Throat | Haemolytic strep. | 2 | 137 | 21 | 6 |
| Red throat | Throat | Faecal strep. | 21 | 32 | 2 | 111 |
| Red throat | Throat | Coliform | 2 | 132 | 21 | 11 |
| Red throat | Throat | *E. coli* | 2 | 140 | 21 | 3 |
| Red throat | Throat | *S. aureus* | 1 | 134 | 22 | 9 |
| Red throat | Throat | Any | 22 | 26 | 1 | 117 |
| Ear infection | Ear | Haemolytic strep. | 0 | 163 | 1 | 21 |
| Ear infection | Ear | Faecal strep. | 0 | 158 | 1 | 6 |
| Ear infection | Ear | Coliform | 0 | 156 | 1 | 8 |
| Ear infection | Ear | *E. coli* | 0 | 163 | 1 | 1 |
| Ear infection | Ear | *P. aeruginosa* | 0 | 159 | 1 | 5 |
| Ear infection | Ear | *S. aureus* | 0 | 158 | 1 | 6 |
| Ear infection | Ear | Any | 0 | 141 | 1 | 23 |

**Table 6.1 Results of Tukey honest significant difference multiple range tests, by site, Surf depth samples**

**Total coliform**

| Geo. mean (count $100ml^{-1}$) | Site | Langland | Southsea | Moreton |
|---|---|---|---|---|
| 82.907 | Langland | | | |
| 207.497 | Southsea | * | | |
| 326.039 | Moreton | * | | |

**Faecal coliform**

| Geo. mean (count $100ml^{-1}$) | Site | Langland | Moreton | Southsea |
|---|---|---|---|---|
| 46.621 | Langland | | | |
| 161.443 | Moreton | * | | |
| 198.894 | Southsea | * | | |

**Faecal streptococci**

| Geo. mean (count $100ml^{-1}$) | Site | Moreton | Langland | Southsea |
|---|---|---|---|---|
| 27.747 | Moreton | | | |
| 45.666 | Langland | * | | |
| 51.360 | Southsea | * | | |

***Pseudomonas aeruginosa***

| Geo. mean (count $100ml^{-1}$) | Site | Langland | Moreton | Southsea |
|---|---|---|---|---|
| 0.622 | Langland | | | |
| 9.718 | Moreton | * | | |
| 10.830 | Southsea | * | | |

* denotes significant difference in geometric mean concentration (count $100\ ml^{-1}$) between depths at $\alpha < 0.05$

**Table 6.2 Results of Tukey honest significant difference multiple range tests, by site, 30 cm depth samples**

**Total coliform**

| Geo. mean (count $100ml^{-1}$) | Site | Langland | Southsea | Moreton |
|---|---|---|---|---|
| 49.026 | Langland | | | |
| 139.378 | Southsea | * | | |
| 314.283 | Moreton | * | * | |

**Faecal coliform**

| Geo. mean (count $100ml^{-1}$) | Site | Langland | Southsea | Moreton |
|---|---|---|---|---|
| 39.281 | Langland | | | |
| 141.922 | Southsea | * | | |
| 160.287 | Moreton | * | | |

**Faecal streptococci**

| Geo. mean (count $100ml^{-1}$) | Site | Moreton | Southsea | Langland |
|---|---|---|---|---|
| 29.304 | Moreton | | | |
| 36.420 | Southsea | | | |
| 43.844 | Langland | * | | |

***Pseudomonas aeruginosa***

| Geo. mean (count $100ml^{-1}$) | Site | Langland | Southsea | Moreton |
|---|---|---|---|---|
| 0.216 | Langland | | | |
| 5.937 | Southsea | * | | |
| 6.130 | Moreton | * | | |

* denotes significant difference in geometric mean concentration (count 100 ml$^{-1}$) between depths at $\alpha < 0.05$

**Table 6.3** **Results of Tukey honest significant difference multiple range tests, by site, Chest depth samples**

**Total coliform**

| Geo. mean (count $100ml^{-1}$) | Site | Langland | Southsea | Moreton |
|---|---|---|---|---|
| 34.711 | Langland | | | |
| 71.644 | Southsea | * | | |
| 168.434 | Moreton | * | * | |

**Faecal coliform**

| Geo. mean (count $100ml^{-1}$) | Site | Langland | Southsea | Moreton |
|---|---|---|---|---|
| 14.014 | Langland | | | |
| 74.214 | Southsea | * | | |
| 148.589 | Moreton | * | * | |

**Faecal streptococci**

| Geo. mean (count $100ml^{-1}$) | Site | Southsea | Moreton | Langland |
|---|---|---|---|---|
| 21.751 | Southsea | | | |
| 23.714 | Moreton | No significant differences | | |
| 31.769 | Langland | | | |

***Pseudomonas aeruginosa***

| Geo. mean (count $100ml^{-1}$) | Site | Langland | Moreton | Southsea |
|---|---|---|---|---|
| 0.212 | Langland | | | |
| 1.531 | Moreton | * | | |
| 3.221 | Southsea | * | * | |

* denotes significant difference in geometric mean concentration (count $100 ml^{-1}$) between depths at $\alpha < 0.05$

**Table 6.4** Two tailed separate variance estimate t-test results for geometric mean total staphylococci (count 100 $ml^{-1}$) at Moreton and Southsea

| Depth | Site | N§ | Geometric Mean | $Log_{10}$ Std. dev | t-value | D.F.¶ | 2 tail p |
|---|---|---|---|---|---|---|---|
| Surf | Moreton | 54 | 135.207 | 0.498 | -6.28 | 51.39 | 0.000* |
| | Southsea | 28 | 791.866 | 0.535 | | | |
| 30 cm | Moreton | 54 | 123.022 | 0.522 | -4.70 | 55.90 | 0.000* |
| | Southsea | 28 | 434.628 | 0.510 | | | |
| Chest | Moreton | 54 | 147.662 | 0.476 | -4.23 | 56.17 | 0.000* |
| | Southsea | 28 | 428.536 | 0.463 | | | |

* result significant at $\alpha < 0.05$

# APPENDIX I

## SUBJECT INFORMATION SHEET

### Study on the Possible Health Effects of Bathing in waters which meet EEC Directive standards

| | |
|---|---|
| *FUNDING AGENCY* | Department of the Environment |
| *MANAGEMENT AGENCY* | Water Research Centre |
| *RESEARCH SUPERVISORS* | Prof F. Jones (Altwell Ltd),<br>Dr D. Kay (University of Wales), |

## 1. NATURE OF THE STUDY

### 1.1 Background

A degree of sewage contamination can be detected at most UK bathing beaches. There is no reliable information, for UK bathing waters, with which to define the minor risks to health caused by bathing in this coastal environment. Britian and our European partners accept the European Bathing Waters Directive standards as one measure of '*acceptable*' bathing water quality. However, we do not know if these standards are either too lax or too stringent to ensure that minor diseases will not be contracted by the bathers. It is the objective of this study to answer some of these questions.

### 1.2 Research Method

This project will involve 400 healthy volunteers. All will be adults over 18 years of age. They will be taken to a beach which has been given a PASS grade on the European bathing water standards. In UK terms this would place the beach in the top 67% of our identified *Eurobeaches*. The chosen beach will be Southsea and the group of bathers would be taking part in a common leisure time activity practiced by millions of other UK and European citizens (i.e. coastal bathing). The beach has relatively '*good*' water quality and has passed the EEC bathing water directive at the Imperative level in recent years. The group of 400 volunteers will be split into two equal groups at the beach. One group will take part in normal beach activities other than water contact pursuits, whilst the other will go into the water. This latter group will each be asked to immerse their heads in the water at least three times during the test, as they might during normal recreational activity.

Every volunteer will have three questionnaire-based assessments to ascertain their state of '*perceived*' health, first on the day before exposure, the second about one week later and the third after three weeks. Paralleling this schedule will be the collection of ear and throat swabs, together with faecal samples, by qualified personnel for analysis by the Public Health Laboratory Service

## 2. Health risks

The Department of Health have indicated that there is only a small risk of illness even if waters are seriously and visibly contaminated. The fact that the study is to be conducted on a beach which meets the standards of the EEC Bathing Waters Directive can give confidence that there is no risk of serious illness. However, previous work in this area, conducted outside the UK, has suggested that there might be a slight risk of contracting minor illnesses such as stomach infections. We cannot guarantee that there is zero risk of volunteers contracting such infections. However, this risk is no greater than that experienced by many millions of coastal bathers each year who use waters which currently meet EEC standards.

## 3. Insurance cover

All participants in the study will be covered for accidental injury. Exact details of this insurance cover are available for inspection on request from any of the supervisors listed above. In broad terms, this policy follows the guidelines recommended by the Royal College of Physicians Research on Healthy Volunteers (1986).

## 4. Expenses

All participants will receive £10 for out of pocket expenses and the inconvenience experienced on the day of exposure and during the associated medical examinations. This token payment is not intended to cover '*risk*'.

## 5. Consent

(i) I have read and understood sections 1 through 4 of this subject information sheet.

(ii) I give my consent for the medical examinations and sample collections outlined and I am willing to be involved in this experiment.

(iii) I understand that insurance cover has been arranged by the project supervisors. I understand that I can pull out of this study at any time but I undertake to inform the supervisors immediately I take such a decision.

(iv) I am willing to provide information on my medical history to the researchers on the understanding that any such information will be treated in strictest confidence.

| | | |
|---|---|---|
| **Signed** ________ | **Daytime Phone No.** ___________ | **No.** |
| **Name (Please print)** ________ | **Home Address** ______ | **GP's Name** ________ |
| | ______________ | **Surgery Address** ______ |
| | ______________ | ______________ |
| | ______________ | ______________ |
| **Date** _/_/_ | ______________ | ______________ |
| | **Phone No.** ________ | |

**Public Health Laboratory Service**

**PHLS Communicable Disease Surveillance Centre (Welsh Unit)**
**Cardiff Royal Infirmary**
**Newport Road**
**Cardiff CF2 1SZ**
**Fax: 0222 497475**
**Telephone: 0222 492235 Ext. 355/426**

**Our Ref** **Your ref**

**IN CONFIDENCE**

**/ /91**

Dear

Re:

This patient has volunteered for a Department of the Environment funded study of the possible minor health risks associated with coastal bathing. A beach currently passing the EC mandatory water quality levels has been selected (Southsea). The study should require no additional work on your part. I am simply writing to keep you informed. The chairman of your local medical committee has been consulted and can see no objections to the survey proposal.

During the study day, (Saturday 6th July), your patient will be allocated at random to a swimming or non-swimming group. "Swimming" will consist of entering the water, swimming, splashing etc. for a minimum of ten minutes. The survey will include two medical interviews, ear and throat swabs and faecal samples, as well as questionnaires.

Study participants will be asked about chronic illnesses and recent health history. They have not been told to check with their GP for fitness to take part, as they are only being asked to carry out a normal leisure activity. If you feel there is any reason why this patient should <u>not</u> take part please telephone me on the above number or contact Dr. D. Kay at St. Davids University College, Lampeter, by telephoning 0570 422351 ext. 249.

People deemed unfit at the pre-exposure interview will be excluded by one of the doctors on the study team.

A copy of the enclosed information sheet, approved by the Royal College of Physicians ethical committee for Research on Healthy Volunteers, has been signed by your patient.

If I do not hear from you, I shall assume that you are happy for the study team to include your patient in the survey.

Yours sincerely,

Mark Wyer

pp Dr. R. L. Salmon, MA, MB, BS, MRCGP, MFPHM

Consultant Epidemiologist

# APPENDIX II

**STRICTLY CONFIDENTIAL**

# SEASIDE HEALTH SURVEY: 1991 SAMPLE

Pre-exposure interview

Interviewer name: ____________________

**Coding only**

Volunteer no. [ | | | ] 1    Form [1] 2

Study no [ | | | | ] 3

date [ | | | | 9 | 1 ] 4

Interviewer [ | ] 5    Barber / non barber [ ] 6

## SECTION ONE-PERSONAL DETAILS

1. Subject name: ____________________

2. Date of birth: [ | | | | | ]    dob [ | | | | | ] 7

3. Sex : MALE [ ] 1    FEMALE [ ] 2    Sex [ ] 8

4. Home address: ____________________

____________________ Postcode ____________________

Post code [ | | | | | | | ] 9

Code for county if postcode unknown

Telephone no. (home): ____________________

5. Work/study address ____________________

____________________

6. Contact details for follow-up (address etc. over next three months).

____________________

____________________

7. Occupation of volunteer :

Student [ ] 1    H/Wife [ ] 2    Empl [ ] 3    Part-time empl [ ] 4

Self-Emp [ ] 5    Unempl [ ] 6    Retired [ ] 7    Other* [ ] 8

Job [ ] 10

Code unpaid work as 0 e.g. voluntary work

*Details/Specify: ____________________

Please give a brief description of your job:

____________________

____________________

**MEDICAL SECTION**

Examining Doctor to check Pages :

| 3 | 4 | 5 | 9 |
|---|---|---|---|
| | | | |

**STRICTLY CONFIDENTIAL**

**PERSONAL DETAILS - CONTINUED**



8. General Practitioner: Name : ____________________

Address : ____________________

____________________

____________________ Tel: ____________________

9. Health Authority:

____________________

H.A. ☐ 11

10. Local Authority:

____________________

L.A. ☐ 12

11. Please list all the members of your household (i.e. all those who live in your home) with their sex and ages :

*(A household means sharing facilities and at least one meal per day - remember to include the interviewee in the total household count)*

| Name (Surname not required) | Sex | Age | Name (Surname not required) | Sex | Age |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Include the interviewee in the total count

Total in household ☐ 13

Total children upto 5 in household ☐ 14

Has anyone in your household been unwell with a possible infection in the past two weeks ?

Yes ☐ 1 No ☐ 0 Not sure ☐ 9

Household illness ☐ 15

If yes please give details

____________________

____________________

Illness type ☐ 16

*Prompt - Diarrhoea, gastric infection (nausea, vomiting etc), sore throat, ear and eye infections*

**STRICTLY CONFIDENTIAL**

Coding only

## SECTION TWO - GENERAL HEALTH

12. Do you have any longstanding illness, disability or infirmity? (Anything that has troubled you over a period of time or is likely to affect you over a period in the future).

Yes ☐ 1   No ☐ 0   Not sure ☐ 9   Long. ill ☐ 17

*if no, turn to question 14, page 5*

If yes, please indicate the nature of the problem by ticking all the boxes that apply from this list on this and the following page. Use the space at the bottom of page 4 to describe any circumstances not covered by the available boxes. *Prompt for each - have you ever had*

| | | | | | |
|---|---|---|---|---|---|
| 1. ARTHRITIS: specify joints ____________ | ☐ | | | Arthritis | ☐ 18 |
| 2. BACK PAIN *(include: aches /lumbago/ disc problems)* | ☐ | | | Back Pain | ☐ 19 |
| **3. raised BLOOD PRESSURE** * | ☐ | | | Blood Pressure | ☐ 20 |
| **4. CHEST PROBLEMS** *(include asthma/bronchitis)* * | ☐ | | | Chest | ☐ 21 |
| *Do you have* **5. DIABETES** * | ☐ | | | Diabetes | ☐ 22 |
| 6. DIGESTION PROBLEMS *(e.g. dyspepsia (ulcer) )* : specify ____________ | ☐ | Digestion problems | ☐ 23 | Problem type | ☐ 24 |
| 7. BOWEL PROBLEMS *(e.g. constipation, colitis, irritable bowel syndrome)* : specify ____________ | ☐ | Bowel problems | ☐ 25 | Problem type | ☐ 26 |
| 8. HEARING LOSS / EAR PROBLEMS : specify | ☐ | Hearing/ear problems | ☐ 27 | Problem Type | ☐ 28 |
| **9. HEART DISEASE** *(include angina)* * | ☐ | | | Heart | ☐ 29 |
| 10. HEPATITIS / LIVER DISEASE | ☐ | Hepatitis | ☐ 30 | Type | ☐ 31 |

If Yes which type of hepatitis? Infectious Type A / B ☐ A / B

*Infective jaundice (type A) or Serum Hepatitis (type B)*   Other type *(Non infectious etc.)* ☐

A = 1
B = 2
other = 3
not known = 9

**STRICTLY CONFIDENTIAL**

**Coding only**

**GENERAL HEALTH - CONTINUED**

11. Problems due to INFECTION ☐

specify infection and problem: ______________________

______________________________________________

Infection ☐ 32 Infection Type ☐ 33

12. Problems resulting from INJURY OR ACCIDENT: ☐
specify : the problem

______________________________________

Injury/Accident ☐ 34

13. KIDNEY or BLADDER problem: ☐

specify: ______________________________

Kidney/ Bladder ☐ 35 Problem type ☐ 36

14. **NEUROLOGICAL Condition: specify** * ☐

______________________________

*(e.g. strokes / epilepsy / paralysis / neuralgia / migraine)*

Neurological ☐ 37 Problem type ☐ 38

15. HAYFEVER ☐

Hay fever ☐ 39

16. **SKIN Problems: specify** * ☐

______________________________

*(e.g. eczema / psoriasis)*

Skin ☐ 40 Problem type ☐ 41

17. STRESS / ANXIETY ☐
*(For which you require medical treatment)*

Stress / Anxiety ☐ 42

18. POOR VISION/ EYES: ☐

specify: ______________________________

*Short sight = 1 Long sight = 2 Glaucoma = 3 Detatched retina = 4*
*Include frequent eye irritation - red eyes = 5*

Eyes ☐ 43 Problem type ☐ 44

19. OTHER PROBLEMS: Please give a brief description ☐

______________________________________________

______________________________________________

______________________________________________

______________________________________________

Other ☐ 45 Problem type ☐ 46

**GENERAL HEALTH - CONTINUED**

**13. Do you see a doctor regularly for any of these problems?** *

Yes ☐ 1 No ☐ 0 Not sure ☐ 9 — Doctor seen ☐ 47

If yes, is this your GP, a hospital specialist, or both

GP ☐ 1 Hosp ☐ 2 Both ☐ 3 Other * ☐ 4 — Doctor Details ☐ 48

* Give details ______________________

14. How many times a year do you have diarrhoea?

*(An increase over your normal bowel habits equal to runny stools lasting at least 24 hours)*

| Often 1-2 a month | Sometimes 3-11 a year | Rarely <2 a year | Hardly ever <1 a year | Never | Not Sure |
|---|---|---|---|---|---|
| ☐ 4 | ☐ 3 | ☐ 2 | ☐ 1 | ☐ 0 | ☐ 9 |

Diarrhoea ☐ 49

**15. Have you in the past 6 months had an illness which caused you to stay home from work, miss normal activities or go to hospital?** *

Yes ☐ 1 No ☐ 0 Not Sure ☐ 9 — Ill in last 6 months ☐ 50

*If no go to Question 16, next page*

If yes please complete the following section.

Diagnosis of illness

Illness ☐ 51 Illness type ☐ 52

Were you admitted to Hospital? Yes ☐ 1 No ☐ 0 — Illness Hosp. adm. ☐ 53

How long were you sick / off work? Weeks ☐ Days ☐ — Illness time off (MWD) ☐ 54

*If more than 1 illness record details of the most serious / recent illness*

Month illness started

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Illness start (M) ☐ 55

Are any of these illnesses / Is this illness still giving you symptoms ?

Yes ☐ 1 No ☐ 0 Not Sure ☐ 9 — Illness still giving symptoms ? ☐ 56

## GENERAL HEALTH - CONTINUED

16. In the last 3 weeks, please answer whether you have had any of the following symptoms, persisting for more than 24 hours.
(Answer Yes, No or Not sure for every symptom) EVERYONE TO ANSWER THIS SECTION

'Flu / cold symptoms *Lasting 24 hours or more*

| | Yes | No | Not Sure | Onset date - Jun / Jul | Duration in days | Coding: Symptom | Onset | Duration |
|---|---|---|---|---|---|---|---|---|
| 1. Fever (Hot and cold, shivers) | 1 | 0 | 9 | | | Fever | | 57 |
| 2. Severe / unusual headache | 1 | 0 | 9 | | | Headache | | 58 |
| 3. Aching arms, legs, joints | 1 | 0 | 9 | | | Aching limbs | | 59 |
| 4. Sore throat | 1 | 0 | 9 | | | Sore throat | | 60 |

Chest symptoms *Lasting 24 hours or more*

| | Yes | No | Not Sure | Onset date - Jun / Jul | Duration in days | Coding: Symptom | Onset | Duration |
|---|---|---|---|---|---|---|---|---|
| 5. Chest pains / aches | 1 | 0 | 9 | | | Chest pains | | 61 |
| 6. Dry cough | 1 | 0 | 9 | | | Dry cough | | 62 |
| 7. Productive cough (phlegm / sputum) | 1 | 0 | 9 | | | Prod. cough | | 63 |
| 8. Wheezing / Shortness of breath | 1 | 0 | 9 | | | Breathing diff. | | 64 |
| 9. Runny nose | 1 | 0 | 9 | | | Runny nose | | 65 |

Ear / eye symptoms *Lasting 24 hours or more*

| | Yes | No | Not Sure | Onset date - Jun / Jul | Duration in days | Coding: Symptom | Onset | Duration |
|---|---|---|---|---|---|---|---|---|
| 10. Ear infection (sore, discharge) | 1 | 0 | 9 | | | Ear infection | | 66 |
| 11. Eye infection (sore red eyes, discharge) | 1 | 0 | 9 | | | Eye infection | | 67 |
| 12. Blurred vision (difficulty with eye sight) | 1 | 0 | 9 | | | Vision | | 68 |

Gut symptoms *Lasting 24 hours or more*

| | Yes | No | Not Sure | Onset date - Jun / Jul | Duration in days | Coding: Symptom | Onset | Duration |
|---|---|---|---|---|---|---|---|---|
| 13. Loss of appetite | 1 | 0 | 9 | | | Appetite | | 69 |
| 14. Indigestion | 1 | 0 | 9 | | | Indigestion | | 70 |
| 15. Stomach cramps (colic / lower abdominal pain / griping) | 1 | 0 | 9 | | | Stomach pain | | 71 |
| 16. Loose bowel motions (looser than normal) | 1 | 0 | 9 | | | Loose bowels | | 72 |

16. Continued

Gut symptoms continued

| | Yes | No | Not Sure | Onset date - Jun / Jul | Duration in days | Coding: Symptom | Onset | Duration |
|---|---|---|---|---|---|---|---|---|
| 17. Diarrhoea (3 or more runny stools in 24 hours) | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Diarrhoea ☐ | ☐ | ☐ 73 |
| 18. Nausea (feeling sick) | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Nausea ☐ | ☐ | ☐ 74 |
| 19. Vomiting (being sick) | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Vomiting ☐ | ☐ | ☐ 75 |

Skin symptoms *Lasting 24 hours or more*

| | Yes | No | Not Sure | Onset date - Jun / Jul | Duration in days | Coding: Symptom | Onset | Duration |
|---|---|---|---|---|---|---|---|---|
| 20. Skin rash on body | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Skin rash ☐ | ☐ | ☐ 76 |
| 21. Skin ulcer / sore | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Skin ulcer / sore ☐ | ☐ | ☐ 77 |
| 22. Itching (irritation) | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Itching ☐ | ☐ | ☐ 78 |

Other symptoms *Lasting 24 hours or more*

| | Yes | No | Not Sure | Onset date - Jun / Jul | Duration in days | Coding: Symptom | Onset | Duration |
|---|---|---|---|---|---|---|---|---|
| 23. Excessive tiredness (unusual fatigue, lassitude) | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Lassitude ☐ | ☐ | ☐ 79 |
| 24. Dizzy or giddy | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Dizziness ☐ | ☐ | ☐ 80 |
| 25. Pins and needles / tingling | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Pins and needles ☐ | ☐ | ☐ 81 |
| 26. Muscle cramps (e.g. cramp in arm or leg) | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Muscle cramps ☐ | ☐ | ☐ 82 |

27. If you have had any symptoms for over 24 hours not on this list, please describe them, listing the onset date and duration:

| | Onset | Duration | Coding: Symptom | Onset | Duration |
|---|---|---|---|---|---|
| 1. ______ | ☐ | ☐ | Other 1 ☐ | ☐ | ☐ 83 |
| 2. ______ | ☐ | ☐ | Other 2 ☐ | ☐ | ☐ 84 |
| 3. ______ | ☐ | ☐ | Other 3 ☐ | ☐ | ☐ 85 |

17. Do you smoke cigarettes at all ? *Prompt for pipe smoking*

Yes ☐ 1 No ☐ 0 Pipe or any other kind of Smoker ☐ 2 Not Sure ☐ 9

Smoker? ☐ 86

*If no go to question 19, next page*

If yes how many cigarettes do you smoke per day? ☐

No. cigarettes ☐ 87

*(Include cigars and 'roll your own' as cigarettes. Each one counts as 1 cigarette.)*

**GENERAL HEALTH - CONTINUED**

18. If you are an ex smoker how long is it since you gave up?
*Non smokers tick appropriate box*

☐☐ Years ☐☐ Months ☐☐ Days

Gave up ☐☐☐ 87
Y M D

19. How often, if ever, do you drink alcohol?

| At least once a week | Less than once a week | Never drink alcohol | Not sure |
|---|---|---|---|
| ☐ 2 | ☐ 1 | ☐ 0 | ☐ 9 |

If the answer to 19 is 'never' skip to question 22 page 9

Alcohol ☐ 88

20. Approximately how many units of alcohol have you consumed in the past seven days?

______________________________

units of alcohol ☐☐ 89

One unit = Half a pint of beer, lager, cider, stout, etc.
a single measure of spirits; whisky, vodka, gin, rum, etc.
a small glass of martini, port, sherry, wine, etc.
a glass of wine

Ask the volunteer to try and remember where they were and who they were with each day - it may help them to recall what they drank.

21. Would you say that last week was fairly typical of what you usually drink in a week?

| Yes | No - volunteer usually drinks less | No - volunteer usually drinks more |
|---|---|---|
| ☐ 1 | ☐ 2 | ☐ 3 |

Normal drinking ☐ 90

## GENERAL HEALTH - CONTINUED

22. Have you taken any tablets or medicines in the last four weeks?
*(Include regular/ chronic prescriptions as well as drugs bought from the chemists/ supplied by the clinic)*

| Yes | No | Not Sure |
|---|---|---|
| ☐ 1 | ☐ 0 | ☐ 9 |

Drugs ☐ 91

| Tick which: | | Name of Tablet/Medicine |
|---|---|---|
| **1. Antibiotics** * | ☐ 1 | ________ |
| **2. Steroids** * | ☐ 1 | ________ |
| 3. Laxatives | ☐ 1 | ________ |
| 4. Stomach remedies *(e.g. Milk of magnesia, antacids etc.)* | ☐ 1 | ________ |
| 5. Other | ☐ 1 | ________ |

Antibiotics ☐ 92
Laxatives ☐ 93
Laxatives ☐ 94
Stomach remedies ☐ 95
Other ☐ 96 Other type ☐ 97

## SECTION THREE - VISITS AT HOME AND ABROAD

23. In the past 4 weeks have you spent any nights away from home, e.g. for a holiday or to visit relatives?

| Yes | No | Not Sure |
|---|---|---|
| ☐ 1 | ☐ 0 | ☐ 9 |

Visits away from home ☐ 98

If yes was this in the U.K. or abroad?

| U.K. | Abroad | Both |
|---|---|---|
| ☐ 1 | ☐ 2 | ☐ 3 |

Visits U.K. / abroad ☐ 99

Please give the date(s) and place(s) visited below:
*In the past 4 weeks only*

| Place(s) | Date(s) | Duration of stay |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

No. visits U.K. ☐ 100 No. visits Abroad ☐ 101

| | UK/ Abroad | Location | Days | |
|---|---|---|---|---|
| 1 | | | | 102 |
| 2 | | | | 103 |
| 3 | | | | 104 |
| 4 | | | | 105 |
| 5 | | | | 106 |

## VISITS AT HOME AND ABROAD - CONTINUED

24. Apart from short holidays, have you spent any time overseas at any time in your life?

*(Excluding 2 week holidays)* Yes ☐ 1 No ☐ 0 Not Sure ☐ 9

Trips overseas ☐ 107

*If no go to section 4, this page.*

If yes how long?

| Up to 1 month | 1 mo to 1 yr | 1-3 yr | >3 yr | Born abroad | Not Sure |
|---|---|---|---|---|---|
| ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 | ☐ 9 |

Time overseas ☐ 108

Please list the country / countries :

______________________________

______________________________

______________________________

______________________________

Country visited 1 ☐ 109
Country visited 2 ☐ 110
Country visited 3 ☐ 111
Country visited 4 ☐ 112

## SECTION FOUR - GENERAL LEISURE ACTIVITIES

25. In an average month, how often do you take part in the following activities at this time of year?

| | Frequent >3 Times | Occasional 1-3 Times | Not at all | Not Sure | No. of times in last month |
|---|---|---|---|---|---|
| 1. Pub/ Drinking club | ☐ 2 | ☐ 1 | ☐ 0 | ☐ 9 | ☐ |
| 2. Party | ☐ 2 | ☐ 1 | ☐ 0 | ☐ 9 | ☐ |
| 3. Leisure centre | ☐ 2 | ☐ 1 | ☐ 0 | ☐ 9 | ☐ |
| 4. Church / religious meeting | ☐ 2 | ☐ 1 | ☐ 0 | ☐ 9 | ☐ |

Pub ☐ 113 Frequency ☐ 114
Party ☐ 115 Frequency ☐ 116
Leisure Centre ☐ 117 Frequency ☐ 118
Church ☐ 119 Frequency ☐ 120

## GENERAL LEISURE ACTIVITIES - CONTINUED

26. In the summer months, how often do you take part in the following water related sports / activities?

*(Please give average/typical exposure in times per month during the summer period with reasonable weather, and in fresh/sea water).*

| | Frequent >3 Times | Occasional 1-3 Times | Not at all | Not Sure | Sea water | Fresh water | No. of times in last month |
|---|---|---|---|---|---|---|---|
| 1. Dinghy sailing/ Canoeing | ☐ 2 | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 1 | ☐☐ |
| 2. Speed / motor boating / rowing | ☐ 2 | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 1 | ☐☐ |
| 3. Subaqua / diving / snorkeling | ☐ 2 | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 1 | ☐☐ |
| 4. Surfing / * water skis / jet skis | ☐ 2 | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 1 | ☐☐ |
| 5. Fishing | ☐ 2 | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 1 | ☐☐ |
| 6. Paddling / wading | ☐ 2 | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 1 | ☐☐ |
| 7. Other * | ☐ 2 | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 1 | ☐☐ |

** Include: wind surfing, sailboarding etc.*

* Specify:

27. How often do you take part in sea or fresh water bathing?

*(Please give average/typical exposure in times per month during the summer period with reasonable weather, and in fresh/sea water).*

| Frequent >3 Times | Occasional 1-3 Times | Not at all | Not Sure | Sea water | Fresh water | No. of times in last month |
|---|---|---|---|---|---|---|
| ☐ 2 | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 1 | ☐☐ |

If yes how far do you usually swim?

*Prompt for an answer in metres*
*1 length of a pool = 25 m*

☐☐☐☐ metres

### Coding only

Code positive response for sea / fresh water as 1 and negative response as 0.

| | | Sea Fresh | Frequ |
|---|---|---|---|
| Dinghy / Canoe | ☐ 121 | ☐☐ 122 | ☐☐ 123 |
| Speed boat | ☐ 124 | ☐☐ 125 | ☐☐ 126 |
| Sub aqua | ☐ 127 | ☐☐ 128 | ☐☐ 129 |
| Surfing etc. | ☐ 130 | ☐☐ 131 | ☐☐ 132 |
| Fishing | ☐ 133 | ☐☐ 134 | ☐☐ 135 |
| Paddling / Wading | ☐ 136 | ☐☐ 137 | ☐☐ 138 |
| Other | ☐ 139 | ☐☐ 140 | ☐☐ 141 |
| Bathing | ☐ 142 | ☐☐ 143 | ☐☐ 144 |

Distance swam ☐☐☐☐ 145

## GENERAL LEISURE ACTIVITIES - CONTINUED

27. Continued

Please specify where you have bathed in the past three weeks:

| | Place(s) | UK 1 | Abroad 2 | No. of visits |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |

| | UK? | Location | Days | |
|---|---|---|---|---|
| 1 | | | | 146 |
| 2 | | | | 147 |
| 3 | | | | 148 |
| 4 | | | | 149 |
| 5 | | | | 150 |

28. How often do you use a swimming pool?

1. PUBLIC swimming pool

| Frequent >3 Times | Occasional 1-3 Times | Not at all | Not Sure | Sea water | Fresh water | No. of times in last month |
|---|---|---|---|---|---|---|
| ☐ 2 | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 2 | ☐ 1 | ☐ |

Public pool ☐ 151 Sea Fresh ☐☐ 152 Freqy ☐ 153

2. OTHER swimming pool (e. g. a private pool or lido)

| Frequent >3 Times | Occasional 1-3 Times | Not at all | Not Sure | Sea water | Fresh water | No. of times in last month |
|---|---|---|---|---|---|---|
| ☐ 2 | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 2 | ☐ 1 | ☐ |

Other pool ☐ 154 Sea Fresh ☐☐ 155 Freqy ☐ 156

29. How often do you visit a beach without going into the water?

| Frequent >3 Times | Occasional 1-3 Times | Not at all | Not Sure | Sea water | Fresh water | No. of times in last month |
|---|---|---|---|---|---|---|
| ☐ 2 | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 2 | ☐ 1 | ☐ |

Beach without bathing ☐ 157 Sea Fresh ☐☐ 158 Freqy ☐ 159

**GENERAL LEISURE ACTIVITIES - CONTINUED**

30. In the last month have you been to a theme / leisure park and used any water rides? *(e.g. log rides, water shutes).*

Yes ☐ 1 No ☐ 0 Not Sure ☐ 9

Water rides ☐ 160

If yes was the site at home or abroad?

U.K. ☐ 1 Abroad ☐ 2

UK? ☐ 161

Please give the name of the site:

Park Location ☐ 162

31. Are you able to swim competently ?

*(Can you swim approximately 2 lengths in a swimming pool?)*

Yes ☐ 1 No ☐ 0 Not Sure ☐ 9

Swimmer? ☐ 163

32. Additional comments. Use the space below to add any other information that you feel will help this study

*(Information about general health, travel / work abroad, and leisure activities relating to recreational use of water)*

Other comments 1 ☐ 164

Other comments 2 ☐ 165

Other comments 3 ☐ 166

**STRICTLY CONFIDENTIAL** | **Coding only**

**MEDICAL SHEET - to be completed by the examining doctor**

Doctor's initials : ☐ | Doctor No. ☐ 167

| | Yes | No | | Coding only | |
|---|---|---|---|---|---|
| Faecal sample presented : | ☐ 1 | ☐ 0 | | Faecal sample 1 presented ? | ☐ 168 |
| Throat swab taken : | ☐ 1 | ☐ 0 | | Throat swab taken ? | ☐ 169 |
| Ear swab taken : | ☐ 1 | ☐ 0 | | Ear swab Taken ? | ☐ 170 |

| | Normal | Red | Infected | Coding only | |
|---|---|---|---|---|---|
| Appearance of Throat : | ☐ 0 | ☐ 1 | ☐ 2 | Appearance of throat | ☐ 171 |

| | Yes | No | Not Sure | Coding only | |
|---|---|---|---|---|---|
| Evidence of any middle ear infection : | ☐ 1 | ☐ 0 | ☐ 9 | Evidence of ear infection | ☐ 172 |

If yes please give brief details :

______________________________

______________________________

Have the medical sections of this questionnaire been checked?

*See Page 1 for details*

| Yes | No | Coding only | |
|---|---|---|---|
| ☐ 1 | ☐ 0 | Medical sections checked ? | ☐ 173 |

Do you recommend exclusion of this volunteer from the study ?

| Yes | No | Coding only | |
|---|---|---|---|
| ☐ 1 | ☐ 0 | Exclusion recommended ? | ☐ 174 |

If yes please state the reason and any medical findings briefly below :

| |
|---|
| |
| |
| |
| |
| |

**STRICTLY CONFIDENTIAL**

# SEASIDE HEALTH SURVEY: 1991 SAMPLE

**Exposure day interview**

Interviewer name: ______________________________

## SECTION ONE-FOOD INTAKE

1. Subject name: ______________________________

2. Have you eaten any of the following foods during the past three days?

| | Yes | No | Not Sure | Prepared or brought from home | Purchased at resort |
|---|---|---|---|---|---|
| 1. Ice cream | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 2 |
| 2. Bought sandwiches | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 2 |
| 3. Chicken | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 2 |
| 4. Eggs | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 2 |
| 5. Mayonnaise *(fresh)* | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 2 |
| 6. Hot dogs | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 2 |
| 7. Hamburgers | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 2 |
| 8. Salad | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 2 |
| 9. Raw milk *(i.e. green top)* | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 2 |
| 10. Cold meat / pâté | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 2 |
| 11. Meat pies / pasties | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 2 |

*List continued on following page*

**Coding only**

Volunteer no. ☐ 201 — Form 2 202

Study no ☐ 203

date 06 07 91 204

Interviewer ☐ 205 — Bather / non bather ☐ 206

Code No as 0 in all boxes, code not sure as 9 in all boxes, code other negative responses as 0.

| | | | |
|---|---|---|---|
| Ice cream | ☐ 207 | Source | ☐ 208 |
| Bought sandwiches | ☐ 209 | Source | ☐ 210 |
| Chicken | ☐ 211 | Source | ☐ 212 |
| Eggs | ☐ 213 | Source | ☐ 214 |
| Mayonnaise | ☐ 215 | Source | ☐ 216 |
| Hot dogs | ☐ 217 | Source | ☐ 218 |
| Hamburgers | ☐ 219 | Source | ☐ 220 |
| Salad | ☐ 221 | Source | ☐ 222 |
| Raw milk | ☐ 223 | Source | ☐ 224 |
| Cold meat / pâté | ☐ 225 | Source | ☐ 226 |
| Meat pies / pasties | ☐ 227 | Source | ☐ 228 |

**STRICTLY CONFIDENTIAL**

**FOOD INTAKE - CONTINUED**



| | Yes | No | Not Sure | Prepared or brought from home | Purchased at resort |
|---|---|---|---|---|---|
| 12. Any Take-away food | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 2 |
| 13. Sea food * *(e.g. shellfish, cockles etc.)* | ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 2 |

*Specify: ______________________________

______________________________

Take away food ☐ 229 Source ☐ 230

Sea food ☐ 231 Source ☐ 232

Sea food type ☐☐ 233

**SECTION TWO-HEALTH**

3. In the last 3 days, including today, please tick whether you have had any of the following symptoms.

*(Answer Yes, No or Not sure for all, or None on next page)*
*Read out the section headings and ask if they have had any symptoms of that type*

Code response to no symptoms (see page 3) as 0 in all boxes

| | Yes | No | Not Sure | Coding only |
|---|---|---|---|---|
| **'Flu / cold symptoms** | | | | |
| 1. Fever (Hot and cold, shivers) | ☐ 1 | ☐ 0 | ☐ 9 | Fever ☐ 234 |
| 2. Headache | ☐ 1 | ☐ 0 | ☐ 9 | Headache ☐ 235 |
| 3. Aching arms, legs, joints | ☐ 1 | ☐ 0 | ☐ 9 | Aching limbs ☐ 236 |
| 4. Sore throat | ☐ 1 | ☐ 0 | ☐ 9 | Sore throat ☐ 237 |
| **Chest symptoms** *Any chest problems ?* | | | | |
| 5. Chest pains / aches | ☐ 1 | ☐ 0 | ☐ 9 | Chest pains ☐ 238 |
| 6. Dry cough | ☐ 1 | ☐ 0 | ☐ 9 | Dry cough ☐ 239 |
| 7. Productive cough (phlegm / sputum) | ☐ 1 | ☐ 0 | ☐ 9 | Prod. cough ☐ 240 |
| 8. Wheezing / shortness of breath | ☐ 1 | ☐ 0 | ☐ 9 | Breathing diff. ☐ 241 |
| 9. Runny nose | ☐ 1 | ☐ 0 | ☐ 9 | Runny nose ☐ 242 |
| **Ear / eye symptoms** *Any ear or eye problems ?* | | | | |
| 10. Ear infection (sore, discharge) | ☐ 1 | ☐ 0 | ☐ 9 | Ear infection ☐ 243 |
| 11. Eye infection (sore red eyes, discharge) | ☐ 1 | ☐ 0 | ☐ 9 | Eye infection ☐ 244 |
| 12. Blurred vision (difficulty with eye sight) | ☐ 1 | ☐ 0 | ☐ 9 | Vision ☐ 245 |

*List continued on following page*

3. Symptoms continued

Gut symptoms Any stomach / bowel problems ?

| | Yes | No | Not Sure |
|---|---|---|---|
| 13. Loss of appetite | ☐ 1 | ☐ 0 | ☐ 9 |
| 14. Indigestion | ☐ 1 | ☐ 0 | ☐ 9 |
| 15. Stomach pain (colic / lower abdominal pain / griping) | ☐ 1 | ☐ 0 | ☐ 9 |
| 16. Loose bowel motions (looser than normal) | ☐ 1 | ☐ 0 | ☐ 9 |
| 17. Diarrhoea (3 or more runny stools in 24 hours) | ☐ 1 | ☐ 0 | ☐ 9 |
| 18. Nausea (feeling sick) | ☐ 1 | ☐ 0 | ☐ 9 |
| 19. Vomiting (being sick) | ☐ 1 | ☐ 0 | ☐ 9 |

Skin symptoms Any skin problems ?

| | Yes | No | Not Sure |
|---|---|---|---|
| 20. Skin rash on body | ☐ 1 | ☐ 0 | ☐ 9 |
| 21. Skin ulcer / sore | ☐ 1 | ☐ 0 | ☐ 9 |
| 22. Itching (irritation) | ☐ 1 | ☐ 0 | ☐ 9 |

Other symptoms Any other problems ?

| | Yes | No | Not Sure |
|---|---|---|---|
| 23. Excessive tiredness (unusual fatigue, lassitude) | ☐ 1 | ☐ 0 | ☐ 9 |
| 24. Dizzy or giddy | ☐ 1 | ☐ 0 | ☐ 9 |
| 25. Pins and needles / tingling | ☐ 1 | ☐ 0 | ☐ 9 |
| 26. Muscle cramps (e.g cramp in arm or leg) | ☐ 1 | ☐ 0 | ☐ 9 |

27. If you had any symptoms not on this list, please write them in the space below:

________________________________________

________________________________________

No symptoms recorded in the last 3 days ☐

If NO illness go to Question 7, next page

Code response to no symptoms as 0 in all boxes

- Appetite ☐ 246
- Indigestion ☐ 247
- Stomach pain ☐ 248
- Loose bowels ☐ 249
- Diarrhoea ☐ 250
- Nausea ☐ 251
- Vomiting ☐ 252
- Skin rash ☐ 253
- Skin ulcer / sore ☐ 254
- Itching ☐ 255
- Lassitude ☐ 256
- Dizziness ☐ 257
- Pins and needles ☐ 258
- Muscle cramps ☐ 259
- Other ☐ 260 Type ☐☐ 261

4. Ring all days on the calendar on which the symptoms occured :

*(When did the illness start, when did it finish and how long did it last? )*

July 1991

| M | T | W | T | F | S |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |

Date of on set ☐☐ | 0 7 | 9 1 262

Duration - days ☐☐ 263

Code as per symptom numbers in the list on pages 2 and 3

Symptom No.

5. What was the first symptom ? __________________ ☐☐

*Number as per the symptom list on pages 2 and 3*

First symptom ☐☐ 264

6. Have you seen your doctor about these symptoms?

Yes ☐ 1 No ☐ 0

Doctor seen ☐ 265

If yes has an illness been diagnosed?

Diagnosis ____________________________________

Diagnosis ☐ 266

7. Apart from this study, have you been swimming, taken part in any water sports / water leisure activities, or visited a beach since the interview with the GREEN FORM

Yes ☐ 1 No ☐ 0 Not sure ☐ 9

Water activities ☐ 267

If yes please give details : ____________________________

________________________________________________

________________________________________________

Activity type ☐☐ 268

8. Do you have any other information you would like to add ?

________________________________________________

________________________________________________

________________________________________________

________________________________________________

Other information ☐ 269

**STRICTLY CONFIDENTIAL**

**Coding only**

Volunteer no. [ | | | ] 301  Form [3] 302

Study no [ | | | ] 303

date [ | ] [0 | 7] [9 | 1] 304

Interviewer [ | ] 305  Bather / non bather [ ] 306

# SEASIDE HEALTH SURVEY: 1991 SAMPLE

Post exposure interview *(1 week after bathing)*

Interviewer name: ______________________________

## SECTION ONE-FOOD INTAKE

1. Subject name: ______________________________

2. Have you eaten any of the following foods during the past week?

Code No as 0 in all boxes, code not sure as 9 in all boxes.

| | Yes | No | Not Sure | Coding only | |
|---|---|---|---|---|---|
| 1. Ice cream | ☐ 1 | ☐ 0 | ☐ 9 | Ice cream ☐ | 307 |
| 2. Bought sandwiches | ☐ 1 | ☐ 0 | ☐ 9 | Bought sandwiches ☐ | 308 |
| 3. Chicken | ☐ 1 | ☐ 0 | ☐ 9 | Chicken ☐ | 309 |
| 4. Eggs | ☐ 1 | ☐ 0 | ☐ 9 | Eggs ☐ | 310 |
| 5. Mayonnaise *(fresh)* | ☐ 1 | ☐ 0 | ☐ 9 | Mayonnaise ☐ | 311 |
| 6. Hot dogs | ☐ 1 | ☐ 0 | ☐ 9 | Hot dogs ☐ | 312 |
| 7. Hamburgers | ☐ 1 | ☐ 0 | ☐ 9 | Hamburgers ☐ | 313 |
| 8. Salad | ☐ 1 | ☐ 0 | ☐ 9 | Salad ☐ | 314 |
| 9. Raw milk *(i.e. green top)* | ☐ 1 | ☐ 0 | ☐ 9 | Raw milk ☐ | 315 |
| 10. Cold meat / pâté | ☐ 1 | ☐ 0 | ☐ 9 | Cold meat / pâté ☐ | 316 |
| 11. Meat pies / pasties | ☐ 1 | ☐ 0 | ☐ 9 | Meat pies / pasties ☐ | 317 |

*List continued on following page*

**STRICTLY CONFIDENTIAL**

**FOOD INTAKE - CONTINUED**

Coding only

| | Yes | No | Not Sure | Coding |
|---|---|---|---|---|
| 12. Any Take-away food | ☐ 1 | ☐ 0 | ☐ 9 | Take away food ☐ 318 |
| 13. Sea food * *(e.g. shellfish, cockles etc.)* | ☐ 1 | ☐ 0 | ☐ 9 | Sea food ☐ 319 |

*Specify: ____________________

____________________

Sea food type ☐☐ 320

## SECTION TWO-HEALTH

3. Since the bathing day, please tick whether you have had any of the following symptoms.

*(Answer Yes, No or Not sure for all, or None on next page) Read out the section headings and ask if they have had any symptoms of that type. Show calendar provided to help ascertain the onset date and duration of each symptom.*

Code response to no symptoms (see page 3) as 0 in all boxes

| 'Flu / cold symptoms | Yes | No | Not Sure | Onset date - Jul | Duration in days | | Symptom | Onset | Duration |
|---|---|---|---|---|---|---|---|---|---|
| 1. Fever (Hot and cold, shivers) | ☐ 1 | ☐ 0 | ☐ 9 | ☐☐ | ☐ | Fever | ☐ | ☐☐ | ☐ 321 |
| 2. Headache | ☐ 1 | ☐ 0 | ☐ 9 | ☐☐ | ☐ | Headache | ☐ | ☐☐ | ☐ 322 |
| 3. Aching arms , legs, joints | ☐ 1 | ☐ 0 | ☐ 9 | ☐☐ | ☐ | Aching limbs | ☐ | ☐☐ | ☐ 323 |
| 4. Sore throat | ☐ 1 | ☐ 0 | ☐ 9 | ☐☐ | ☐ | Sore throat | ☐ | ☐☐ | ☐ 324 |
| **Chest symptoms** *Any chest problems ?* | | | | | | | | | |
| 5. Chest pains / aches | ☐ 1 | ☐ 0 | ☐ 9 | ☐☐ | ☐ | Chest pains | ☐ | ☐☐ | ☐ 325 |
| 6. Dry cough | ☐ 1 | ☐ 0 | ☐ 9 | ☐☐ | ☐ | Dry cough | ☐ | ☐☐ | ☐ 326 |
| 7. Productive cough (phlegm / sputum) | ☐ 1 | ☐ 0 | ☐ 9 | ☐☐ | ☐ | Prod. cough | ☐ | ☐☐ | ☐ 327 |
| 8. Shortness of breath | ☐ 1 | ☐ 0 | ☐ 9 | ☐☐ | ☐ | Breathing diff. | ☐ | ☐☐ | ☐ 328 |
| 9. Runny nose | ☐ 1 | ☐ 0 | ☐ 9 | ☐☐ | ☐ | Runny nose | ☐ | ☐☐ | ☐ 329 |
| **Ear / eye symptoms** *Any ear or eye problems ?* | | | | | | | | | |
| 10. Ear infection (sore, discharge) | ☐ 1 | ☐ 0 | ☐ 9 | ☐☐ | ☐ | Ear infection | ☐ | ☐☐ | ☐ 330 |
| 11. Eye infection (sore red eyes) | ☐ 1 | ☐ 0 | ☐ 9 | ☐☐ | ☐ | Eye infection | ☐ | ☐☐ | ☐ 331 |
| 12. Blurred vision (difficulty with eye sight) | ☐ 1 | ☐ 0 | ☐ 9 | ☐☐ | ☐ | Vision | ☐ | ☐☐ | ☐ 332 |

*List continued on following page*

3. Symptoms continued

Code response to no symptoms as 0 in all boxes

| | Yes | No | Not Sure | Onset date - Jul | Duration in days | Coding only | Symptom | Onset | Duration |
|---|---|---|---|---|---|---|---|---|---|
| **Gut symptoms** *Any stomach / bowel problems ?* | | | | | | | | | |
| 13. Loss of appetite | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Appetite | ☐ | ☐ | ☐ 333 |
| 14. Indigestion | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Indigestion | ☐ | ☐ | ☐ 334 |
| 15. Stomach pain (colic / abdominal pain) | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Stomach pain | ☐ | ☐ | ☐ 335 |
| 16. Loose bowel motions (looser than normal) | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Loose bowels | ☐ | ☐ | ☐ 336 |
| 17. Diarrhoea (3 or more runny stools in 24 hours) | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Diarrhoea | ☐ | ☐ | ☐ 337 |
| 18. Nausea (feeling sick) | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Nausea | ☐ | ☐ | ☐ 338 |
| 19. Vomiting (being sick) | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Vomiting | ☐ | ☐ | ☐ 339 |
| **Skin symptoms** *Any skin problems ?* | | | | | | | | | |
| 20. Skin rash | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Skin rash | ☐ | ☐ | ☐ 340 |
| 21. Skin ulcer / sore | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Skin ulcer / sore | ☐ | ☐ | ☐ 341 |
| 22. Itching (irritation) | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Itching | ☐ | ☐ | ☐ 342 |
| **Other symptoms** *Any other problems ?* | | | | | | | | | |
| 23. Excessive tiredness (unusual fatigue, lassitude) | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Lassitude | ☐ | ☐ | ☐ 343 |
| 24. Dizzy or giddy | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Dizziness | ☐ | ☐ | ☐ 344 |
| 25. Pins and needles / tingling | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Pins and needles | ☐ | ☐ | ☐ 345 |
| 26. Muscle cramps (e.g. cramp in arm or leg) | ☐ 1 | ☐ 0 | ☐ 9 | ☐ | ☐ | Muscle cramps | ☐ | ☐ | ☐ 346 |

27. If you had any symptoms not on this list, please write them in the space below:

Other ☐ 347 Type ☐ 348

________________________________________

________________________________________

When did these symptoms start ? ☐ How many days did they last? ☐

Other-onset ☐ 349 Other-duration ☐ 350

**No symptoms recorded in the last 3 days** ☐

If NO illness go to Question 7, next page

4. Ring all days on the calendar on which any of the symptoms occured :

*(When did the illness start, when did it finish and how long did it last? )*

Date of onset [ | 0 7 | 9 1 ] 351

Duration - days [ | ] 352

July1991

| M | T | W | T | F | S | S |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 |

*(Code first day of onset and total duration)*

5. Have you seen your doctor about these symptoms?

Yes ☐1 No ☐0

Doctor seen ☐ 353

If yes has an illness been diagnosed?

Diagnosis ____________________

Diagnosis ☐ 354

6. How many days work / normal activities did you miss because of this illness / symptom?

__________ days work / activities

Days lost [ | ] 355

Were you admitted to hospital ?

Yes ☐1 No ☐0

Hospital admission ☐ 356

If yes which hospital: ____________________

7. Apart from this study, have you been swimming, taken part in any water sports / water leisure activities, or visited a beach since the bathing day

Yes ☐1 No ☐0 Not sure ☐9

Water activities ☐ 357

If yes please give details : ____________________

____________________

____________________

Activity type [ | ] 358

**STRICTLY CONFIDENTIAL**

**Coding only**

## MEDICAL SHEET - to be completed by the examinining doctor

Doctor's initials : ☐

| | Yes | No | | Coding only |
|---|---|---|---|---|
| Faecal sample presented : | ☐ 1 | ☐ 0 | | Faecal sample 1 presented ? ☐ 360 |
| Throat swab taken : | ☐ 1 | ☐ 0 | | Throat swab taken ? ☐ 361 |
| Ear swab taken : | ☐ 1 | ☐ 0 | | Ear swab Taken ? ☐ 362 |
| | **Normal** | **Red** | **Infected** | |
| Appearance of Throat : | ☐ 0 | ☐ 1 | ☐ 2 | Appearance of throat ☐ 363 |
| | **Yes** | **No** | **Not Sure** | |
| Evidence of any middle ear infection : | ☐ 1 | ☐ 0 | ☐ 9 | Evidence of ear infection ☐ 364 |

Doctor No. ☐☐☐ 359

If yes please give brief details :

______________________________

______________________________

If the volunteer shows evidence of infection, please give a suspected diagnosis :

| |
|---|
| |
| |
| |
| |
| Temperature (if indicated) °C |

Action taken :

| | | |
|---|---|---|
| Advised to see G. P. if symptoms persist / worsen | ☐ 1 | Action taken ☐ 365 |
| Letter sent to G. P. | ☐ 2 | |
| Telephone call to G. P. | ☐ 3 | |
| Other* | ☐ | |

* Specify: ______________________________

______________________________

**STRICTLY CONFIDENTIAL**

Coding only

Volunteer no. 401 Form 4 402

Study no 403

date 9 1 404

Bather / non bather 405

# SEASIDE HEALTH SURVEY: 1991 SAMPLE

**Post exposure postal questionnaire**

**Please read through this form and then answer the questions carefully. Please answer every question, circling items, or ticking boxes e.g. :**

July 1991

| M | T | W | T | F | S | S |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 29 | 30 | 31 | | | | |

YES ☑ 1 NO ☐ 0

**or providing written answers, as necessary.**

**Please do not write in the section for coding at the right hand side of the form.**

**The completed form should be returned in the envelope provided as soon as possible.**

1. Name: ____________________

2. Date of Birth ___ / ___ / ___ (Day Month Year) — dob 406

3. Sex : MALE ☐ 1 FEMALE ☐ 2 — Sex 407

4. Home address: ____________________

   ____________ Postcode ____________ — Post code 408

   Telephone no. (home): ____________________

5. Work/study address ____________________

   ____________________

6. Contact details for follow-up (address etc. over next three months).

   ____________________

   ____________________

   ____________________

7. In the last three weeks (since 6 July) have you had any of the following symptoms? Please answer YES, NO or NOT SURE for each. If you answer YES to any symptom please give the date, as far as you can recall, for when each symptom started and how many days it lasted

'Flu / cold symptoms

| | YES | NO | NOT SURE | Date Started | How long it lasted (days) | Coding only | Onset | Duration | |
|---|---|---|---|---|---|---|---|---|---|
| (1.) Fever (Hot and cold, shivers, raised temperature) | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Fever | | | 409 |
| (2.) Severe Headache | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Headache | | | 410 |
| (3.) Aching arms , legs, joints | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Aching limbs | | | 411 |
| (4.) Sore throat | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Sore throat | | | 412 |

Chest symptoms

| | YES | NO | NOT SURE | Date Started | How long it lasted (days) | Coding only | Onset | Duration | |
|---|---|---|---|---|---|---|---|---|---|
| (5.) Chest pains / aches | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Chest pains | | | 413 |
| (6.) Dry cough | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Dry cough | | | 414 |
| (7.) Cough with phlegm / mucus | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Prod. cough | | | 415 |
| (8.) Wheezing / Shortness of breath | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Breathing diff. | | | 416 |
| (9.) Runny nose | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Runny nose | | | 417 |

Ear / eye symptoms

| | YES | NO | NOT SURE | Date Started | How long it lasted (days) | Coding only | Onset | Duration | |
|---|---|---|---|---|---|---|---|---|---|
| (10.) Ear infection (sore and / or discharge) | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Ear infection | | | 418 |
| (11.) Eye infection (sore red eyes and / or discharge) | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Eye infection | | | 419 |
| (12.) Blurred vision (difficulty with eye sight) | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Vision | | | 420 |

Stomach / bowel symptoms

| | YES | NO | NOT SURE | Date Started | How long it lasted (days) | Coding only | Onset | Duration | |
|---|---|---|---|---|---|---|---|---|---|
| (13.) Loss of appetite | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Appetite | | | 421 |
| (14.) Indigestion | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | In-digestion | | | 422 |
| (15.) Stomach pain (colic / lower abdominal pain / griping) | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Stomach pain | | | 423 |

**Symptom list continued on the following page**

## Symptoms continued

### Stomach / bowel symptoms continued

| | YES | NO | NOT SURE | Date Started | How long it lasted (days) | Coding only |
|---|---|---|---|---|---|---|
| (16.) Loose bowel motions | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Loose bowels (Onset / Duration) 424 |
| (17.) Diarrhoea (3 or more runny stools in 24 hours) | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Diarrhoea 425 |
| (18.) Nausea (feeling sick) | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Nausea 426 |
| (19.) Vomiting (being sick) | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Vomiting 427 |

### Skin symptoms

| | YES | NO | NOT SURE | Date Started | How long it lasted (days) | Coding only |
|---|---|---|---|---|---|---|
| (20.) Skin rash on body | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Skin rash 428 |
| (21.) Skin ulcer / sore | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Skin ulcer / sore 429 |
| (22.) Itching (irritation) | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Itching 430 |

### Other symptoms

| | YES | NO | NOT SURE | Date Started | How long it lasted (days) | Coding only |
|---|---|---|---|---|---|---|
| (23.) Excessive tiredness (unusual fatigue, lassitude) | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Lassitude 431 |
| (24.) Dizzy or giddy | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Dizziness 432 |
| (25.) Pins and needles / tingling | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Pins and needles 433 |
| (26.) Muscle cramps (e.g. cramp in arm or leg | ☐ 1 | ☐ 0 | ☐ 9 | ______ | ______ | Muscle cramps 434 |

(27.) If you had any symptoms not on this list, please write them in the space below:

| | Date Started | How long it lasted (days) | Coding only |
|---|---|---|---|
| 1. ______________________ | ______ | ______ | Other 1 435 |
| 2. ______________________ | ______ | ______ | Other 2 436 |
| 3. ______________________ | ______ | ______ | Other 3 437 |

**If you had NO SYMPTOMS AT ALL please skip to Question 16 on page 6**

**If you answered YES to ANY SYMPTOMS please answer the Questions on the next page**

8. Were the symptoms you ticked part of one illness?

| | | |
|---|---|---|
| YES - One illness | ☐ 1 | Single illness? ☐ 438 |
| NO - I had more than one illness | ☐ 0 | |
| NOT REALLY AN ILLNESS - I was not unwell | ☐ 2 | |
| UNSURE | ☐ 9 | |

9. On the calendar below, please circle all the days on which you were unwell or had these symptoms

Date of onset ☐☐ 0☐ 9 1 439

Duration of illness (days) ☐☐ 440

**July / August 1991**

| M | T | W | T | F | S | S |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 29 | 30 | 31 | 1 | 2 | 3 | 4 |
| 5 | 6 | 7 | 8 | 9 | 10 | 11 |

**To help you remember, the bathing day is shaded**

10. What was the first symptom of your illness?

______________________________

______________________________

Code 01 - 26 as per symptom list

First Symptom ☐☐ 441

11. If you had more than one illness please give details below, especially the date each illness started

______________________________

______________________________

______________________________

______________________________

______________________________

______________________________

______________________________

______________________________

12. Was this illness diagnosed by your G.P.?

YES ☐ 1 NO ☐ 0

Diagnosis illness ? ☐ 442

If **YES**, what was the diagnosis?________________________

Please tick if we may approach your doctor for more information, if necessary :

YES ☐ 1 NO ☐ 0

Doctor may be consulted ? ☐ 443

13. Did you take any drugs or medicines for your illness, **PRESCRIBED BY YOUR DOCTOR ?**

YES ☐ 1 NO ☐ 0

Prescr. drugs ☐ 444 Drug type ☐ 445

If **YES** please list:________________________

14. Have you received hospital treatment for any illness since the bathing day?

YES ☐ 1 NO ☐ 0

Hospital treatment ☐ 446

If **YES** which hospital did you attend?________________________

15. How many days did you have away from work or normal activities because of this illness?

| NONE | ONE DAY ONLY | 2-7 DAYS | 7-14 DAYS | MORE THAN 14 DAYS | NOT SURE |
|---|---|---|---|---|---|
| ☐ 0 | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 9 |

Working days lost ☐ 447

16. Have you ever become ill soon after bathing in waters in the U. K. ?

YES ☐ 1 NO ☐ 0

Any illness from UK bathing ☐ 448

If YES, what was it any of the following illneses (You can tick more than one):

Headache ☐ 1 Toothache ☐ 2 Earache ☐ 3 Diarrhoea ☐ 4 Vomiting ☐ 5

Fever ☐ 6 A common cold ☐ 7 Sore throat ☐ 8 Eye irritation ☐ 10 Other* ☐

Type of illness ☐ 449

* Please specify: ______________________

17. Have you ever gone to the beach feeling ill?

YES ☐ 1 NO ☐ 0

Visits to beach feeling ill ☐ 450

If YES, what was it any of the following illneses (You can tick more than one):

Headache ☐ 1 Toothache ☐ 2 Earache ☐ 3 Diarrhoea ☐ 4 Vomiting ☐ 5

Fever ☐ 6 A common cold ☐ 7 Sore throat ☐ 8 Eye irritation ☐ 10 Other* ☐

Type of illness ☐ 451

* Please specify: ______________________

18. Did feeling ill on these occasions prevent you from entering the water?

YES ☐ 1 NO ☐ 0 NOT SURE ☐ 9

Illness prevent bathing? ☐ 452

19. How often do you get sunburned while at the beach?

| Always | Frequently | Rarely | Never |
|---|---|---|---|
| ☐ 1 | ☐ 2 | ☐ 3 | ☐ 0 |

Sunburn? ☐ 453

20. How often do you apply some sort of medication or home remedy to a sun burn aquired at the beach?

| Always | Frequently | Rarely | Never | Not Sure |
|---|---|---|---|---|
| ☐ 1 | ☐ 2 | ☐ 3 | ☐ 0 | ☐ 9 |

Sunburn medication? ☐ 454

21. Are you prone to motion sickness while travelling in automobiles, buses or trains?

| Always | Frequently | Rarely | Never |
|---|---|---|---|
| ☐ 1 | ☐ 2 | ☐ 3 | ☐ 0 |

Motion sickness? ☐ 455

22. Has anyone else in who lives in your household been unwell with a possible infection in the last 3 weeks? (The household includes only the people you live with or with whom you share facilities, such as a kitchen or toilet).

| YES | NO | NOT SURE |
|---|---|---|
| ☐ 1 | ☐ 0 | ☐ 9 |

Household illness ☐ 456

**If NO - no new illnesses in last 4 weeks, go to question 25 on page 8**

23. If **YES** - did any illness in your household / family start before yours?

| YES | NO | NOT SURE |
|---|---|---|
| ☐ 1 | ☐ 0 | ☐ 9 |

Ill before ☐ 457

24. Please give details below :

For type of illness write:

| | | |
|---|---|---|
| **'D'** | for | **Diarrhoea** |
| **'S'** | for | **Stomach upsets** (e.g. felt or was sick) |
| **'EAR'** | for | an **EAR** infection (e.g. ear ache) |
| **'EYE'** | for | an **EYE** infection (e.g sore red eyes) |
| **'F'** | for | **Fever** or **High Temperature** |
| **'T'** | for | a sore **Throat** |
| **'O'** | for | **Other** symptoms |

e.g. if a child had diarrhoea, an upset stomach and an ear infection you would write: '**D, S, EAR**' for type of illness

| Name or initials | Age | Type of illness | Date illness started |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

| | Age | Illness Type | Onset Date | |
|---|---|---|---|---|
| 1 | | | | 458 |
| 2 | | | | 459 |
| 3 | | | | 460 |
| 4 | | | | 461 |
| 5 | | | | 462 |

Please write any other details which could help e.g. suspected cause, other information about the illness and symptoms:

Other details 1 ☐ 463

Other details 2 ☐ 464

25. Have you taken part in any water sports since the visit to Southsea on 6 th July?

YES ☐ 1    NO ☐ 0    NOT SURE ☐ 9

Water activities ☐ 465

If NO go to QUESTION 26, on PAGE 9.

If YES please continue on the next page

## QUESTION 25 CONTINUED

If YES please answer the following section, by ticking the appropriate box for each of the activities in the following list, i.e. please answer for all of the activities listed:

| | YES | NO | NOT SURE | NUMBER OF TIMES SINCE 6 JULY |
|---|---|---|---|---|
| Public swimming pool | ☐ 1 | ☐ 0 | ☐ 9 | ☐☐ |
| Other swimming pool | ☐ 1 | ☐ 0 | ☐ 9 | ☐☐ |

Public pool ☐ 466 Frequency ☐☐ 467
Other pool ☐ 468 Frequency ☐☐ 469

**For each of the water sports below, please tick whether it took place in sea or fresh water (tick both if this applies). Fresh water includes Rivers Lakes and reservoirs etc.**

Code positive response for sea / fresh water as 1 and negative response as 0.

| | YES | NO | NOT SURE | If YES, tick type of water | |
|---|---|---|---|---|---|
| (1.) Dinghy sailing/ Canoeing | ☐ 1 | ☐ 0 | ☐ 9 | SEA ☐ 1 | FRESH ☐ 1 |
| (2.) Speed / motor boating / rowing | ☐ 1 | ☐ 0 | ☐ 9 | SEA ☐ 1 | FRESH ☐ 1 |
| (3.) Subaqua / diving / snorkeling | ☐ 1 | ☐ 0 | ☐ 9 | SEA ☐ 1 | FRESH ☐ 1 |
| (4.) Surfing / water ¶ skis / jet skis | ☐ 1 | ☐ 0 | ☐ 9 | SEA ☐ 1 | FRESH ☐ 1 |

¶ Include : wind surfing, sailboarding etc.

| | YES | NO | NOT SURE | | |
|---|---|---|---|---|---|
| (5.) Fishing | ☐ 1 | ☐ 0 | ☐ 9 | SEA ☐ 1 | FRESH ☐ 1 |
| (6.) Paddling / wading | ☐ 1 | ☐ 0 | ☐ 9 | SEA ☐ 1 | FRESH ☐ 1 |
| (7.) Other * | ☐ 1 | ☐ 0 | ☐ 9 | SEA ☐ 1 | FRESH ☐ 1 |

*Details of other water sport:

______________________________

Dinghy / Canoe ☐ 470 Sea Fresh ☐☐ 471
speed boat ☐ 472 Sea Fresh ☐☐ 473
sub aqua ☐ 474 Sea Fresh ☐☐ 475
Surfing etc. ☐ 476 Sea Fresh ☐☐ 477
Fishing ☐ 478 Sea Fresh ☐☐ 479
Fishing ☐ 480 Sea Fresh ☐☐ 481
Other ☐ 482 Sea Fresh ☐☐ 483

26. Do you consider water related activities dangerous ?

YES ☐ 1 NO ☐ 0

Water activities dangerous? ☐ 484

QUESTION 26 IS CONTINUED ON THE NEXT PAGE

**QUESTION 26 CONTINUED**

If **YES** which of the following water-related activities do you consider dangerous? (You can tick more than one):

Dinghy sailing ☐ 1 | Canoeing ☐ 2 | Wind sufing / sailboating ☐ 3 | Scuba / snorkeling ☐ 4

Water skiing ☐ 5 | Surfing ☐ 6 | Swimming / bathing ☐ 7 | Other* ☐

* Please specify: ____________________

Dangerous activity ☐ 485

27. Since the day at Southsea have you spent any nights away from home, e.g. for a holiday or to visit relatives?

YES ☐ 1 | NO ☐ 0 | NOT SURE ☐ 9

Visits away from home ☐ 486

If **YES** was this in the U.K. or abroad?

U.K. ☐ 1 | ABROAD ☐ 2 | BOTH ☐ 3

Visits U.K. / abroad ☐ 487

Please give the date(s) and place(s) visited below :

No. visits U.K. ☐ 488 | No. visits Abroad ☐ 489

| Place(s) | Date(s) | Duration of stay |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |

| | UK/ Abroad | Location | Date of return | |
|---|---|---|---|---|
| 1 | | | | 490 |
| 2 | | | | 491 |
| 3 | | | | 492 |
| 4 | | | | 493 |

28. Have you been swimming in the sea, or in a lake or river since the day at Southsea?

YES ☐ 1 | NO ☐ 0 | NOT SURE ☐ 9 | SEA WATER ☐ 1 | LAKE / RIVER ☐ 1 | NUMBER OF TIMES SINCE 6 JULY ☐

Code positive response for sea / fresh water as 1 and negative response as 0.

Bathing ☐ 494 | Sea Fresh ☐☐ 495 | Frequ ☐ 496

**QUESTION 28 IS CONTINUED ON THE NEXT PAGE**

## QUESTION 28 CONTINUED:

If YES please list where you have been swimming, ticking whether in the United Kingdom or abroad and specifying dates if possible:

| | Place(s) | UK 1 | Abroad 2 | Date(s) |
|---|---|---|---|---|
| 1. | | | | |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |

| | UK? | Location | No. of visits | |
|---|---|---|---|---|
| 1 | | | | 488 |
| 2 | | | | 489 |
| 3 | | | | 490 |
| 4 | | | | 491 |

29. Have you visited any beaches without going into the water since the day at Southsea?

| YES | NO | NOT SURE | SEA WATER | LAKE / RIVER | NUMBER OF TIMES SINCE 6 JULY |
|---|---|---|---|---|---|
| ☐ 1 | ☐ 0 | ☐ 9 | ☐ 1 | ☐ 1 | ☐ |

Beach no bathing ☐ 492 Sea Fresh ☐☐ 493 Frequ ☐ 494

If YES please list any beaches visited, ticking whether in the United Kingdom or abroad and specifying dates if possible:

| | Place(s) | UK 1 | Abroad 2 | Date(s) |
|---|---|---|---|---|
| 1. | | | | |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |

| | UK? | Location | No. of visits | |
|---|---|---|---|---|
| 1 | | | | 495 |
| 2 | | | | 496 |
| 3 | | | | 497 |
| 4 | | | | 498 |

30. When you visit a beach do you bathe or enter the water :

| Every visit | Most visits | Rarely | Never |
|---|---|---|---|
| ☐ 1 | ☐ 2 | ☐ 3 | ☐ 0 |

Water entry ☐ 499

31. How frequently do you immerse your head while bathing?

| Always | Frequently | Rarely | Never |
|---|---|---|---|
| ☐ 1 | ☐ 2 | ☐ 3 | ☐ 0 |

Head immersion ☐ 500

32. Since the day at Southsea, have you been to a theme / leisure park and used any water rides? (e.g. log rides, water shutes).

YES ☐ 1 NO ☐ 0 NOT SURE ☐ 9

Water rides ☐ 501

If YES was the site at home or abroad?

U.K. ☐ 1 ABROAD ☐ 2

UK? ☐ 502

Please give the name of the site:

Park Location ☐☐ 503

---

33. Have you heard anything regarding the way beaches are maintained in th U. K. ?

YES ☐ 1 NO ☐ 0

State of UK beaches ☐ 504

**If NO go to QUESTION 34, below**

If YES has this information been positive or negative:

Positive ☐ 1 Negative ☐ 0

+/- UK beach maintenance ☐ 505

If NEGATIVE, how often do you worry about this issue?

Not at all ☐ 0 Somewhat ☐ 1 Very much ☐ 2 Not Sure ☐ 9

Head immersion ☐ 506

34. Have you heard anything regarding the cleanliness of bathing waters in the U. K. ?

YES ☐ 1 NO ☐ 0

State of UK beaches ☐ 507

**If NO go to QUESTION 35, next page**

If YES continue on next page

**QUESTION 34 CONTINUED:**

If YES has this information been positive or negative:

| Positive | Negative |
|---|---|
| ☐ 1 | ☐ 0 |

+/- UK beach cleanliness ☐ 507

If NEGATIVE, what specific problems have you heard about? (You can tick more than one box):

| Oil spills | Floating objects | Health risk |
|---|---|---|
| ☐ 1 | ☐ 2 | ☐ 3 |
| **Chemical pollution** | **Sewage pollution** | **Other *** |
| ☐ 4 | ☐ 5 | ☐ 6 |

beach problems ☐ 508

* Please specify: ____________________

35. Have you ever refused to go bathing for any of the following reasons:

| Beach too dirty | Water too dirty | Surf / waves too rough | Fear of illness |
|---|---|---|---|
| ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 |

refusal to bathe ☐ 509

36. How did you first hear about this study? (Please tick one box)

| From a friend / relation | From a recruiter | On television | In a newspaper | Other * |
|---|---|---|---|---|
| ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |

Source of info ☐ 510

* Please specify:

____________________

37. Have you seen any news / media coverage of the study?

| YES | NO |
|---|---|
| ☐ 1 | ☐ 0 |

Media ☐ 511

38. Are you a member of an environmental organisation?

| YES | NO |
|---|---|
| ☐ 1 | ☐ 0 |

Environmental organisation ☐ 512

39. Which national daily newspaper do you read (If none write NONE)

______________________________

Newspaper 513

40. Comments. Please write any other information that will help our study :

______________________________

______________________________

______________________________

______________________________

Other comments 1 514

Other comments 2 515

Other comments 3 516

Signature: ______________________________

Date of completion: ___/___/___

Code in box 404 at the top of page 1

**Thankyou for taking the time and trouble to fill in this form. Please return the completed form as soon as possible in the envelope provided.**

**Also, please remember to send away your final specimen in the container and stamped addressed box supplied.**

**Address for correspondence :**

**Dr. D. Kay,**
**Department of Geography,**
**St. David's University college,**
**Lampeter, Dyfed**
**SA48 7ED,**
**Wales.**

**Tel. 0570 422351 ext 249**

Supervisor Name ____________________

Supervisor No. ____

* Locations : 1= Surf Zone, 2= >50 cm, 3= >1 m

**Activities : 1=paddle/wade, 2=swim, 3=full immersion

| Swallowed water? Y / N | Name / No. | No. | time in / time out | Time | 0-10 mins | | | 10-20 mins | | | 20-30 mins | | | 30-40 mins | | | 40-50 mins | | | 50-60 mins | | | 60-70 mins | | | 70-80 mins | | | 80-90 mins | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | * Location | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| | | | ** Activity | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| | | 1 | | Loc. | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | Act. | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 2 | | Loc. | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | Act. | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 3 | | Loc. | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | Act. | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 4 | | Loc. | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | Act. | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 5 | | Loc. | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | Act. | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 6 | | Loc. | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | Act. | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 7 | | Loc. | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | Act. | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 8 | | Loc. | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | Act. | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 9 | | Loc. | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | Act. | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 10 | | Loc. | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | Act. | | | | | | | | | | | | | | | | | | | | | | | | | | | |

# APPENDIX III

## APPENDIX III

## Environmental Bacteriology

### Introduction

Water quality was assessed during the period of the study by examining samples taken at three depths and 10 sampling stations along the beach. Immediately after collection, samples were delivered to a mobile laboratory situated immediately adjacent to the control centre. Samples were examined for total coliforms, faecal (thermotolerant) coliforms, faecal streptococci, *Pseudomonas aeruginosa* and total staphylococci.

### Materials and Methods

### Sampling

Water samples were collected into each of two sterile polystyrene containers (Northern Media Ltd) to provide a combined volume of 300 ml. All sample containers were pre-labelled with a unique reference denoting the sample station, depth and run number. Samples were transported immediately after collection as indicated above. On receipt samples were checked for completeness and placed in the laboratory to await analysis. Laboratory analysis was carried out as soon as possible and within six hours of collection in all cases. Meteorological and environmental conditions at the time of sampling were recorded on a *pro forma*.

Membrane filtration techniques (MF) were used for microbial enumerations. Volumes of sample analysed were determined from data produced from routine monitoring undertaken by NRA (Southern Region) for the immediately preceding weeks. Small volumes of sample (<50 ml) were added to approximately 50 ml of sterile distilled water prior to filtration. The MF apparatus consisted of polycarbonate filter funnels, the bases of which were held in a three place manifold (both Gelman Sciences Ltd). Filter funnels were sterilised by autoclaving for 15 minutes at 121°C before use and by immersion in a boiling water bath for 10 minutes between samples. Membrane filters of 47mm diameter having a pore size of 0.45 μm were used throughout (GN6 Grade, Gelman Sciences Ltd). Depending upon the organisms sought, absorbent pads (Gelman Sciences Ltd) soaked in an excess of liquid broth or the appropriate agar medium was used in Petri dishes of 55mm diameter.

### Analytical techniques

Total and faecal coliforms were enumerated using membrane lauryl sulphate broth (Oxoid MM615), incubating for 14 hours at 35°C and 44°C respectively following an initial incubation period of four hours at 30°C for both (1). Faecal streptococci were enumerated using Slanetz & Bartley agar (Oxoid CM377) after incubation for 44 hours at 44°C, following an initial incubation period of four hours at 37°C (1).

*Ps. aeruginosa* were enumerated on a modification of King's A broth (1), solidified by the addition of agar (1.5% w/v) which was sterilised by autoclaving at 121°C for 15 minutes, allowed to cool to 50°C before the addition of filter sterilised ethanol. The complete medium was poured into 55mm Petri dishes and allowed to solidify. Membranes were incubated at 37°C for 48 hours and colonies producing a diffusible green pigment counted as *Ps. aeruginosa*, identification being assisted by viewing under long wave UV illumination.

Total staphylococci were determined using a membrane filtration procedure as described by Alico and Dragonjac (1986). Membranes were placed grid uppermost on plates of Vogel-Johnson agar containing sodium pyruvate. Plates were incubated at 37°C for 48 hours, following which all typical colonies were enumerated. Confirmation of staphylococci was made on the basis of cell morphology and Gram staining.

Volumes of 0.1, 1.0 and 10 ml were examined for total coliforms with 1.0 and 10 ml aliquots being used for faecal coliforms. All other assays took place using 10ml and/or 50 ml volumes of sea-water. In the case of coliform counts all dilutions were counted and the final result expressed as the weighted average of all plates producing a value. Assays for faecal coliforms and faecal streptococci were performed in triplicate.

The residual sample remaining after completion of all membrane procedures was retained (approximately 100 ml). These retained samples were pooled and examined for *Salmonellae*. A single volume of 7.5 litres was examined for the presence of *Salmonellae* using standard procedures (Anon, 1982). Sampling for *Cryptosporidium* was performed throughout the trial. A portable 12v pump was used to filter water collected from the mid-point of the sampling grid. Filtration was conducted at 1.5 litres/minute and a total of 151.3 litres was examined (as measured by an in-line meter). Procedures for the isoloation and identification of Cryptosporidium oocysts followed the standard method (Anon, 1989).

**Quality control**

On each run, quality control samples consisting of duplicated samples were collected and examined along with that batch. During the exposure period 7 such samples were taken for comparison with actual samples for the analyses of total coliform, faecal coliform, faecal streptococci, *Pseudomonas aeruginosa* and total staphylococci. In addition NRA (Southern) analysed duplicate samples from the 14.30 and 16.30 runs. Geometric mean values for the samples and their matching replicates were tested for significant differences using a two tailed paired sample t-test (Tables 1 and 2). The only significant difference was found for analyses of total coliform duplicates taken by Altwell Ltd.

**Table 1** Paired t-test results for quality control samples taken at Southsea, 06.07.91 - Samples taken and analysed by Altwell Ltd.

| Variable | Geo. Mean | $\log_{10}$ Std. dev | Std. error | N | t | 2-tail *p* |
|---|---|---|---|---|---|---|
| Total coliform[1] | 132.814 | 0.212 | 0.080 | 7 | | |
| Total coliform[2] | 197.290 | 0.140 | 0.053 | 7 | -2.62 | 0.040† |
| Faecal coliform[1] | 142.648 | 0.150 | 0.057 | 7 | | |
| Faecal coliform[2] | 152.532 | 0.136 | 0.052 | 7 | -0.47 | 0.652 |
| Faecal streptococci[1] | 49.793 | 0.191 | 0.072 | 7 | | |
| Faecal streptococci[2] | 55.156 | 0.163 | 0.062 | 7 | -1.37 | 0.219 |
| *Pseudomonas aeruginosa*[1] | 5.069 | 0.563 | 0.213 | 7 | | |
| *Pseudomonas aeruginosa*[2] | 11.123 | 0.354 | 0.134 | 7 | -1.87 | 0.110 |
| Total staphylococci[1] | 328.306 | 0.613 | 0.232 | 7 | | |
| Total staphylococci[2] | 395.185 | 0.696 | 0.263 | 7 | -0.30 | 0.773 |

1 Samples, 2 Duplicates, † Significant difference at $\alpha < 0.05$, DF = N-1

**Table 2** Paired t-test results for quality control samples taken at Southsea, 06.07.91 - Samples taken and analysed by NRA Southern region

| Variable | Geo. Mean | $\log_{10}$ Std. dev | Std. error | N | t | 2-tail *p* |
|---|---|---|---|---|---|---|
| Total coliform[1] | 174.025 | 0.225 | 0.056 | 16 | | |
| Total coliform[2] | 217.223 | 0.267 | 0.067 | 16 | -1.63 | 0.123 |
| Faecal coliform[1] | 158.074 | 0.265 | 0.066 | 16 | | |
| Faecal coliform[2] | 132.968 | 0.189 | 0.047 | 16 | 1.87 | 0.081 |
| Faecal streptococci[1] | 21.930 | 0.496 | 0.124 | 16 | | |
| Faecal streptococci[2] | 28.847 | 0.367 | 0.092 | 16 | -0.80 | 0.434 |

1 Samples, 2 Duplicates, † Significant difference at $\alpha < 0.05$, DF = N-1

**Environmental virology - Isolation of Enteric Viruses from large volumes of water**

Although enteric viruses are present initially in very high concentrations in sewage contaminated with stools from infected individuals, the subsequent dilution of sewage/sewage effluent in waters into which it is discharged, ensure that the final concentration of viruses in the aquatic environment is considerably less than the initial concentration in faeces. Thus, the isolation of enteric viruses from the aquatic environment involves the concentration of large volumes (10-20 litres) of water into small workable volumes (10 ml) which can then be assayed for the presence of viruses using tissue culture or an appropriate assay for viral particles or antigens.

A variety of methods for the concentration of low numbers of viruses from large volumes of water have been described (Gerba *et al.*, 1978; Ramia and Sattar, 1980). The method chosen for this study is the one used routinely by Acer Environmental and is suitable for the isolation of both enteroviruses and rotavirus. It involves a two-stage concentration procedure, adsorption and elution of viruses on microporous filters, followed by organic flocculation.

In aqueous solution, viruses behave as amphoteric, hydrophilic colloids and the net charge is a function of pH, ionic composition and ionic strength of the solution (Morris and Waite, 1981). These properties are exploited in the concentration of viruses from large volumes of water. At low pH in the presence of cations, viruses adsorb by virtue of their surface charge to a variety of media, including cellulose nitrate and glass fibre. Elution from this initial adsorptive phase is achieved using an organic material at high pH, resulting in a primary eluate of more manageable volume. Further concentration of viruses is achieved by a secondary concentration step. This procedure, known as organic flocculation (Katzenelson *et al.*, 1976), utilises the property of organic materials to precipitate or flocculate when the pH of the solution is lowered near the isoelectric point of the material. Viruses are effectively adsorbed to this *de novo* precipitate, which forms spontaneously upon lowering the pH of the solution. The precipitate and associated viruses are subsequently collected by low speed centrifugation. Viruses are then recovered for assay by dissolving the precipitate in a suitably small volume of moderately alkaline buffer.

**Materials and Methods - Concentration of sample**

**Adsorption**

10 litre samples of water were collected in sterile pots from fixed stations along the designated beach and transported to the Virology laboratory for processing within 24 hours of sampling.

The sample was acidified to pH 3.5 with concentrated HCl. Then aluminium chloride, to a final concentration of 0.0005M, was added to enhance virus adsorption (Goyal and Gerba, 1982). The sample was then filtered through a polypropylene cartridge pre-filter (pore size 75μm) and then through a glass fibre cartridge filter (pore size 8μm) using a peristaltic pump. The pre-filter prevented the pores of the membrane from becoming clogged with sand and fine silt commonly found in marine water samples. After all the water had passed through the filtration apparatus adsorbed virus was eluted from the filters by passing 500 ml of 1% beef extract in 0.05M glycine (adjusted to pH 9.5 by addition of 1M NaOH) using a peristaltic pump.

**Flocculation**

IM glycine (pH 2.0) was added dropwise to the filter eluate until a fine brown precipitate began to form at around pH 4.0, the isoelectric point of beef extract, which generally coincided with the formation of a dense brown precipitate. The eluate was transferred to a refrigerator at 4°C. After 1 hour, the precipitate took on a flaky appearance forming a "floc". This floc was centrifuged at 2800g for 20 minutes and the resultant pellet was resuspended in 10 ml 0.15M $Na_2HPO_4$ buffer. The pH of the concentrate was adjusted to 7.5 before dividing it into two equal aliquots and storage at
-70°C until the samples were assayed for enteroviruses (aliquot I) and rotavirus (aliquot 2).

**Assay for enteroviruses**

Buffalo Green Monkey kidney (BGM) cells (passage numbers 101-103) were used in the assay for enteroviruses. These cells are fibroblastic in morphology and have reported viral sensitivity to poliovirus types 1, 2 and 3, echovirus types 3, 6, 7, 9, 11 ,12 and 27, coxsackie virus types A9 and B 1 , B2 and B3 and reovirus type 1 . The BGM cell cultures were propagated serially in growth medium (HMEM) supplemented with 50% Leibovitz L15 medium and 10% Foetal Calf Serum (Gibco Laboratories Ltd).

The samples were assayed for enteroviruses using the suspended cell method in vented petri dishes. The 5 ml concentrate derived after concentration of water samples was divided into 1 ml aliquots and each aliquot was added to one petri dish. 1 ml of BGM cell suspension containing approximately $3x10^7$ cells and 10ml agar overlay medium were also added to each petri dish and the three constituents were mixed thoroughly. When the agar was set, the petri dishes were inverted and incubated in a $CO_2$ incubator in the dark for up to 5 days. The agar overlay medium contains the vital dye, neutral red, which specifically stains live cells. Virus-infected cells are apparent macroscopically as areas in the monolayer where the vital dye has not been taken up by the cells. These areas of dead cells (plaques), which usually correspond to the number of infectious units of virus in the sample, were noted, and after their confirmation as plaques (and not artifacts) using the inverted light microscope to detect cytopathic effect (CPE), were counted and for each sample expressed as plaque-forming units (pfu) per 5 litres. This figure was then multiplied by 2 to obtain the estimated level in the original 10 litre sample. Results were then expressed as plaque-forming units (pfu) per 10 litre sample. Poliovirus 2 was included as a control each time and batch of sample concentrates were assayed for the presence of enterovirus by the plaque assay.

**Assay for rotavirus**

Unlike the enteroviruses described above, human rotavirus cannot be cultivated directly in vitro by current organ or tissue culture techniques. However, if the virus is centrifuged at low speed on to a preformed monolayer of cells, the cells become more susceptible to infection and in the presence of trypsin and absence of serum, the virus undergoes an incomplete replicative cycle, producing viral antigens in the cell. Although the infection is abortive and yields little or no infectious virus (Thouless *et al*, 1977), the viral antigens that are produced can be detected using immunofluorescent antibodies.

The immunofluorescence technique is based on the antibody-antigen reaction in which the antibody-antigen complex is made visible by incorporating a fluorochrome in the antibody molecule. Fluorescence is then detected by dark-ground illumination using ultra-violet light or visible blue light. In this way, individual fluorescent foci (cells) are recorded and are quantified as infectious units.

Rhesus Monkey kidney (LLC-MK2) cells (passage number 240-245) were used for assay for rotavirus. These cells are susceptible to infection by both human and a variety of animal rotaviruses (McNulty *et al.*, 1977; Thouless *et al.*, 1977) and are used widely for immunofluorescence assays. The LLC-MK2 cultures are propagated serially in growth medium (HMEM) supplemented with 50% Leibovitz L15 medium and 10% foetal calf serum.

The sample concentrates were assayed for rotavirus as follows: LLC-MK2 cells were removed from maintenance culture flasks by trypsinisation with 0.005% trypsin-EDTA solution. After addition of growth medium, the resultant cell suspension was centrifuged at 800 g for 5 minutes. The supernatant was discarded and the cell pellet was resuspended in serum free medium (SFM) containing 0.5 mg $ml^{-1}$ trypsin (without EDTA). Cells were seeded in 96-well microtitration plates at a rate of 5 x $10^4$ cells/100 µl/ well (Figure 2). The plates were incubated for 1 hour at 37°C with high $CO_2$ concentration and then for a further 1.5 hours with low $CO_2$ concentration. 100 ml of the sample concentrate was then added to each well and the plates were centrifuged at 1400 g for 60 minutes. The plates were then incubated at 37°C for 1 hour, when the sample was removed and replaced with 150 ml SFM (without trypsin). The plates were then incubated overnight at 37°C in 5% $CO_2$/air atmosphere.

After overnight incubation, the medium was removed and each well was washed once with phosphate buffered saline (PBS). The cells were then fixed in ice cold methanol at 4°C for 10 minutes, rehydrated with PBS and then incubated at room temperature for 10 minutes. The plates were then air-dried and 100 ml rabbit-antirotavirus antiserum (1:40 dilution in PBS) was added to each well and, after shaking for 5 minutes, the plates were incubated for 1 hour at 37°C. Each well was washed 3 times with PBS (with shaking) and 100 ml FITC conjugated goat-anti-rabbit antiserum (1:40 dilution in PBS) was added to each well. After shaking for 5 minutes, the plates were incubated for 1.5 hours at 37°C.

Each well was washed 3 times with PBS and 50 ml of 1% solution amido black was added to each well. After shaking for 10 minutes at room temperature each well was washed three times with PBS, and then the plates were air-dried. The number of fluorescing cells (fluorescing foci (ff)), which usually corresponds to the number of infectious rotavirus particles in the sample, were then counted using a Nikon "Diaphot" inverted microscope at an excitation wavelength of 495 mm. The results were then expressed as fluorescing foci per 10 litre sample. Human rotavirus extracted from stools from infected individuals, was used as a control and was included each time a batch of sample concentrates were assayed for rotavirus by the immunofluorescence test.

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**Clinical sample analysis - swabs and faeces**

***Escherichia coli*/Coliform**

Single colonies were picked from MacConkey agar to purity plates and tested for production of glucoronidase enzyme.

glucoronidase producer - *E.coli*
glucoronidase negative - Coliform

***Pseudomonas aeruginosa***

Single colonies were picked from MacConkey agar and tested to determine whether they were oxidase positive or negative. Oxidase positive colonies were then tested for resistance to cetrimide and production of pyocyanin and pyoverdin.

***Staphylococcus aureus***

Single colonies were emulsified in Wellcome Staphaurex latex suspension. Colonies causing latex agglutination were identified as Staphylococcus aureus.

***Streptococcus faecalis***

Single colonies were picked from blood agar and MacConkey agar onto a pyruvate containing medium and incubated anaerobically for 24 hours. Streptococci which fermented pyruvate were confirmed by Group O antigen detection - (Wellcome - Streptex). Fifteen isolates selected at random were confirmed by using the API 20 strep typing system.

**Haemolytic streptococci**

Single colonies were picked from anaerobic blood agar to blood agar purity plates. The streptococcal group was then determined using the Wellcome streptex grouping system.

***Salmonella***

Colonies were picked from MLCB and/or XLD agars (Oxoid) to MacConkey purity plates. Cultures were then identified or excluded serologically.

***Shigella***

Colonies were picked from XLD agar (Oxoid) onto MacConkey purity plates. Cultures were then identified or excluded serologically.

***Campylobacter***

Single colonies were picked from Charcoal selective Campylobacter medium to microaerophilic blood agar purity plates. Oxidase positive organisms were tested for aerobic growth, biotyped and phage typed.

***E.coli* 0157**

Up to five non-sorbitol fermenting colonies were picked and tested with E.coli 0157 antisera (PHL Colindale).

# APPENDIX IV

## Appendix IV

**Swab results 1 week**

| Symptom | Bather + | Bather - | Non Bather + | Non Bather - | *p* | Relative Risk | 95% Confidence Interval Lower | 95% Confidence Interval Upper | Attack rate (‰) Bather | Attack rate (‰) Non Bather |
|---|---|---|---|---|---|---|---|---|---|---|
| a. ear swabs | | | | | | | | | | |
| Haemolytic strep. | 1 | 164 | 1 | 172 | 1.0000* | 1.05 | 0.07 | 16.63 | 6 | 6 |
| Faecal strep. | 17 | 148 | 6 | 167 | 0.0227† | 2.97 | 1.20 | 7.35 | 103 | 35 |
| Coliform | 9 | 156 | 9 | 164 | 0.8894 | 1.05 | 0.43 | 2.58 | 55 | 52 |
| *E. coli* | 0 | 165 | 1 | 172 | 1.0000* | -.- | -.- | -.- | 0 | 6 |
| *P. aeruginosa* | 2 | 163 | 6 | 167 | 0.3153* | 0.35 | 0.07 | 1.71 | 12 | 35 |
| *S. aureus* | 4 | 161 | 6 | 167 | 0.8098* | 0.70 | 0.20 | 2.43 | 24 | 35 |
| Any determinand | 26 | 139 | 24 | 149 | 0.7379 | 1.14 | 0.68 | 1.90 | 158 | 139 |
| b. throat swabs | | | | | | | | | | |
| Haemolytic strep. | 6 | 157 | 8 | 163 | 0.8559 | 0.79 | 0.28 | 2.22 | 37 | 47 |
| Faecal strep. | 122 | 41 | 136 | 35 | 0.3732 | 0.94 | 0.84 | 1.06 | 748 | 795 |
| Coliform | 16 | 147 | 14 | 157 | 0.7422 | 1.20 | 0.60 | 2.38 | 98 | 82 |
| *E. coli* | 1 | 162 | 5 | 166 | 0.2377* | 0.21 | 0.02 | 1.78 | 6 | 29 |
| *S. aureus* | 10 | 153 | 10 | 161 | 0.9043 | 1.05 | 0.45 | 2.45 | 61 | 58 |
| Any determinand | 130 | 33 | 143 | 28 | 0.4392 | 0.95 | 0.86 | 1.06 | 798 | 836 |
| c. either swab | | | | | | | | | | |
| Any determinand | 135 | 27 | 146 | 26 | 0.8121 | 0.98 | 0.89 | 1.08 | 833 | 849 |

* Fisher's exact test (expected cell count < 5)

† Significant $\alpha = 0.05$

**Pre-exposure questionnaire**

| Symptom | Bather + | Bather - | Non Bather + | Non Bather - | *p* | Relative Risk | 95% Confidence Interval Lower | 95% Confidence Interval Upper | Attack rate (‰) Bather | Attack rate (‰) Non Bather |
|---|---|---|---|---|---|---|---|---|---|---|
| 'Flu | 45 | 133 | 46 | 140 | 1.0000 | 1.02 | 0.72 | 1.46 | 253 | 247 |
| Fever | 5 | 173 | 6 | 180 | 0.9410 | 0.87 | 0.27 | 2.80 | 28 | 32 |
| Headache | 18 | 160 | 9 | 177 | 0.0856 | 2.09 | 0.96 | 4.53 | 101 | 48 |
| Aching joints | 11 | 167 | 8 | 178 | 0.5688 | 1.44 | 0.59 | 3.49 | 62 | 43 |
| Sore throat | 26 | 152 | 30 | 156 | 0.7971 | 0.91 | 0.56 | 1.47 | 146 | 161 |
| Chest symptoms | 35 | 142 | 58 | 128 | 0.0179† | 0.63† | 0.44 | 0.91 | 198 | 312 |
| Chest pains | 3 | 175 | 4 | 182 | 1.0000* | 0.78 | 0.18 | 3.45 | 17 | 22 |
| Dry Cough | 18 | 160 | 13 | 173 | 0.3793 | 1.45 | 0.73 | 2.86 | 101 | 70 |
| Prod. cough | 9 | 168 | 11 | 175 | 0.9077 | 0.86 | 0.37 | 2.02 | 51 | 59 |
| Wheezing | 4 | 174 | 7 | 179 | 0.5903 | 0.60 | 0.18 | 2.00 | 22 | 38 |
| Runny nose | 22 | 155 | 42 | 144 | 0.0164† | 0.55† | 0.34 | 0.88 | 124 | 226 |
| Ear / eye symptoms | 6 | 172 | 16 | 170 | 0.0610 | 0.39† | 0.16 | 0.98 | 34 | 86 |
| Ear infection | 3 | 175 | 7 | 179 | 0.3742* | 0.45 | 0.12 | 1.70 | 17 | 38 |
| Eye infection | 2 | 176 | 8 | 178 | 0.1205* | 0.26 | 0.06 | 1.21 | 11 | 43 |
| Blurred vision | 1 | 177 | 3 | 183 | 0.6563* | 0.35 | 0.04 | 3.32 | 6 | 16 |
| GI symptoms | 28 | 150 | 21 | 165 | 0.2770 | 1.39 | 0.82 | 2.36 | 157 | 113 |
| Loss of appetite | 6 | 172 | 4 | 182 | 1.0000* | 1.57 | 0.45 | 5.46 | 34 | 22 |
| Indigestion | 9 | 169 | 4 | 182 | 0.2260 | 2.35 | 0.74 | 7.50 | 51 | 22 |
| Stomach pain | 3 | 175 | 6 | 180 | 0.5468* | 0.52 | 0.13 | 2.06 | 17 | 32 |
| Loose motions | 12 | 166 | 9 | 177 | 0.5799 | 1.39 | 0.60 | 3.23 | 67 | 48 |
| Diarrhoea | 5 | 173 | 6 | 180 | 0.9410 | 0.87 | 0.27 | 2.80 | 28 | 32 |
| Nausea | 4 | 173 | 5 | 181 | 1.0000* | 0.84 | 0.23 | 3.08 | 23 | 27 |
| Vomiting | 4 | 174 | 6 | 180 | 0.8057 | 0.70 | 0.20 | 2.43 | 22 | 32 |
| Skin symptoms | 15 | 163 | 17 | 169 | 0.9562 | 0.92 | 0.48 | 1.79 | 84 | 91 |
| Skin rash | 13 | 165 | 9 | 177 | 0.4434 | 1.51 | 0.66 | 3.44 | 73 | 48 |
| Skin ulcer | 3 | 175 | 4 | 182 | 1.0000* | 0.78 | 0.18 | 3.45 | 17 | 22 |
| Itching | 3 | 175 | 9 | 177 | 0.1643 | 0.35 | 0.10 | 1.27 | 17 | 48 |
| Other symptoms | 10 | 160 | 10 | 166 | 0.8804 | 1.04 | 0.44 | 2.42 | 59 | 57 |
| Lassitude | 7 | 170 | 7 | 179 | 0.8587 | 1.05 | 0.38 | 2.94 | 40 | 38 |
| Dizziness | 4 | 173 | 3 | 181 | 0.9572* | 1.39 | 0.31 | 6.11 | 23 | 16 |
| Pins & needles | 6 | 171 | 5 | 181 | 0.9334 | 1.26 | 0.39 | 4.06 | 34 | 27 |
| Muscle cramps | 5 | 173 | 4 | 182 | 0.9453* | 1.31 | 0.36 | 4.79 | 28 | 22 |
| Any symptom | 82 | 93 | 107 | 76 | 0.0362† | 0.80† | 0.66 | 0.98 | 469 | 585 |
| Bathing symptom | 81 | 97 | 101 | 85 | 0.1158 | 0.84 | 0.68 | 1.03 | 455 | 543 |

* Fisher's exact test (expected cell count < 5)

† Significant $\alpha = 0.05$

Exposure day questionnaire

| Symptom | Bather + | Bather - | Non Bather + | Non Bather - | *p* | Relative Risk | 95% Confidence interval Lower | 95% Confidence interval Upper | Attack rate (‰) Bather | Attack rate (‰) Non Bather |
|---|---|---|---|---|---|---|---|---|---|---|
| 'Flu | 40 | 135 | 49 | 135 | 0.4806 | 0.86 | 0.60 | 1.23 | 229 | 266 |
| Fever | 2 | 173 | 4 | 180 | 0.7327* | 0.53 | 0.10 | 2.83 | 11 | 22 |
| Headache | 24 | 151 | 27 | 157 | 0.9131 | 0.93 | 0.56 | 1.56 | 137 | 147 |
| Aching joints | 8 | 167 | 12 | 172 | 0.5652 | 0.70 | 0.29 | 1.67 | 46 | 65 |
| Sore throat | 14 | 161 | 20 | 164 | 0.4546 | 0.74 | 0.38 | 1.41 | 80 | 109 |
| Chest symptoms | 36 | 139 | 45 | 139 | 0.4509 | 0.84 | 0.57 | 1.24 | 206 | 245 |
| Chest pains | 4 | 171 | 8 | 176 | 0.4279 | 0.53 | 0.16 | 1.71 | 23 | 43 |
| Dry Cough | 11 | 164 | 7 | 177 | 0.4038 | 1.65 | 0.66 | 4.17 | 63 | 38 |
| Prod. cough | 9 | 166 | 7 | 177 | 0.7200 | 1.35 | 0.51 | 3.55 | 51 | 38 |
| Wheezing | 4 | 171 | 10 | 174 | 0.2048 | 0.42 | 0.13 | 1.32 | 23 | 54 |
| Runny nose | 28 | 147 | 35 | 149 | 0.5395 | 0.84 | 0.54 | 1.32 | 160 | 190 |
| Ear / eye symptoms | 9 | 166 | 7 | 177 | 0.7200 | 1.35 | 0.51 | 3.55 | 51 | 38 |
| Ear infection | 3 | 172 | 3 | 181 | 1.0000* | 1.05 | 0.22 | 5.14 | 17 | 16 |
| Eye infection | 3 | 172 | 1 | 183 | 0.5857* | 3.15 | 0.33 | 30.04 | 17 | 5 |
| Blurred vision | 3 | 172 | 4 | 180 | 1.0000* | 0.79 | 0.18 | 3.47 | 17 | 22 |
| GI symptoms | 17 | 158 | 20 | 164 | 0.8523 | 0.89 | 0.48 | 1.65 | 97 | 109 |
| Loss of appetite | 7 | 168 | 7 | 176 | 0.8514 | 1.05 | 0.37 | 2.92 | 40 | 38 |
| Indigestion | 4 | 171 | 8 | 176 | 0.4279 | 0.53 | 0.16 | 1.71 | 23 | 43 |
| Stomach pain | 5 | 170 | 6 | 178 | 0.9327 | 0.88 | 0.27 | 2.82 | 29 | 33 |
| Loose motions | 3 | 172 | 3 | 181 | 1.0000* | 1.05 | 0.22 | 5.14 | 17 | 16 |
| Diarrhoea | 0 | 175 | 1 | 183 | 1.0000* | -.- | -.- | -.- | 0 | 5 |
| Nausea | 2 | 173 | 6 | 178 | 0.3176* | 0.35 | 0.07 | 1.71 | 11 | 33 |
| Vomiting | 1 | 174 | 3 | 181 | 0.6610* | 0.35 | 0.04 | 3.34 | 6 | 16 |
| Skin symptoms | 13 | 162 | 15 | 169 | 0.9532 | 0.91 | 0.45 | 1.86 | 74 | 82 |
| Skin rash | 10 | 165 | 12 | 172 | 0.9214 | 0.88 | 0.39 | 1.98 | 57 | 65 |
| Skin ulcer | 3 | 172 | 0 | 184 | 0.2296* | -.- | -.- | -.- | 17 | 0 |
| Itching | 7 | 168 | 9 | 175 | 0.8782 | 0.82 | 0.31 | 2.15 | 40 | 49 |
| Other symptoms | 8 | 161 | 10 | 167 | 0.8876 | 0.84 | 0.34 | 2.07 | 47 | 56 |
| Lassitude | 6 | 168 | 7 | 177 | 0.9183 | 0.91 | 0.31 | 2.64 | 34 | 38 |
| Dizziness | 2 | 172 | 1 | 183 | 0.9580* | 2.11 | 0.19 | 23.12 | 11 | 5 |
| Pins & needles | 5 | 170 | 8 | 176 | 0.6361 | 0.66 | 0.22 | 1.97 | 29 | 43 |
| Muscle cramps | 4 | 170 | 5 | 179 | 1.0000* | 0.85 | 0.23 | 3.10 | 23 | 27 |
| Any symptom | 74 | 98 | 87 | 96 | 0.4546 | 0.90 | 0.72 | 1.14 | 430 | 475 |
| Bathing symptom | 73 | 102 | 87 | 97 | 0.3397 | 0.88 | 0.70 | 1.11 | 417 | 473 |

* Fisher's exact test (expected cell count < 5)

**Post-exposure questionnaire 1 week**

| Symptom | Bather + | Bather - | Non Bather + | Non Bather - | p | Relative Risk | 95% Confidence Interval Lower | 95% Confidence Interval Upper | Attack rate (‰) Bather | Attack rate (‰) Non Bather |
|---|---|---|---|---|---|---|---|---|---|---|
| 'Flu | 62 | 116 | 64 | 122 | 0.9797 | 1.01 | 0.76 | 1.34 | 348 | 344 |
| Fever | 6 | 172 | 9 | 177 | 0.6595 | 0.70 | 0.25 | 1.92 | 34 | 48 |
| Headache | 39 | 139 | 38 | 148 | 0.8280 | 1.07 | 0.72 | 1.59 | 219 | 204 |
| Aching joints | 17 | 161 | 10 | 175 | 0.1920 | 1.77 | 0.83 | 3.75 | 96 | 54 |
| Sore throat | 26 | 152 | 29 | 156 | 0.8906 | 0.93 | 0.57 | 1.52 | 146 | 157 |
| Chest symptoms | 41 | 136 | 53 | 133 | 0.2988 | 0.81 | 0.57 | 1.16 | 232 | 285 |
| Chest pains | 5 | 173 | 3 | 182 | 0.6814* | 1.73 | 0.42 | 7.14 | 28 | 16 |
| Dry Cough | 11 | 167 | 17 | 169 | 0.3883 | 0.68 | 0.33 | 1.40 | 62 | 91 |
| Prod. cough | 14 | 164 | 19 | 167 | 0.5499 | 0.77 | 0.40 | 1.49 | 79 | 102 |
| Wheezing | 5 | 173 | 5 | 181 | 1.0000* | 1.04 | 0.31 | 3.55 | 28 | 27 |
| Runny nose | 26 | 151 | 42 | 144 | 0.0732 | 0.65 | 0.42 | 1.01 | 147 | 226 |
| Ear / eye symptoms | 14 | 164 | 8 | 177 | 0.2327 | 1.82 | 0.78 | 4.23 | 79 | 43 |
| Ear infection | 6 | 171 | 3 | 183 | 0.4545* | 2.10 | 0.53 | 8.28 | 34 | 16 |
| Eye infection | 6 | 172 | 4 | 181 | 0.7030* | 1.56 | 0.45 | 5.43 | 34 | 22 |
| Blurred vision | 3 | 175 | 1 | 185 | 0.5902* | 3.13 | 0.33 | 29.86 | 17 | 5 |
| GI symptoms | 78 | 99 | 46 | 138 | 0.0002† | 1.76 | 1.31 | 2.38 | 441 | 250 |
| Loss of appetite | 18 | 159 | 10 | 174 | 0.1377 | 1.87 | 0.89 | 3.94 | 102 | 54 |
| Indigestion | 16 | 161 | 8 | 178 | 0.1085 | 2.10 | 0.92 | 4.79 | 90 | 43 |
| Stomach pain | 24 | 153 | 24 | 162 | 0.9765 | 1.05 | 0.62 | 1.78 | 136 | 129 |
| Loose motions | 42 | 135 | 28 | 156 | 0.0559 | 1.56† | 1.01 | 2.40 | 237 | 152 |
| Diarrhoea | 5 | 172 | 10 | 176 | 0.3385 | 0.53 | 0.18 | 1.51 | 28 | 54 |
| Nausea | 31 | 146 | 13 | 173 | 0.0036† | 2.51† | 1.36 | 4.63 | 175 | 70 |
| Vomiting | 5 | 172 | 3 | 183 | 0.6695* | 1.75 | 0.42 | 7.22 | 28 | 16 |
| Skin symptoms | 25 | 152 | 25 | 161 | 0.9709 | 1.05 | 0.63 | 1.76 | 141 | 134 |
| Skin rash | 12 | 165 | 9 | 177 | 0.5708 | 1.40 | 0.61 | 3.24 | 68 | 48 |
| Skin ulcer | 2 | 175 | 2 | 184 | 1.0000* | 1.05 | 0.15 | 7.38 | 11 | 11 |
| Itching | 19 | 158 | 17 | 169 | 0.7396 | 1.17 | 0.63 | 2.19 | 107 | 91 |
| Other symptoms | 25 | 148 | 14 | 167 | 0.0673 | 1.86 | 1.00 | 3.45 | 145 | 77 |
| Lassitude | 20 | 156 | 11 | 173 | 0.1025 | 1.90 | 0.94 | 3.85 | 114 | 60 |
| Dizziness | 7 | 170 | 3 | 182 | 0.3018 | 2.44 | 0.64 | 9.28 | 40 | 16 |
| Pins & needles | 4 | 172 | 7 | 179 | 0.6034 | 0.60 | 0.18 | 2.03 | 23 | 38 |
| Muscle cramps | 6 | 171 | 5 | 181 | 0.9334 | 1.26 | 0.39 | 4.06 | 34 | 27 |
| Any symptom | 118 | 58 | 116 | 70 | 0.4117 | 1.08 | 0.92 | 1.25 | 670 | 624 |
| Bathing symptom | 116 | 62 | 115 | 71 | 0.5804 | 1.05 | 0.90 | 1.23 | 652 | 618 |

* Fisher's exact test (expected cell count < 5)

† Significant $\alpha = 0.05$

Post-exposure questionnaire 3 weeks

| Symptom | Bather + | Bather - | Non Bather + | Non Bather - | *p* | Relative Risk | 95% Confidence interval Lower | 95% Confidence interval Upper | Attack rate (‰) Bather | Attack rate (‰) Non Bather |
|---|---|---|---|---|---|---|---|---|---|---|
| 'Flu | 44 | 121 | 44 | 124 | 0.9795 | 1.02 | 0.71 | 1.46 | 267 | 262 |
| Fever | 10 | 156 | 6 | 165 | 0.4069 | 1.72 | 0.64 | 4.62 | 60 | 35 |
| Headache | 19 | 146 | 13 | 154 | 0.3342 | 1.48 | 0.76 | 2.90 | 115 | 78 |
| Aching joints | 15 | 150 | 12 | 159 | 0.6183 | 1.30 | 0.63 | 2.68 | 91 | 70 |
| Sore throat | 22 | 144 | 28 | 142 | 0.4995 | 0.80 | 0.48 | 1.35 | 133 | 165 |
| Chest symptoms | 38 | 127 | 42 | 129 | 0.8405 | 0.94 | 0.64 | 1.38 | 230 | 246 |
| Chest pains | 0 | 166 | 3 | 168 | 0.2590 | -.- | -.- | -.- | 0 | 18 |
| Dry Cough | 10 | 155 | 7 | 164 | 0.5663 | 1.48 | 0.58 | 3.80 | 61 | 41 |
| Prod. cough | 15 | 150 | 7 | 164 | 0.1030 | 2.22 | 0.93 | 5.31 | 91 | 41 |
| Wheezing | 5 | 161 | 7 | 164 | 0.8091 | 0.74 | 0.24 | 2.27 | 30 | 41 |
| Runny nose | 23 | 143 | 31 | 140 | 0.3572 | 0.76 | 0.47 | 1.25 | 139 | 181 |
| Ear / eye symptoms | 17 | 148 | 10 | 161 | 0.1932 | 1.76 | 0.83 | 3.73 | 103 | 58 |
| Ear infection | 10 | 156 | 4 | 167 | 0.1551 | 2.58 | 0.82 | 8.05 | 60 | 23 |
| Eye infection | 7 | 159 | 4 | 166 | 0.5135 | 1.79 | 0.53 | 6.01 | 42 | 24 |
| Blurred vision | 2 | 162 | 2 | 169 | 1.0000* | 1.04 | 0.15 | 7.32 | 12 | 12 |
| GI symptoms | 66 | 96 | 46 | 125 | 0.0106† | 1.51† | 1.11 | 2.06 | 407 | 269 |
| Loss of appetite | 12 | 154 | 8 | 161 | 0.4635 | 1.53 | 0.64 | 3.64 | 72 | 47 |
| Indigestion | 12 | 153 | 10 | 161 | 0.7587 | 1.24 | 0.55 | 2.80 | 73 | 58 |
| Stomach pain | 19 | 146 | 15 | 156 | 0.5140 | 1.31 | 0.69 | 2.50 | 115 | 88 |
| Loose motions | 42 | 121 | 29 | 142 | 0.0668 | 1.52 | 1.00 | 2.32 | 258 | 170 |
| Diarrhoea | 10 | 154 | 10 | 160 | 0.8825 | 1.04 | 0.44 | 2.42 | 61 | 59 |
| Nausea | 25 | 140 | 7 | 164 | 0.0011† | 3.70† | 1.65 | 8.32 | 152 | 41 |
| Vomiting | 5 | 160 | 5 | 166 | 1.0000* | 1.04 | 0.31 | 3.51 | 30 | 29 |
| Skin symptoms | 23 | 143 | 12 | 159 | 0.0603 | 1.97† | 1.02 | 3.84 | 139 | 70 |
| Skin rash | 12 | 153 | 6 | 165 | 0.1972 | 2.07 | 0.80 | 5.39 | 73 | 35 |
| Skin ulcer | 2 | 164 | 1 | 170 | 0.9777* | 2.06 | 0.19 | 22.51 | 12 | 6 |
| Itching | 16 | 150 | 7 | 164 | 0.0715 | 2.35 | 0.99 | 5.58 | 96 | 41 |
| Other symptoms | 20 | 141 | 12 | 150 | 0.1861 | 1.68 | 0.85 | 3.32 | 124 | 74 |
| Lassitude | 13 | 150 | 9 | 161 | 0.4448 | 1.51 | 0.66 | 3.43 | 80 | 53 |
| Dizziness | 10 | 156 | 5 | 165 | 0.2696 | 2.05 | 0.72 | 5.86 | 60 | 29 |
| Pins & needles | 6 | 159 | 4 | 166 | 0.7133* | 1.55 | 0.44 | 5.38 | 36 | 24 |
| Muscle cramps | 5 | 161 | 5 | 165 | 1.0000* | 1.02 | 0.30 | 3.47 | 30 | 29 |
| Any symptom | 105 | 57 | 89 | 79 | 0.0382† | 1.22† | 1.02 | 1.47 | 648 | 530 |
| Bathing symptom | 104 | 59 | 88 | 82 | 0.0347† | 1.23† | 1.02 | 1.48 | 638 | 518 |

* Fisher's exact test (expected cell count < 5)

† Significant $\alpha = 0.05$

## Relationships between ingestion of water and Gastrointestinal symptoms

**1 week**

| Symptom | Swallowed + | Swallowed - | Did not Swallow + | Did not Swallow - | *p* | Relative Risk | 95% Confidence Interval Lower | 95% Confidence Interval Upper |
|---|---|---|---|---|---|---|---|---|
| GI symptoms | 61 | 74 | 14 | 19 | 0.9277 | 1.07 | 0.69 | 1.65 |
| Loss of appetite | 12 | 123 | 6 | 127 | 0.2237* | 0.49 | 0.20 | 1.21 |
| Indigestion | 13 | 122 | 2 | 31 | 0.8051* | 1.59 | 0.38 | 6.70 |
| Stomach pain | 21 | 114 | 2 | 31 | 0.2471* | 2.57 | 0.63 | 10.40 |
| Loose motions | 31 | 104 | 8 | 25 | 0.9411 | 0.95 | 0.48 | 1.87 |
| Diarrhoea | 3 | 132 | 1 | 32 | 1.0000* | 0.73 | 0.08 | 6.83 |
| Nausea | 23 | 112 | 5 | 28 | 1.0000 | 1.12 | 0.46 | 2.74 |
| Vomiting | 4 | 131 | 1 | 32 | 1.0000* | 0.98 | 0.11 | 8.46 |

**3 weeks**

| Symptom | Swallowed + | Swallowed - | Did not Swallow + | Did not Swallow - | *p* | Relative Risk | 95% Confidence Interval Lower | 95% Confidence Interval Upper |
|---|---|---|---|---|---|---|---|---|
| GI symptoms | 50 | 76 | 14 | 15 | 0.5233 | 0.82 | 0.53 | 1.27 |
| Loss of appetite | 8 | 120 | 4 | 27 | 0.3696* | 0.48 | 0.16 | 1.51 |
| Indigestion | 7 | 121 | 5 | 25 | 0.1051* | 0.33 | 0.11 | 0.96 |
| Stomach pain | 13 | 114 | 5 | 26 | 0.5215* | 0.63 | 0.24 | 1.65 |
| Loose motions | 30 | 96 | 10 | 20 | 0.4003 | 0.71 | 0.39 | 1.29 |
| Diarrhoea | 6 | 121 | 3 | 27 | 0.4689* | 0.47 | 0.13 | 1.78 |
| Nausea | 21 | 106 | 3 | 28 | 0.5157* | 1.71 | 0.54 | 5.37 |
| Vomiting | 3 | 124 | 2 | 29 | 0.5070* | 0.37 | 0.06 | 2.10 |

* Fisher's exact test (expected cell count < 5)

## Food exposure in the bather and non-bather groups

| Food type | Bathers + | Bathers - | Non-bathers + | Non-bathers - | *p* |
|---|---|---|---|---|---|
| Ice cream | 95 | 82 | 104 | 81 | 0.7035 |
| Bought Sandwich | 39 | 139 | 42 | 144 | 0.9779 |
| Chicken | 94 | 84 | 83 | 103 | 0.1451 |
| Eggs | 113 | 64 | 119 | 66 | 0.9889 |
| Mayonnaise | 22 | 156 | 9 | 176 | 0.0180† |
| Hot Dogs | 9 | 169 | 12 | 174 | 0.7294 |
| Hamburgers | 30 | 148 | 42 | 144 | 0.2152 |
| Salad | 138 | 40 | 147 | 39 | 0.8252 |
| Raw milk | 12 | 166 | 9 | 177 | 0.5799 |
| Cold meat/pâté | 91 | 87 | 88 | 98 | 0.5337 |
| Meat pies/pasties | 57 | 121 | 70 | 115 | 0.2931 |
| Take away food | 56 | 122 | 59 | 127 | 0.9526 |
| Sea food | 39 | 139 | 34 | 151 | 0.4788 |

† significant difference, $\alpha = 0.05$

**Summary of stratified analysis - effects of sea bathing on G. I. symptoms controlling for mayonnaise**

| | Mayonnaise = yes | | | | Mayonnaise = no | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bather | | Non-Bather | | Bather | | Non-Bather | | | | | |
| Symptom | + | - | + | - | + | - | + | - | p* | RR§ | LCI | UCI |
| Loss of appetite | 6 | 15 | 0 | 9 | 12 | 144 | 10 | 165 | 0.2382 | 1.73 | 0.78 | 3.84 |
| Indigestion | 3 | 18 | 1 | 8 | 13 | 143 | 7 | 169 | 0.1571 | 1.95 | 0.86 | 4.44 |
| Stomach pain | 2 | 19 | 1 | 8 | 22 | 134 | 23 | 153 | 0.9366 | 1.07 | 0.63 | 1.81 |
| loose motions | 6 | 15 | 3 | 6 | 36 | 120 | 25 | 149 | 0.0867 | 1.49 | 0.97 | 2.29 |
| Diarrhoea | 1 | 20 | 1 | 8 | 4 | 152 | 9 | 167 | 0.2848 | 0.49 | 0.17 | 1.42 |
| Nausea | 3 | 18 | 0 | 9 | 28 | 128 | 13 | 163 | 0.0031† | 2.58 | 1.38 | 4.81 |
| Vomiting | 1 | 21 | 0 | 9 | 5 | 151 | 3 | 173 | 0.4825 | 2.09 | 0.51 | 8.57 |
| Any G. I. | 7 | 14 | 3 | 6 | 71 | 85 | 43 | 132 | 0.0002† | 1.77 | 1.31 | 2.39 |

* Mantel-Haenszel summary $\chi 2$
§ Mantel-Haenszel weighted RR
¶ 95% confidence interval (Greenland and Robins, 1985)
† significant difference, $\alpha = 0.05$

**Serious illness at one week**

| | Bather | | Non Bather | | p |
|---|---|---|---|---|---|
| Symptom | + | - | + | - | |
| GP consulted | 7 | 170 | 12 | 172 | 0.3919 |
| Days lost | 6 | 168 | 5 | 179 | 0.9250 |
| Hospital | 1 | 174 | 1 | 183 | 1.0000* |

* Fisher's exact test, 2x1tailed-p

**Serious illness at three weeks**

| | Bather | | Non Bather | | p |
|---|---|---|---|---|---|
| Symptom | + | - | + | - | |
| GP consulted | 8 | 155 | 4 | 162 | 0.3605 |
| Days lost | 16 | 148 | 9 | 154 | 0.2177 |
| Hospital | 2 | 163 | 0 | 167 | 0.4928* |

* Fisher's exact test, 2x1tailed-p

**Post-exposure questionnaire 1 week - medical diagnosis rates**

| | Bather | | Non Bather | | p | Relative Risk | 95% Confidence Interval | | Attack rate (‰) | |
|---|---|---|---|---|---|---|---|---|---|---|
| Symptom | + | - | + | - | | | Lower | Upper | Bather | Non Bather |
| Red Throat | 28 | 137 | 23 | 147 | 0.4690 | 1.25 | 0.75 | 2.09 | 170 | 135 |
| Infected Throat | 1 | 137 | 0 | 147 | 0.9684* | -.- | -.- | -.- | 7 | 0 |
| Red / infected Throat | 29 | 137 | 23 | 147 | 0.3966 | 1.29 | 0.78 | 2.14 | 175 | 135 |
| Ear infection | 1 | 162 | 1 | 166 | 1.0000* | 1.02 | 0.06 | 16.24 | 6 | 6 |

* Fisher's exact test, 2-tailed p

**Ranges of microbial concentrations (count 100 ml$^{-1}$) in the three cohort studies**

| Parameter (Count 100 ml$^{-1}$) | Langland Bay 02.09.89 | | Moreton 04.08.90 | | Southsea 06.07.91 | |
|---|---|---|---|---|---|---|
| Total coliform | 0 | 1434 | 36 | 8144 | 0 | 711 |
| Faecal coliform | 0 | 1310 | 9 | 4773 | 0 | 961 |
| Faecal streptococci | 0 | 196 | 2 | 250 | 0 | 180 |
| *Ps. aeruginosa* | 0 | 201 | 1 | 400 | 1 | 160 |
| Total staphylococci | - | - | 11 | 1464 | 3 | 4320 |

**Symptom comparison between studies. RR and 95% CI**

| | Langland Bay 02.09.89 | Moreton 04.08.90 | Southsea 06.07.91 |
|---|---|---|---|
| **Symptom** | **3 days** | **1 week** | **1 week** |
| Sore throat | 1.01<2.08>4.27 | 1.50>3.01<6.05 | 0.57<0.93>1.52 |
| Dry cough | 0.44<1.18>3.16 | 1.19>3.59<10.88 | 0.33<0.68>1.40 |
| Ear infection | -.- | 1.18>5.38<24.49 | 0.53<2.10>8.28 |
| Eye infection | 1.09<8.25>65.02 | -.- | 0.45<1.56>5.43 |
| Stomach Pain | N D | 1.09>2.77<7.02 | 0.62<1.05>1.78 |
| loose motions | N D | 1.15>2.30<4.60 | 1.01<1.56>2.40 |
| Nausea | 0.59<5.00>42.23 | 0.54<1.36>3.44 | 1.36<2.51>4.63 |
| 'flu / cold | N D | 1.40<2.26>3.65 | 0.76<1.01>1.34 |
| Chest | N D | 1.04<1.83>3.23 | 0.57<0.81>1.16 |
| Gastrointestinal | N D | 1.06<1.70>2.72 | 1.31<1.76>2.38 |
| | **3 weeks** | **4 weeks** | **3 weeks** |
| Diarrhoea | 1.22<3.22>8.55 | 0.74<2.39>7.77 | 0.44<1.04>2.42 |
| Nausea | 0.32<0.84>2.18 | 0.83<2.18>5.73 | 1.65<3.70>8.32 |
| 'flu / cold | N D | 1.08<1.73>2.75 | 0.71<1.02>1.46 |
| Gastrointestinal | N D | 1.01<1.57>2.44 | 1.11<1.51>2.06 |
| Skin symptoms | N D | 0.48<1.39>4.05 | 1.02>1.97<3.84 |

# APPENDIX V

**Appendix V** **Social, demographic, leisure and recreational water activities and general health (all as %)**

| Gender | All | Bather | Non-Bather |
|---|---|---|---|
| Male | 45.3 | 47.2 | 43.5 |
| Female | 54.7 | 52.8 | 56.5 |

| Age | All | Bather | Non-Bather |
|---|---|---|---|
| 18-24 | 28.6 | 21.3 | 35.5 |
| 25-34 | 45.1 | 48.9 | 41.4 |
| 35-44 | 13.5 | 14.0 | 12.9 |
| 45-54 | 6.9 | 7.9 | 5.9 |
| 55-64 | 3.0 | 3.9 | 2.2 |
| 65+ | 3.0 | 3.9 | 2.2 |

| Occupation | All | Bather | Non-Bather |
|---|---|---|---|
| Student | 8.8 | 8.4 | 9.1 |
| Housewife | 18.0 | 20.8 | 16.1 |
| Employed | 38.2 | 37.1 | 39.2 |
| Part-Time | 9.3 | 7.9 | 10.8 |
| Self Employ | 2.7 | 2.2 | 3.2 |
| Unemployed | 16.2 | 16.3 | 16.1 |
| Retired | 4.1 | 5.1 | 3.2 |
| Other | 2.2 | 2.2 | 2.2 |

| Household | All | Bather | Non-Bather |
|---|---|---|---|
| Up to Two | 34.1 | 33.7 | 34.4 |
| 3-4 | 45.9 | 44.4 | 47.3 |
| 5-8 | 19.0 | 21.3 | 16.7 |
| 8+ | 1.1 | 0.6 | 1.6 |

| Children Under 5 | All | Bather | Non-Bather |
|---|---|---|---|
| None | 67.0 | 63.5 | 70.4 |
| One | 17.6 | 19.1 | 16.1 |
| Two | 12.9 | 15.2 | 10.8 |
| Three+ | 2.5 | 2.2 | 2.7 |

| Smoking | All | Bather | Non-Bather |
|---|---|---|---|
| No | 62.6 | 62.4 | 62.9 |
| Yes | 36.3 | 36.5 | 36.0 |
| Other | 0.8 | 1.1 | 0.5 |
| NK | 0.3 | 0.0 | 0.5 |

| No of Cigs. | All | Bather | Non-Bather |
|---|---|---|---|
| None | 63.5 | 62.9 | 64.0 |
| <20 | 32.7 | 33.7 | 31.7 |
| 20-40 | 1.9 | 2.2 | 1.6 |
| 40-60 | 0.3 | 0.0 | 0.5 |
| 60+ | 1.6 | 1.1 | 2.2 |

| Drinking | All | Bather | Non-Bather |
|---|---|---|---|
| Never | 11.5 | 10.7 | 12.4 |
| <Once/Week | 32.4 | 35.4 | 29.6 |
| >Once/Week | 56.0 | 53.9 | 58.1 |
| NK | 0.0 | 0.0 | 0.0 |

| Alcohol Units | All | Bather | Non-Bather |
|---|---|---|---|
| <2 | 80.8 | 80.3 | 81.2 |
| 2-4 | 11.8 | 10.7 | 12.9 |
| 4-8 | 5.8 | 6.7 | 4.8 |
| 8+ | 1.1 | 1.1 | 1.1 |
| NK | 0.5 | 1.1 | 0.0 |

| Drugs | All | Bather | Non-Bather |
|---|---|---|---|
| No | 54.1 | 60.7 | 47.8 |
| Yes | 45.6 | 38.8 | 52.2 |
| NK | 0.3 | 0.6 | 0.0 |

| Antibiotics | All | Bather | Non-Bather |
|---|---|---|---|
| No | 97.0 | 97.2 | 96.8 |
| Yes | 2.5 | 2.2 | 2.7 |
| NK | 0.5 | 0.6 | 0.5 |

| Steroids | All | Bather | Non-Bather |
|---|---|---|---|
| No | 97.8 | 97.8 | 97.8 |
| Yes | 1.6 | 1.7 | 1.6 |
| NK | 0.5 | 0.6 | 0.5 |

| Laxatives | All | Bather | Non-Bather |
|---|---|---|---|
| No | 99.5 | 99.4 | 99.5 |
| Yes | 0.0 | 0.0 | 0.0 |
| NK | 0.5 | 0.6 | 0.5 |

| Stomach Remedies | All | Bather | Non-Bather |
|---|---|---|---|
| No | 99.2 | 99.4 | 98.9 |
| Yes | 0.3 | 0.0 | 0.5 |
| NK | 0.5 | 0.6 | 0.5 |

| Pub | All | Bather | Non-Bather |
|---|---|---|---|
| No | 20.9 | 25.3 | 16.7 |
| Occ. | 37.4 | 39.3 | 35.5 |
| Freq. | 41.8 | 35.4 | 47.8 |
| NK | 0.0 | 0.0 | 0.0 |

| Party | All | Bather | Non-Bather |
|---|---|---|---|
| No | 52.7 | 55.1 | 50.5 |
| Occ. | 39.8 | 37.6 | 41.9 |
| Freq. | 6.6 | 7.3 | 5.9 |
| NK | 0.8 | 0.0 | 1.6 |

| Leisure Centre | All | Bather | Non-Bather |
|---|---|---|---|
| No | 44.2 | 41.6 | 46.8 |
| Occ. | 21.4 | 20.8 | 22.0 |
| Freq. | 34.3 | 37.6 | 31.2 |
| NK | 0.0 | 0.0 | 0.0 |

| Church | All | Bather | Non-Bather |
|---|---|---|---|
| No | 82.7 | 81.5 | 83.9 |
| Occ. | 7.4 | 9.0 | 5.9 |
| Freq. | 8.5 | 7.3 | 9.7 |
| NK | 1.4 | 2.2 | 0.5 |

| Dinghy | All | Bather | Non-Bather |
|---|---|---|---|
| No | 86.0 | 82.6 | 89.2 |
| Occ. | 9.6 | 11.8 | 7.5 |
| Freq. | 3.8 | 4.5 | 3.2 |
| NK | 0.5 | 1.1 | 0.0 |

| Boating | All | Bather | Non-Bather |
|---|---|---|---|
| No | 93.7 | 93.8 | 93.5 |
| Occ. | 5.2 | 4.5 | 5.9 |
| Freq. | 0.8 | 1.1 | 0.5 |
| NK | 0.3 | 0.6 | 0.0 |

| Sub Aqua | All | Bather | Non-Bather |
|---|---|---|---|
| No | 93.7 | 92.1 | 95.2 |
| Occ. | 4.9 | 6.2 | 3.8 |
| Freq. | 0.8 | 0.6 | 1.1 |
| NK | 0.5 | 1.1 | 0.0 |

| Surfing | All | Bather | Non-Bather |
|---|---|---|---|
| No | 89.3 | 92.1 | 86.6 |
| Occ. | 6.6 | 4.5 | 8.6 |
| Freq. | 4.1 | 3.4 | 4.8 |
| NK | 0.0 | 0.0 | 0.0 |

| Fishing | All | Bather | Non-Bather |
|---|---|---|---|
| No | 93.1 | 92.1 | 94.1 |
| Occ. | 4.4 | 5.1 | 3.8 |
| Freq. | 2.5 | 2.8 | 2.2 |
| NK | 0.0 | 0.0 | 0.0 |

| Paddling | All | Bather | Non-Bather |
|---|---|---|---|
| No | 47.0 | 48.3 | 45.7 |
| Occ. | 29.1 | 28.7 | 29.6 |
| Freq. | 23.9 | 23.0 | 24.7 |
| NK | 0.0 | 0.0 | 0.0 |

| Bathing | All | Bather | Non-Bather |
|---|---|---|---|
| No | 27.7 | 32.6 | 23.1 |
| Occ. | 31.6 | 28.1 | 34.9 |
| Freq. | 39.8 | 38.8 | 40.9 |
| NK | 0.8 | 0.6 | 1.1 |

| Public Pool | All | Bather | Non-Bather |
|---|---|---|---|
| No | 28.8 | 26.4 | 31.2 |
| Occ. | 39.8 | 43.8 | 36.0 |
| Freq. | 31.0 | 29.2 | 32.8 |
| NK | 0.3 | 0.6 | 0.0 |

| Other Pool | All | Bather | Non-Bather |
|---|---|---|---|
| No | 91.8 | 91.0 | 92.5 |
| Occ. | 4.9 | 6.7 | 3.2 |
| Freq. | 1.9 | 0.6 | 3.2 |
| NK | 1.4 | 1.7 | 1.1 |

| Beach Only | All | Bather | Non-Bather |
|---|---|---|---|
| No | 15.9 | 18.0 | 14.0 |
| Occ. | 31.9 | 36.0 | 28.0 |
| Freq. | 51.9 | 45.5 | 58.1 |
| NK | 0.3 | 0.6 | 0.0 |

| Water Rides | All | Bather | Non-Bather |
|---|---|---|---|
| No | 89.0 | 88.8 | 89.2 |
| Yes | 11.0 | 11.2 | 10.8 |
| NK | 0.0 | 0.0 | 0.0 |

| Long Term Illness | All | Bather | Non-Bather |
|---|---|---|---|
| No | 66.5 | 73.6 | 59.7 |
| Yes | 32.7 | 25.3 | 39.8 |
| NK | 0.8 | 1.1 | 0.5 |

| Arthritis | All | Bather | Non-Bather |
|---|---|---|---|
| No | 93.1 | 91.0 | 95.2 |
| Yes | 6.6 | 8.4 | 4.8 |
| NK | 0.3 | 0.6 | 0.0 |

| Back Pain | All | Bather | Non-Bather |
|---|---|---|---|
| No | 86.3 | 85.4 | 87.1 |
| Yes | 13.5 | 14.0 | 12.9 |
| NK | 0.3 | 0.6 | 0.0 |

| Blood Pressure | All | Bather | Non-Bather |
|---|---|---|---|
| No | 96.2 | 95.5 | 96.8 |
| Yes | 3.6 | 3.9 | 3.2 |
| NK | 0.3 | 0.6 | 0.0 |

| Chest Problems | All | Bather | Non-Bather |
|---|---|---|---|
| No | 87.6 | 89.3 | 86.0 |
| Yes | 12.1 | 10.1 | 14.0 |
| NK | 0.3 | 0.6 | 0.0 |

| Diabetes | All | Bather | Non-Bather |
|---|---|---|---|
| No | 99.2 | 98.9 | 99.5 |
| Yes | 0.5 | 0.6 | 0.5 |
| NK | 0.3 | 0.6 | 0.0 |

| Digestion Problems | All | Bather | Non-Bather |
|---|---|---|---|
| No | 95.9 | 94.9 | 96.8 |
| Yes | 3.8 | 4.5 | 3.2 |
| NK | 0.3 | 0.6 | 0.0 |

| Bowel Problems | All | Bather | Non-Bather |
|---|---|---|---|
| No | 95.9 | 96.1 | 95.7 |
| Yes | 3.8 | 3.4 | 4.3 |
| NK | 0.3 | 0.6 | 0.0 |

| Ear Problems | All | Bather | Non-Bather |
|---|---|---|---|
| No | 91.5 | 93.8 | 89.2 |
| Yes | 8.2 | 5.6 | 10.8 |
| NK | 0.3 | 0.6 | 0.0 |

| Heart Problems | All | Bather | Non-Bather |
|---|---|---|---|
| No | 98.1 | 96.6 | 99.5 |
| Yes | 1.6 | 2.8 | 0.5 |
| NK | 0.3 | 0.6 | 0.0 |

| Hepatitis | All | Bather | Non-Bather |
|---|---|---|---|
| No | 98.4 | 97.8 | 98.9 |
| Yes | 1.4 | 1.7 | 1.1 |
| NK | 0.3 | 0.6 | 0.0 |

| Infection Problem | All | Bather | Non-Bather |
|---|---|---|---|
| No | 95.1 | 93.8 | 96.2 |
| Yes | 4.7 | 5.6 | 3.8 |
| NK | 0.3 | 0.6 | 0.0 |

| Accident | All | Bather | Non-Bather |
|---|---|---|---|
| No | 94.8 | 94.9 | 94.6 |
| Yes | 4.9 | 4.5 | 5.4 |
| NK | 0.3 | 0.6 | 0.0 |

| Kidney Problems | All | Bather | Non-Bather |
|---|---|---|---|
| No | 97.3 | 97.8 | 96.8 |
| Yes | 2.5 | 1.7 | 3.2 |
| NK | 0.3 | 0.6 | 0.0 |

| Neurological Problems | All | Bather | Non-Bather |
|---|---|---|---|
| No | 92.0 | 91.0 | 93.0 |
| Yes | 7.7 | 8.4 | 7.0 |
| NK | 0.3 | 0.6 | 0.0 |

| Hay Fever | All | Bather | Non-Bather |
|---|---|---|---|
| No | 83.2 | 86.5 | 80.1 |
| Yes | 16.5 | 12.9 | 19.9 |
| NK | 0.3 | 0.6 | 0.0 |

| Skin Problems | All | Bather | Non-Bather |
|---|---|---|---|
| No | 84.9 | 87.6 | 82.3 |
| Yes | 14.8 | 11.8 | 17.7 |
| NK | 0.3 | 0.6 | 0.0 |

| Stress Problem | All | Bather | Non-Bather |
|---|---|---|---|
| No | 95.9 | 96.1 | 95.7 |
| Yes | 3.8 | 3.4 | 4.3 |
| NK | 0.3 | 0.6 | 0.0 |

| Eye Problem | All | Bather | Non-Bather |
|---|---|---|---|
| No | 71.4 | 71.9 | 71.0 |
| Yes | 28.3 | 27.5 | 29.0 |
| NK | 0.3 | 0.6 | 0.0 |

| Other Problem | All | Bather | Non-Bather |
|---|---|---|---|
| No | 93.7 | 95.5 | 91.9 |
| Yes | 6.0 | 3.9 | 8.1 |
| NK | 0.3 | 0.6 | 0.0 |