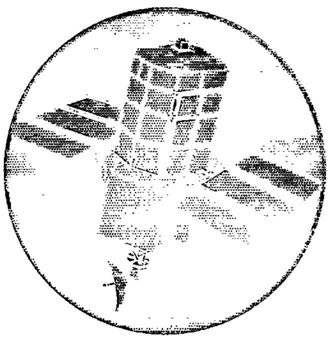
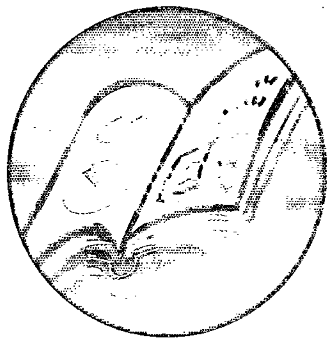
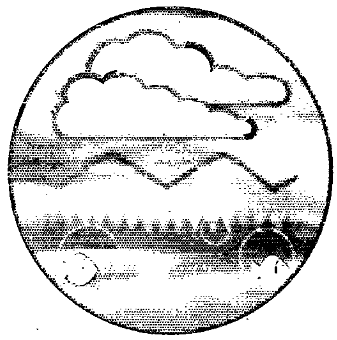
Sea Empress Cost-Benefit Project

Final Report

Research and Development

Technical Report

P119

ENVIRONMENT AGENCY

Sea Empress Cost-Benefit Project

Technical Report P119

L Y Moore, A J Footitt, L M Reynolds, M G Postle, P J Flyod, T Fenn S Virani

Research Contractor:
Risk & Policy Analyts Ltd.

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Environment Agency
Rio House
Waterside Drive
Aztec West
Bristol
BS32 4UD Tel: 01454 624400 Fax: 01454 624409

IC Code: BDOQ

Dissemination status
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Statement of use
This Technical Report fully describes a study with the aim of developing monetary estimates of the economic impacts arising from the Sea Empress oil spill and clean-up, and identifying cost-effective risk mitigation measures to prevent future spills. It will be of interest to Water Quality staff likely to be affected by such incidents when they arise, and will also be of interest to organisations and individuals outside the Agency who have an interest in UK coastal waters.

Research Contractor
R&D Project P2-100 was carried out by:

Risk & Policy Analysts Ltd
Farthing Green House
1 Beccles Road
Lodden
Norfolk
NR14 6LT Tel: 01508 528465 Fax: 01508 520758

Environment Agency's Project Manager
The Agency's Project Manager for R&D Project P2-100 was:

Dr. Melanie Barton, Welsh Region

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FOREWORD

The *Sea Empress* incident resulted in the release of 72 000 tonnes of crude oil, the pollution of around 200 kilometres of coastline and the implementation of a ban on commercial and recreational fishing in the affected area. This, in turn, led to costs to: the tourism industry; recreational activities; commercial fisheries; the environment; and human health.

This report, commissioned by the Environment Agency, provides an estimate of the monetary value of the financial and economic impacts of the *Sea Empress* oil spill and describes the approaches used to value these impacts. It also quantifies the likelihood of a similar incident occurring in the future in UK waters. Financial costs of the incident are estimated to be between £60 million and £114 million, with the majority of these (£49 million to £58 million) arising from the clean-up and salvage operations and from the lost cargo and the repair of the *Sea Empress*. Economic costs range between £75 million and £106 million, with a value of between £23 million and £35 million estimated for environmental impacts.

ACKNOWLEDGEMENTS

We, the authors, would like to thank SEEEC for allowing us previews of its Final Report and other documents. We would also like to thank the many other individuals and organisations that provided information for this study.

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GLOSSARY OF ECONOMIC TERMS

Capitalised value: the sum of the discounted values of a future stream of costs or receipts - a once off value (as for property)

Catastrophic event: that which has a sudden, dramatic and widespread impact upon the environment

Complementary goods: those which are purchased along with another good (for example petrol with a car)

Consumer surplus: the difference between the amount paid for a good or service and the maximum amount that an individual would be willing to pay

Contingent valuation method (CVM): a social survey technique used to derive values for environmental change by estimating people's willingness to pay (or to accept compensation) for a specified effect

Cost-benefit analysis (CBA): a form of economic analysis in which costs and benefits are converted into money values for comparison

Demand function: an algebraic expression of the demand schedule with values expressed for all factors affecting demand

Demand schedule: a table showing the level of demand for a good at various prices

Discounting: converts future costs and benefits into comparable units (present value). The discount rate is set by the Treasury at 6%

Dose-response technique: determines the economic value of changes in, say, pollutant concentrations by estimating the market value of the resulting changes in output

Economic analysis: aimed at evaluating all of the effects of a policy or project and valuing them in national resource terms. Takes place in a with and without framework

Economic rent: a payment in excess of what is necessary to keep to its present employment

Existence values: values which result from an individual's altruistic desire to ensure that an environmental asset is preserved and continues to exist into the future (a non-use value)

Externalities: goods which remain unpriced and thus are external to the market (i.e. free goods such as those relating to the environment, with an example being pollution)

Financial analysis: aimed at determining the cash flow implications of a policy or a project to the commissioning organisation and ensuring that these are sustainable in that sufficient funds are generated to meet outflows

Hedonic pricing method (HPM): an implicit price for an environmental attribute is estimated from consideration of the real markets in which the attribute is effectively traded (e.g. water quality improvements and property values)

Implicit price: the opportunity cost of the use of resources that a producer already owns

Intrinsic/inherent values: related to existence values and are those which are said to reside in non-human biota and which are not related to any form of human satisfaction

Irreversible effects: e.g. the loss of a unique natural feature, an ecosystem or species and very long-term changes to the natural environment

Market price approach: in a perfectly competitive market the market price of a good provides an appropriate estimate of its economic value. In markets which are not perfectly competitive, economic value is calculated by removal of subsidies or other price distortions

Neo-classical economics: an economic theory which uses the general approach methods and techniques of the original nineteenth century economists

Net present value (NPV): the present value (i.e. in year 0) of the difference between the discounted stream of benefits and the discounted stream of costs

Non-use value: values which are not related to direct or indirect use of the environment (option, existence and bequest values)

Opportunity cost: the value of a resource in its next best alternative use

Option value: value to a consumer of retaining the option to consume a good

Protest votes: the responses of those who refuse to take part in a contingent valuation survey (e.g. those who refuse to value the environment because it is priceless)

Replacement costs approach: impacts on environmental assets are measured in terms of the cost of replacing or recreating that asset

Residual value: the remaining value of an asset at the end of the analysis

Resource costs/values: cost of marketed goods or services (adjusted to economic prices) used as inputs to, or consumed as a consequence of an action

Scarce resources: resources available are insufficient to satisfy wants

Sensitivity analysis: key assumptions and values are varied so as to determine their effect on the choice of best option

Social benefit: the sum of the gains or benefits from an activity

Social cost: the sum of money which is just enough when paid as compensation to restore all losses to their utility level

Sustainable development: some acceptable measure of national well being (e.g. gross national product or some other agreed measure of welfare) which is at least constant and preferably rising over time

Total economic value (TEV): the sum of use values (direct and indirect) plus non-use values (option, bequest and existence)

Transfer payment: a payment for which no good or service is obtained in return, e.g. a tax or subsidy

Travel cost method (TCM): the benefits arising form the recreational use of a site are estimated in terms of the costs incurred in travel to the site

Uncertainty: stems from a lack of information, scientific knowledge or ignorance and is characteristic of all predictive assessments

Use value: a value related to the actual direct or indirect use of the environment (e.g. recreational values)

Utility: the satisfaction an individual receives from the use, access to or existence of a good

Willingness to accept (WTA): (also willingness to sell) the amount an individual will take in lieu of being able to partake in an activity for a given length of time (usually a year, or season)

Willingness to pay (WTP): the valuation placed by an individual on a good or service in terms of money

With and without framework: economic analysis considers the costs and benefits both with and without a proposed option. The without option is sometimes known as the do-nothing option

EXECUTIVE SUMMARY

INTRODUCTION

On 15 February 1996, the *Sea Empress* ran aground on its approach to the Port of Milford Haven, resulting in the loss of 72 000 tonnes (t) of crude oil which subsequently impacted 200 kilometres of the South Wales coastline. The area affected was of considerable conservation importance, being associated with a large number of designated sites including two National Nature Reserves and a Marine Nature Reserve. Much of the affected coastline lies within the Pembrokeshire Coast National Park which was designated largely for its coastal landscape.

The majority of the oiled area was clean by May 1996, the operation involving at its peak over 1000 workers. The bulk of the oil, for example that at high priority sites, was removed by the end of February and early March. However, partly as a result of storms, some cleaned areas were subsequently re-oiled. Some oiled areas have been left to clean themselves naturally, while other cleaned areas continued to contain patches of deep sub-surface oil residues over one year after the incident.

Some local industries were particularly affected by the spill. For example, the area has a thriving tourist industry which is closely linked to the coastal environment and its excellent watersports opportunities. The number of tourists visiting the area was lower than predicted from recent trends and limited access to beaches owing to the oil and clean-up operations affected both local and visitor recreational activities. The local economy also has an historical reliance on harvests from commercial fisheries. Following the spill, Fisheries Exclusion Orders caused the cessation of all commercial and recreational fishing activity in a designated area and in all associated rivers and streams. Having been removed in nine stages, parts of the ban were still in place until September 1997. In addition to these costs, health effects were reported by the clean-up workers as well as the general population.

In early 1997, the Environment Agency (EA) commissioned Risk & Policy Analysts Limited to develop monetary estimates of the economic impacts of the *Sea Empress* oil spill and clean-up, and to quantify the risks associated with the movement of oil in UK waters. The results of this work are to be used in identifying cost-effective risk mitigation measures to prevent future spills.

Key sources of data were the International Oil Pollution Compensation (IOPC) Fund, the Sea Empress Environmental Evaluation Committee (SEEEC) Final Report and the reports of individual SEEEC projects. These were augmented by wider literature review and consultation. Whilst several factors acted as major barriers to rapid and efficient data gathering, it has still been possible to place a monetary value on many of the impacts arising from the *Sea Empress* incident and to quantify risks associated with the seaborne transport of oil in UK waters.

For economic impacts, the valuation approach was that of social cost-benefit analysis (CBA) which is described below. For the risks associated with the movement of oil, data on the number and nature of vessels, their cargoes, operational characteristics of the port, etc. were combined with the numbers of past incidents and accidents to derive 'expected' incident and accident rates. Thus it was possible to establish whether actual accident rates for UK waters differ significantly from the expected.

COST-BENEFIT ANALYSIS

CBA is based on the principles of neo-classical welfare economics which is concerned with the allocation of scarce resources. It provides a rational and systematic framework for evaluating actions by expressing all potential impacts in a directly comparable unit of measurement, that of money. Thus, all costs and benefits are treated in the same manner, ensuring that environmental and social effects are given equal consideration to private sector gains and losses. CBA therefore extends beyond financial analysis, by analysing the implications of an action from a social perspective. As an economic analysis of costs and benefits, CBA differs from the financial analysis in three main respects: (1) it places a monetary value on impacts which normally fall outside the marketplace such as environmental costs and benefits - for example, conservation effects; (2) it is concerned with changes in profit and not changes in income - for example, commercial fisheries; and (3) it estimates net national losses by taking into account the potential shift of activities elsewhere - for example, tourism.

Of relevance to this study is the concept of 'total economic value' (TEV) of an environmental asset. This is the sum of 'use' values and 'non-use' values. The former are benefits gained from actual use of the environment (for example, angling) and comprise two components: the cost of undertaking an activity; and the additional willingness to pay for that activity (deemed 'consumer surplus'). Non-use values comprise option values, bequest values and existence values. The first of these relates to the ability to use an environmental asset in the future, the second to the ability to bequeath an asset to future generations, and the third to an altruistic desire to preserve an asset and ensure its continued existence.

A range of valuation techniques has been developed for valuing environmental effects (although it may not always be possible or appropriate to convert all effects into money values). Many of these derive an individual's willingness to pay for an environmental benefit as revealed in the marketplace, through individuals' actions, or as directly expressed through surveys. For some affected sectors, a benefit transfer approach has been adopted in valuing non-market goods. Benefit transfer involves taking a value or benefit estimate developed for a previous project or policy decision and transferring it to another. Thus, some impacts of the *Sea Empress* oil spill have been valued using estimates derived through previous surveys of 'willingness to pay' to avoid similar impacts. (All valuations are given in 1996 prices).

CLEAN-UP AND SALVAGE COSTS

The *Sea Empress* incident imposed costs on those involved in the clean-up and salvage operations. For example, clean-up costs were incurred by the Marine Pollution Control Unit (MPCU) which was responsible for marine clean-up and Pembrokeshire Country Council (PCC) who undertook land-based clean-up.

Under the 1969 Convention on Civil Liability for Oil Pollution Damage and the 1971 Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, the costs incurred as a result of spills of persistent oils can be recovered from the Ship Insurers (Skuld Club) and the IOPC Fund (although specific criteria must be met in order for payment to be agreed). Data available at the time of the analysis indicated that claims totalling nearly £9 million had been made for costs associated with clean-up and property damage, with £3.6 million approved for payment. (Data gathering for the study ceased at the end of November 1997. The most recent IOPC Fund data provided at this time were dated 1st October 1997). These data do not include the costs incurred by some organisations which had not claimed at this time, for example MPCU incurred costs of just under £12 million. In addition, the then Department of Transport may have incurred costs associated with monitoring salvage operations. Estimates of total payments under the Fund range from £22 million to £30 million.

It would be inappropriate to take payments under the 1971 Fund as a measure of the financial costs of the incident because: (1) Fund criteria only address some of the costs arising from oil spills; (2) some organisations may be unable to substantiate claims (and thus will not receive compensation); and (3) not all those eligible will claim from the Fund. For the first of these, the fact that loss or damage would not have occurred had the oil spill not happened is not sufficient to claim compensation - a reasonable degree of proximity must also to demonstrated. In addition, the 1971 Fund is not responsible for compensating for the repair of the *Sea Empress* (circa £21 million) nor for loss of cargo (circa £5 million) which are covered by separate insurance.

Overall, direct costs are estimated at between £49 million and £58 million, taking account of other costs such as those related to research commissioned as a result of the oil spill.

TOURISM

Pembrokeshire is a popular destination for Welsh, other UK and overseas visitors. Its tourism industry employs between 15 000 and 20 000 people and has a revenue of around £200 million per annum. To estimate the costs to tourism from the *Sea Empress* oil spill, payments under the 1971 Fund were used as a first source of data. However, consultation indicated that 70% of tourism businesses that experienced a financial impact may not have claimed due to: (1) the complexity of the claims procedure; (2) the requirement to provide records of performance and income over time; or (3) the requirement to provide written evidence of lost bookings owing directly to the spill. Owing to the nature of the tourism industry, many smaller, less organised operators would not collate this information.

Several studies have attempted to value the tourism impacts from the *Sea Empress* oil spill and clean-up. The Wales Tourist Board (WTB) analysed these studies to establish the level and nature of identified impacts. They concluded that "no consistent or measurable trends in tourism performance emerge for Pembrokeshire overall in 1996". Despite the year's overall performance remaining relatively unchanged, there were specific, significant impacts to some individual operators including one company specialising in water-based activities which lost half of its turnover for 1996 and one quarter of that for 1997. A number of actions was also taken to minimise impacts to the region including a reassurance campaign co-ordinated by Tourism South and West Wales.

Four estimates of costs to the tourism industry were provided from various sources: (1) estimates of total payments under the 1971 Fund indicate costs of between £4 million and £18 million, assuming that payments are only half of costs incurred; (2) WTB estimate that lost bookings may be equivalent to between £1.3 million and £5 million; (3) a 7% decrease in hotel bed-nights sold during 1996 compared with 1995 may be equivalent to between £20 million and £27 million; and (4) the Pembrokeshire Tourism Federation has suggested that lost revenue across tourism in

Pembrokeshire between 1995 and 1996 may be between £12 million and £46 million. The mid point of this range (i.e. £18/£20 million) is taken as the value of financial impacts.

Financial costs cannot be assumed to represent economic costs because of a potential shift in activities to elsewhere (e.g. if a holidaymaker chose not to visit Pembrokeshire but somewhere else in Wales, there may be no net impacts to the Welsh economy). Based on the assumptions concerning the percentage of financial costs which represent profit and the alternative holiday destinations chosen by those visitors lost from Pembrokeshire and Wales, it is estimated that for financial losses of £20 million economic costs would be £1.3 million for Wales and £0.13 million for the UK.

RECREATION

There is a relationship between impacts on tourism and recreation; however, the costs associated with each are quite different. Costs to tourism relate mainly to the impact of the oil spill on the overall performance of tourism in 1996. Recreational costs, on the other hand, relate to lost activity days owing to the spill, or changes in the quality of activity undertaken. For example, less bathing occurred during the summer of 1996 in response to the oil spill.

Other activities which appear to have been affected by the spill and clean-up include canoeing, sand/land yachting and paracarting, surfing and windsurfing. Access to popular coastal sites was affected immediately following the spill and during the clean-up. Impacts to other activities were minimised due to the timing of the spill. Longer-term impacts were experienced, however, by more formal events, such as the Celtic Watersports Festival. This did not take place until August and yet suffered reduced attendance as a result of perceived impacts.

Estimating lost access to the 64 beaches affected by the oil spill and clean-up involved scoring and ranking beaches according to key features (i.e. access, facilities and quality of bathing waters) and then attributing visit numbers to them (using some visitor data combined with information on the spread of beach visits throughout the year). Using this approach, it appears that 450 000 general beach visits may have been lost directly following the spill (based on an assumption that access was not possible from February 15 until March 10, with visit rates then at half their normal number until the end of March). The economics literature suggests that lost visits to UK beaches have a value of between £1.00 and £5.20 per visitor day, leading to costs of between £0.45 million and £2.3 million.

Overall, recreational impacts are estimated at between around £1 million and £2.8 million, with £0.5 million associated with reduced participation in swimming (for 100 000 lost visits valued at a consumer surplus of £5 per visit); however, data did not permit the valuation of impacts to surfing and windsurfing.

COMMERCIAL FISHERIES

The fishing industry in South West Wales employs approximately 1000 fishermen and there are over 300 licensed fishing vessels. It is estimated that for every job at sea, there are between 3 and 5 shore-based jobs. The main markets are for commercial fish, lobster, brown crab and spider crab, whelks and cockles, which are supplied to Spain, Brittany, Portugal, Japan, Korea and local markets.

Immediately following the oil spill, local fishermen agreed a voluntary fishing ban and the fishery was later closed by the Ministry of Agriculture, Fisheries and Food (MAFF). The fisheries exclusion zone (FEZ) impacted both commercial inshore and offshore fisheries, as well as recreational angling. Once the FEZ was lifted for a given species and area, there was the potential for residual impacts associated with reductions in harvesting rates arising from reductions in fish numbers or impacts on spawning for example. In addition, there was the possibility that the incident may have reduced the market for fish from the oiled area. Despite the potential for effects, SEEEC studies have not identified any long term negative impacts resulting from the spill. Indeed, there are reports that the *Sea Empress* spill has indirectly improved some aspects of the fishery, for example the ban on fishing has allowed populations of some species to recover.

At the time of the study, data indicated approval for payments of £6.8 million by the 1971 Fund, with £5.5 million of this associated with normal fishing activity within the FEZ. Data from the South Wales Sea Fisheries Committee (SWSFC) indicates that the landed value of the catch from its District in 1996 was £5.6 million, which is similar to previous years. The fact that payments under the 1971 Fund equal the value of the catch from the SWSFC District (which encompasses the FEZ) indicates that, unlike other sectors, payments under the Fund provide a fair estimate of financial costs to fishermen. Indeed, payments under the Fund are surprisingly high.

Despite the above, the fact that compensation claims are rigorously audited by the Fund indicates that payments do reflect the lower bound of losses incurred by fishermen. As such, payments under the 1971 Fund of £6.8 million are taken as the lower bound estimate of the financial costs to commercial fisheries arising from the *Sea Empress* oil spill. Upper bound costs are estimated at £10 million which includes MAFF's costs in operating the FEZ. Most of these costs are financial, with economic costs valued at between £0.67 million and £1 million (assuming that 10% of lost income is profit).

RECREATIONAL FISHERIES

In addition to the above restriction, a ban was also placed on fishing for migratory salmon and sea trout in all rivers and streams discharging into the affected area due to risks associated with the consumption of fish which may have passed through contaminated water during migration. This affected the start of the fishing season until 21 May 1996 (i.e. for about 22% of the season). Claims to the 1971 Fund have been made by those owning or leasing fishing rights in the rivers affected by the fishing ban. Known direct costs to angling clubs and riparian owners amount to £0.13 million, although a further nine clubs may also be putting in claims for loss of income.

Migratory salmon and sea trout anglers were also impacted, incurring consumer surplus losses associated with reductions in angling visits. Information provided by five of the 21 angling clubs affected by the ban indicates that between 1995 and 1996, club membership reduced by around 7%. If these five clubs are representative of all those affected, total club membership will also have reduced to the same degree. It also appears that there was a 21% reduction in visit rate across all types of anglers, with the largest reduction experienced by occasional anglers. The reduction in the number of angling visits is estimated to lie between 21 700 and 36 900 and, using a benefit transfer approach with a value per visit of £26, there may be a corresponding change in consumer surplus of between £0.56 million and £0.95 million.

There was also a reduction in the numbers of sea- and coastal-based angling visits for species such as bass, cod, whiting and mackerel. The number of lost visits was estimated from national data on participation rates combined with an estimate of the percentage of trips lost as a result of the ban, taking into account the availability of alternative sites. The associated costs were valued using consumer surplus estimates for bass, which were adjusted for other species using wholesale fish prices (i.e. it was assumed that consumer surplus varies in direct proportion to the wholesale price of fish). Surveys of bass anglers indicate a wide variation in the consumer surplus associated with a years angling (£88 to £2140 per annum), valuing the impacts of the *Sea Empress* incident to this group at between £0.07 million and £1.7 million.

The overall costs to all recreational anglers appears to be between about £0.76 million and £2.7 million.

INDUSTRY

Traditionally, the key components of the Pembrokeshire economy have been agriculture, tourism, the oil industry (and related businesses), the defence industry and, to some extent, fisheries. However, the importance of agriculture is in decline, following a general decline in this sector coupled with other factors such as the BSE crisis. In addition, the military has scaled down its activities in the area considerably. As a result, other industries, particularly tourism and the oil industry, are increasing in importance. With respect to the latter, of the original four refineries based at Milford Haven, one closed in the 1980s and one other announced its closure last year.

It is understood that the refineries suffered some disruption to oil deliveries and the export of oil products as a result of the spill. Imports of fuel to Pembroke Power Station may also have been similarly impacted, and as the power station was on-line during some of the incident, cooling water flows were interrupted. It has been suggested that the *Sea Empress* incident was a key factor in National Power's decision to drop its plans for burning orimulsion at the power station, and that this impact should be valued in monetary terms. This has not been possible due to a number of factors including: (1) the difficulties in obtaining a true estimate of the importance of the incident; (2) an inability to quantify the likelihood that the scheme would have been given the go-ahead had the oil spill not occurred; and (3) the need to estimate the change in risks arising from the sea transport of the orimulsion fuel.

The military facility at Pendine supports a rocket test track and a firing range and the former is operated as a business. It is reported that some business was lost as a result of the clean-up. Total costs are estimated to be between £0.013 million and £0.021 million and were not reclaimed from the 1971 Fund. Costs to the order of £0.004 million were also incurred by the Castlemartin Range. These costs were limited as the spill occurred during that part of the year when the Range training facility is not in operation. At any other time of the year costs associated with lost training may have been up to £0.001 million per day.

While there were some costs to industry in Pembrokeshire, the economy of the county also benefited from the oil clean-up. For example, the clean-up operations provided temporary employment for some individuals.

CONSERVATION EFFECTS

The affected coastline is of outstanding beauty and scientific interest, and most lies within Pembrokeshire Coast National Park, the only national park in Britain primarily designated for its coastal and estuarine landscapes. The main area impacted by the spill contains 35 Sites of Special Scientific Interest and two National Nature Reserves. In addition, part of the area forms one of the UK's three Marine Nature Reserves and much of the coastline has been defined as Heritage Coast. Parts of the area are further designated by the European Commission as Special Protection Areas under the EC Birds Directive and there are also plans for three Special Areas of Conservation under the Habitats and Species Directive (1992).

In the weeks following the spill, large numbers of dead or moribund marine animals were washed-up on beaches. Longer-term impacts on the offshore marine community appears to be minimal, apart for a reduction in small crustacean species, such as amphipods, in some locations.

One heavily affected rocky shoreline species was the limpet and it is expected that in the worst affected areas populations could take between ten and 15 years to recover. There were also some large scale mortalities of barnacles, but these effects were short-lived and by October 1996 barnacle densities were similar to those before the spill. In addition, 137 of the rare population of 150 cushion starfish (*Asterina phylactica*) were lost and recovery has been slow and uncertain. These impacts aside, there does not appear to be any serious or long-term damage to lower shore or rockpool communities.

The oil spill also resulted in some impacts to sediment shores which are particularly important as fish nurseries and are feeding areas for migrant birds. The greatest decrease was of small crustaceans, especially amphipods, with molluscs also being impacted to some extent. With respect to maritime vegetation, while some was impacted by the oil, most effects have been short-lived. The saltmarsh in Milford Haven waterway was directly impacted by the oil spill and studies have been initiated to map long-term effects.

There was no impact on mammals as a result of the *Sea Empress* incident, however large numbers of birds were oiled. The worst hit species was the common scoter which made up two thirds of the birds recorded. Most of the rest were auks, mainly guillemots, which together with common scoters and razorbills made up over 90% of recorded casualties. These birds are vulnerable to oiling as they spend much time on the surface of the water and dive to feed. In contrast, many gulls and herring gulls survived oiling and a number of important species appear to have avoided any significant impact. In particular, puffins, Manx shearwaters and storm petrels were away from the region at the time of the spill, and the oil did not reach the important gannet population at Grassholm Island.

Applying the replacement costs approach to observed strandings of marine animals generates a value of the order of £0.05 million. This involved quantifying the numbers of individuals stranded for each affected species (from mainly qualitative reports) and combining this with a price per individual from a biological supply company. If estimates of amphipod losses are taken into account, then costs would be of the order of millions of pounds. For this value to be considered sound in theoretical terms there has to be an indication that society would be willing to pay such replacement costs. In the case of amphipods, evidence suggests that losses will be relatively short-lived, with some populations already at pre-spill levels. Whether a valuation of millions of pounds would be accepted for the temporary loss of these crustaceans is debatable.

Non-use values were applied to give a monetary valuation of the environmental impacts of the oil spill. Three values were considered appropriate for application to the *Sea Empress*: (1) willingness to pay (WTP) values of £0.14 per household per beach for protecting 23 EC designated beaches from pollution giving a valuation of £30 million per event for all households in the Welsh Water region; (2) WTP values of £166 per household per spill for avoiding a moderate oil spill giving a valuation of £23 million per event for all households in Dyfed; and (3) WTP values of £32 per household for avoiding an *Exxon Valdez* type oil spill giving a valuation of £35 million per event for all households in the Welsh Water region.

HUMAN HEALTH

The vapour cloud resulting from the *Sea Empress* oil spill had the potential to impact the health of workers involved in the clean-up and the health of the general population. A study by Dyfed Powys Health Authority (DPHA) examined the impacts of the oil spill on the health of the general population and found increased prevalence of some symptoms including nausea, headaches, sore eyes and skin irritation.

Modelling of the vapour cloud emanating from the pool of oil released from the *Sea Empress* indicates that as many as 37 500 people could have been exposed to oil vapour at a concentration above the odour threshold - the level at which some symptoms could result. In addition, around 25 500 people are estimated to have been exposed to oil vapour via oiled beaches. Using data from DPHA, it is estimated that a total of around 19 000 people experienced symptoms as a result of the *Sea Empress* oil spill. The cost of symptoms has been estimated from data on their prevalence and willingness to pay for their avoidance. For example, it is estimated that around 8 875 people experienced headaches as a result of the oil spill. Studies indicate a willingness to pay of £12 per day to avoid a headache valuing this symptom at £0.1 million (assuming headaches lasted one day). Total acute health effects have been valued at between £0.23 million and £1.1 million, with the variation arising from different assumptions concerning the frequency of symptoms and their value.

The *Sea Empress* oil spill is also reported to have resulted in psychological impacts to those living in the area affected by the incident. In particular, the psychological health of the exposed population was found to be 4.8% lower than a control group. It has been possible to value these impacts using a stress model which compares the stress associated with oil spills with that arising from other disasters. Using this approach it is estimated that the value of psychological effects ranges between £0.95 million and £1.9 million, with the analysis being particularly sensitive to assumptions concerning the size of the affected population.

SUMMARY OF COSTS

The summarised costs of the *Sea Empress* oil spill and clean-up are presented in Table 1. As this shows, the total financial costs are in the range of £60 million to £114 million, and economic costs are in the range £75 million to £106 million. Either ends of these ranges represent lower and upper bound costs with the actual costs of the incident most likely falling somewhere between.

Table 1: Summary of Costs (£ million)

Category	Financial Costs		Economic Costs	
	Lower Bound	Upper Bound	Lower Bound	Upper Bound
Direct Costs	49.1	58.1	49.1	58.1
Tourism	4.0	46.0	0.0	2.9
Recreation	-	-	1.0	2.8
Commercial Fisheries	6.8	10.0	0.8	1.2
Recreational Fisheries	0.1	0.1	0.8	2.7
Local Industry	0.0	0.0	0.0	0.0
Conservation/Non-Use	-	-	22.5	35.4
Human Health	-	-	1.2	3.0
Total	**60.0**	**114.3**	**75.3**	**106.1**

Note: Costs are to the nearest £0.1 million.

MARINE TRANSPORT RISKS

Data on tanker incidents and oil spills were analysed to derive incident rates at international and national levels. Internationally, the serious casualty rate (as defined by the International Maritime Organization - IMO) for large vessels is 0.02 per vessel per year (for vessels in excess of 10 000 deadweight tonnes - dwt). In other words, there is 1 chance in 50 per year that a particular tanker will be involved in an event which leads to a total loss, serious structural damage, loss of life, pollution or a breakdown necessitating towage. Not all serious casualties result in oil spills.

The probability that an incident will escalate to a major spill (where a major spill is 30 000t or more) is 0.014, or 1 chance in 70, based on historical data since 1986. Historically, on average, there has been a major spill (>30 000t) every year somewhere in the world, with most (28%) resulting from groundings.

Each year, 1 830 million tonnes of oil/oil products are transported globally compared with 217 million tonnes in UK waters. It might, therefore, be expected that 12% of international serious casualties, or 7.5 per annum (pa), would occur in UK waters. Incident data suggests that the actual number of serious casualties in and around UK waters is in the range 4 to 8 pa. Thus, the general level of tanker safety in UK waters is not significantly better or worse than that experienced internationally. With a best estimate of six serious casualties per year and the escalation probability given above, a major spill (>30 000t) would be expected in UK waters once every 12 years. This is entirely consistent with the incidents involving the *Torrey Canyon* (1967), the *Braer* (1993) and the *Sea Empress* (1996).

CONCLUSIONS

Based on historical data relating to oil tanker incidents and disasters, the *Sea Empress* oil spill was to be expected. Another major oil spill (>30 000t) would be expected in UK waters within the next 12 years. The economic impact of the incident was minimised owing to the time of year when it occurred, for example tourist, fishing and defence training activities were not at peak levels. Even so, the oil spill and clean-up resulted in financial costs of between £60 million to £114 million, and economic costs of between £75 million to £106 million.

RECOMMENDATIONS

Given that there is a significant risk of another major oil spill in Milford Haven, it is recommended that priority be given to implementing a range of risk reduction measures. The numbers of future shipping incidents and oil spills should continue to be monitored (and analysed) to determine the effectiveness of the adopted risk reduction strategy.

At a national level, it is recommended that much greater emphasis is placed on using the information on shipping incidents in UK waters (routinely gathered by MAIB and others) to reduce marine transport risks.

KEY WORDS:

clean-up
cost benefit analysis
fisheries
human health
industrial
marine pollution
oil spillage
recreation
risk analysis
tourism

1. INTRODUCTION

1.1 Background to the Study

On 15 February 1996, the *Sea Empress* ran aground approaching the Port of Milford Haven. In the following days, attempts were made to refloat the vessel during which a total of 72 000 tonnes of oil were spilt. This followed only three years after the *Braer* incident in 1993 (an oil release of 83 000 tonnes) and the *Torrey Canyon* incident in 1967 (119 000 tonnes of oil spilt). These spills identify the UK with three of the world's top twenty oil spills.

As a result of the *Sea Empress* oil spill, 200 kilometres of the South Wales coastline were oiled. The area affected is important environmentally, being associated with a large number of designated sites including two National Nature Reserves and a Marine Nature Reserve. It is also home to the Pembrokeshire Coast National Park which is the only such park designated for its coastal features and one of the attractions drawing large numbers of tourists to Pembrokeshire each year. The area also supports locally significant commercial and recreational fisheries and related businesses.

As may be expected, the *Sea Empress* oil spill did have an impact on the ecology and economy of the area. In order to estimate the scale of the former, the Government set up the Sea Empress Environmental Evaluation Committee (SEEEC) which commissioned over 80 scientific studies for this purpose.

This report presents the results of a cost-benefit analysis of the incident and is separate from the work commissioned by SEEEC. The study was commissioned by the Environment Agency, with the aim of developing monetary estimates of the economic impacts arising from the spill and of identifying cost-effective risk mitigation measures to prevent future spills.

1.2 The Study Objectives and Approach

The objectives of this study were to:

- define the impacts of the disaster from evidence produced by SEEEC projects;
- cost the impact of the Sea Empress oil disaster on the local economy;
- cost the environmental and recreational impacts of the Sea Empress oil disaster;
- analyse the risks of oil transport for the local economy and the environment; and
- recommend the most cost-effective option for preventing a similar future disaster occurring in UK waters.

The approach to the study was based on both a literature review and consultation with relevant parties. One of the key sources of literature was the SEEEC Final Report and the reports of individual SEEEC projects. However, while the SEEEC studies provide comprehensive coverage of environmental impacts, some socio-economic effects such as those on tourism and recreation are not considered to the same degree, with others such as human health not being considered at all. As a result, it was necessary to look for data further afield. In some instances, this involved a review of relevant literature, but in the main additional data were gathered through an extensive consultation exercise. A list of all those contacted is given in Annex 1.

While it has been possible to gather sufficient data to undertake the assessment, the data collection process was frustrated by a number of factors. In particular, the Environment Agency's investigation into the causes of the incident and the subsequent announcement of its intention to prosecute two of the associated parties was a major barrier to rapid and efficient data gathering. This led to delays and constraints on those who could be contacted. While these were necessary to maintaining the propriety of the investigation, they clearly had an impact on the timing and completeness of data collection.

While both the economic and risk assessment components of the project were affected by the above, data collection for the risk assessment suffered the most, owing to a ban on consultation with all consultees until five months into the project. Data gathering was then confounded by other difficulties including legal problems associated with the provision of data by the Department of the Environment, Transport and the Regions and an initial inability to retrieve information from the database operated by the Marine Accident Investigation Branch. The delays in consultation left insufficient time to stagger the consultation exercise concerning the costs of risk mitigation measures and thus did not allow for a phased approach towards focussed data gathering. In addition, some basic data were not supplied in time for inclusion in the report, including up-to-date information from the International Oil Pollution Compensation Fund and information on fisheries impacts from the Sea Empress Fisheries Claimants Group. (In this regard, it should be noted that data gathering ceased at the end of November 1997.)

Despite these problems, it has still been possible to place a monetary value on many of the impacts arising from the *Sea Empress* incident and to quantify associated risks.

1.3 The Cost-Benefit Analysis Approach

1.3.1 Economic versus Financial Analysis

Social cost-benefit analysis (CBA) provides the framework for the analytical approach towards assessing the monetary value of the impacts of the *Sea Empress* spill and towards identifying the most cost-effective risk mitigation option. CBA is based on the principles of neo-classical welfare economics which is concerned with the allocation of scarce resources. It provides a systematic means of evaluating the impacts of a particular course of action by expressing all of the potential impacts in a directly comparable unit of measurement, that of money. By so doing, all costs and benefits are treated in the same manner in the analysis. This approach helps ensure that environmental and social effects are given equal consideration to private sector gains and losses.

As the aim of a social CBA is to analyse the implications of an action from a social perspective, it extends beyond financial analysis, which examines only private costs and benefits. The main differences between the two types of analysis are that:

- financial analysis is aimed at determining only the cash flow or profit and loss implications of a policy or a project; while

- economic analysis is aimed at assessing **all** of the effects of a policy or project and valuing them in national resource terms.

Within a CBA, all costs and benefits are valued at their 'opportunity cost' to the nation. This means that transfer payments, such as taxes and subsidies, are removed from estimated costs or benefits, since these represent neither a gain nor a loss to the nation as a whole.

More significant, however, is the manner in which a CBA treats impacts on private sector operators. A financial analysis involves estimating the change in revenues to an operator associated with a given action, taking into account increases in costs or losses of income. In contrast, a CBA looks at the changes in 'economic rent' or the opportunity costs to the nation as a whole. In this context, economic rent can be defined as returns to an activity, or profits (frequently adjusted for some level of 'normal' returns). For some private sector operations, a loss of productivity is not considered an economic loss to the nation as it is assumed that another firm will increase production to meet demand.

For an analysis such as this, however, it is important to consider not just the economic costs and benefits, but also the financial implications of the *Sea Empress* incident. Financial considerations are obviously important given the impact which the incident had on certain sectors of the local, and potentially regional, economy[1].

1.3.2 Valuation of Environmental Costs and Benefits

A full social CBA includes consideration of all 'external' effects in order to estimate the total social costs or benefits (in addition to financial costs and benefits). External costs and benefits (or externalities) include those corresponding to the range of environmental and human health impacts which occur when the actions of one party cause a loss in the well-being (or satisfaction) of another party, and that loss remains uncompensated. Externalities occur because the functions and services provided by the natural environment are not traded in the marketplace. As a result, the value of effects on the environment and health are not automatically reflected in market prices and have to be assessed in some other way.

One of the key requirements in CBA, therefore, is the valuation of environmental and other social costs and benefits in monetary terms. A range of economic valuation techniques has been developed to assist in the valuation process (although it may not always be possible or appropriate to convert all environmental effects into money values). These techniques attempt to derive an individual's willingness to pay for an environmental benefit (or willingness to be compensated for an environmental loss) as revealed in the marketplace, through individuals' actions, or as directly expressed through surveys.

There are four main groups of methods which can be used to derive monetary values for environmental and human health impacts. For those categories where the benefits relate to non-market effects (e.g. recreation, amenity and conservation benefits), techniques such as the travel cost method, hedonic pricing and the contingent valuation method are used most frequently to

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1 It should be noted that the IOPC Fund uses the term 'economic' in a different way from that used in this report. Indeed, 'economic' costs as defined by the Fund equate to financial costs in this report.

develop estimates of economic gain (or loss). The principles underlying these techniques and the analytical procedures involved in their application can briefly be summarised as follows:

- **Market price/effect on production approach**: for goods sold in a perfectly competitive market, price provides an estimate of economic value. In other markets (e.g. where subsidies are in effect) prices are corrected to reflect opportunity costs (while uncorrected prices reflect financial values).

  One technique in this category is the dose-response technique, which determines the economic value of changes in pollutant concentrations by estimating the market value of the resulting changes in output. For example, changes in fisheries yield are linked to changes in water quality. The replacement costs approach measures impacts on environmental assets in terms of the costs of restoring or recreating the asset.

- **Travel Cost Method (TCM)**: This approach is based on the concept that people spend time and money travelling to a recreational site and that these expenditures, or costs, can be treated as revealing the demand for the site. Surveys of site visitors are undertaken to determine visit rates, where these are a function of travel expenditure, income, any entry fees, environmental characteristics and the availability of substitute sites.

- **Hedonic Pricing Method (HPM):** The hedonic pricing method is based on the concept that the price paid for a complementary good (e.g. a residential property) reflects the buyer's willingness to pay for a particular environmental attribute (e.g. adjoining a high quality river). Application requires the use of regression analysis to determine the relationship between the market price of the property and its attributes, where some relate to environmental characteristics. From this, the implicit price (as part of the overall property price) for a given environmental characteristic is derived.

- **Contingent Valuation Method (CVM):** This method relies on the creation of an hypothetical or experimental market for an environmental good or for a reduced risk of a specified health effect. Individuals are surveyed to determine their willingness to pay (WTP) (or willingness to accept (WTA) compensation) for a specified change in the quality or quantity of the environmental good/health effect. The mean willingness to pay value across all bids (including valid zero bids) is then used to provide an indication of the economic value of the specified change.

The applicability of the above techniques will vary across the different environmental or health impacts of concern. The travel cost method is only applicable to the valuation of recreation related benefits, while the dose-response and hedonic pricing techniques require that a well-functioning market for the good of concern or a complementary good exists. In general, the applicability of the techniques is limited by whether the impacts relate to direct use of the environment or to concerns more associated with conservation and preservation. These two aspects together comprise the *total economic value* of an environmental asset.

The *total economic value* (TEV) of an environmental asset is the sum of what are referred to as *use values* (direct and indirect) plus *non-use values* (option, bequest, and existence). *Use values* are those associated with the benefits gained from actual use (or 'consumption') of the environment and may include private sector uses (industry, agriculture, etc.), recreation benefits (from fishing, hiking, bird watching, photography, etc.), education and scientific benefits, and general amenity benefits.

Non-use values (also known in literature as *passive-use values*) are of three different types: *option values, bequest values* and *existence values. Option values* relate to the desire of an individual to maintain the ability to use the environment at some time in the future (for example, the desire to be able to go sea angling in the future). They reflect an individual's willingness to pay to secure the future of a good and thus express the potential benefits of that good. A related form of value is that attached to preservation or conservation of the environment so that future generations may also have the option of using that asset; this is referred to as *bequest value*.

Existence values are defined as those values which result from an individual's altruistic desire to preserve an environmental asset and ensure its continued existence into the future. These values are not associated with actual or potential use, but solely with the knowledge that the asset is being conserved or preserved (with the continued existence of whales being a good example).

1.3.3 Benefit Transfer Within a CBA

In deriving economic estimates of the costs and benefits associated with an incident such as the *Sea Empress*, there are two approaches which could be adopted. The first is to commission site and problem specific assessments by directly applying the valuation techniques set out above, while the second is to adopt a *benefit transfer* approach. The direct application of the different valuation techniques would involve commissioning specialists studies, which can be costly in both financial and resource terms. Such studies could not be undertaken within the time and budget allowed for this study.

In contrast, a benefit transfer approach can be used to derive order of magnitude estimates of likely costs and benefits. This type of approach reduces the need for field research and simplifies the analysis, and it is this approach which forms the basis for a range of current CBA methodologies such as that set out in the Foundation for Water Research Manual on *Assessing the Benefits of Surface Water Quality Improvements* (FWR, 1996).

Benefit transfer can be defined as the process of taking a value or benefit estimate developed for a previous project or policy decision and transferring it to another. In other words, estimates based on the use of the above valuation techniques, such as the value of a recreational user-day, for one specific site and environmental quality change are assumed to provide a reasonable approximation of the value attached to another site given a similar type of environmental improvement.

There are three different approaches which might be adopted in benefit transfer:

- the transference of mean unit values;
- the transference of adjusted unit values; and
- the transference of a demand function.

Although the latter two approaches are preferred to the first approach, the pool of UK valuation studies available for benefit transfer is relatively small for any given effect, as is the pool of relevant studies carried out in the US and elsewhere. This impacts on the degree of reliability which can be attached to benefit transfer based results at the present time (particularly, as there has been very little work carried out to date on the transferability of results from one country [and therefore culture] to another). However, if the aim is to develop relative order of magnitude indicators of costs and benefits, then the transfer of mean values provides a mechanism for achieving this within an analysis such as this.

1.4 The Risk Assessment Approach

Risk assessment involves the systematic study of potential incidents including an analysis of their causes, likelihood of occurrence and associated consequences. At a broad level, by combining data on the numbers and nature of vessels, their cargoes, operational characteristics of the port, etc. with the numbers of incidents, it is possible to derive 'baseline' incident rates.

Every year, over 1.5 billion tonnes of oil (crude oil and oil products) are moved by vessels ranging in size from small barges to supertankers. Every year (on average), there is a major spill comparable to that from the *Sea Empress*. In addition to such major spills, there are many more smaller spills and other incidents involving the marine transport of oil.

The purpose of the risk assessment component of this study is to review available data on reported spills and incidents at international, national and local levels in order to determine, *inter alia*:

- the likelihood of incidents similar to that of the *Sea Empress*;
- the most likely causes of spills and other incidents;
- whether the historical record for Milford Haven is significantly different than that for the UK national waters; and
- whether the historical record for the UK national waters is significantly different than that for marine transport of oil elsewhere.

Given the results of the analysis, a range of potential risk mitigation measures has been identified.

The *Sea Empress* disaster has been subject to a formal investigation (MAIB, 1997b) resulting in a number of recommendations covering such topics as improving the standards of piloting, reviewing emergency plans and procedures and urging the International Maritime Organisation to review regulations for tanker design. Whilst some of these recommendations are referred to, it is not the intention to review the practicality and cost-effectiveness of each of these recommendations in detail, rather, the intention is to 'stand back' from the *Sea Empress* disaster and consider some of the more general issues relating to the likely success of different options.

1.5 Structure of the Report

Section 2 provides an overview of the *Sea Empress* oil spill, the area affected by it and associated impacts. The valuation of the consequences associated with the oil spill are presented in Sections

3 to 10, which respectively cover costs arising from clean-up and salvage operations, tourism, recreation, commercial fisheries, recreational fisheries, local industry, conservation and human health. These values are brought together in Section 11.

Section 12 sets out the risks associated with the transport of oil to and from Milford Haven, while Section 13 covers possible risk mitigation measures. Conclusions and recommendations are presented in Section 14.

Supporting information for each of the Sections 1 through to 12 is presented in the corresponding Annex (for example, supporting data on tourism (Section 4) are presented in Annex 4).

2. THE OIL SPILL AND AFFECTED AREA

2.1 The Grounding of the *Sea Empress* and Subsequent Oil Spill

At 2007 hours on 15 February 1996, the 147 000 dead weight tonnes (dwt) tanker *Sea Empress* grounded on the western edge of the Mid Channel Rocks on its approach to Milford Haven[2]. After this initial grounding and despite the fact that the main engine had been put astern and both anchors dropped, the vessel's momentum continued to carry it such that it came to rest aground some 900 m northwest of the initial grounding position. The vessel was subsequently refloated and, despite plans to tow the casualty into deeper water, *Sea Empress* was held in position for lightering. In the face of worsening weather conditions, a decision was made to turn *Sea Empress* to face an incoming gale. This operation was completed on 17 February but, with tugs and main engines unable to hold her position, the casualty grounded off St Ann's Head at about 1805 hours. *Sea Empress* was evacuated in the early hours of 18 February due to concerns over structural failure. At about 0800 hours she drifted free of her grounded position. There were a number of subsequent groundings as tugs tried to maintain her position within 'the pool' until the casualty was finally refloated on the evening of 21 February and taken to a berth on the north side of the Haven.

Sea Empress was loaded with a cargo of 130 018 tonnes (t) of Forties light crude oil blend. The initial grounding caused the rupture of the starboard side cargo and segregated ballast tanks, causing the release of around 2 000 t of oil[3]. The estimated timing and sizes of subsequent releases are provided in Table 2.1.

2.2 Brief Summary of Response and Fate of Oil

Conditions were very favourable for the primary response to the spill - the application of dispersants to assist the dispersion and dilution of oil into the water column. It has been estimated that between 43% and 57% of the spill was dispersed at sea, by both chemical and natural means[4]. The ultimate fate of this oil is unknown but it is probable that a proportion will still be attached to bottom sediments in the affected area (the remaining being carried away by currents). Between 1% and 2% of the spill was recovered at sea using mechanical recovery, with a significant proportion targeted near sensitive areas.

In all, around 200 kilometres (km) of coastline was affected by oil coming ashore (see Figure 2.1). A number of tar balls washed up on shores both north of St Ann's Head and on the south coast of Ireland. It is estimated that between 1.5% and 3.5% of the spill was recovered from the shoreline with between 4% and 8% still remaining on it. Between 35% and 45% of the spill evaporated.

2 This sub-section is based on the findings of the official MAIB Inquiry into the incident (MAIB, 1997b).

3 It should be noted that the Master reported an initial cargo loss of around 5 000 t. The figure of 2 000 t reflects the estimates of the Marine Pollution Control Unit (MPCU) from its surveys.

4 Information on the fate of oil is taken from the SEEEC Report Draft 4 (SEEEC, 1997).

Table 2.1: Estimated Times and Dates of Cargo Losses from *Sea Empress*

Date	Time	Estimated Oil Loss (t)
15 February	2139	2 000
17 February	2334	5 000
18 February	1158	2 000
19 February	0019	5 000
	1243	8 000
20 February	0103	20 000
	1326	15 000
21 February	0145	10 000
	1408	5 000
TOTAL LOSS		**72 000**

2.3 Overview of Impacts

The rugged coastline of south west Wales is of outstanding beauty and scientific interest, comprising a wide range of beach types including: rocky shores; sand, gravel and shingle beaches; mudflats; and saltmarshes. The oiled coastline is associated with a number of designated sites, specifically:

- 35 Sites of Special Scientific Interest (SSSIs)
- 2 National Nature Reserves: Grassholm and Skomer Island
- a Marine Nature Reserve at Skomer (the only such reserve in Wales)
- Special Protection Areas (SPAs): large parts of exposed cliff coasts, including the main sea bird islands, are designated as SPA's under the EU Wild Birds Directive for their chough populations
- Special Areas of Conservation (SACs): much of the coastline is designated as a candidate SAC under the EU habitats and Species Directive; in addition, the Pembrokeshire Islands, including Milford Haven is a possible SAC due to its marine biological features.

These are shown on Figure 2.2 with sensitivity maps included in Annex 2 of this report.

The area has a thriving tourist industry and, as pictures of the oiled Pembrokeshire coastline were broadcast around the world, a reduction in the number of tourists visiting the area was reported. At the same time, access to beaches for recreational purposes was limited due to the presence of oil and the clean-up operations. Over 1 000 workers were involved in the clean-up and there have been reports of health effects in this group as well as in the general population.

Immediately following the spill, local fishermen imposed a voluntary fishing ban across the affected area. To ensure that human health and commercial fisheries in the area were protected, this was followed by the placing of a Fisheries Exclusion Order covering approximately 810 square miles of sea. Subsequently, a separate order was made for all rivers and streams discharging into the designated area. Thus, all commercial and recreational fishing activity in the area stopped and was unable to resume until the ban was lifted. This was removed progressively in nine stages with the last restriction remaining in place until September 1997.

With respect to environmental impacts, the timing of the spill was, in many respects, fortunate. Several important bird populations, including Manx shearwaters and puffins, had not yet returned to the region for breeding. Relatively few fish were in the area, several species being out to sea for the winter, and feeding activity was at a seasonal low. Had the spill occurred later in the year, for example, during the seal pupping season, the overall impact may have been quite different.

More generally, there were a number of factors acting in combination which limited the effects of the oil spill. There were:

- the time of the year;
- the type of oil;
- weather conditions at the time of the spill;
- the clean-up response; and
- the natural resilience of many marine species.

More information on the effects of the oil spill are included in subsequent sections which deal with the following impact categories: direct costs, tourism, recreation, commercial fisheries, recreational fisheries, local industry, conservation/non-use and human health. Further details of the environmental impacts of the oil spill are set out in the SEEEC Final Report (SEEEC, 1998).

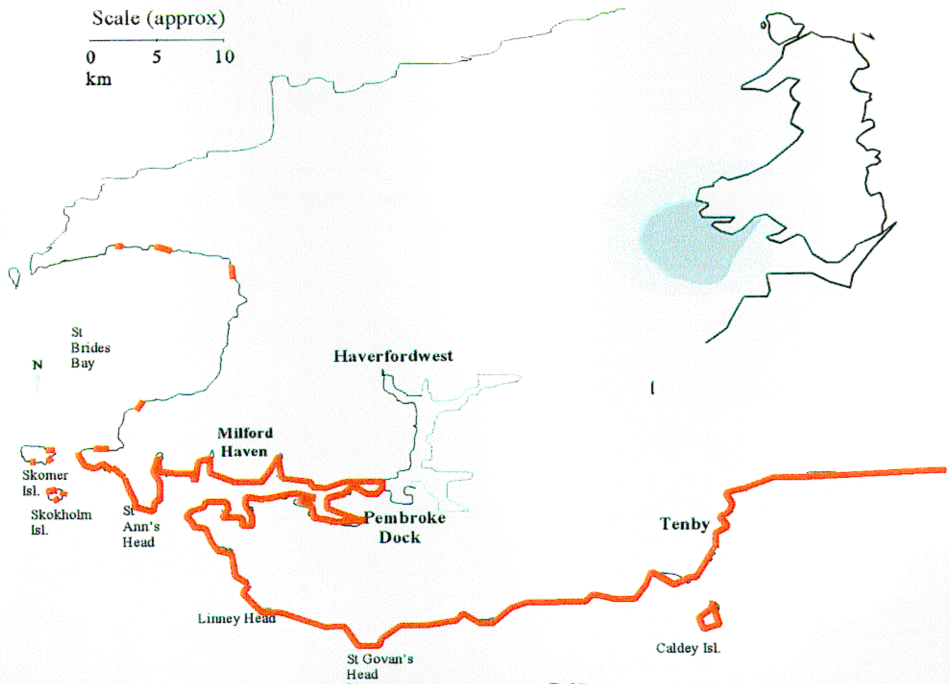

Figure 2.1: Extent of *Sea Empress* Oil

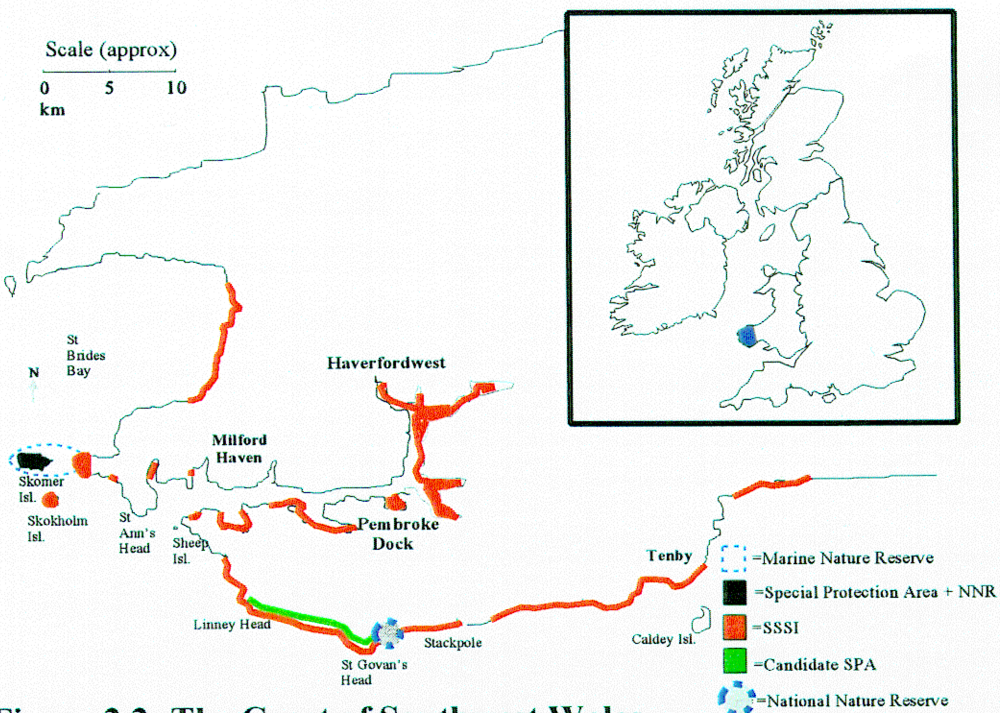

Figure 2.2: The Coast of Southwest Wales

3. CLEAN-UP AND SALVAGE COSTS

3.1 The Nature of Clean-up and Salvage Costs

The *Sea Empress* incident resulted in costs to those organisations involved in the clean-up and salvage operations. With respect to the former, costs were incurred by the Marine Pollution Control Unit (MPCU) which was responsible for marine clean-up and Pembrokeshire Country Council (PCC) who undertook land-based clean-up.

In addition, costs were incurred by other organisations such as the Royal Society for the Prevention of Cruelty to Animals (RSPCA) and the Countryside Council for Wales (CCW). The RSPCA was responsible for the handling of oiled birds, with CCW organising surveys of birds at risk and the collection of oiled corpses for research purposes. Surveys were mainly undertaken voluntarily by local ornithologists (Evans, 1997). In terms of the nature of costs incurred, those for RSPCA include the setting up of an emergency treatment station at Milford Haven and the cleaning and ringing of birds.

Costs were also incurred by government departments such as the Ministry of Agriculture, Fisheries and Food (MAFF). MAFF's costs include paying fishermen and divers to collect samples, transporting samples by courier for analysis, analysing and setting up and enforcing the fisheries exclusion zone (Hearne, 1997). A list of organisations involved in the clean-up is given in Table 3.1.

Table 3.1: Organisations Involved in the Clean-up

Nature of Involvement	Organisation
Cleaning, ringing oiled birds	Royal Society for the Prevention of Cruelty to Animals (RSPCA)
Feeding clean-up workers	WRVS, Salvation Army, WI
First Aid Cover on beaches	British Red Cross, St John's Ambulance
Fisheries Closures	MAFF through WOAD, CEFAS (Centre for Environment, Fisheries and Aquaculture Science) and Burnham Crouch Laboratory
Marine Clean-up	Marine Pollution Control Unit (MPCU), MAFF (advised on the use of dispersants)
Shore-based Clean-up	Pembrokeshire Country Council (PCC), Texaco
Surveys	Countryside Council for Wales (CCW), Environment Agency (EA), Pembrokeshire Coast National Parks Authority (PCNPA), Pembrokeshire County Council (PCC)

Source: Evans, 1997; Elms, 1997; Walder, 1997; Hearne, 1997

3.2 Compensation Under the International Oil Pollution Compensation Fund

3.2.1 Introduction

Under the 1969 Convention on Civil Liability for Oil Pollution Damage and the 1971 Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, the costs incurred as a result of spills of persistent[5] oils can be recovered from the Ship Insurers (Skuld Club[6]) and the International Oil Pollution Compensation (IOPC) Fund. Since its establishment in 1978, the IOPC Fund has been involved in 77 incidents worldwide, and has paid over £132 million in compensation (IOPC, 1996a). Of this, £46 million has been paid to date in respect of the *Braer*.

3.2.2 Claims Approved by the 1971 Fund for the *Sea Empress* Oil Spill

The IOPC Fund's 1996 Annual Report (IOPC, 1996a) provides a summary of payments for oil spills made under the 1971 Fund. This summarises payments into seven categories which include clean-up, fisheries, tourism, farming and environment. Available data on claims made to the Fund for clean-up and property damage in the case of the *Sea Empress* are presented in Annex 3 and are summarised in Table 3.2[7]. This indicates that claims for clean-up and property damage had been made totalling around £8.8 million, with around £3.6 million approved for payment[8]. As these costs are based on losses at the time of the incident, they are taken as 1996 prices.

Table 3.2: Claims for Direct Costs under the 1971 Fund (£1996)

Claimant	Amount of Claim (£)	Amount Approved (£)
Local Authorities Clean-up	6 778 600	3 438 900
Regulatory Bodies Clean-up	1 613 200	-
Others Clean-up	167 100	700
Property Damage	274 600	171 600
Total	**8 833 500**	**3 611 200**
Source: IOPC, 1996a, 1997a, 1997b and 1997c		

5 Persistent oils are defined as those which are usually slow to dissipate naturally when spilled into the marine environment and which are therefore likely to spread and require cleaning-up. Persistent oils include crude, fuel, heavy diesel and lubricating oils but not gasoline, light diesel oil and kerosene (IOPC, 1996b).

6 The Skuld Club insures the third party liability of shipowners.

7 Data on claims of relevance to other impact categories (for example tourism) are discussed in the relevant sections of the report.

8 Data gathering for this project ceased at the end of November 1997. The most recent IOPC data provided at this time were dated 1/10/97.

3.2.3 Claims Still to be Submitted to the 1971 Fund

There is a number of organisations which had not claimed compensation for the cost of clean-up operations from the 1971 Fund at the time of the analysis. The costs which we are aware of are presented in Table 3.3. All of the costs associated with MPCU's activity should be met from the Fund, while this is likely to be the case for only a proportion of those associated with salvage operations. Under the IOPC Fund's criteria, only salvage costs which are associated with preventing pollution damage can be compensated[9]. The proportion of costs which are of this type is not known (but see also Section 3.2.4).

Table 3.3: Costs to be Submitted to the 1971 Fund (£1996; £ million)

Organisation	Nature of Costs	Costs Incurred
Department of Transport	Costs associated with salvage, mainly the monitoring of operations.	small
MPCU	Marine clean-up, provision of equipment and labour for the shore-based clean-up, scientific support.	12.0

Sources: Anon (1997a) and pers. comm.

3.2.4 Estimates of Total Payments Under the 1971 Fund

Estimates of the total clean-up, property damage and salvage claims under the 1971 Fund have been made by both the IOPC Fund and the UK Government. High and low estimates of claims are summarised in Table 3.4. Estimates differ most for claims for preventative measures, although since making its estimate the UK Government has indicated that the estimate of £7 million is "unrealistically high, since the value of ship and cargo salved was substantial" (IOPC, 1997a).

Table 3.4: Estimates of Total Payments by the 1971 Fund for Direct Costs (£1996; £ million)

Category	UK Government Estimates❖		IOPC Estimates ✦	
	Low	High	Low	High
Clean-up Operations	23	23	22	23
Preventative Measures (including salvage)	0	7	0	4
Total	23	30	22	27

❖ Anon (1997a)
✦ IOPC (1997b)

9 Salvage costs are generally paid by the tanker owner's hull insurers, with some contribution from the third party liability insurers and the IOPC Fund.

3.3 Other Costs

3.3.1 *Introduction*

Payments approved under the 1971 Fund could be used as a measure of the financial costs associated with the *Sea Empress* oil spill. However, these payments are likely to be less than the actual financial costs for the following reasons:

- the size of compensation payments is determined using IOPC Fund criteria which exclude some costs from consideration;

- the Fund requires that losses are proven. Those organisations unable to provide the necessary evidence to substantiate claims are unable to claim compensation; and

- not all of those eligible to claim costs will have claimed from the Fund. Some may claim in the future with others choosing not to submit claims.

In addition, there is an upper limit of £51 million on compensation payments. In a number of recent cases, including the *Braer*, the aggregate amount of the claims has greatly exceeded the maximum amount payable (Welsh Affairs Committee, 1996). Had the spill occurred after 30 May 1996, then the upper limit would be £114 million (as a result of changes introduced in the 1992 Protocols to the Conventions).

3.3.2 Claims Rejected Under Fund Criteria

The IOPC Fund will only pay compensation for the following categories of losses[10]:

- **clean-up operations and property damage:** including clean-up operations on shore and at sea, some salvage measures, other preventative measures, disposal of collected material, the cleaning of oiled property and studies aimed at quantifying damages for the purpose of claiming compensation from the Fund;

- **consequential loss and pure economic loss:** the former relates to loss of earnings resulting from oil contamination of property, while the latter relates to loss of earnings by other means[11]. Claims for pure economic loss are not admissible for the sole reason that the loss or damage would not have occurred had the oil spill not happened. Instead a reasonable degree of proximity needs to be demonstrated; and

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10 Compensation is also payable for environmental damages which are discussed in Section 9.

11 An example of consequential loss would be a fisherman's loss of income as a result of his nets becoming contaminated with oil, while a fisherman prevented from fishing as a result of oil on the area of sea where he normally fishes would be an example of pure economic loss. In this regard, it should be noted that the IOPC Fund uses the term 'economic' in a different way from this report. Indeed, 'economic' costs as defined by the Fund equate to financial costs in this report.

- **research:** the costs of studies which are aimed at establishing the nature and extent of pollution damage and/or the need for reinstatement can be compensated under the Fund. Studies of a purely scientific nature are not eligible for compensation.

Ship Repair and Loss of Cargo

The 1971 Fund is not responsible for compensating for the repair of the *Sea Empress* herself nor for loss of cargo which are covered by separate insurance. Table 3.5 presents available information gathered on the scale of these costs. The costs of purchasing additional liability insurance has been estimated at £0.1 million. This is less than 0.15% of the amount insured and is believed to be a conservative estimate.

Table 3.5: Costs to be Met from Sources other than the 1971 Fund (£1996)

Organisation	Nature of Costs	Costs Incurred (£m)
Insurers of the *Sea Empress*	Cost of purchasing an additional £66 million liability insurance required to allow the *Sea Empress* to enter the Port of Belfast for Repair	0.1
John Fredriksen's Sea Tankers (the *Sea Empress's* Owners)	Estimated costs associated with repairs including dry-dock costs (of £33 000 per day).	21.0
Insurers of the cargo of the *Sea Empress*	Costs associated with the oil lost from the Sea Empress	5.0

Source: Hooke, 1997

Consequential Loss and Pure Economic Loss

Table 3.6 presents information on costs which have been rejected by the Fund under criteria used to judge consequential and economic losses. The engineering contractor which had a claim rejected by the Fund is a local contractor undertaking engineering works for local authorities. The *Sea Empress* oil spill resulted in local authority activity being focussed on the clean-up with few monies available for programmed engineering works. The contractor estimates that this led to a loss of turnover of £0.138 million. This claim was rejected by the Fund on the basis that the losses were caused by a lack of local authority funds and not by the oil spill.

Table 3.6: Costs Rejected by the Fund

Organisation	Nature of Costs	Costs Incurred (£m)
Engineering Contractor	Loss of local authority contracts due to the allocation of funds to the clean-up operations.	0.138

Source: IOPC 1997a

Even where the oil spill is considered to be the cause of pure economic loss, compensation from the 1971 Fund will only be forthcoming where a reasonable degree of proximity can be demonstrated, taking into account:

- the geographic proximity between the activity and the contamination;
- the degree to which the claimant was economically dependent on the affected resource;
- the extent to which a claimant had alternative sources of supply or business opportunities; and
- the extent to which the claimant's business formed an integral part of the economic activity within the area affected by the spill (IOPC, 1996b).

Claims rejected by the Fund on the basis of an inability to meet the proximity criterion alone should be included in this cost-benefit analysis. Unfortunately, the number and size of such claims is not known, although such claims are most likely to be associated with impact categories other than clean-up and salvage costs. In addition, many businesses not meeting the proximity criterion will not have bothered to claim compensation in the first place.

Research

The *Sea Empress* oil spill has resulted in the commissioning of a large number of research studies. Many of these have been commissioned by the *Sea Empress* Environmental Evaluation Committee (SEEEC), with others being undertaken by regulators (e.g. the Environment Agency - EA), Government (e.g. the Welsh Office) and conservation organisations (e.g. the Wildlife Trust West Wales - WTWW).

SEEEC's total budget was around £2 million and it was only able to commission some of the research which was suggested as being of value following the oil spill. Of those studies which were not taken up by SEEEC, those which were considered to be of particular importance were commissioned by others. For example, the WTWW commissioned a report on the effects of the oil spill on crustaceans.

As indicated above, only some studies qualify for compensation under IOPC Fund criteria. As a result, no claim was made to the Fund for the cost of SEEEC studies and of those claims which were made for the costs of research, some were rejected. For example, most of the Joint Nature Conservation Committee's (JNCC's) claim was rejected by the Fund on the basis that the studies were of a "purely scientific character" (IOPC, 1997a).

3.3.3 The Need to Substantiate Claims

To receive compensation from the 1971 Fund for costs incurred, claims must be substantiated and verified. This can be a lengthy process and it is possible to claim back from the Fund some of the costs associated with the verification process itself. For example, to verify its claim for costs, PCC has been asked to identify all *Sea Empress* phone-calls from its phone bill and to indicate on which beach meals provided for the clean-up workers were eaten. The associated costs include the four members of staff employed full-time pulling together PCC's claim and the time spent by other council officers to assist with this process. While the costs of full-time staff can be claimed from the 1971 Fund, the principle has not been established as to whether other officer's costs can be claimed for. These additional costs could be significant for individual organisations, for example, PCC reports that 20% of its chief accountant's time is spent on the *Sea Empress* (pers. comm.).

3.3.4 Those Not Claiming from the Fund

While the government has claimed compensation for the costs incurred as a result of clean-up and monitoring, it cannot claim compensation for the 'fixed' costs of the Welsh Office (WO) or the Department of the Environment, Transport and the Regions. For example, the WO had a number of people working on the incident almost full time for the first few weeks after the spill and was still incurring some costs at the end of 1997.

In addition, some solicitors have been unable to claim for the time spent giving advice to claimants. For example, one solicitor reported giving hundreds of hours of free advice, for which he had not been paid a penny (pers. comm.). While compensation can be claimed for legal fees which are 'worthwhile', it is IOPC's view that legal advice is often not needed in order to make a claim. Such fees are, therefore, often not compensatable. The result is that claimants are unwilling to pay for professional advice as this would need to be paid for out of any compensation.

3.4 Total Costs for Clean-up and Salvage

A summary of the direct costs of the *Sea Empress* incident are presented in Table 3.7 overleaf. In the absence of additional information, assumptions have been used to generate the upper bound values.

Table 3.7: Summary of Clean-up and Salvage Costs (£1996; £ million)

Description	Lower Bound Value	Upper Bound Value	Comments
Claim for clean-up and property damage costs under the 1971 Fund	21.0	23.0	Lower bound from the total claims to the 1971 Fund (Table 3.2) plus MPCU costs (Table 3.3). Upper bound from IOPC/ UK Government estimates (Table 3.4).
Salvage and repair costs	26.1	30.1	Lower bound from cost of ship repairs, liability insurance and cargo loss (Table 3.5). Upper bound from this plus IOPC's high estimate of salvage costs.
Research Costs	2.0	4.0	Lower bound from SEEEC costs alone (Section 3.3.2). Upper bound assumed to be double SEEEC costs.
Other costs❖	0.0	1.05	Lower bound assumes no such costs. Upper bound assumed an additional 5% on top of the lower bound estimate of claims for direct costs under the 1971 Fund.
Total	49.1	58.15	

❖ Includes claims rejected under pure economic loss (Section 3.3.2), costs which cannot be substantiated (Section 3.3.3) and those not claiming from the Fund (Section 3.3.4).

4. TOURISM

4.1 Pembrokeshire and Tourism

4.1.1 The Tourism Product

Pembrokeshire's tourism product is not singular, but means different things to different people. The nature of Pembrokeshire's attractions are such that:

- some visitors are drawn to its peace and tranquillity, its rugged coast, natural beauty and wildlife;
- some are drawn to the quality and number of its heritage sites;
- some are drawn to its watersports, adventure parks and activity centres; while
- others are drawn to its busy holiday resorts.

It may simply be the choice and variety of holiday activities that make Pembrokeshire such a popular destination for both day-trippers and holiday makers alike.

This section considers the impacts to the tourism industry in terms of service providers, for example hire companies, hoteliers and restauranteurs. It would be more usual for financial impacts to all activities relating to the provision of recreational pursuits (such as windsurf hire) to be considered under the 'recreation' heading (i.e. under Section 5 which follows). However, the detail provided in the about claims to the 1971 Fund has not enabled the grouping of financial and economic impacts by specific tourism service provider. As such, the financial and economic impacts to those providing recreational activities cannot be separated from other tourism compensatory claims. Therefore, this section deals with all tourism financial impacts, while Section 5 deals with economic impacts relating to lost recreational opportunities.

The Landscape

Pembrokeshire is surrounded by the Atlantic on three sides, and the coast is characterised by rugged rocky cliffs, sheltered sandy coves as well as wide and, in some places, exposed beaches. In contrast, estuaries and the inland landscape are wooded and secluded (for example the Cleddau estuary and the Gwaun Valley), while the gently rolling Preseli Hills are more open.

Pembrokeshire is the only National Park in Britain designated for its coastal landscape and many stretches of the coastline are also Sites of Special Scientific Interest (SSSIs; 65 in total) and National Nature Reserves (NNRs; four in total). In addition, Pembrokeshire has been awarded four Special Protection Areas, as well as two coastal and two inland Special Areas for Conservation, which are internationally designated.

The uniqueness of Pembrokeshire landscape is matched by its resident and migratory wildlife, which not only take refuge on the mainland but also take advantage of Pembrokeshire's islands. Skomer and Skolkholm Islands are internationally renowned nature reserves, the seabed surrounding the former being one of only three Marine Reserves in Britain.

In addition to the natural attractions in the area, Pembrokeshire has a rich human heritage including neolithic burial chambers, earthworks, Iron Age forts, Viking remains, Norman castles, Medieval churches and much more. In addition, the area's relationship with the Atlantic over the centuries has provided it with a strong sense of maritime history.

Visitor Attractions

Pembrokeshire has a wealth of day-visitor attractions providing entertainment of every kind, such as activity and adventure centres, aquariums and sea-life centres, castles, country parks, craft centres, galleries, museums, organised outings (for example walks, boat trips and excursions) special breed and traditional farms and wildlife centres[12]. In addition to these are organised events throughout the main tourist season such as arts festivals, family fun days, fireworks displays, re-enactments, competitions and carnivals. There are also a number of regional, national and international sports competitions which draw large numbers of visitors into the area for several days at a time.

Longer-term holidays are also available, centred around sports activities such as learning to sail or 'adventure' holidays for both adults and children to experience or improve abseiling, climbing, diving, fishing, golfing, horse riding, watersports, etc. Pembrokeshire has a range of these types of activity breaks aimed specifically at schools, in addition to field study centres such as the one at Dale.

Accommodation

Pembrokeshire's accommodation varies, from luxury hotels and country lodges to smaller sea front hotels, bed and breakfast facilities, self catering chalets, holiday parks, caravans, youth hostels and camping. In turn, these range from rural to resort sites.

Tenby, for example, is a famous UK seaside resort and accommodation here is dominated by holiday parks, some of which have self-contained activities such as golf, indoor and outdoor pools, as well as bowling and other entertainments. Similarly, Saundersfoot and Narberth have self-catering leisure parks. That said, all of these resorts also have a wealth of luxurious large guest houses and more secluded inns. Away from these resorts are more rural farm accommodation, quiet campsites, country house hotels and youth hostels accessed mainly along the Pembrokeshire Coast Path. Picturesque fishing villages and market towns offer the full range of accommodation throughout the county.

4.1.2 The Volume, Value and Nature of Visits

Volume of Visits

Visits to Carmarthenshire/Pembrokeshire and Wales from the International Passenger Survey are set out in Table 4.1 for 1995 and 1996. As can be seen, it appears that in 1995 and 1996 there

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12 For the more 'high profile' or 'stylised' visitor attractions, such as themed adventure parks, the adult entry fee seems to be around £3.50. For more 'natural' attractions such as Castles and wildlife centres, the entry fee for adults seems to be between £2.00 and £3.00.

were 0.08 million and 0.1 million visits to Carmarthenshire/Pembrokeshire respectively. In terms of bednights, in 1995 there were 0.6 million and in 1996 this increased to 0.7 million for Carmarthenshire/Pembrokeshire. To Wales overall, bednights increased from around 5 million in 1995 to 6 million in 1996.

Table 4.1: Visits to Wales and Carmarthenshire/Pembrokeshire 1995 and 1996 (£1996)

Year	Area	Million Visits	Million Nights	Total Visits (million)	Expenditure[13] (£ million)
1995	Carmarthenshire/ Pembrokeshire	0.08	0.6	0.68	219.64
	Wales	0.73	5.2	5.93	1 915.39
1996	Carmarthenshire/ Pembrokeshire	0.1	0.7	0.8	258.4
	Wales	0.83	6.1	6.93	2 238.39

Source: Wales Tourist Board (pers. comm.).

People living in Wales made over 270 million day visits from home (including visits from holiday bases) in 1994 (UKDVS[14]). Most of these visits, around 70%, were to the South Wales Region, including Pembrokeshire Coast National Park. Across the whole of the UK, 4% of day visits in 1994 were made to the coast, but for Wales alone this was much higher at 8%; thus, the coast as a destination is twice as important to tourism in Wales than it is to tourism in the rest of the UK.

PCC estimates that there are between 0.75 million and 5.5 million visitors to Pembrokeshire each year (from outside the area), depending on the categorisation of visitors (pers. comm.)[15]. In total, around 10 million visits to the South Wales coast were made in 1994, constituting around 50% of total trips to the Welsh coast (where this includes visits made by residents as well as holiday makers to the area).

Visits to the coast are highly seasonal. Across the whole UK, the coast received 123 million visits in 1994 in summer and around half this number, 61 million visits, in winter (UKDVS). Out of England, Scotland and Wales, the latter had the highest proportion of people visiting the coast in winter. Furthermore, although summer is the most popular time for coastal visits (in Wales, 30%

13 Based on average visitor expenditure per holiday trip in Wales of £510 from 1996 Wales Visitor Survey and £136 from UK Tourism Survey (UKTS, believed to relate to 1996 data - provided by Wales Tourist Board), the average spend per holiday trip is taken to be £323.

14 UKDVS - UK Day Visits Survey (CRN, 1996).

15 i.e. whether the data include day visits, those visiting friends and relatives, just those using formal accommodation (such as regularly surveyed hotels), and so on.

of annual coastal visits occur in August and September), it appears that 20% occur over Easter, i.e. shortly after the oil spill had occurred.

In summary then:

- the region of South Wales, including Pembrokeshire Coast National Park, is the most popular destination for day visitors from Welsh homes or holiday bases;

- the coast is twice as important to Welsh tourism than it is to tourism in the rest of the UK; and

- more visits to the Welsh coast occur in winter (the time of the *Sea Empress* oil spill) than for the rest of the UK.

Value of Visits

Compared to other activities (such as visiting urban areas or visiting the countryside), average spend per visit was found to be highest on visits to the UK coast at around £10.00 per visitor. However, spend per visit to the Welsh coast was less than for other activities at around £8.50 per visitor (CRN, 1996). Spend in summer is also higher than spend in winter by around £1.50 per visit (CRN, 1996).

In terms of the total average expenditure per holiday trip to Wales, the Wales Visitor Survey found it to be £510, while the UKTS found it to be much less at £136 (the mean is £323 per holiday trip).

In terms of the overall value of tourism to Pembrokeshire, there are no firm data available due, in part, to the 'casual' nature of some sectors of the industry. The data presented in Table 4.1 indicate that tourism-related income was in the region of £220 million in 1995, rising to around £260 million in 1996 for Carmarthenshire/Pembrokeshire. This is consistent with anecdotal evidence that annual tourism income to Pembrokeshire is usually accepted to be around £200 million[16] and is not inconsistent with the data provided in the Draft SEEEC Report (1997) that tourism contributed about £160 million to the Pembrokeshire economy in 1995.

Although, again, no official figures are available, it is generally accepted that this level of tourism to Pembrokeshire directly supports between 15 000 and 20 000 people[17]. For Wales as a whole, 95 000 jobs (which represents more than nine percent of all employment in Wales) are due to tourism. Around two thirds of these are serving tourists directly in various tourism-related industries and more than 30 000 are in industries supplying tourism (Wales Tourist Board, 1995). As is the case with the tourism industry in general, there will be an element of seasonality inherent within any associated employment.

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16 Pembrokeshire Tourism Federation, pers. comm., based on evidence provided for a planning application for a jetty to support use of Orimulsion at Pembroke Power Station, April, 1996.

17 Pembrokeshire Tourism Federation, pers. comm.

Nature of Visits

The main purposes of trips to the Welsh coast are summarised in Table 4.2. As this shows, the most popular reason for visiting the South Wales coast is to walk, followed by to drive, picnic and/or sightsee then eating/drinking out. Visiting the beach/seaside in general appears to be the main purpose of nearly 1 million annual visits to the South Wales coast.

Assuming that 10 million visits to the coast are made each year to the South Wales Region (and not just in 1994), at £8.50 per visitor day this is equivalent to £85 million of expenditure on day visits to the South Wales coast.

Table 4.2: Main Purpose for Visiting Welsh Coast in 1994

Purpose	% of Total Visits	Number of Total Visits (million)	Assuming 48% of these Trips are to South Wales then Numbers (million)
Eat/drink out	13	2.7	1.30
Walk	23	4.7	2.26
Visit Friends & Relatives (VFR)	9	1.9	0.91
Entertainment	1	0.2	0.10
Leisure shopping	4	0.9	0.43
Outdoor Sport	2	0.4	0.19
Indoor Sport	1	0.3	0.14
Drive, Picnic and/or Sightsee	20	4.1	1.97
Pursue hobby	4	0.9	0.43
Visit tourist attraction	3	0.7	0.34
Swim indoors	1	0.2	0.10
Undertake Countryside sport	3	0.7	0.34
Watch sport	1	0.3	0.14
Cycle	1	0.3	0.14
Informal sport	1	0.1	0.05
Visit the beach/seaside	9	1.9	0.91
	Total:	20.3	9.74

Source: UKDVS (CRN, 1996)

A survey undertaken by Beaufort Research (1996) of visitors to Pembrokeshire (mainly undertaken at beach car parks) found that the majority of those surveyed (88%) were on holiday to the area and the majority of these were from the UK (72%). Selected findings of the survey are set out in Table 4.3. These may indicate the extent to which financial tourism losses due to the oil spill can be considered as economic losses for Wales as a whole, as discussed further in Section 4.5.3.

Table 4.3: Summary Profile of Visitors to Pembrokeshire

		Category of Visit			
		On Holiday	**Day Visit**	**VFR**[18]	**All Categories**
Purpose of Visit (all respondents)		88%	8%	3%	
Origin of Respondent:	Welsh	24%	89%		29%
	Other UK	72%	11%		67%
	Overseas	4%	0%		4%

Source: Beaufort Research, (1996)

4.2 The Impacts of the *Sea Empress* Oil Spill

4.2.1 Introduction

As the above discussion indicates, the area of coast affected by the *Sea Empress* oil spill is an important tourism destination for Wales. The spill was widely publicised by the media both in the UK and overseas and had the potential to influence tourists' decisions concerning their holiday location. If tourists decided not to visit Pembrokeshire as a result of the *Sea Empress* oil spill, then there would have been impacts to all those involved in the provision of associated services, including accommodation and food providers.

On the other hand, the oil spill itself may have attracted an element of 'disaster tourism' or longer-term benefits to the industry having simultaneously publicised the area to potential UK and international visitors. Indeed, some visitors claimed to be disappointed that they were unable to see any oil (pers. comm.).

At the outset it should be noted that the comparison of tourism performance before and after the *Sea Empress* oil spill has been hampered to some extent by the amalgamation of South Pembrokeshire and Preseli Pembrokeshire District Councils into PCC. This occurred in April 1996 and many of the procedures for collating tourism and marketing statistics for the affected

18 VFR - Visiting Friends and Relatives

area were not carried across into the new Council. In addition, some methods of data analysis (for example those relating to Tourist Information Centres) were overhauled. Many individuals with expert knowledge of tourism and recreation in the affected area have changed posts and associated data sources have not always been immediately available. Consultation suggests that some of these procedures will be re-instigated in due course but the continuity of data collection and analysis has been lost for the critical period covering the spill (pers. comm.)[19].

Data were sought from a variety of sources including tourism associations. The general response was that the information required to verify impacts was simply not collected by the vast majority of tourism operators. Thus, estimates of the costs stemming from the *Sea Empress* oil spill have been derived from available surveys, anecdotal evidence and expert knowledge.

4.2.2 Summary of Nature of Impacts

The *Sea Empress* oil spill occurred in February during the period of peak booking for summer holidays, especially for tourists planning to undertake self-catering visits over the summer. Anecdotal evidence has suggested that up to two thirds of annual tourism income relates to bookings taken before and during this time (pers. comm.). The impacts on different service providers varied according to their relationship with the sea and the coast. As such, it appears that companies offering watersports and coastal activities suffered the greatest impacts. For a number of these, bookings stopped for a period of about six weeks immediately after the spill. After this time, interest increased slowly but only recovered later in the year through extensive positive advertising campaigns on behalf of the region as a whole, as well as through individual company efforts. Some with expert knowledge of the local tourism industry have suggested that recovery was only due to the growing UK trend of taking later domestic second holidays in mid summer, for which bookings are made later in the year (pers. comm.).

The only identifiable impact to Pembrokeshire's tourism in 1996 was a reduction in bednights of around 7% (see Annex 4 for a more detailed discussion). Following detailed analysis of various surveys, the Wales Tourist Board (WTB) have concluded that no consistent or measurable trends in tourism performance emerge for Pembrokeshire overall in 1996[20]. Thus, overall, it appears that the *Sea Empress* oil spill has had no long-term impacts on tourism to Pembrokeshire. However, within this overall trend are hidden some significant long- and short-term losses as impacts on performance will not have been uniform across the tourism industry. For example, it has been suggested that individual businesses with seaside locations and without the means to undertake any re-marketing activities experienced up to 30% reductions in business (pers. comm.).

While some businesses experienced losses, others gained visitors as patterns of activity shifted in response to the oil spill. For example, some of the attractions close to the affected beaches in Tenby and Manorbier experienced reductions in visitor numbers in excess of 10%, while some inland attractions experienced increases of a similar scale. The WTB's annual survey of visitors

19 This has meant an increased reliance on less robust data.

20 This is despite a diverse range of data being available for analysis.

to tourist attractions in Wales found an overall 3% rise in attendances (WTB: Survey of Visitors to Attractions, in WTB, 1997a).

One of the most significantly impacted businesses appears to be West Wales Wind, Surfing and Sailing whose position on St Ann's Head has meant that they were very badly positioned with respect to the extent of oiling. The company had to close for three months in 1996 as contact watersports were banned and courses were immediately cancelled. Their turnover for 1996 reduced by half and the spill has reduced bookings for 1997 by between 25% and 30%, equivalent to losses of £0.1 million for each year. These losses mainly relate to: cancellation of a six month long residential watersports instructor course; cancellations of family holidays; and cancellations of beginner courses, participants of which tend to return for more advanced courses the following year. In addition, the company was in the process of expanding at the time of the spill and they estimate that it will take around three more years to regain the level of growth they were experiencing prior to the spill (pers. comm.). This company has claimed compensation from the 1971 Fund, which is discussed in Section 4.3.

The ability of operators to undertake positive advertising immediately following the incident may have limited adverse impacts to their business (pers. comm.). For example, immediately after the spill, the phones at a central booking agent for watersports centres in Pembrokeshire stopped ringing. Considerable amounts of money (£30 000) were spent immediately to recover the reputation of watersports in the area[21]. As a consequence, the overall performance in 1996 was 2% to 3% up on that for 1995, and this trend has continued into 1997 where they have experienced increases of around 8% on 1996 performance (pers. comm.). Some of this growth may be related to the positive advertising undertaken following the oil spill and so the company may be experiencing long-term benefits from the spill.

In general, it is expected that those operators able to invest in marketing following the oil spill would have been medium to large sized, owing to their size of turnover and so accessibility to funds for immediate marketing activities. Thus, longer-term negative impacts may be centred around smaller businesses who may also be those unable to provide evidence of their financial losses in order to qualify for compensation from the 1971 Fund.

There have been suggestions that those operators in South-West Wales to have under-performed in 1996 have continued to under-perform on into the first half of 1997 (pers. comm.). Other consultees have suggested that, despite the immediate negative impact, the oil spill has 'put Pembrokeshire on the map' both in the UK and internationally and so bookings have recovered well.

4.2.3 Actions to Minimise Impacts

Actions were taken by a number of organisations including PCC and the WTB with the aim of minimising the impacts of the *Sea Empress* oil spill on tourism. These actions took the form of a reassurance campaign coordinated by Tourism South and West Wales (Beaufort Research,

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21 The watersports company claimed compensation from the 1971 Fund and payments relating to this are included in Section 4.3. It is unknown whether the company additionally claimed for promotional expenditure and, if so, whether the Fund compensated for this.

1996). The WTB concentrated on the 'pan-Wales' level of tourism on the assumption that visitors from overseas would associate the disaster with Wales as a whole (Fielding, 1997). The actions of the Tourism and Leisure Services Department of PCC focussed on Pembrokeshire alone and included (Fielding, 1997):

- encouraging positive editorials in the national and English regional press;
- some 'advertorial' - upbeat copy supported by advertising;
- a competition which attracted over 1,000 entries; and
- interviews with travel writers and foreign journalists.

Actions were also taken to ensure that visitors had access to accurate and up-to-date information in response to visitors' questions and concerns.

Tourism South and West Wales has submitted a claim to the 1971 Fund for marketing and IOPC Fund liaison activities in response to the *Sea Empress* oil spill of around £0.07 million against a programme totalling £0.1 million (which includes a £0.04 million grant from WTB).

PCC have estimated that marketing actions undertaken by them may have resulted in additional costs over and above the norm for that time of year at around £0.028. However, it is commented that these were very difficult to pinpoint (pers. comm.).

Details of actual payments from the 1971 Fund have not been provided.

4.3 Compensation Under the 1971 Fund

4.3.1 Claims Approved by the 1971 Fund for the *Sea Empress* Oil Spill

Available data on claims made to the Fund by businesses in the tourism sector following the *Sea Empress* oil spill are presented in Table 4.4[22]. This indicates that 398 claims have been made by operators in the tourist industry, with the majority of claims being from small operators providing bed and breakfast or self-catering accommodation (IOPC, 1997b). To date, claims totalling around £1.2 million have been approved for payment.

Despite the IOPC Fund stating that the majority of claims have been from small operators, consultation with organisations co-ordinating tourism claims to the Fund have indicated that claimants are larger, more organised companies. Indeed, several consultees have commented that smaller operators will not have recorded the type of data required in order to qualify for compensation under the Fund.

22 All of this information is taken from IOPC literature although the Consultants have also held discussions with IOPC.

Table 4.4: Claims to the 1971 Fund for Costs to Tourism (£1996; £ million)

Claimant	Nature of Claim	Amount of Claim	Amount Approved
Operators of tourism-related businesses	Claims from hoteliers, bed and breakfast businesses, caravan parks, shops and restaurants, sailing school, watersports centre, a diving school and angling shops. As of 1/11/97, 227 claims had been approved.		1.217
Tourism Marketing	Wales Tourist Board	0.030	
	Tourism South and West Wales	0.070	
	Cost of promotional activities to reduce the impact of negative publicity and to rebuild the image of the area prior to the 1996 tourist season. Some items in this claim were considered admissible on the basis that these aimed to prevent or minimise pure economic loss.		
(Known) Total		0.100	1.127

Source: IOPC, 1996a, 1997a, 1997c, and pers. comm.

4.3.2 Claims Still to be Submitted to the 1971 Fund

At the end of May 1997 the IOPC Fund reported that 580 potential claimants from the tourism sector had requested claims forms but had not yet submitted claims (IOPC, 1997a). Of the 244 which responded to a follow-up letter from the Fund, 130 stated that they intended to present a claim and 144 stated that they did not intend to submit a claim.

At the beginning of October 1997, the Fund literature implies that one firm of solicitors representing 24 claimants in the tourism sector still had to submit claims totalling approximately £0.25 million on behalf of his clients (IOPC, 1997a).

4.3.3 Estimates of Total Payments Under the 1971 Fund

Estimates of the total size of claims under the 1971 Fund have been made by both the Fund itself and the UK Government. High and low estimates of claims are summarised in Table 4.5 and differ considerably for the tourist industry. In this regard the IOPC Fund has indicated that the advice of the WTB is that claims, including those already submitted, are "likely to be well below £9 million" (IOPC, 1997a).

Table 4.5: Estimates of Total Payments Under the 1971 Fund to the Tourist Industry (£1996)

Category	UK Government Estimates[a]		IOPC Estimates[b]	
	Low (£ million)	High (£ million)	Low (£ million)	High (£ million)
Tourist Industry	3	9	2	4

a *Sea Empress Disaster Bill may Reach £50 million,* ENDS Report 265, February 1997, pp29-30.
b IOPC (1997b): Executive Committee, 54th Session, Agenda Item 3, Incidents Involving the 1971 Fund, *Sea Empress.*

4.3.4 Claims not Covered by the 1971 Fund

At the beginning of October 1997 the IOPC Fund reported that it had rejected 76 claims from the tourism industry on the basis that the organisations involved had not shown that they had suffered any economic loss (IOPC, 1997c). However, as set out above, lack of supporting evidence may be no indication of lack of impacts. Even for one of the most directly affected tourism operators, it has apparently taken two employees three whole months of full time work to compile the data requested by the Fund in order to qualify for compensation. This has forfeited marketing activity and has delayed preparation of their 1998 brochure. As such, claiming compensation itself may have adversely affected their forthcoming season (pers. comm.).

The company outlined above is a large operator and so, as a matter of course, compiles the records required by the Fund. For other operators, there are indications that claims have not been submitted due to the complexity of the claims procedure and the requirement to provide records of performance and income over time. For the majority of tourism operators in Pembrokeshire, the documentation required by the IOPC Fund is simply not collated. Furthermore, as losses would have related not only to cancellations but also to lost bookings, it is very difficult (in most cases impossible) to prove that lost interest in bookings were as a result of the *Sea Empress.* Thus, many of those in the tourism industry have not been able to substantiate or verify their claims, particularly smaller business.

As indicated in Section 3, in order to claim compensation from the 1971 Fund, organisations also need to demonstrate a reasonable degree of proximity. In the case of tourism businesses, the Fund divided these into three categories:

- **businesses located in the directly affected area between the Gower Peninsula and St Davids:** claims from all such businesses were considered admissible (except those selling goods not normally bought by tourists) as long as there was a link of causation (and a reasonable degree of proximity) between the loss and the incident;

- **tourist businesses located on the coast North and East of the fisheries exclusion zone:** as visitors would not distinguish between this and the affected area when deciding whether to holiday in Pembrokeshire, tourist businesses would qualify for compensation assuming other criteria were fulfilled; and

- **tourist businesses located some distance inland from the affected area:** the factors to be taken into account in assessing the criterion of proximity include, the nature of the business, the dependency of the business on the polluted coast, the distance from the coast and tourist travel time.

Finally, some businesses which were able to claim compensation from the Fund could not claim for all costs incurred as a result of the oil spill. For example, the Wildlife Trust West Wales (WTWW) submitted a claim to the Fund which included the costs associated with lost income from Skomer Island arising from reduced bookings from schools and educational groups following the *Sea Empress* incident. However, the Trust was not able to claim opportunity costs arising from the oil spill. These were incurred when members of the WTWW were engaged in actions arising from the *Sea Empress* oil spill and thus unable to raise funds for the Trust or to market Skomer Island, for example.

Given the above discussion, it is clear that the level of tourism-related claims received by the Fund is an underestimate of the true financial and economic impacts to Pembrokeshire's tourism. Indeed, consultation has suggested that 70% of tourism businesses that experienced a financial impact did not claim. Furthermore, around 50% of businesses that originally registered with the Claims Office have not submitted a claim. Those that did claim would have been those of a larger, more 'organised' nature; by far the majority of smaller operators have not and will not claim (pers. comm.).

4.4 Other Cost Estimates

4.4.1 Views of the Tourist Industry

Establishing the true cost of the impacts of the oil spill on Pembrokeshire's tourism industry has been difficult. Annex 4 provides a more detailed discussion of the different studies that have attempted to calculate these impacts. In the long-term and across the whole industry, it appears that tourism to Pembrokeshire was not adversely affected by the *Sea Empress* oil spill. However, the following estimates of short-term impacts have been made:

- of those to have requested a Pembrokeshire brochure in 1996, 19% of those who did not visit Pembrokeshire agreed or strongly agreed with the statement that "the *Sea Empress* oil spillage was the main reason why I decided not to holiday in Pembrokeshire in 1996". Given that the average expenditure per holiday trip to Wales may be between £510 (Wales Visitor Survey) and £136 (UKTS), these lost bookings may be equivalent to between £1.3 million and £5 million of lost revenue/income (pers. comm.). However, it is likely that this is an underestimate as it takes no account of those who did not request a brochure because of the oil spill and no data have been identified which provide an indication of the number to which this may relate;

- it appears that there may have been a 7% decrease in hotel bedstock sold during 1996 compared with 1995. This is equivalent to losses of between £2 million and £2.7 million to the accommodation sector, or between £20 million and £27 million to the Pembrokeshire tourism industry as a whole (WTB, 1997a); and

- the Pembrokeshire Tourism Federation has suggested that the general decline in tourism business across Pembrokeshire between 1995 and 1996 is considered to be around 6%. Given the fact that tourism to Wales as a whole increased by 17% over the same period (WTB, 1997a), the decline in Pembrokeshire's tourism may have been as high as 23%. Given this and the lack of any firm and reliable actual data, the Pembrokeshire Tourism Federation consider that this reflects a general impact to Pembrokeshire tourism equivalent to lost income of £46 million (given that the total annual income due to tourism is generally accepted to be around £200 million; [pers. comm.]).

4.5 Summary of Costs to Tourism

4.5.1 Using IOPC Fund Data

As set out above, 226 operators have claimed compensation from the 1971 Fund. It has been suggested that this number may represent only 30% of operators which experienced negative financial impacts from the *Sea Empress* oil spill (although they are likely to be the larger operators) and that 70% of operators have not and will not claim. This implies that perhaps 530 businesses may have been adversely affected by the *Sea Empress* oil spill and yet did not claim compensation from the 1971 Fund for a number of reasons.

It has been suggested that the non-claiming businesses may have been smaller, and so it can be assumed that their individual losses may also have been smaller than for those operators claiming from the Fund. It could, therefore, be expected that the amount claimed by the larger operators represents about 50% of overall losses to tourism operators owing to the *Sea Empress* oil spill. Given these factors, it is assumed here that the total costs incurred by the non-claiming (and probably smaller) operators are equal to the estimated total payments expected by the IOPC Fund for those operators claiming reimbursement (as set out in Table 4.5). In other words, the amount expected to be claimed by tourism operators from the 1971 Fund is expected to represent 50% of overall losses to tourism operators owing to the *Sea Empress* oil spill, and so the true costs may be twice those expected to be claimed from the Fund (set out in Table 4.5). Thus, the total costs may be in the region of:

- based on UK Government estimates: Low of £6 million;
High of £18 million;

- based on IOPC Fund estimates: Low of £4 million; and
High of £8 million.

As data have yet to be received on the amounts claimed versus the amounts approved for compensation by the Fund, these calculations are based on amounts expected to be approved (see Table 4.5), and so represent lower bound estimates.

4.5.2 Summary of Financial Costs

Valued and unvalued costs to Pembrokeshire's tourism industry from the *Sea Empress* oil spill are set out in Table 4.6. This shows that:

- the lower bound total financial costs may be £4 million; and
- the upper bound total financial costs may be £46 million.

Table 4.6: Summary of Financial Costs to Tourism Industry in Pembrokeshire (£1996)

Cost Estimate Option	Description	Values (£ million) Lower Bound	Upper Bound	Comments
1	Estimated Total 1971 Fund Payouts for Tourism	2	9	The lower bound presented here is taken from the 1971 Fund estimate which is consistent with that estimated from Pembrokeshire Brochure distribution analysis. The upper bound is that estimated by the UK Government, from Table 4.5.
	Estimated Costs to Non-Claimants	2	9	
	Total	4	18	
2	WTB Estimates based on Bedstock Performance	20	27	
3	PTF Estimates based on Overall Tourism Performance	12	46	The lower bound assumes that Pembrokeshire would have otherwise experienced no increase on performance in 1995.

There appears to be convergence around the £18/£20 million level and it is expected that this represents the mid bound and thus the most likely value of financial impacts from the *Sea Empress* oil spill to Pembrokeshire's tourism. That said, a consultee has indicated that structured surveys undertaken by the tourism sector (which formed the basis of the bedstock calculation in Cost Estimate Option 2) tend to include only member operators or those of a more organised nature. Thus, they can represent the 'tip of the iceberg' rather than the full picture.

However, the impacts on tourism in Wales more generally may be lower as there may have been a shift from Pembrokeshire to elsewhere (discussed in more detail below).

4.5.3 Summary of Economic Costs

Financial costs cannot be assumed to represent economic costs because of a potential shift in activities to elsewhere and thus there being only limited net national losses. Economic losses relate only to losses in profit and as tourism is part of the service industry, it is considered that 10% of financial losses will constitute profit.

From the data on origin of visitors to Pembrokeshire set out in Table 4.3, given that 29% of visitors travelled from Wales to the affected area, it follows that the same proportion of visitors would choose an alternative site also in Wales. As such, although visits to South and perhaps North Pembrokeshire may have declined slightly due to the oil spill, 29% of these visits may have been redistributed to other Welsh destinations.

It is less clear which other destinations the 67% of visitors to Pembrokeshire from other UK locations and the 4% of overseas visitors would have chosen. It seems reasonable to suggest that the majority of visitors from the UK would have chosen other UK destinations with similar scenery, climate and watersports attractions, such as Cornwall. It seems reasonable to assume that some visitors would choose other sites in Wales (say 10%) or would choose alternative holiday destinations overseas, such as France (say 10%).

With respect to international visitors to the affected area, it is expected that they would remain within the UK if not within Wales. For consistency, it is therefore assumed that 10% of these visitors remained within Wales while 90% visited other UK destinations.

Table 4.7 overleaf sets out the estimated economic losses to tourism in Pembrokeshire, Wales and the UK as a whole given the above assumptions as a result of the *Sea Empress* oil spill and clean-up. From this it can be seen that the economic costs to the tourism industry as a result of the *Sea Empress* incident range between:

- £0.25 million and £3 million for Wales; and
- £0.03 million and £0.3 million for the UK more generally.

As set out in the table, it is considered that the most likely economic costs to the tourism industry may, however, be around £1.3 million to Wales and around £0.134 million to the UK more generally.

Table 4.7: Summary of Economic Losses to Tourism from the *Sea Empress* Oil Spill (£1996; £ million)

	Visitor Origin	Indication of Shift in Activities Expressed Financially		Lost Economic 'Rent' or Profit*	
		from Wales	**from the UK**	**from Wales**	**from the UK**
Based on Financial Lower Bound of £4 million	Welsh	None[A]	None[A]	None	None
	UK	2.412[B]	0.268[C]	0.241	0.027
	Overseas	0.144[D]	None[D]	0.001	None
	Totals:	**2.556**	**0.268**	**0.255**	**0.027**
Based on most likely Financial Mid Bound of £20 million	Welsh	None[A]	None[A]	None	None
	UK	12.060[B]	1.340[C]	1.206	0.134
	Overseas	0.720[D]	None	0.072	None
	Totals:	**12.780**	**1.340**	**1.278**	**0.134**
Based on Financial Upper Bound of £46 million	Welsh	None[A]	None[A]	None	None
	UK	27.738[B]	3.082[C]	2.738	0.308
	Overseas	1.656[D]	None	0.165	None
	Totals:	**29.394**	**3.082**	**2.939**	**0.308**

*	10% of financial losses from Wales/UK (previous columns)
A	All visitors from Wales stayed within Wales (so no losses to Wales or UK).
B	10% of visitors from other UK locations chose other Welsh sites and 10% chose overseas destinations. 67% of all visitors to Pembrokeshire are from other UK locations. So, 90% of 67% of either £4 or £46 million lost from Wales.
C	10% of visitors from other UK locations chose other Welsh sites and 10% chose overseas destinations. 67% of all visitors to Pembrokeshire are from other UK locations. So, 10% of 67% of either £4 or £46 million lost from UK.
D	4% of visitors to Pembrokeshire are from overseas. All remained within UK and 10% remained within Wales. So, 90% of 4% of either £4 or £46 million lost from Wales and none lost from UK.

5. RECREATION

5.1 Recreational Activities in Pembrokeshire

5.1.1 Types and Locations of Potentially Affected Activities

As outlined in Section 4, around 10 million annual visits may be made to the South Wales coast and these trips are dominated by walking, followed by sightseeing and eating/drinking out. Visiting the beach/seaside in general appears to be the main purpose of nearly 1 million annual visits to the South Wales coast. Not all coastal activities would have been affected by the *Sea Empress* oil spill. Table 5.1 sets out the water contact pursuits undertaken at or from each affected beach. Annex 5 contains a map marked with the key sites and activities. Table A5.1 in Annex 5 sets out the recreational characteristics of each amenity beach to have been affected by the oil spill.

In addition to those activities highlighted in Table 5.1, general beach visits including sunbathing and picnicking can occur at any beach, as can swimming and bathing. In terms of non-immersible pursuits, walking is popular all along the South Pembrokeshire coast and the Coast Path runs across some beaches. The other popular non-immersible coastal activity undertaken in South Pembrokeshire is rock climbing. All of these activities are discussed below.

While there is a relationship between tourism and recreation, the costs associated with each due to the oil spill and clean-up are quite different. As set out in the previous section, most tourist destinations were largely clean by the time the 1996 tourism season began. As such, bathing seems to have been the only activity that would have been undertaken by tourists during the summer appear which was affected. In contrast, recreational losses relate to the lost activity that would have otherwise taken place during the time of the oil spill and clean-up. It appears that, on the whole, the majority of participants in these recreational activities would have been locals and not 'tourists'. Thus, lost recreational activity does not convert into economic losses to the region or to Wales apart from where attendance at national or international events was affected.

Lost recreational activity does not result in financial losses, unless some form of expenditure is involved with undertaking the activity (such as hiring a surf board or dinghy). All financial losses relating to reduced recreational activity are considered in Section 4 as they contribute to the value of the local and regional tourism industry. This section deals entirely with economic losses, or rather the value of lost enjoyment that would have been gained from participating in foregone recreational activities, owing to the *Sea Empress* oil spill and clean-up.

5.1.2 Description of Non-Immersible Activities

Data for visitor activities at coastal locations in Pembrokeshire are presented in Table 5.2 (Beaufort Research, 1996). The sampling sites used in the associated survey were classified into three broad categories, corresponding to high, medium and low visitor use. The sampling sites were car parks often associated with beaches and the data necessary for classification were provided by the Pembrokeshire Coast National Park Authority (PCNPA). This explains the divergence between Table 5.2 and Table 4.2 in Section 4, the former relating to tourism activities undertaken when in Wales, rather than tourism activities undertaken from beach car parks.

Table 5.1: Water Contact Recreational Pursuits Undertaken at Affected Beaches

Beach	Activity Undertaken							
	Canoeing/ Kayaking	Jetskiing	Land/ Sand yachting	Sailing	Sub aqua	Surfing	Waterskiing	Windsurfing
Abereiddy	✔				✔✔	✔		
Amroth		✔					✔	
Broadhaven (Haverfordwest)	✔				✔	✔✔		✔✔
Dale	✔			✔✔✔	✔	✔	✔	✔✔
Freshwater East				✔		✔		✔
Freshwater West	✔✔					✔✔✔		✔
Gelliswick	✔			✔✔✔	✔			
Little Haven				✔	✔			
Manorbier	✔					✔✔✔		✔
Martin's Haven						✔		
Newgale Sands	✔		✔			✔✔✔		✔✔
Nolton Haven	✔			✔				✔
Pembrey Beach			✔✔✔					
Pendine Sands		✔	✔✔✔	✔			✔	
Sandy Haven				✔				
Saundersfoot				✔	✔		✔	
Skomer Island					✔			
Solva (Porth y Rhaw)				✔				
St Brides Haven	✔				✔			
St David's, Caerfai	✔					✔		
Tenby, North				✔				
Tenby, South				✔	✔	✔	✔	✔
Westdale Bay						✔✔✔		
West Angle Bay	✔			✔		✔		✔

Key: ✔ activity occurs; ✔✔ important site (hire/tuition occurs here); ✔✔✔ key national site.
Source: PCNP (1994); Tidy Britain Group (1997); and pers. comm.

Table 5.2: Visitor Activities[A]

Activity	All Visitors %	Holiday Visitors %	Day Visitors %
Going for a short walk (up to 2 hours)	82	85	46
Going for a long walk (over to 2 hours)	38	42	7
Driving around and sightseeing - from car	65	68	36
Visiting a tourist/historic attraction	55	60	13
Going to the beach/seaside	90	90	80
Watching wildlife	33	36	5
Visiting a nature reserve/trail	23	25	3
Pursuing a hobby or special interest	15	16	6
Swimming in the sea	47	49	21
Water sport (e.g. sailing, windsurfing)	13	13	12
Other sporting activity (e.g. climbing)	4	5	1
None of these	1	1	2

A Indicates activities which visitors had undertaken or intended to undertake during the course of their trip to Pembrokeshire

Source: Beaufort Research, 1996

Walking

Walking in Pembrokeshire is dominated by the Pembrokeshire Coast Path, which is 186 miles in length and is one of 11 coastal paths in the UK. Access to the whole path was completed in 1970 having taken 17 years to accomplish (PCNP, 1997). It runs from Amroth in the South to Poppit in the North. The Coast Path receives around 1.3 million walkers annually, of which about 5% would have been in February (65 000), 7% in March (91 000) and 8% in April (104 000)[23]. Thus, over the period affected by the spill, between February and the end of April, around 250 000[24] Coast Path walkers may have used the area or had their visit affected by the oil spill.

23 from www.pembrokeshirecoast.org/educat11.htm; and Tourism in Wales Statistics on the WTB site at www.tourism.wales.gov.uk/wtb/english/stats95.html.

24 Half of those expected for February given that the spill occurred half way through the month, and all of March and April.

A counter positioned on a stile along the Pembrokeshire Coast Path measuring foot traffic between September 1996 and September 1997 indicates that the most popular period for using the path is during May, over the school summer half-term break. This is followed in popularity by the end of March/early April which coincided in 1997 with the school Easter holidays. Visits over the summer are also high but do not match these earlier peaks in terms of numbers on the path at a given time; rather, there is prolonged moderate use of the Coast Path instead of high peaks of visitors. It has been suggested that this may indicate that other activities are undertaken within the region over the summer, or that holidays are taken elsewhere (pers. comm.).

Expenditure while using the Coast Path is set out in Table 5.3 for the summer. Based on data (which is unconfirmed) from the same source, it appears that winter spend figures are somewhat higher, perhaps around three times those for the summer. Combining these data suggest that over the time of the spill and clean-up (from mid-February to the end of April), perhaps £11.75 million would usually have been spent in relation to walking the Coast Path.

Table 5.3: Pembrokeshire Coast Path Spend per User Figures for 1996

	Summer 1996		**Winter 1996/1997** (averaged and assumed ≈ 300% of summer)[25]
	Short distance users	**Long distance users**	
Expenditure on accommodation per person per night	£8.45	£9.99	£30.00
Expenditure on other things per person per day	£4.96	£6.34	£17.00
Totals	£13.41	£16.33	£47.00

Source: Coast Path User Survey, PCNPA, pers. comm.

Climbing

The main sites for coastal climbing are at St Govan's Head (Huntsman's Leap and Stennis Ford), St David's Head, and Stack Rocks. Huntsman's Leap and Stennis Ford are both small narrow inlets which are cut into the cliff-face. They are used extensively by climbers and are well known to those involved in the sport. Stack Rocks is a principal venue for rock climbing in Europe and is uniquely positioned in the mouth of the Haven.

The spread of climbing visits throughout the year appears to be similar to that described above for walking, from data provided on activity at the Castlemartin Range.

25 It is expected that this increase may relate to changes in accommodation (e.g. use of hostels, hotels or bed and breakfast facilities rather than camping) and perhaps increased expenditure on food (meals out rather than cooking in the open).

Specific data on overall participation rates have not been identified. Given the data presented in Table 5.2 above, around 4% of visitors to Pembrokeshire's coast may have undertaken 'other sporting activity (e.g. climbing)'. As Section 4 indicates, there may be around 10 million visits to the South Wales coast each year. Assuming that climbing activity comprises one quarter of these 'other' sporting activities, then total annual climbing visits to the South Pembrokeshire coast may be in the region of 0.1 million. Given that 37% of trips to the Welsh coast occur in winter (CRN, 1996), rough guesstimates of the number of climbing trips that may occur along the South Wales coast are set out in Table 5.4.

Table 5.4: Estimated Number of Climbing Trips to South Wales Coast

Season	Average Climbers per Day
Winter: October to March (27 weeks)	195
Summer: April to September (27 weeks)	335

General Beach Visits

Comprehensive data are not available on the number of visitors at given beaches. In order to establish the extent of beach use for different types of beaches, eight Pembrokeshire beaches were surveyed on behalf of the Consultants (Tenby South, Castle Beach, Tenby North, Saundersfoot, Newgale, Poppit, Newport and White Sands) covering the range of affected beaches (from those which were severely oiled to those which escaped oiling). Surveys were co-ordinated by PCC's Beaches Officer and were undertaken by lifeguards over the period of the school summer holidays and August Bank Holiday (between Saturday 9 August and Monday 25 August 1997). With respect to seasonal timing (and location), this survey is comparable with the visitor perception survey undertaken by Beaufort Research (1996) which took place between 26 July and 6 September 1996 in coastal locations.

These and other sources of information have been used to score affected amenity beaches (using the system set out in Table A5.2, Annex 5) and so to rank them according to their expected popularity. Knowing the visit numbers for some beaches from the beach use surveys undertaken by lifeguards and from Environment Agency Garber Data, sites of similar rank have been attributed similar visit numbers. As such, those beaches ranked in between those of known visit numbers have been assigned 'reasonable' visit numbers to coincide with their ranking. As a result, Table A5.3 in Annex 5 provides an indication of the popularity of all the identified affected amenity beaches in ranked order, and also indicates the 'peak' number expected to be on the beach on a busy August Sunday. The rank order has been confirmed by PCC.

There are several very popular beaches for general beach recreation in the coastal area affected by the oil spill. The most popular appear to be Tenby South, Newgale Sands, Saundersfoot (and Coppet Hall), Dale and Broadhaven (Haverfordwest). However, many others have high levels of use, including Barafundle, West Angle Bay and Whitesands.

Data indicate that visits to welsh beaches vary by month as set out in Table 5.5 for the months of February, March, April, May and August. Furthermore, around one third of visits to the beach occur on a Sunday (as also set out in Table 5.5). From this, it has been possible to use visit figures for a peak Sunday in August to estimate the average daily visitors to each beach for February, March, April and May. The results are set out in Table A5.4, Annex 5.

Table 5.5: Data on Welsh Beach Visits

Period	% Total Visits Undertaken
February	2
March	4
April	10
May	2
August	14
Weekday	52
Saturday	15
Sunday	33

Source: CRN, 1996

5.1.3 Description of Immersible Activities

Bathing

From Table 5.2, 47% of all visitors to the beach may have gone swimming. Given the data presented in Section 4, there may be around 10 million visits to the South Wales coast each year. This suggests that there may be around 4.7 million coastal swimming visits in South Wales per year. It is assumed that only those visiting beaches in the summer (between April to September) would swim. Given that 67% of trips to the Welsh coast occur during summer (CRN, 1996), there may have been around 3.2 million swimming visits to the South Wales coast during the summer.

Canoeing/Kayaking

The whole South Pembrokeshire coast is popular for canoeing and kayaking, particularly surf kayaking, 'play-boating', touring and 'rock hopping'. These sports are increasing in popularity and are concentrated around St Davids Head and Ramsey Island, making use of Ramsey Sound.

Surf kayaking takes place on the most exposed beaches, such as Freshwater West, Whitesands and Newgale. The first of these provides a venue for surf kayaking competitions. There are reports that the Pembrokeshire coast is one of the finest sea kayaking venues in Britain. The area of white water in Ramsey Sound and around the Bitches has become internationally known for 'play-boating' and white water kayaking.

In addition to surf kayaking, the Daugleddau Estuary and Milford Haven Waterway offers superb sheltered touring water for open Canadian canoes. As well as other canoeing events, Pembrokeshire Coast National Park Authority organises around ten canoeing events throughout the year.

Specific participation data are not available for canoeing trips around the Pembrokeshire coast. However, from national sources it appears that 1% of UK holiday makers will undertake canoeing (Leisure Consultants, 1989). Based on data from Section 4 (Table 4.1), this suggests that between 1 000 and 8 000 annual canoeing trips may occur in Pembrokeshire, perhaps the former relating more realistically to sea canoeing alone.

The season for surf kayaking and 'play-boating' tends to peak when the inland white waters are becoming less challenging, i.e. between May and June. The Whitsun half term holidays is a "big week". More dedicated locals, however, canoe all year round. Before April, weekend activity usually occurs.

Access to canoe at sea is free. For organised tours on rivers, an average charge may be around £5 for a member for a weekend, or £10 for a non-member. However, this may vary considerably. For example a recent 'tour' on the River Dee cost participants £4 per day for both members and non-members alike. To launch onto a lake usually costs in the region of £2.50. Charges to access whitewater sites may be in the region of £5 (pers. comm.).

Jetskiing

It is understood that there is some activity in the area which takes place in specific zoned areas; however, more data have not been provided.

Land/Sand Yachting

South Pembrokeshire is an important area for sand/land yachting in Wales. Some activity occurs at Newgale Sands, but Pembray Beach and Pendine Sands are the most popular sites in the area as they extend for some miles and receive good winds. Despite the area being nationally important for the sport, participation is very low compared to other activities.

Unlike most water contact sports, the season for sand/land yachting runs from the equinox at the end of September through until the equinox in Spring, around Easter. The Summer, although warmer, has lighter winds and brings more people onto the beaches which interferes with the sport. The winter brings westerly storm winds and miles of empty beaches. Keen sand/land yachters tend to move around the world to catch the best winds for the time of year.

Local activity takes place most weekends and falls into two categories: 'conventional' land yachting and 'paracarting' (which relies on kite traction rather than a sail, sometimes called 'kite buggying'). There are two 'conventional' land yachters who use Pendine Sands almost every weekend throughout the season.

There is one 'paracarter' for whom kite traction is his livelihood. As such, customers interested in new kites come from around the world to test them on Pembrey Beach or to be trained, for example teams learning the technique for use on polar expeditions. He and his employees would undertake the sport more frequently than at weekends during the season if ammunition testing did not take place on Pendine Sands and Pembrey Beach.

Sand/land yachters and paracarters travel several miles along beaches and so it is unusual for independent activity to occur; groups tend to comprise between two and ten people.

To undertake sand/land yachting costs around £20 in the UK for a day's activity (normally lasting about three hours; pers. comm.).

Sailing and Boating Activity

Sailing is a very popular activity in South Pembrokeshire, particularly in the open coastal waters, around the islands and in the Haven Waterway. The area attracts many holiday makers for whom sailing activities provide a focus for their visit. National and international sailing events often occur in the area. Four sailing schools in the area have been identified: West Wales Wind, Surfing and Sailing (Dale); St Davids Adventure Days; Dale Sailing; Haven Multihulls; and Cleddau Classic Cruising (Llangwn Ferry).

In the Haven itself, there were 1 500 moorings and berths in 1993 (more recent data have not been provided). The sailing season starts around the last week of March or the first week of April. Before this time the weather is usually too cold and few, if any, events are organised.

Specific participation data for South Pembrokeshire sailing activity are unavailable. According to national data, 2% of UK holiday makers will undertake sailing (Leisure Consultants, 1989). Based on the data presented in Section 4 (Table 4.1), this suggests that between 2 000 and 16 000 annual sailing trips occur in the affected area.

Pleasure boat trips are also popular from Tenby, Saundersfoot, Martins Haven, St Justinians and Whitesands, with the islands being the main focus of interest. Permission is required from Dyfed Wildlife Trust to land visitors on Skomer, Skolkholm and Grassholm Islands as numbers are restricted for conservation reasons (pers. comm.). According to national data, 22% of UK holiday makers will undertake commercial boat trips and cruises (Leisure Consultants, 1989). Based on the data presented in Section 4 (Table 4.1), this suggests that between 22 000 and 128 000 commercial boat trip may occur annually in the affected area. However, consultation with local commercial boat companies indicates that the upper bound may be closer to 60 000 (pers. comm.).

Consultation has confirmed that the most popular times of year for undertaking pleasure boat trips coincide with the most popular times of year for tourism in the area. The season begins at Easter and peaks during the summer period, continuing until the end of October (pers. comm.).

Sub Aqua

Diving activities occur all around the Pembrokeshire coast. The Blue Lagoon, an old slate mine, is so popular that those exploring the site are referred to as "the Blue Lagooners". The bottom has not yet been reached due to its depth.

The West Wales Diving Centre in Haverfordwest forms a focal point for local sub aqua activity. The Centre can cater for 18 divers staying on site, or 600 divers using 67 RIBs and 20 inflatables. To give an indication of participation in the activity, all of these were used on one August bank holiday.

Martins Haven, Broadhaven, Dale, Gelliswick, Little Haven, Saundersfoot, Skomer Island, St Brides haven, Whitesands and Tenby are all popular launch sites for dive boats.

Surfing

Surfing is a major activity in South Pembrokeshire. As Pembrokeshire is surrounded on three sides by the Atlantic, the resulting exposed beaches and high winds provide high energy seas and perfect surfing conditions. The most famous surfing beach in the area is Freshwater West which is described as "one of the main surfing beaches in the UK" (MPCU, 1996). Manorbier, Newgale Sands, Whitesands Bay and Westdale Bay are also important surfing sites in the area. Board hire is available at several locations, such as Dale.

Storm winds, such as those that occur early in the year are very popular for surfing as they produce good surf waves. Participation data have not been provided.

Waterskiing

Waterskiing is a high contact sport; as such, those participating in the activity spend a lot of time totally immersed in the water. Therefore, the majority of waterskiing activity takes place during the warmer months of the year, between April and September. Although the season can stretch into March and October, skiing before May is usually too cold.

Milford Haven Marina is considered by some to be one of the best waterskiing venues available to the sport. The Haven Marina has been the venue for the National Ski Race since 1990 and this has usually taken place in early May to 'kick-off' the season. Competitors from the States and Australia sometimes compete and the event usually attracts around 500 people[26]. Next year will be the first year for the event to occur later, in July, due to tides.

There are two ski clubs in the Haven. Lawrenny and Burton are recognised waterskiing sites, while other locations are reserved for non-motorized activities.

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26 In terms of competitors, the event usually attracts around 50 skiers and for each of these there are two crew in the boat, resulting in around 150 competitors in all.

Table 5.9: Examples of Recreation Willingness to Pay Studies (£1996)

Method of Valuation and Criteria	Value	Study and Comments
Lost value from beach erosion	Mean £2.57 /recreation day	Green *et al*, 1990
CVM - bathing water quality improvement from failure to meet EC Directive (76/160) to that safe for swimming	Mean £11.19 /household/year (£5.59 per adult occupant)	Maidwell, 1995 (FWR)
CVM - WTP additional water rates to ensure that bathing water constantly passes EC standard	Lowestoft: Mean £0.76 per person per trip £14.32 all/household £14.49 holiday/household £14.53 day trippers/household £13.50 local resident/household Great Yarmouth: £1.07 per person per trip £12.64 all/household £14.16 holiday/household £10.42 day trippers/household £9.33 local resident/household	Georgiou *et al*, 1996 Per person per trip values taken from FWR Manual, 1996
CVM - Value of enjoyment per recreational visit to beaches in 4 conditions	£5.22, £8.89, £10.50 and £15.51 /adult visit	Penning-Rowsell *et al*, 1989 in Bateman *et al*, 1993
CVM - Recreational value of cliff tops (walking)	£2.03 - £3.13 /resident/year	Penning-Rowsell *et al*, 1992 in Bateman *et al*, 1993
CVM - Coastal recreational WTP per day. Values are split into general (walkers, picnickers, swimmers etc.) and specialised (water sports users and anglers).	General: Foreign visitor: £50.48 Out of state visitor: £4.67 Local uses: £4.67 Specialised: Foreign visitor: £72.04 Out of state: £29.46 Local users: £16.36	Kearney, 1991 in King, 1994 - US study
CVM - WTP for beach stabilisation	Holiday: beach charge mean £1.28 /adult visit Day trip: beach charge mean £1.57 /adult visit Local: beach charge: £1.02 /adult visit Car park charge: £1.68 /car/visit	PDE, 1991

Had the incident affected general beach use at the height of the summer, then higher values may have been attributed to lost activity. From Section 5.3.1 it is estimated that around 0.45 million general beach visitor days were lost as a result of the oil spill and clean-up. Combining the economic value per visitor day with the number of lost general beach visits results in values of

5.2.2 Long-term Impacts on Levels of Participation

There may have been impacts on participation rates on amenity beaches even after they were cleaned and made accessible to the public, resulting from residual oil or users' perceptions. Data on levels of residual oil are available from surveys undertaken by the Joint Response Centre (JRC) in February/April 1997. These indicate that the majority of beaches showed some signs of surface oil or staining and sub-surface surveys indicated the more frequent presence of sheens, free oil and tarballs. Tenby North, for example, had surface and sub-surface tarballs and pats as well as sub-surface free brown oil. Tenby South had pockets of dense oil at depths of two or three feet.

Impacts resulting from visitors' perceptions are contingent on awareness of the incident. In its study into the impacts of the *Sea Empress* oil spill on tourism, WTB concluded that "awareness of the *Sea Empress* incident and its geographical impact was extremely high among those who visited Pembrokeshire in 1996[27], but there is little evidence to suggest that it influenced their behaviour during their stay" (WTB, 1997a). While true in general terms, some impacts on the behaviour of coastal visitors were identified by Beaufort Research in their survey of visitors perceptions (Beaufort Research, 1996). Respondents to the survey were asked to indicate the effects of the *Sea Empress* incident on their present visit. Results of relevance to this cost-benefit study are presented in Table 5.6. These data can be used to estimate reductions in participation rates during the summer of 1996 for oiled beaches.

Table 5.6: Effect on Leisure Activities

Type of Question[A]	Nature of Effect	All Visitors %	Holiday Visitors %	Day Visitors %
Open	Activities not affected at all	91	-	-
	Would not go swimming in the sea	3	-	-
	Unable to collect cockles	<1	-	-
	Fewer opportunities for birdwatching	<1	-	-
Closed	It hasn't affected our behaviour in any way	36	36	32
	We have avoided swimming in the sea or undertaking watersports	5	4	9
	We have spent less time swimming in the sea or undertaking water sports	5	5	9
	It has made our visit less enjoyable	2	2	6

A Respondents were first asked to describe in what way, if any, their activities had been affected (i.e. open questioning). They were then given a list of examples of possible responses to a major oil spill and then asked which, if any, applied to them (i.e. closed questioning).

Source: Beaufort Research, 1996

27 Unprompted awareness of the incident: 96% all visitors, 98% Welsh visitors, 96% Other UK visitors and 69% overseas visitors (Beaufort Research, 1996); (WTB: Wales Visitor Survey 1996, in WTB, 1997a).

While the data in Table 5.6 indicate the changes in activity undertaken by visitors to the affected coast, it has also been suggested that long-term impacts may also have been felt by beaches outside the oiled area. This appears to be linked to perceptions of the extent of coast which was oiled. In general terms, research indicates that there is a high correlation between respondents' perceptions of which parts of the coast had been affected and the reality of what actually happened. However, a reasonable proportion of the general public were misinformed about the extent of oiling; while 40% of coastal visitors thought that some of the Pembrokeshire coast had been affected by the oil spill, 37% thought that most had been affected and 10% that the whole coast was oiled (Beaufort Research, 1996).

5.2.3 Impacts on Enjoyment

Visitors to Pembrokeshire beaches following the main clean-up may have had their enjoyment reduced as a result of the *Sea Empress* oil spill (either due to residual oil or their perceptions). There is evidence of this impact in studies of the incident. In a survey of visitor perceptions, it was found that 11% of visitors to the Pembrokeshire coast believed that public enjoyment of the area had been affected a lot, 47% only a little and 39% not at all (Beaufort Research, 1996). A survey of visitors to Wales as a whole found that 72% thought that the incident had affected public enjoyment a little or a lot (WTB: Wales Visitor Survey 1996, in WTB, 1997a). However, there have been other comments that the popular areas have never been so clean, and in fact appear cleaner than most other UK beaches (pers. comm.).

In a study on the health effects of the *Sea Empress* oil spill (Lyons *et al,* 1996 - see Section 10), questions were also asked concerning the impact of the spill on "enjoyment of the local surroundings". The survey found that 74% of the exposed population (i.e. those living in coastal areas oiled by the spill) felt that their value of enjoyment of the local surroundings had been affected as a result of the oil spill, compared with 19% of the control group. When questioned about the future, 62% of the exposed population felt that enjoyment of the local surroundings would be worse as a result of the incident, compared with 28% of the control group.

5.2.4 Actions Taken to Limit Recreational Impacts

Within Pembrokeshire, actions were taken to ensure that Tourist Information Centres (TICs) were able to provide accurate and up-to-date information in response to visitors' questions and concerns. The TICs were provided with daily bulletins from the JRC, bathing water quality information from the Environmental Health Department of PCC (supplied to the local authority by the Environment Agency) and a statement on safety and hydrocarbon levels. This was supplemented by a telephone 'Hotline' established by the Regional Tourism Company, signage at beaches advising of the current conditions and by a touring exhibition provided by the PCNPA (Fielding, 1997). The costs of these actions are included in Section 4 where available.

5.3 Valuation of Impacts

5.3.1 Participation Rates

Overview

Valuation of impacts on recreational activities requires information on participation rates for each of the affected activities to which economic values on a per visit basis can then be assigned. This section brings together data from a wide range of sources, including consultation with many affected sports organisations. Overall, data are not available on the number of participants engaged in each recreational pursuit during the time of the spill. Information presented, therefore, is sometimes general in nature.

Non-Immersible Activities

Walking the Coast Path may not have been significantly affected by the oil spill as almost all of the length will have still been accessible. However, the number of walkers expected to be using the path between the spill and the 10 March (the most affected period) would usually have been around 0.078 million[28]. From this time until the end of March (assumed to have had 50% reduction in beach access), the path would have usually expected a further 0.045 million visitors.

Data have been provided by the PCNPA on the number of walkers and climbers present at Castlemartin Range for the periods April to August, 1992 to 1997. Additional data have been provided for the month of March in 1996 and 1997. Although these do not provide visit numbers for the time of the oil spill and clean-up, they can be used to establish overall trends by comparing year with year.

When analysed, it appears that the average presence of walkers did not decrease following the spill, but actually may have increased by around 20% for 1996 and 1997 when compared with the average number of walkers in previous years, irrespective of the additional data for March in 1996 and 1997. As the months over which data are available alter at the same time as the apparent increase in walkers, it may be that the survey technique was also altered around this time which may explain the different results (although similar trends are not noticeable for climbing, using a similar data set).

If, however, the number of walkers has generally increased since the oil spill by the 20% suggested by the data, then there may be an additional 0.3 million visits[29] to Pembrokeshire Coast Path each year for 1996 and 1997. If this is a continuing trend, it may result in increased expenditure in the region of £7.8 million per annum[30]. Whether this is as a result of the *Sea Empress* oil spill can be neither confirmed nor dismissed.

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28 ½ of February's 0.065 million visitors plus ½ of March's 0.091 million visitors.

29 20% of 1.3 million Coast Path users.

30 ((£13.41 + £16.33 + £47.00)/3) x 0.3 million additional visitors per year.

For **climbing**, the data show quite a different picture. The lowest year for annual participation in climbing at Castlemartin Range appears to have been 1993, with 1995 being the peak year since 1992. The levels of participation fell in 1996 and 1997 to numbers similar to those for 1992 and 1993. Thus, 1994 and 1995 may have been peak years for the sport, or perhaps competitions were taking place at this site. The spread of participation changed in 1997, with a higher presence throughout the period, rather than the more usual peak around Easter and trough around June. Whether these trends are repeated at the other climbing sites in South Pembrokeshire is not yet known. Again, there is no means of linking these trends with the occurrence of the oil spill, despite potential loss of access to climbing sites.

With respect to the **general usage of beaches** during the spill and clean-up, the incident appears to have resulted in lost beach access totalling around 0.45 million visitor days across all of the affected beaches with some (even if very low) amenity value (and taking the very general assumptions about periods of lost access)[31]. As outlined above, these results stem from a ranking process whereby beach count data were used to 'pin' visitor numbers to beaches of particular rank order. The supporting data for this process is provided in Annex 5 (Tables A5.1 to A5.4).

Immersion Activities

The discussion provided in Section 5.1.2 indicates that there are usually around 3.2 million **swimming visits** to the South Wales coast during the summer. However, the data provided in Table 5.6 suggest that between 3% and 4% of usual swimming activity may not have occurred in the holiday season of 1996 due to concerns over bathing water quality. Thus, around 0.1 million swimming visits may have been lost owing to the oil spill[32].

Table 5.7 indicates the number of 'casual' people-activity-days lost for each identified water contact activity where data have been identified (with a more detailed version provided in Table A5.5, Annex 5). Due to the time over which the oil spill restricted access to the coast and surrounding waters, the peak season for most sports activities had not begun. In most cases, local participants were aware of the extent of the oiling and clean-up and so impacts were short-term.

Longer-term impacts were experienced by some sports, such as sailing, where competitions suffered from reduced attendance as visitors into the area perceived that oil would still have affected activities, even in August. Table 5.8 on page 16 sets out the more organised events that were affected, where data have been provided (Table A5.5 in Annex 5 also sets out more details of these events). There is a general feeling that impacts on the activities were largely due to the negative media coverage at the time of the spill which was not balanced out by positive coverage of the area once it was clean again (pers. comm.). The impacts on each sport are discussed below, relating to both casual participation and also more organised events.

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31 It should be noted that these are separate from tourism related bookings (discussed in Section 4), referring instead to lost recreational activity at the time of the spill, which is expected to comprise mainly local use general use of beaches.

32 This number of visitors still used the beaches during the summer period, but their activity altered. As such, it is assumed here that these visitors lost enjoyment from their beach visit as a result of the *Sea Empress* oil spill. These are not, therefore, lost visits to the affected area.

Table 5.7: Impacts of *Sea Empress* Oil Spill on Specific 'Casual' Activities

Activity	Number of Days Affected	People Participating per Day		Total Activity Days Lost	
		Low	**High**	**Low**	**High**
Canoeing	29 days in all[a]	3	22[33]	85	640
Kayaking	None	-		None	
Land/Sand Yachting	4 weekends	2		8	16
Paracarting	10 weekends[b]	2	10	20	200
Sailing	None	-		None	
Sub Aqua	None	-		None	
Surfing	At least 30	?		?	
Waterskiing	None	-		None	

a 11 weekends (22 days (up to end of April) plus ½ term (one week))
b activity over two months

Different reports have been received from canoeists and kayakers. Consultation with **canoeists** suggests that until the beginning of April the majority of casual sea canoeing moved to Cardigan Bay in North Pembrokeshire. This would have impacted weekend activity and also the half-term (one week). As Table 5.7 sets out, the number of canoeing days affected may be between 85 and 600. Given that this is calculated from total holiday visits to Pembrokeshire, rather than total holiday visits to Pembrokeshire's south coast, the lower bound figure is probably a truer representation of sea canoeing trips than the higher bound.

Consultation with **kayakers** suggests that coastal activity would not have begun until May or June and, as such, weekend programmes continued unaffected. Occasional trips were altered but access and launch sites remained the same. The worst location was apparently west around the rocks at Stackpole Quay where clean-up teams were still in operation. In some of the more sheltered coves and in caves, the unusually calm weather had left a mixture of petrol and detergent which led to lightheadedness and so those areas were initially avoided. In some areas with oiled rocks, surf kayaking was undertaken in place of 'rock hopping' (i.e. using the tide to sweep kayaks out of rocky bays). Thus, no sea kayaking trips were lost from the spill.

In terms of **land/sand yachting**, Pendine Sands (the worst affected), was clean enough to continue the sport seven weeks after the incident, resulting in potentially six weekends of lost activity. One of these weekends was spent out of the area at a competition and the consultee also suggested that one other weekend would have been lost due to unusually calm winds. Thus, a maximum of four weekends were lost to two participants due to the spill, or between eight and 16 people-activity-days.

33 Based on 1 000 to 8 000 canoeing visits per year.

Table 5.8: Specific Events Impacted by *Sea Empress* Oil Spill

Event	Date	Impact on Attendance
Impala European Sailing event	July	Neyland Yacht Club expecting between 18 and 28 boats but only nine came. Thus, about 15 boats may not have attended.
Celtic Watersports Festival	August	Neyland Yacht Club organise Disabled Sailing Teams - normally have six or seven but dropped to the French, Irish (for ½ time) and Welsh only. Thus, about four Disabled Sailing Teams may not have attended.
1st round of National Series (Sand Yachting)	March	30 to 50 competitors, 100 to 150 in all. Event moved to Weston Super Mare.
Milford Haven National Ski Race (waterskiing)	Early May	50 skiing competitors. For each of these there are two in the boat (100). Including supporters, total number around 500. Same number attended in 1996.

Paracarting activity totally ceased for two months, resulting in between 20 and 200 lost activity days. In addition, the first of three rounds of the National Series had to be relocated to Weston Super Mare from Pembrey Beach, affecting between 30 and 50 competitors and up to 100 supporters from all over the UK. This event was to have taken place in March.

Local **sailing** activity was apparently not affected due to the timing of the spill. However, the Celtic Watersports Festival (overall participation data are awaited), held in August, and the Impaler European sailing competition, held in July, both suffered reduced sailing attendance, as set out in Table 5.8. Neyland Yacht Club have claimed from the 1971 Fund for lost bar takings due to the latter.

Consultation has indicated that **sub Aqua** activity was not lost, although some short-term visibility impacts were noticed. Over the longer-term, consultees have suggested that the area is now cleaner and so the sport has improved.

It is understood that **surfing** activity was significantly affected by the oil spill and clean-up over the short-term, with competitions being reorganised from Freshwater West. Anecdotal evidence suggests that the spill affected peak activity time, when popular storm winds provide good surf. Surfers ventured back into the water about one month after the incident, before the quality of water had been confirmed as being 'safe'. Apparently some surfers suffered rashes, but in no greater number than usual. Participation data for this activity and also for windsurfing have not been available.

There were apparently no impacts to **waterskiing** activity as the season had not begun. The Milford Haven National Ski Race was scheduled to take place in Milford Haven Marina in early May, three months after the spill. Three weeks before the event, its organiser considered that the Marina was cleaner than it had been previously; as such, the competition went ahead with the full attendance of around 500 people. Following the event, letters of commendation were received on the choice of venue. Thus, there were no lost waterskiing activity days due to the oil spill.

5.3.2 Economic Values for Recreational Activities

General Beach Use and Bathing

To determine an economic value for the benefits (or dis-benefits) accrued by visitors when they use (or cease to use) coastal recreation sites, an appropriate willingness to pay figure is required. These are available for general beach use from previous studies and examples are given in Table 5.9 overleaf. The full results of the literature review with respect to economic values of beach use are presented in Table A5.6 of Annex 5.

From this table, it can be seen that values differ dramatically and measure a number of different environmental changes including the 'value of enjoyment', improvements in bathing water quality or a day of coastal recreation. Thus, care has been taken in selecting appropriate values for changes in recreational activity due to the *Sea Empress* oil spill and the following factors were considered:

- given that the presence of oil is one of the criteria determining compliance with the EC Bathing Water Directive, the use of a value relating to water quality improvements to meet the requirements of this Directive may be the most appropriate for those avoiding swimming;
- data on the factors affecting the public's enjoyment of a beach indicate that the presence of oil is of similar importance to the presence of sewage contamination, with scores of 9.2 and 9.8 respectively, out of a maximum of ten (reported in Bent & Thomas, 1996);
- similarly, research into users' priorities at Gower beaches in Pembrokeshire found that the most highly prioritised beach attributes in order of importance were absence of sewage, debris, oil and litter, followed by clean bathing water (*ibid*);
- 98% of people surveyed about perceptions of water quality considered that oily smells were indicative of poor water quality (*ibid*); and
- loss of access to beaches occurred during February and March and so WTP to access the beaches are expected to be lower than for the summer, holiday season.

As the incident occurred in February and affected mainly local general beach use, it was decided that the following values should be attributed to lost activity resulting from the *Sea Empress* oil spill and clean-up:

- Lower bound: £1.00 per visitor day[34]; and
- Upper bound: £5.20 per visitor day[35].

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[34] Based on PDE local beach charge value of £0.88 in 1991, in 1996 prices.

[35] Based on Penning-Rowsell, 1989 (in Bateman *et al*, 1993) lower figure of £3.86, in 1996 prices.

Table 5.9: Examples of Recreation Willingness to Pay Studies (£1996)

Method of Valuation and Criteria	Value	Study and Comments
Lost value from beach erosion	Mean £2.57 /recreation day	Green *et al*, 1990
CVM - bathing water quality improvement from failure to meet EC Directive (76/160) to that safe for swimming	Mean £11.19 /household/year (£5.59 per adult occupant)	Maidwell, 1995 (FWR)
CVM - WTP additional water rates to ensure that bathing water constantly passes EC standard	Lowestoft: Mean £0.76 per person per trip £14.32 all/household £14.49 holiday/household £14.53 day trippers/household £13.50 local resident/household Great Yarmouth: £1.07 per person per trip £12.64 all/household £14.16 holiday/household £10.42 day trippers/household £9.33 local resident/household	Georgiou *et al*, 1996 Per person per trip values taken from FWR Manual, 1996
CVM - Value of enjoyment per recreational visit to beaches in 4 conditions	£5.22, £8.89, £10.50 and £15.51 /adult visit	Penning-Rowsell *et al*, 1989 in Bateman *et al*, 1993
CVM - Recreational value of cliff tops (walking)	£2.03 - £3.13 /resident/year	Penning-Rowsell *et al*, 1992 in Bateman *et al*, 1993
CVM - Coastal recreational WTP per day. Values are split into general (walkers, picnickers, swimmers etc.) and specialised (water sports users and anglers).	General: Foreign visitor: £50.48 Out of state visitor: £4.67 Local uses: £4.67 Specialised: Foreign visitor: £72.04 Out of state: £29.46 Local users: £16.36	Kearney, 1991 in King, 1994 - US study
CVM - WTP for beach stabilisation	Holiday: beach charge mean £1.28 /adult visit Day trip: beach charge mean £1.57 /adult visit Local: beach charge: £1.02 /adult visit Car park charge: £1.68 /car/visit	PDE, 1991

Had the incident affected general beach use at the height of the summer, then higher values may have been attributed to lost activity. From Section 5.3.1 it is estimated that around 0.45 million general beach visitor days were lost as a result of the oil spill and clean-up. Combining the economic value per visitor day with the number of lost general beach visits results in values of between around £0.45 million and £2.3 million[36], which represents the value of lost general beach activity owing to the *Sea Empress* oil spill and clean-up.

There may also have been lost beach activity later on in the year owing to public perceptions of beach cleanliness (as discussed in Section 5.2.2). However, consultation suggests that general beach use in the summer of 1996 was not significantly affected.

For reduced bathing activity, it was considered that the values relating to bathing water quality improvements were most representative. Considering the values presented in Table 5.9, it was decided that a value of around £5 per visit (£1997) would be appropriate here. As such, the 0.1 million swimming visits that did not occur between April and September 1996 due to concerns over the quality of bathing water following the oil spill can be valued at around £0.5 million.

Specific Recreational Activities

The review of economics literature did not identify any WTP values relating to specific sea or coastal recreational pursuits, such as canoeing or sailing. Therefore, it has been necessary to derive consumer surplus values from data provided on average costs of a day's activity for each affected pursuit. These are set out in Table 5.10 overleaf, which also brings together information on the number of lost activity days (from Table 5.7) and summarises the lost consumer surplus relating to the *Sea Empress* oil spill and clean-up, by activity.

5.4 Summary of Costs to Recreational Activity

Valued and unvalued impacts from the *Sea Empress* oil spill and clean-up to recreational activities in South Pembrokeshire are summarised in Table 5.11. As this shows, the overall recreational impacts may be between around £1 million and £3 million. This is expected to represent a lower bound given that it has not been possible to value lost surfing/windsurfing activity and reduced attendance at watersports competitions.

It is important to note that the overall impacts on recreational activity were minimised by:

- the time of year the spill occurred; and
- the speed with which important amenity beaches were cleaned.

Visits to the Welsh coast in July, August and September represent 40% of total annual visits, whereas visits during February, March and April represent only 16%. Given this, had the spill occurred in July, for example, it could be assumed that recreational impacts would have been two and a half times as great, equivalent to between £2.5 and £7.5 million.

[36] or £2.475 million

Table 5.10: Costs of Lost Activity Days

Activity	Average Cost of a Day's Activity	A: Estimated Consumer Surplus			B: Number of People Activity Days Affected			Consumer Surplus Affected (A x B)			Area Affected
		Low (10%)	Mid (30%)	High (50%)	Low	Mid	High	Low	Mid	High	
Canoeing	£5	£0.50	£1.50	£2.50	85	343	600	£42.50	£514	£1 500	South Pembrokeshire lost visits while North Pembrokeshire gained visits
Jetskiing	No Data										
Kayaking	£5	£0.50	£1.50	£2.50	None			£0			'Casual' activity continued
Land/Sand Yachting	£20	£2	£6	£10	20	-	200	£40	£1 020	£2 000	'Casual' activity days completely lost
Paracarting (Kite Buggying)					8	-	16	£16	£88	£160	
					30	-	50	£300	£400	£500	National Competition - consumer surplus lost from region. Upper bound value is used for competitors as national event; Mid bound value is used for supporters.
					100			£600			
Sailing	-				Virtually non; season yet to start			£0			'Casual' activity continued
Sub Aqua	-				None			£0			-
Surfing/Windsurfing	No Data										
Waterskiing	-				None; season yet to start			£0			-
							Totals	£998.50	£2 622	£4 760	

Table 5.11: Summary of Recreation Costs from the *Sea Empress* Oil Spill (£1996)

Description	Values (£)		Comments
	Lower	Upper	
General Beach Visits	450 000	2 340 000	Represents consumer surplus only. Mainly local use. Activity probably moved to other local sites.
Swimming	500 000		Represents consumer surplus only. Holiday makers between April and September. Totally lost activity.
Canoeing	43	1 500	Represents consumer surplus only. Casual activity moved to North Pembrokeshire.
Land/Sand Yachting	40	2 000	Represents consumer surplus only. Casual activity totally lost.
Paracarting	16	160	
Surfing			Expected to be high. One of main UK sites inaccessible at popular time of year for at least one month.
Walking			Appears to have been 20% increase in Pembrokeshire Coast Path use since 1995, but cannot be attributed to oil spill.
Land/Sand Yachting Competition	900	1 100	Represents consumer surplus only. Activity lost from region to Western Super Mare
Other Competitions			Low attendance for some National and International events, suggesting lost income and lost consumer surplus for not only the region but also the nation.
Total	**951 000**	**2 844 760**	

6. COMMERCIAL FISHERIES

6.1 The Nature of Commercial Fisheries

The main commercial species of fish caught in the area of the *Sea Empress* oil spill are set out in Table 6.1. MAFF's Directorate of Fisheries Research reports (in Welsh Affairs Committee, 1996) that there is a broadly-based fin fishery all year round catching demersal (bottom feeding) fish, with the high value bass increasing in importance since the late 1980s. Pelagic fish attract a smaller amount of effort. There are also important fisheries for salmon and sea trout, which are exploited both commercially and for sport. With respect to shellfish, harvesting areas are designated under EC legislation and a valuable export market for whelks developed in the mid 1990s. In addition, three species of edible seaweed are collected for the local laver bread, and samphire is collected from saltmarsh areas for use in domestic cooking.

Table 6.1: The Main Commercial Species Caught in the Area of the *Sea Empress* Oil Spill

Fin Fish	Demersal fin fish	Bass, Brill, Cod, Conger, Dab, Dogfish, Flounder, Gurnard, Haddock, Hake, Lemon Sole, Ling, Megrim, Anglerfish, Mullet, Plaice, Pollack, Saithe, Skate, Dover Sole, Turbot, Whiting
	Pelagic fin fish	Herring, Mackerel
Shellfish	Crustaceans	Brown Crab, Lobster, Spider Crab, Crawfish, Velvet Swimmer Crab, Green Crab, Prawns
	Bivalve molluscs	Cockle, Mussel, Scallop
	Cephalopods	Squid
	Gastropod molluscs	Whelk, Winkle

Source: Memorandum from the Welsh Office and MAFF in Welsh Affairs Committee, 1996

Overall, the fishing industry in South West Wales employs approximately 1 000 fishermen on a full or part-time basis. There are over 300 licensed fishing vessels[37], many of which are small boats operating on a part-time basis and within the inshore fishery (Welsh Affairs Committee, 1996). The inshore fishery (i.e. within six miles of the coast[38]) supports approximately 370 vessels and 720 full or part-time jobs. The offshore fishery (i.e. outside the six mile limit) consists of 52 foreign owned, UK (Milford) Registered vessels which employ 624 persons (Coates & Davies, 1996). The commercial fishing industry also provides additional employment in relation to

37 Since 1993, all vessels that fish for profit have been required to register as a fishing vessel with the Registrar General of Shipping and Seamen at Cardiff and have a relevant MAFF licence to fish (Coates & Davies, 1996).

38 Since the six mile limit is calculated to extend from any island, it extends up to 22 miles from the coast of the Pembrokeshire mainland.

wholesaling, processing and distribution. It is estimated that for every job at sea, there are between three and five shore-based jobs[39]. Further jobs are involved in support of sport and hobby fishing, for example in operating angling charter vessels (Welsh Affairs Committee, 1996). The main market for commercial fish landed at Milford Haven is Spain (70%) and Brittany. The majority of lobster, brown crab and spider crab are sent alive and unprocessed to Spain and Portugal. Whelks are processed locally and frozen to supply Japan and Korea. Cockles are still sold locally, but the majority are processed in the UK and bottled/canned in Holland for European markets including the UK.

The South Wales Sea Fisheries Committee (SWSFC) is the statutory body responsible for the regulation, management and conservation of fish and shellfish stocks between Cardigan and Cardiff to six miles offshore. It reports that (see Coates & Davies, 1996), landings of shellfish and (some) fin fish species taken from the south Wales coastline in 1995 were at an all time high. The first sale value of species landed amounted to £5.58 million, the majority of this arising from bass, rays, dogfish, flatfish, lobsters, crab, cockles and whelks. The processed value of fish is reported to be between two and four times first sale value, and retail values up to six times this much. The weather, more than any other naturally occurring event, determines the quantity of fish and shellfish harvested, particularly by small inshore based vessels.

6.2 Overview of Impacts

Immediately following the oil spill, local fishermen agreed a voluntary fishing ban in the area of the spill (which was in place by 20 February). Concurrently, MAFF observed and modelled the spill and took and analysed samples of fish to evaluate the possible effects of the spill on human health via the aquatic food chain. Traces of hydrocarbons were found and on the basis of this contamination the fishery was closed using the emergency powers in the Food and Environmental Protection Act (FEPA) 1985. The 'Designated Area' covered approximately 810 square miles and a chronology of the closures is presented in Table 6.2 (based on Hearne, 1997).

The fisheries exclusion zone (FEZ) is reported to be 'very similar' to the commercial fishermen's voluntary ban. It impacted both commercial inshore and offshore fisheries, as well as recreational angling. As can be seen from Table 6.2, restrictions have been progressively lifted to reflect the findings of the sampling programme. One of the requirements for lifting the ban on a given species has been that taste tests reveal no taint (Hearne, 1997).

In general terms, fin fish and crustaceans suffered only slight contamination considering the quantity of oil spilled. This was probably due to the spring of 1996 being colder than usual, so feeding activity may have been reduced around the time that the oil was released.

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39 MAFF estimates between three and four (in Welsh Affairs Committee, 1996) and SWSFC between four and five (Coates & Davies, 1996).

Table 6.2: Key Events for Fisheries

Date	Event
28 February 1996	Restrictions placed on all fishing activities, gathering edible seaweed and samphire in coastal waters between St David's Head and Port Eynon Point in south west Wales.
20 March 1996	Restriction imposed on catching salmon and migratory trout in all freshwater rivers and streams which discharge into the sea between St David's Head and Port Eynon Point.
3 May 1996	Restrictions lifted for salmon and migratory trout.
21 May 1996	Restriction on all fin fish removed.
3 July 1996	All restrictions lifted from the commercial shellfish (i.e. cockles) area of the Bury Inlet.
30 August 1996	Restrictions on whelks and crustaceans lifted outside Milford Haven.
12 September 1996	Restrictions lifted from the commercial shellfish (i.e. cockles) area of the Three Rivers Estuary.
17 October 1996	Restrictions lifted from crustaceans in Milford Haven.
7 February 1997	Ban lifted from whelks in Milford Haven.
10 June 1997	Restrictions lifted on edible plants (seaweeds and samphire) and casual gathering of shellfish (excluding crustaceans) in the intertidal zone between St David's Head and Port Eynon Point.
12 September 1997	Restrictions lifted on all shellfish (other than crustaceans and whelks) outside the Burry Inlet and the Three Rivers Estuary (i.e. on the oyster fishery in Milford Haven estuary).

Source: Hearne, 1997

Much higher tissue concentrations were seen in bivalve molluscs, from both within and without Milford Haven[40]. With respect to direct losses resulting from oil contamination, there were mass strandings of bivalve molluscs following the incident, but none of those reported affect commercial species (see Section 9).

Once the FEZ was lifted for a given species and area, there was the potential for residual impacts associated with reductions in harvesting rates, arising from reductions in fish numbers or impacts on spawning for example. In addition, there was the possibility that the incident may reduce the market for fish from the oiled area. Shortly after the spill, estimates were made of the scale of the impacts. For example, the National Federation of Fishermen's Organisations estimated that the effects may last for up to seven years (Welsh Affairs Committee, 1996). Despite the potential for effects, SEEEC studies have not identified any long term negative impacts resulting from the spill (see Section 6.5.4).

40 Data from Law et al 1997(a) and (b) which report the findings of the sampling programme.

Indeed, there are reports that the *Sea Empress* spill has indirectly improved some aspects of the fishery. For example, lobster catches increased from around 70t in 1995 to around 105t in 1997. This apparently anomalous impact is a direct result of the FEZ - man is the biggest predator of many species and a ban on fishing allowed populations to recover.

6.3 Claims to the 1971 Fund

6.3.1 Claims Approved by the 1971 Fund for the *Sea Empress* Oil Spill

Available data on claims made to the Fund by businesses in the fisheries sector following the Sea Empress oil spill are presented in Table 6.3, with additional information presented in Table A6.1 of Annex 6. Almost 160 claims have been made by fishermen operating in the area of the FEZ, and 14 by businesses dependent on the fish caught in the FEZ. In total, £6.75 million has been approved for payment.

Table 6.3: Claims to the 1971 Fund for Impacts to Commercial Fisheries

Claimant	Nature of Claim	Amount of Claim (*£ million*)	Amount Approved (*£ million*)
158 fishermen in the FEZ	Claims for loss of income due to the fishing ban, with some claims for damage and loss of fishing gear.		5.49
1 oyster farmer in the FEZ	Stock contaminated by the spill and loss of market due to the ban.		0.11
14 fish/shellfish processors	Claims for being deprived of raw materials during the ban.		1.15
(Known) Total		not known	6.75

Source: IOPC, 1996a, 1997a and 1997c

6.3.2 Estimates of Total Payouts under the 1971 Fund

Estimates of the total size of claims under the 1971 Fund have been made by both the Fund itself and the UK Government. Both parties have estimated that claims will range between £8 million and £10 million. It is not known whether claims are still to be made by fishermen or affected industries.

A number of key issues have been identified which have the potential to impact the scale of the total costs. These are the timing of the oil spill, the criteria for compensation claims and the implementation of the FEZ. With respect to the first of these, the spill came at the end of a lean winter season when fishermen had used up their previous year's earnings and taken out loans to pay for new fishing gear for the forthcoming season. In particular, many fishermen in West Wales had invested heavily in new equipment in order to move to the burgeoning whelk industry (Welsh Affairs Committee, 1996).

It has also been argued that the FEZ could have been implemented differently to reduce the costs to fishermen. For example (*ibid*):

- some areas within the FEZ remained unaffected for some time during the ban (e.g. it was 'several weeks' before cockle beds in Penclawdd became affected); and
- market confidence could have been better restored had fishing been banned in a larger area and reduced on the basis of sampling evidence. However, this was not possible under the terms of FEPA 1985.

We approached the *Sea Empress* Fisheries Claimants Association (SEFCA) for information on past and future claims, but no information was forthcoming. We were also hoping that the SEFCA would be able to comment on claims not covered by the Fund (see below) and the impact of the IOPC Fund procedures on the actions of fishermen. For example, one of the criteria for compensation claims is the requirement to mitigate loss. It is reported that this criterion resulted in (Welsh Affairs Committee, 1996 and pers. comm.):

- a fish processor being advised to sack his staff;
- a requirement for fishermen outside the FEZ to continue to fish (and thus pay for bait, fuel and their crew) even though there was no market for their catch; and
- a fish wholesaler/processor taking shellfish caught outside the FEZ to sell in Spain on the understanding that this was necessary under the Fund's requirement to mitigate losses. However, there was no market for these shellfish and the company was later informed that these actions were inadmissible for claims.

6.3.3 Claims not Covered by the 1971 Fund

At the end of May 1997, the IOPC Fund reported that it had rejected claims totalling £7 million from the fishing industry (IOPC, 1997a). Full details of these rejected claims are not known but it is reported that (IOPC, 1996 and pers. comm.):

- some claims for lost fishing gear have been rejected on the basis that the gear was not in the water at the time of the spill or was outside the affected area;
- a claim from a fish processor based in Cornwall has been rejected on the basis of the proximity criterion; and
- a claim from a local haulier transporting whelks from Saundersfoot to the processing factory has also been rejected as being too remote. The haulier claimed that the fishing ban caused a major loss of business and it is reported that this haulier has now gone out of business.

With respect to the second of these, claims from fishermen outside the FEZ are still being examined by the Fund against this criterion. Available information suggests that claims for areas just outside the FEZ may be accepted, while those for other areas may be rejected. For example, the movement of fishermen from the FEZ put extra pressure on the area normally fished by the Gower fishermen and it is reported that the Gower fishermen were able to claim compensation for the resultant reduction in catches. For areas further afield, while a claim has been made by those fishing for squid and whitefish in the Bristol Channel, the IOPC Fund Reports that MAFF has not undertaken any special monitoring of these stocks and did not expect any long-term damage as a result of the incident (IOPC, 1997a). More generally, the Fund's view is that the offshore fishing activities based at Milford Haven are unlikely to have been affected by the spill as these operate in areas remote from the spill and sell their catches in distant European markets (IOPC, 1996).

6.4 Data from the South Wales Sea Fisheries Committee

6.4.1 Overview

The South Wales Sea Fisheries Committee (SWSFC) produces annual and quarterly reports on catches and landings within the SWSFC District. It's 1996 Annual Report (SWSFC, 1997) provides data on and discussion of the impacts of the *Sea Empress* oil spill on commercial fisheries. The FEZ covered around 35% of the most productive and heavily fished part of the District and had some impact on landings of fish from the district. However, landings into the district include those from outside the six mile limit and, for fish caught within the District, impacts were reduced to some extent by increased fishing activity outside the FEZ (i.e. to the east of Port Eynon Point and north of Saint David's Head) by fishermen on the borders of the FEZ taking action to mitigate their losses.

The landing figures for 1996 and the three preceding years are presented in Table 6.4. This reveals that although overall catches were down in 1996, the value of these catches equalled those in 1995 due to higher fish prices. The impacts on different parts of the fishery are discussed in subsequent sections.

Table 6.4: Landings Figures for the South Wales Sea Fisheries District

Year	Size of Catch		First Sale Value (£ million)	
	Tonnes	%❖	£ million	%✦
1993	10 820	23%	6.29	11%
1994	6 830	-22%	5.15	-8%
1995	9 460	12%	5.58	0%
1996	8 360	0%	5.57	0%

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern

With respect to overall impacts on fisheries, SWSFC believes that the following factors worked together to limit these:

- **the timing of the spill:** in mid February, most species were either semi-dormant or had migrated out of the area, and were not in a sensitive reproductive or juvenile period;

- **the composition of the oil:** this leant itself to high evaporative losses and high initial dispersion; and

- **the prevailing weather:** this resulted in a general movement of oil out to sea, with it largely missing the Three Rivers and Burry Inlet Estuaries.

6.4.2 Impacts on the Molluscan Fishery

Landing figures for mollusca are presented in Table 6.5 with details for individual molluscs given in Sections A6.2 to A6.8 of Annex 6. This shows that 1996 landings of mollusca were up on landings in 1993 and 1995, with the value of 1996 landings being the highest over the four year period 1993 to 1996.

Table 6.5: Landings Figures for the Molluscan Fishery

Year	Size of Catch		First Sale Value (£ million)	
	Tonnes	%❖	£ million	%✦
1993	8 020	24%	1.45	-45%
1994	4 150	-47%	1.64	-28%
1995	6 800	11%	1.64	-28%
1996	6 080	0%	2.10	0%

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern

The key factors are as follows:

- the FEZ did not cover the main scallop fishery and thus had little impact on landings. Indeed, scallop landings were up by a factor of four on 1995;

- while the FEZ had some impact on harvests of cockles and mussels, high prices were paid due to high demand. Thus the first-sale value of both the cockle and the mussel fishery was the highest for four years;

- although the FEZ impacted local whelk fishermen, catches were landed by larger vessels fishing outside the FEZ and the six mile limit. As a result, whelk landings were up nearly 50% on those in 1995 and first sale value up nearly 80%; and

- in contrast, the FEZ had a severe impact on winkle landings, with virtually none being landed in 1996. Similarly, oyster landings were down 90% on 1995 levels.

SWSFC estimates that without the FEZ, the whelk fishery in Camarthen Bay would have been exploited by inshore boats at the start of the year when whelk prices were high. As a result, it is estimated that the FEZ reduced landings of whelks by a first sale value of between £0.5 million and £0.75 million. In addition, there are concerns that the whelk fishery may collapse in the future with the deployment of new pots and gear bought with compensation money from the 1971 Fund (i.e. the increased pressure on the fishery will not be sustainable).

6.4.3 Impacts on Whitefish

Landing figures for whitefish are presented in Table 6.6, with details for individual species given in Sections A6.9 to A6.12 of Annex 6. This shows that 1996 landings of whitefish were up on those for 1995, but down slightly on other years. With respect to bass, catches in 1996 were 40% down on those in 1995, although this is thought to be due to factors other than the FEZ which was lifted in time for the main summer fishing season.

Table 6.6: Landings Figures for Whitefish

Year	Size of Catch		First Sale Value (£ million)	
	Tonnes	%❖	£ million	%✦
1993	2 090	7%	3.21	10%
1994	1 970	2%	3.02	4%
1995	1 810	-7%	2.46	-17%
1996	1 940	0%	2.89	0%

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern

The FEZ had little impact on reported catches of demersal and pelagic fish most of which are sourced from outside the six mile limit. In addition, landings of pelagic fish were a factor of ten higher than previous years. Thus the FEZ appears to have had little impact on reported catches of whitefish. However, only vessels over 10m in length reported catches (to MAFF), while vessels under 10m are those which fish inside the six mile limit and which would be affected by the FEZ[41]. Thus, reported catches do not indicate impacts to local fishermen. Given that local fishing boats

[41] A survey of ports in the SWSFC District in 1995 identified 35 vessels over 10m and 299 under 10m.

(i.e. those < 10m) outnumber other fishing boats (i.e. those > 10m) by a factor of 8.5, these impacts could have been significant.

6.4.4 Impacts on Crustaceans

Landing figures for crustaceans are presented in Table 6.7 overleaf with details for individual species given in Sections A6.13 to A6.17 of Annex 6. This shows that 1996 landings of crustaceans were over 50% down on previous years. However, 1996 data were also compiled on a different basis from those in previous years[42]. Other key factors are:

- mainly as a result of the FEZ, days at sea reduced by 54% and the number of pot hauls by 59% from 1995;
- shellfishing continued outside the affected area, indeed, fishing effort increased outside the FEZ. However, markets for all Welsh fish were reduced; and
- the ban came just as fishermen were preparing to relay pots following the winter break and it was lifted close to the end of the season for some species. Due to the autumn gales, some fishermen chose not to deploy gear that year.

Table 6.7: Landings Figures for Crustaceans

Year	Size of Catch		First Sale Value (£ million)	
	Tonnes	%❖	£ million	%✦
1993	710	52%	1.60	64%
1994	710	52%	1.28	55%
1995	840	60%	1.48	61%
1996	340	0%	0.58	0%

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern

SWSFC estimates that the overall value of the crustacean fishery is around one third of that expected. In other words, the operation of the FEZ reduced landings of crustaceans by a first sale value of £1.15 million in 1996.

42 In previous years, data collected under the SWSFC permit scheme have been compared with data provided by merchants. Merchant data were not available in 1996. Thus, landings of lobsters, velvets, green crab, prawns and spider crabs may be underestimated and landings of edible crab and crawfish may be overestimated.

With respect to the longer-term, there are concerns that the new equipment bought with compensation payments from the 1971 Fund may increase pressure on the fishery. In addition, it is not known what effect the oil and detergents may have had on spawning or juveniles.

6.5 The Valuation of Costs Arising from the *Sea Empress* Oil Spill

6.5.1 The Nature of Costs

The above discussion has indicated that the impacts associated with the *Sea Empress* oil spill can be divided into the following costs:

- direct costs to fishermen associated with loss of equipment;
- the costs associated with the operation of the Fisheries Exclusion Zone;
- the costs arising from long-term changes in harvest rates; and
- those arising from reductions in markets.

There may also have been direct losses of fish and shellfish resulting from oil contamination. However, as indicated in Section 2, most impacts are associated with communities which are not commercially exploited. The main exception to this is impacts on an oyster farmer who was forced to destroy all stock which was in the water at the time of the *Sea Empress* incident (IOPC, 1997c). These costs are included in the those associated with reductions in markets as data from the IOPC Fund do not allow the two types of costs to be separated.

6.5.2 Costs Associated with Loss of Equipment

Costs of £40 400 have been approved for payment to fishermen who lost fishing gear as a result of the oil spill[43].

6.5.3 Costs Associated with the Fisheries Exclusion Zone

The Nature of Costs

While a FEZ is in operation for a given fishery type or area, there are direct costs to fishermen associated with lost income and the payment of unused licence fees, etc. These costs can be valued using the above data from the IOPC Fund and the SWSFC.

In addition, there will be costs to MAFF associated with the operation of the FEZ. For example, the number of surveillance flights over the area was increased and protection vessels regularly visited the area (Welsh Affairs Committee, 1996). Information on the costs associated with the operation of the FEZ were requested from MAFF but were not made available, thus these costs remain unvalued in the assessment.

43 Payments have also been made for damage to nets and loss of pots but these cannot be separated out from payments for losses due to the operation of the FEZ.

Finally, the FEZ was put in place to protect human health. If it is assumed that the size and the location of the FEZ was appropriate to its purpose, then there will be no residual human health costs. In practice, this may not be the case as oil was found outside the FEZ and there is apparently no agreement as to what constitutes a safe level of hydrocarbons or polycyclic aromatic hydrocarbons (PAHs[44]) in fish (Welsh Affairs Committee, 1996). In particular, it has been reported that the delineation of the FEZ did not relate well to the areas of pollution with, for example, some condemned whelks (i.e. those with oil levels above the acceptable limit) being caught from the area outside the FEZ.

Valuation of Costs

As indicated in Section 6.3, payments of £6.64 million have been approved under the 1971 Fund of which £5.45 million (i.e. just over 80%) is associated with fishermen normally fishing within the FEZ[45]. Data from the SWSFC indicates, however, that the first sale value of the catch from its District in 1996 was £5.57 million, which is on a par with previous years.

The fact that payments to fishermen under the 1971 Fund equal the value of the catch from the SWSFC District (which encompasses the FEZ) indicates that, unlike other sectors, payments under the Fund provide a fair estimate of financial costs to fishermen. Indeed, payments under the Fund are surprising high. However, the fact that compensation claims are rigorously audited by the Fund indicates that payments do reflect the lower bound of losses incurred by fishermen.

With respect to the processing industry, claims approved by the Fund are around one quarter of those to fishermen. As indicated in Section 6.1, the processed value of fish is reported to be between two and four times first sale value, and retail values up to six times this much. The size of the value added by processing varies by species and by the end-market. For example, for cockles in 1995 prices were:

- £10/bag raw meat;
- £20 cooked on market; and
- £28 in supermarket.

The importance of this added value to the local community will depend on whether processing is undertaken locally or not. For example, local stages in the chain of trade for cockles include gathering, processing and first sale on the market stall. Overall, it is estimated that the local value of fisheries is three to four times the first sale value when taking account of processing, etc.

Based on added value alone, the impacts to the processing industry associated with the oil spill could be estimated to equal between £11 million and £16.5 million. However, not all the impacts to fishermen were associated with reduced catches, while processors and sellers are likely to have sourced fish from elsewhere. In the absence of additional information it is not possible to justify increasing impacts to processors from the £1.15 million paid under the Fund.

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44 PAHs include compounds whose metabolites form known and potent human carcinogens, benzo[a]pyrene being the prime example (Law et al, 1997b).

45 This includes some (limited) costs associated with damaged and lost fishing gear.

6.5.4 Long-Term Changes in Harvest Rates

There do not appear to have been any serious impacts on stocks of commercial fin fish or shellfish arising from the spill. It is believed that oil concentrations in contaminated fish and shellfish returned to background levels quickly as a result of oil dispersing out of the area. In addition, many of the commercially exploitable species were out of the area at the time of the spill when oil concentrations were at their highest (SEEEC, 1997).

With respect to 1997 catches, only those for crawfish are low. Catches for edible crab are reported to be average to good, those for spider crab and bass good, and those for lobster very good. Therefore, there appears to be few negative impacts from the oil spill on 1997 catches. Indeed, catches of lobsters are believed to be high as a direct result of the spill, although these benefits are likely to be short lived.

In the medium-term, there may also be increased catches for some species associated with the purchase of new equipment by fishermen and, in the longer-term, this new equipment will put extra pressure on the fishery. With respect to longer-term impacts on specific species (ibid):

- **sea bass:** studies have found lower growth rates, lower abundance and late arrival of the 0-group (i.e. fish born that year). These suggest increased mortality of eggs and larvae along the South Wales Coast in 1996. This could affect future catches along the coast and possibly the Bristol Channel as a whole; and

- **crabs, lobsters and whelks:** it is not certain whether 1996 year classes of crabs, lobsters or whelks successfully spawned and survived, and this will not be evident until at least 1998. However, there is clear evidence that adult populations remained healthy and they appeared to breed normally in 1997.

Given the uncertainty concerning medium- and long-term effects, no attempt has been made at valuation.

6.5.5 Reductions in Markets

Short-term Changes

Immediately after the oil spill, it was reported that reductions in markets were impacting both trawlermen and inshore fishermen. These mainly resulted from changes in perception of the south Wales sea fishery. For example, while trawlermen were able to fish outside the FEZ following the oil spill, there was no market for their fish; one fish processor indicated that Spanish buyers refused to accept fish "caught well away from" the polluted area (Welsh Affairs Committee, 1996).

From information on payments under the 1971 Fund, only the £112 000 paid to the oyster farmer is reported to be associated with a reduction in markets (and loss of stock). Consideration was given to the possibility of using a simple *ex post* forecasting methodology to value changes in the market for fish from Pembrokeshire. This would require the prices of fish to be calculated as if the spill had not occurred and compared to actual prices (see for example Cohen, 1995).

However, examination of the prices paid for fish and shellfish in period 1993 to 1996 (see Figures A6.1 to A6.3 in Annex 6) reveals no clear trends on which to base such estimates. In addition, for some species prices were up on previous years. For example, for cockles prices were up due to shortages in Europe. For whelks, increased prices resulted from an increased demand from Korea.

The Longer-term

In the longer-term, it appears that markets for south Wales fish have not been lost as a result of the oil spill. In the main, this is believed to be due to the FEZ being put in place early enough to ensure confidence in the safety of the supply. However, it may be the case that individual fishermen have lost part of their market as demand was filled from fish caught elsewhere.

6.6 Summary of Costs to Commercial Fisheries

6.6.1 Financial Costs

Financial costs to commercial fisheries are set out in Table 6.8. In the absence of additional information, it is assumed that:

- around 25% of costs arising from the loss of fishing gear were uncompensated by the Fund. Thus, upper bound costs are taken to equal £50 000;
- similarly, around 25% of costs associated with reductions in markets were uncompensated by the 1971 Fund. Thus upper bound costs are taken to equal £140 000;
- the upper bound for all costs to fishermen is taken to be the upper limit of the estimates made by the Government and the IOPC Fund (i.e. £10 million); and
- thus, the upper bound estimate of costs to fishermen associated with operation of the FEZ is £9.81 million[46] (with the lower bound being the total payments to fishermen[47]).

Long term changes in harvest rates are unvalued in the assessment.

Financial costs are estimated to lie between £6.75 million and £10 million. In the absence of additional information, it is estimated that actual costs could be around £8.4 million. This is the mid point between the lower and upper bound costs and also represents an across the board increase of 25% on lower bound costs.

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[46] i.e. £10 000 000 - £50 000 - £140 000

[47] Minus the £112 000 paid to the oyster farmer.

Table 6.8: Summary of Costs to Commercial Fisheries (£1996)

Description	Lower Bound Value (£ million)	Upper Bound Value (£ million)	Comment on Lower Bound Value
Loss of fishing gear by Fishermen	0.04	0.05	Lower bound from 1971 Fund payments. Upper bound assumes around 20% of costs were uncompensated.
Loss of income to fishermen arising from operation of the FEZ	6.60	9.81	Lower bound from 1971 Fund payments. Includes claims from fish/shellfish processors and some costs associated with loss of gear. MAFF's costs remain unvalued in the lower bound estimate. Upper bound estimate assumes costs are equal to upper limit of estimates of payments under the 1971 Fund minus all other costs.
Reductions in markets	0.11	0.14	Some of the lower bound costs may be included in those for the operation of the FEZ. Upper bound assumes some costs remain uncompensated by the 1971 Fund.
Total	6.75	10.00	Upper bound is upper limit of estimates of payments under the 1971 Fund.

6.6.2 Economic Costs

Economic costs are equal to financial costs with the exception of the costs to fishermen associated with operation of the FEZ. These costs relate to losses in income to fishermen and, in the absence of additional information, it has been assumed that only 10% of this income is profit. Thus, the upper and lower bound estimates for this component of total costs are 660 000 and 980 000 respectively.

7. RECREATIONAL FISHERIES

7.1 Introduction

The rivers and coastal waters of South West Wales provide recreational fishing for both freshwater and sea-based anglers. Game anglers are attracted to rivers such as the Twyi, Taf, and Eastern and Western Cleddaus by the opportunities presented for salmon and sea trout fishing; while the Pembrokeshire coastline is a prized location for bass and other sea-based species.

As indicated in Section 6, in order to protect the commercial fishery and human health, MAFF placed a ban on all fishing activity in a designated area between Port Enyon Point and St. David's Head on 28 February 1996. Recognising that there could be a risk associated with the consumption of fish which may have passed through contaminated water during migration, a ban was also placed on fishing for salmon and sea trout in all rivers and streams discharging into the affected area. The ban was put in place on 19 March 1996, the day before the fishing season started, and was lifted on 3 May 1996. Restrictions on fin-fish (e.g. bass, cod, etc.) were removed on 21 May 1996.

This section considers the impact of the Sea Empress oil spill on recreational angling for salmon and sea trout, bass and other species of sea fish.

7.2 Salmon and Sea Trout

7.2.1 Overview of Impacts

The main impact of the *Sea Empress* oil spill on the recreational fishery for salmon and sea trout was associated with operation of the fisheries exclusion zone. This resulted in losses to the owners and leasers of fishing rights on the affected rivers and losses in consumer surplus to game anglers. There were no direct losses of fish as a result of the spill, however, there are concerns that the oil spill may have caused some long-term changes in harvest rates for sea trout.

7.2.2 Claims to the 1971 Fund

Claims to the 1971 Fund have been made by those owning or leasing fishing rights in the rivers affected by the fishing ban. The claims are based on losses incurred during the ban (i.e. for about 22% of the fishing season) and are reported in Table 7.1. These costs include:

- the costs to angling clubs associated with renting a fishery and paying insurance premiums over the period of the ban;
- the costs to angling clubs associated with reductions in membership as a result of the incident; and
- the costs to anglers of 'lost' subscriptions paid for the period of the fisheries ban.

Table 7.1: Claims for Compensation for Impacts to Recreational Fisheries (£1996)

Nature of Claim	Description of Claim	Size of Claim (£)	Admissibility of Claim
Loss of income by six angling clubs	Reduction in the sale of day tickets and/or from club members not renewing their subscriptions in 1996.	14 900	Admissible in Principle
Loss of income by owner of fishing rights	Reduction in the sale of day tickets and reduction in income from a fishing school, accommodation and the sale of food and beverages.	74 000	Admissible in Principle
Refund of rod fees by owner of fishing rights	Refund of rod fees to 107 anglers for the period of the ban (refund was made by the owner of the fishing rights)	12 900	Inadmissible
Refund of membership fees by angling clubs	Compensation for members of angling clubs for membership fees paid during the period of the ban.	19 000	Inadmissible
Expenses incurred by angling clubs	Expenses including the lease of fishing rights, insurance premiums, river maintenance, bailiff fees, water rates and other standing charges.	14 900	Inadmissible
All		**135 700**	**£88 900 admissible**

Source: IOPC, 1997c and pers. comm

Table 7.1 indicates that three categories of claim were ruled inadmissible by the IOPC Fund:

- **Refund of rod fees:** the Fund ruled that the company owning the fishing rights was not entitled to compensation as it was under no obligation to refund rod fees. From the perspective of this assessment, the payment of rod fees for the period of the fishing ban resulted in opportunity costs and therefore can be included as economic and financial impacts resulting from the *Sea Empress* oil spill;

- **Refund of membership fees:** the Fund ruled that individual club members should be considered as claimants and that the loss suffered by them was one of loss of enjoyment which is not admissible for compensation. As above, membership fees paid for the period of the ban resulted in opportunity costs and thus in financial and economic impacts which can be included in this assessment; and

- **Expenses:** the Fund ruled that claims for expenses were not admissible since these would have been incurred whether or not there had been a fishing ban. From an economic perspective, only the costs associated with the lease of fishing rights and with solicitors fees can be claimed as an impact of the *Sea Empress* oil spill. Other expenditure provides benefits which are unrelated to whether or not the waters can be fished. The costs which can be claimed under this category amount to £14 100.

On the basis of the above, known direct costs to angling clubs and owners of fishing rights amount to £134 900[48]. Total direct costs are likely to be greater than this, as it is understood that a further nine clubs will also be putting in claims for loss of income (IOPC, 1997c). The size of these claims relative to those of the six clubs which have already claimed is not known.

7.2.3 Costs to Anglers

In addition to the costs associated with the payment of angling club membership fees for the period of the fishing ban, anglers incurred costs associated with reductions in angling visits. These costs can be valued by estimating the change in the number of visits and combining these with estimates of the resultant changes in consumer surplus.

Reductions in the Number of Angling Visits

The *Sea Empress* oil spill is reported to have reduced the number of anglers fishing affected rivers in 1996, as well as the visit rate for each angler. Information provided by five of the twenty one angling clubs affected by the angling ban indicates that, between 1995 and 1996, club membership reduced by around 7%. If it is assumed that these five clubs are representative of all those affected, total club membership will have reduced from around 3 500 to 3 270.

It is possible, however, that club membership could be higher or lower than this estimate. Firstly, consultation with the Camarthen Fisherman's Federation indicates that these membership numbers are an underestimate of club activity in the affected area. Thus the estimated reduction in membership may be smaller than that actually experienced. Secondly, work for the Environment Agency suggests that the *Sea Empress* incident was only one of a number of factors causing anglers to stop fishing in west Wales in 1996 (Simpson, 1997). While the decline in angling is similar to that indicated above[49], it is suggested that the *Sea Empress* incident is responsible for between only 22% and 29% of that reduction[50].

The above study also provides information on the reduction in angling visits between 1995 and 1996. These reductions are reported in Table 7.2 overleaf. This indicates that there was a 21% reduction in visit rates across all types of anglers, with the largest reduction experienced for occasional anglers. This indicates that (other factors aside) the *Sea Empress* had the greatest impact on those who fish the affected area less frequently.

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48 i.e. £135 700 - £800. The £800 represents those expenses which cannot be claimed to result from the *Sea Empress* oil spill.

49 The report for the Environment Agency found an 8% reduction in the number of 'local regular' anglers and a 12% reduction in the total number of anglers.

50 For 'local regular' and 'local occasional' anglers respectively.

Table 7.2: Reductions in Angling Visits per Angler

Category	Visit Rate per Angler per Year		% Reduction
	1995	1996	
Local Regular	33.0	27.5	16.6%
Local Occasional	20.8	8.2	60.7%
Visitor Regular	19.8	18.1	9.0%
Visitor Occasional	5.4	2.7	50.0%
Total	**28.1**	**22.3**	**21.0%**

Source: Simpson, 1997

The Value of a Day's Fishing

In the UK, most freshwater recreational fisheries are priced, with users either having to belong to a club to use a fishery or buy a permit for a day's fishing. Therefore, total economic value of angling benefits comprises two components:

- the cost of a day's angling; and
- the additional willingness to pay of anglers for a day's activity and for any changes in fishery quality.

The additional willingness to pay is deemed 'consumer surplus' and, in general, fisheries economics studies have found that consumer surplus is around 50% to 100% of day ticket price for migratory salmonids (ECOTEC, 1993 and Radford *et al*, 1991). For this assessment, reduced visits have been valued using a figure of £25.66 (£1996) for the consumer surplus associated with a salmon and sea trout angling visit. This value has been taken from the FWR Manual (1996) and is based on contingent valuation survey results. Other fisheries value are included in Table A7.1 in Annex 7.

Estimates of Changes in Consumer Surplus

The above information has been used to develop estimates of the reduction in angling trips and associated changes in consumer surplus arising from the *Sea Empress* oil spill. Results are presented in Table 7.3 with details given in Table A7.2 in Annex 7.

Using the above approach, the middle figure for the total reduction in the number of angling visits (taking into account club membership, syndicate rods, private-owned fisheries and day permit sales) is estimated to be 28 780 with a corresponding change in consumer surplus of £0.72 million.

The above estimate assumes that the reduction in salmon and sea trout angling trips is not countered by an increase in other types of angling activity. Information collated for the EA suggests that this assumption may not hold true for some anglers. In particular, there was found

Table 7.3: Estimates of Reductions in Consumer Surplus (£1996)

Factor	Lower Bound	Middle Estimate	Upper Bound
Total Angling Population in 1995❖	3980	3980	4940
Reduction in Angling Population in 1996	50	275	375
Visit Rate 1995 ♲	33.0	33.0	33.0
Visit Rate 1996 ♲	27.5	27.5	27.5
Lost Angling Days in 1996✦	21725	28780	36900
Value per Angler per Trip (£1996)	£25.66	£25.66	£25.66
Reduction in Consumer Surplus (£1996)	£0.56 million	£0.72 million	£0.95 million

❖ The angling population consists of angling club members, syndicate members and private fishery owners.

♲ Visit rates for 1995 and 1996 are those for the 'local regular' anglers from the Environment Agency study (Simpson, 1997). This provides a lower estimate of days lost that for a 'local occasional' angler - see Table 7.2. Rates for visiting anglers are thought inappropriate for use with the angling population under consideration here.

✦ Lost angling days takes into account increases in sales of day permits in 1996. It is assumed that day permit sales are bought by visiting anglers and, in 1996, by ex-club members.

Source: Table A7.2 in Annex 7

to be an increase in the number of trout and coarse fishing licences sold to 'local regular' salmon and sea trout anglers in 1996 (from 2% of anglers to 13% of anglers[51]). However, the significance of this factor to overall estimates of consumer surplus are small. For example, if it is assumed that all of the 11% of game anglers able to fish for trout and/or coarse fish gave up game fishing completely in preference for coarse fish, then the resultant change in consumer surplus would be valued at £44 600[52], or just over 6% of the middle estimate. If these anglers undertook trout

51 However, there was no increase in the numbers of other licences (i.e. non-salmon and sea trout licences) sold to other classes of anglers (i.e. to anglers other than 'local regular' salmon and sea trout anglers).

52 3 165 trips to coarse fisheries (i.e. 11% of 28 780) valued at £11.58 per trip (FWR, 1996) gives £44 600.

fishing (and not coarse fishing), then the resultant change in consumer surplus would be smaller still[53].

7.2.4 Changes in Harvest Rates

It has been suggested that the *Sea Empress* oil spill may have resulted in reductions in catches for some recreational fisheries. In particular, some have expressed concerns that sea trout populations may have been 'seriously' affected by the oil spill.

Figures A7.1 to A7.5 in Annex 7 present catch data for the following rivers affected by the oil spill: Tywi, Gwili and Cothi; Taf; East and West Cleddau; Gwendraeths; and Loughour. In all cases, 1996 catch levels were lower than the ten year average (for 1986 to 1995). However, 1996 catch levels were also higher than those in 1995 for:

- salmon catches on the Tywi, Gwili and Cothi (marginally higher);
- sea trout catch on the Gwendreaths (there being no salmon on these rivers) and;
- catches of both species on the Taf and Loughour .

Examination of catch alone does not take into account any change in angling effort resulting from the spill. To allow a real comparison of 1996 catch data with that for previous years, the Environment Agency has compared 'catch per unit effort' (CPUE) data on two rivers, the Tywi and the Teifi (a river not affected by the ban). It appears that rod catches of salmon have not been affected by the oil spill, with the mean monthly CPUE on the Tywi being the highest of any year between 1990 and 1996. This is not the case for sea trout, however, with CPUE data for the Tywi showing "markedly" low catches. This trend was particularly evident in May, June and July, after which catches improved and were within the variation for previous years. To assess whether this pattern is also true of other rivers - as is suggested anecdotally - further research is being undertaken (Environment Agency, 1997a).

With respect to the longer-term, the question remains as to whether possible exposure to oil has affected the ability of salmon and sea trout to breed successfully (SEEEC, 1997). To assist in this regard, the Environment Agency is also undertaking a study of juvenile salmonids to assess whether populations of salmon and sea trout have declined as a result of a possible reduction in the number of adult spawners in 1996/1997. Preliminary results indicate (Environment Agency, 1997b):

- salmon fry densities showed a moderate increase or remained similar on the Eastern Cleddau, Western Cleddau and Taf compared with historical data, with a more substantial increase on the Tywi;

- similar increases were also found on the same rivers for sea trout fry densities; and

- sea trout parr were more abundant than salmon parr, however, both showed a general decline of 50% to 60% from the historical mean.

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53 3 165 trips to trout fisheries valued at £18.70 per trip (FWR, 1996) gives £22 000.

7.3 Bass

7.3.1 Overview of the Bass Fishery

Fishing for bass is a highly valued activity, possibly considered by anglers to be of greater importance than salmon fishing. The coast of Pembrokeshire is a prized location for bass fishing, due in part to the nature of the coastline and nursery areas (for example, in the Burry Inlet). Excellent fishing locations, from both beaches and rocks, can be found all around the coast, including popular areas such as Pembroke Docks, Freshwater West and Broad Haven. Table A7.3, in Annex 7, lists the most popular fishing locations, together with species which can be caught and details of major fishing events.

Numbers of anglers involved in bass fishing also appear to be increasing. The number of bass anglers is estimated to have increased by 20% between 1987 and 1992 despite an overall decrease by 32% in the number of sea anglers (Dunn *et al*, 1995). Bass has also become the most popular species fished for during the summer, and third most popular overall (behind cod and mackerel - Pickett et al, 1995).

The introduction of the fishing ban on 28 February 1996 had the effect of prohibiting all fishing in the designated area, including pleasure angling from the shoreline. This resulted in a complete cessation of angling activity from Swansea to St Davids Head, affecting around 30 angling locations and associated anglers. When the ban was lifted on 21 May 1996, angling activity had been affected for 84 days.

Several shore anglers were seen, by Fishery Officer patrols, during the first few days after the ban, and were reported to be unaware that the fishing ban extended to shore angling. Similarly, when the ban was lifted there was little activity returning to beaches between Laugharne and Milford Haven, with members of the public still requesting if the ban would be lifted on 26 May. Shore anglers began to return to Pendine and Saundersfoot around the 27 May.

It is reported that impacts to sea anglers were mostly associated with activity in the Haven, with the majority of keen anglers seeking alternative angling sites (particularly Fishguard) as a result of the fishing ban. Thus, although fishing activity continued for some anglers, there were additional costs associated with increased travel.

Impacts on charter boats reached further than the exclusion zone, with boats from Swansea and Penarth also reporting reduced bookings and cancellations which were directly attributed to the oil spill, and in spite of the quality of the fishing. In February, for example, boats from Penarth were having "exceptional catches" of over 50 fish per day (Coates, 1996b).

With respect to the longer-term, there is some evidence to suggest that the oil spill resulted in increased mortality of bass eggs and larvae. This has the potential to result in reduced catches for about five years after the incident (once bass reach five years old they may migrate off shore or larger distances) within a radius of 50 miles (the approximate distance bass migrate before reaching five years of age).

7.3.2 Claims from the 1971 Fund

Charter boat operators have reported that the *Sea Empress* incident resulted in a loss of bookings throughout the whole of 1996, and not just for the duration of the fishing ban. This is because February and March is the peak booking time for charter boat trips, with anglers choosing to make trips elsewhere for fear that the fishing ban may last some time.

Operators were able to claim compensation from the 1971 Fund for reductions in bookings arising from the *Sea Empress* oil spill. However, it is reported that claims were only accepted for bookings which were cancelled in writing, giving the *Sea Empress* as the cause, with records of usage over the past five years not being accepted as indicating reductions in income for 1996. It has been estimated that, in general, operators were compensated for around two thirds of losses, with the remainder relating to anticipated bookings.

Data from the IOPC Fund does not specifically identify claims from charter boat operators which are assumed to be included in claims from the 'tourism' industry.

7.3.3 Impacts to Bass Anglers

The ban on bass fishing resulted in a cessation of angling activity in the affected area and an increase in the number of trips to locations outside the fisheries exclusion zone. Thus, to estimate the costs to bass angling resulting from the oil spill it is necessary to consider:

- the change in angling activity in the area affected by the ban;
- alternative sites to which activity could move; and
- the change in consumer surplus arising from the ban.

The Change in Angling Activity in the Area Affected by the Ban

In 1995, there were 361 000 bass anglers in England and Wales of which 4.5%, i.e. around 16 250 were based in Dyfed (Dunn *et al*, 1995).

The ban on bass fishing existed for 84 days of the year from February to May and Table 7.4 presents information on the percentage of angling activity affected by the ban over this period. Given that the main bass angling season runs from May to September, the effects of the ban on angling activity were minimised to some degree.

In total, 9.8% of charter boat trips, 20.4% of private boat trips and 15.9% of shore trips are estimated to have been affected by the fisheries ban. Data from the National Survey of Bass Angling (Dunn *et al*, 1995) indicates that:

- all bass anglers fish from the shore, and make an average of 44 trips per year;
- 56.5% of bass anglers make five trips per year on a charter boat; and
- 67.6% of bass anglers make 16 private boat trips per year.

Table 7.4: Impacts on Angling Activity as a Percentage of Average Annual Activity

Affected by the Ban?	Month	Charter Boats	Private Boats	Shore
Affected by the Ban	February	0.0%	0.3%	0.07%
	March	0.0%	4.0%	2.5%
	April	4.2%	8.0%	5.5%
	May	5.6%	8.1%	7.8%
Not affected by the Ban	Other	90.2%	79.6%	84.2%

Source: based on angling activity data in Dunn et al, 1995

Table 7.5 combines the above information to give the total number of trips affected by the fisheries ban. Since the proportions for charter and private boat and shore angling are calculated from different totals the arithmetic mean would not be relevant to the actual proportion of the season affected. Therefore, a weighted mean has been calculated using average number of trips. It is estimated that 16.4% of the bass fishing season has been affected by the fisheries ban.

Table 7.5: Number of Trips Affected by the Fisheries Ban

	Charter Boats	Private Boats	Shore
Annual Number of trips	45890	175710	714780
		TOTAL	**936380**
% affected	9.8%	20.4%	15.9%
Number of trips affected	4500	35840	113650
		TOTAL	**153990**
		Weighted Mean of Trips Affected	16.4%

Alternative Angling Sites

Not all trips previously undertaken along the coastline affected by the ban would cease. Some activity could move to alternative sites. The nearest bass fishing sites, outside of the fisheries exclusion zone, are at Fishguard and Swansea (or the Gower Peninsula). It is assumed that anglers will move to the nearest alternative site, but they will not make as many trips to the alternative site as to their usual fishing location, due to the increased travelling distance.

The reduction in bass angling trips for any given angler has been estimated as follows:

- percentage of trips falling within the duration of the ban: 16.4%;

- nearest bass angling site (within the area of the ban): for example for an angler from Pembroke, this is Angle Bay, at a distance of eight miles;

- nearest alternative site outside the area of the ban: for the Pembroke-based angler this is Fishguard at a distance of 25 miles;

- the proportion of trips to the alternative site: it is assumed that trips to the alternative site will be reduced in direct proportion to the increased distance travelled. Thus for the Pembroke-based angler, trips to the alternative site will be only 32% (i.e. eight divided by 25) of those to the nearest site;

- the proportion of lost trips: for the Pembroke angler, the fishing ban results in 68% fewer trips during the ban; and

- the reduction in trips arising from the fishing ban: this is the percentage of trips falling within the duration of the ban multiplied by the percentage of lost trips. This is 11% (i.e. 16.4% multiplied by 68%) for the angler from Pembroke.

A full listing of estimates for anglers based in each of the Dyfed wards affected by the fisheries ban is given in Table A7.4 in Annex 7.

Change in Consumer Surplus

Valuation of the consumer surplus associated with bass angling has been undertaken by Dunn et al (1995) who developed estimates of both willingness to accept (i.e. the amount an angler would accept to compensate him or her for the loss of their right to go bass angling for a year) and willingness to pay (i.e. the amount that an angler would pay for bass angling). Theoretically, both measures should give the same value, but due to the nature of 'selling' and 'buying', willingness to sell is invariably higher than willingness to pay. Two estimates were made:

- a random sample of on-site shore anglers in 1993 elicited a willingness to accept of around £900 and a willingness to pay of £88 (values given in £1996); and

- a re-survey of contacts from a previous survey in 1987 gave willingness to accept and willingness to pay values of around £2 140 and £610 (in £1996), respectively.

It is argued that the higher values given by the re-survey of 1987 contacts reflects their longer involvement in bass angling, hence their higher valuation (Dunn *et al*, 1995).

Valuation of the Fishing Ban for Bass Anglers

Table 7.6 presents estimates of the change in consumer surplus for bass anglers arising from the fishing ban. The overall costs are estimated to range between £58 000 and £1.4 million across the

84 day ban. The best estimate of the costs may be given by estimates derived using willingness to accept values as these value potential losses, or reductions, in bass angling activity, which is the case for the *Sea Empress*. Of these two estimates, the lower figure, of £582 000, may be more appropriate, as this is based on the full population of anglers rather than those with at least nine years involvement in the sport.

Table 7.6: Estimated Costs to Bass Angling (£1996; £ million)

District	Number of Anglers per District	Willingness to Accept		Willingness to Pay	
		Lower	Upper	Lower	Upper
Carmarthen	1 102	0.088	0.209	0.009	0.059
Dinefwr	928	0.031	0.074	0.003	0.021
Llanelli	2 096	0.204	0.484	0.020	0.138
Preseli Pembrokeshire	1 324	0.128	0.305	0.013	0.087
South Pembrokeshire	1 147	0.131	0.310	0.013	0.088
	TOTAL	**0.582**	**1.382**	**0.058**	**0.393**

7.4 Other Sea Fisheries

7.4.1 Overview

Many other sea fish can be caught from Pembrokeshire, either from the shore or boats. These include cod, thornback ray, smoothhound, conger eel, spotted ray, small-eyed ray, black bream, flounder, dogfish, turbot, huss, plaice, tope, stingray, pollack, whiting and mackerel. Table 7.7 overleaf lists the most popular species fished for throughout England and Wales. This indicates that anglers tend to fish for more than one species with, for example, cod, rays and plaice being popular with 70.2%, 56.4% and 50.4% of boat-based fishermen respectively.

7.4.2 Impacts on Sea Angling

As for bass angling, the fisheries ban forced a complete cessation of all angling activity in the affected area.

The reduction in angling activity at the start of the ban had a knock-on effect on fishing tackle shops in the area. For example, in the six weeks immediately following the incident when the coarse fishing season was closed, one tackle shop reported “absolutely no sales”. It is further reported that once the ban was lifted, there was a continued reduction in activity amongst some anglers, due to concerns about the health of fish. Club membership also declined as a result of the oil spill, perhaps by as much as 30% from pre-spill levels.

Table 7.7: Percentage of Anglers Fishing for Each Sea Fish Species

Rank	Shore		Boat	
1	Bass	49.6%	Cod	70.2%
2	Cod	47.1%	Rays	56.4%
3	Whiting	39.6%	Plaice	50.4%
4	Flounder	37.9%	Pollack	50.4%
5	Mackerel	34.4%	Bass	45.9%
6	Plaice	29.7%	Whiting	40.4%

Source: Dunn et al, 1995

A number of tournaments also had to be cancelled or postponed, including the EFSA Welsh boat championships. These were eventually held in January 1997 from Penarth, near Swansea. In November 1997, the South Wales area was to be host to the World Championship for sea anglers. The event was moved to an alternative location as a result of the *Sea Empress* spill, although it has been rescheduled to take place in the area in 1999. The 1997 event was expected to bring in £0.75 million to the region, from entrance fees of £1 000 for the 200 to 240 entrants and associated expenditure on accommodation, etc.

7.4.3 Claims from the 1971 Fund

Consultation has indicated that compensation claims have been made to the IOPC Fund by tackle shop owners and affected sea angling clubs. Information on the size or the nature of these claims is not available, although compensation for one tackle shop is known to be included in the 'tourism' claims reported in Section 4.

7.4.4 Impacts on Other Sea Anglers

The costs of the *Sea Empress* oil spill to other sea anglers has been estimated using a similar approach to that for bass anglers.

The Change in Angling Activity in the Area Affected by the Ban

The number of anglers is estimated using the total number of sea anglers in England and Wales, at 1 226 000. Of these, 361 000 have already been counted as bass anglers. This leaves 865 000 throughout England and Wales. It is assumed that 4.5% of these anglers, as for bass, live in Dyfed. There are therefore, 38 925 potential sea anglers within the county.

To avoid double counting of those anglers who fish for more than one species, the percentages fishing for each species have been normalised as shown in Table 7.8.

Table 7.8: Number of Anglers for Each Species

Species	Shore	Boat	Overall	Normalised Percent Fishing per Species	Estimated Number of Anglers
Cod	47.1%	70.2%	52.1%	26.4%	10 263
Whiting	39.6%	40.4%	39.8%	20.1%	7 835
Mackerel	34.4%	39.9%	35.6%	18.0%	7 013
Plaice	29.7%	50.4%	34.2%	17.3%	6 741
Rays	7.3%	56.4%	18.0%	9.1%	3 550
Pollack	8.8%	50.4%	17.9%	9.1%	3 523
		TOTAL	**197.6%**	**100.0%**	**38 925**

Alternative Angling Sites

The existence of alternative angling sites has been taken into account using the same approach as used for bass. In this regard, it has been assumed that for the majority of wards, the nearest bass angling site also corresponds to the nearest sea angling site in general. However, for Pembroke, for example, the nearest site has been changed to reflect the sea angling opportunity from the Docks area. A full listing of the calculations, by ward, can be found in Tables A7.5 to A7.10 in Annex 7.

Change in Consumer Surplus

Estimates of consumer surplus are only available for bass which is a particularly prized species and thus not directly comparable with others such as cod. In the absence of specific consumer surplus estimates for other species, it has been assumed that the relationship between the wholesale value of cod, for example, and the wholesale value of bass is the same as the relationship between anglers' consumer surplus for the two species. Implicit in this approach is the assumption that recreational value is linked to commercial value and as such is not related to those motivational factors which make a certain species more desirable to recreational fishermen.

The relative prices for each of the six most important species are presented in Table 7.9.

Table 7.9: Comparison of Wholesale Prices for Most Popular Species

Rank	Most Popular Shore Species price per tonne (£)		Proportion of Bass Price	Most Popular Boat Species price per tonne (£)		Proportion of Bass Price
1	Bass	9 180		Cod	1 025	11.2%
2	Cod	1 025	11.2%	Rays	925	10.1%
3	Whiting	425	4.6%	Plaice	1 175	12.8%
4	Flounder	nd	-	Pollack	1 000	10.9%
5	Mackerel	150	1.6%	Bass	9 180	
6	Plaice	1 175	12.8%	Whiting	425	4.6%

Source: MAFF Sea Fisheries Statistics

Valuation of the Fishing Ban for Other Sea Anglers

The estimated costs of the *Sea Empress* incident, by each of the six species considered, are given in Table 7.10. As for costs to bass angling, the best estimate is probably the lower bound willingness to accept estimate, at almost £120 000. However, the approach adopted (i.e. the use of wholesale prices to develop species-specific consumer surplus estimates) is likely to underestimate costs to sea anglers. In addition, the approach assumes that all sea anglers fish for only one of these six species, and that they have only one willingness to accept (or pay) value relevant to the species they are assumed to fish for; this may obviously not be the case.

Table 7.10: Estimated Costs to Sea Angling (£1996)

Species	Proportion of Anglers Fishing for Species	Number of Anglers	Willingness to Accept		Willingness to Pay	
			Lower	Upper	Lower	Upper
Cod	26.4%	10 568	£43,800	£103 900	£4 300	£29 600
Whiting	20.1%	8 068	£13 700	£32 600	£1 300	£9 300
Mackerel	18.0%	7 221	£4 300	£10 100	£400	£2 900
Plaice	17.3%	6 941	£32 900	£78 000	£3 200	£22 200
Rays	9.1%	2 499	£9 300	£22 100	£900	£6 300
Pollack	9.1%	3 628	£14 600	£34 700	£1 400	£9 900
		TOTAL	**£118 600**	**£281 400**	**£11 500**	**£80 200**

7.5 Summary of Costs to Recreational Fishing

Costs to recreational fisheries are summarised in Table 7.11. The costs to the owners and leasers of salmonid fishing rights represent both financial and economic costs, with all others being economic costs alone.

Table 7.11 does not include any estimate of the costs associated with reduced catches of bass which could occur over a five year period following the spill. However, reduced catch rates may not affect bass anglers to any large degree since bass catches are infrequent, and this is often stated as one of the reasons why it is such a prized recreational activity. With respect to other species, it is thought unlikely that the *Sea Empress* incident will result long-term effects on catch rates.

Table 7.11: Overall Costs to Recreational Fishing (£1996; £ millions)

Cost Component	Lower Bound	Best Estimate	Upper Bound
Costs to Owners and Leasers of Salmonid Fishing Rights	0.13	0.13	0.13
Costs to Salmonid Anglers	0.56	0.72	0.95
Costs to Bass Anglers	0.06	0.58	1.38
Costs to other Sea Anglers	0.01	0.12	0.28
Costs to Operators of Charter Boats	-	-	
Long-term Changes In Harvest Rates	-	-	
TOTAL	**0.76**	**1.55**	**2.74**

8. IMPACTS ON INDUSTRY

8.1 Overview

Traditionally, the key components of the Pembrokeshire economy have been agriculture, tourism, the oil industry (and related businesses), the defence industry and, to some extent, fisheries. However, the importance of agriculture is in decline, following a general decline in this sector coupled with other factors such as the BSE crisis. In addition, the military has scaled down its activities in the area considerably. As a result, other industries, particularly tourism and the oil industry are increasing in importance. With respect to the latter, of the original four refineries based at Milford Haven, one closed in the 1980's and one other announced its closure in 1997.

The impacts of the *Sea Empress* oil spill on tourism and associated industries, including marinas, has been considered in Section 4. Other industries to have experienced a negative impact as a result of the spill are:

- the three oil refineries;
- the ferry from Pembroke Dock to Ireland;
- the defence industry at Pendine and Castlemartin; and
- Pembroke Power Station.

In contrast, those parts of the Pembrokeshire economy involved with the clean-up of oil benefited from the spill.

8.2 Port-Related Industries

One of the main industry sectors potentially affected by the *Sea Empress* oil spill was the oil industry itself. There are three refineries at Milford Haven, all of which will have suffered some disruption to the delivery of oil and the export of oil products. Similarly, the movement of ferries between Pembroke Dock and Ireland will have been affected to some extent[54] as will the movement of other vessels.

Immediately after the incident, it is reported that sand dredging activities from Pembroke Dock ceased, resulting in a reduction of on-shore stocks. In addition, the fuel bunkering service was curtailed while the fuel supply vessels were deployed for use by the Marine Pollution Control Unit (Bryan et al, 1996).

In general terms, the effects of the *Sea Empress* incident will depend on the nature of restrictions placed on the movement of vessels in and out of the affected area and the number of expected movements. In this regard, average movements to and from the Port of Milford Haven are:

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54 The ferry company has been contacted for details of impacts, but has not provided data.

- 14.2 per day for tankers;
- 3.8 per day for ro-ro ferries; and
- 0.2 per day for dry cargo.

It is not known to what degree movements of vessels to and from Milford Haven were impacted during the time between the initial grounding of the *Sea Empress* on 15 February and its eventual arrival at the oil company jetty on 21 February[55]. However, by 22 February, vessel movements had resumed as there was a 'hazardous incident' between a tanker and a ferry in the waterway.

Pembroke Power Station also had the potential to be impacted by any restrictions on movements of vessels in the vicinity of the grounded tanker and associated oil spill as it produces electricity by burning oil which is imported by ship. However, the power station is rarely fired up, being used mainly to satisfy peak demand for electricity. It is reported that the power station was on-line for part of the time during the incident and that cooling water flows were interrupted to some extent.

At the time of the *Sea Empress,* National Power had plans to convert the power station to orimulsion, a bitumen emulsion (i.e. a suspension of bitumen in water). Since then, these plans have been withdrawn. Some have contended that the *Sea Empress* incident was a key factor is this decision and that this impact should be valued in monetary terms. This has not been possible due to a number of factors including:

- the difficulties in obtaining a true estimate of the importance of the incident;

- an inability to quantify the likelihood that the scheme would have been given the go-ahead had the oil spill not occurred; and

- the need to estimate the change in risks arising from the sea transport of orimulsion.

8.3 The Defence Industry

8.3.1 Pendine

The military facility at Pendine supports a rocket test track and a firing range. The former is operated as a business and is used to test both military and commercial products. Consultation has indicated that personnel from the Pendine facility were involved in the clean-up of oiled beaches and that some business was lost as a result of the *Sea Empress* incident. These costs were associated with:

- "frantic" activity involving around five to ten people, for a period of two weeks. On the basis of a 40 hour per week and at an average staff cost of £20/hour, these can be valued at between £8 000 to £16 000. In addition, there were other costs associated with the use of transport and equipment such as land-rovers, trailers, etc.; and

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55 Milford Haven Port Authority indicated that it was unwilling to speak to the Consultants until after its prosecution by the Environment Agency.

- Pendine agreed to stop firing at certain specified times to allow the clean-up of beaches to proceed. To some extent these costs were recouped, with concentrated efforts being made to recover lost ground through working overtime, etc. In total, the costs associated with lost business can probably be valued at around £5 000 for the two week period of the clean-up.

Thus, total costs to the test track facility at Pendine are estimated to be between around £13 000 and £21 000. These were not reclaimed from the 1971 Fund.

8.3.2 Castlemartin

The military training facility at Castlemartin was also impacted, to some extent, by the *Sea Empress* oil spill. Overall, the involvement of the Castlemartin Range and thus the associated costs were not great, partly because most of the clean-up was undertaken by local workers and not by range personnel. However:

- some of the range personnel did help with oiled birds;
- the range loaned vehicles, tractors, JCBs, stores, tables and tents for the clean-up;
- firing was stopped to allow aircraft to fly over to observe the spill;
- the agencies involved in the clean-up were given access to the range; and
- the range was prepared to accommodate the villagers of Angle, should there be fears of an explosion aboard ship and thus a need to evacuate.

Some costs were claimed (indirectly) from the 1971 Fund. In particular, the costs associated with the loan of a JCB and the provision of meals for clean-up workers were claimed from the JRC, who in turn claimed these from the 1971 Fund. Thus, this component of costs is already included in the direct cost estimates provided in Section 3.

There were also costs associated with staff time, which take the form of opportunity costs. In particular, it is estimated that 200 hours were spent by the Commandant of the range and his colleagues associated with briefings, booking people out onto the range, time spent in meetings of the Range Recording Advisory Group, etc. At an average staff cost of £20/hour, these costs can be valued at around £4 000.

Had the spill occurred at any other time of the year, then the costs to the Castlemartin Range would have been higher. In particular, firing takes place on the range for 44 weeks, but not in January or February. The range costs are around £10 000 per day. Had it been necessary to stop firing, it is anticipated that owing to time-constraints, training opportunities would have been lost (as it may not be possible to reschedule training).

8.4 Benefits to the Pembrokeshire Economy

While there were some costs to industry in Pembrokeshire, the economy of the county also benefited from the oil clean-up. In particular, local people were employed as workers and local businesses benefited from the money spent by media and those involved in scientific research, for example.

Table 3.7 in Section 3 indicates that the direct costs of the incident ranged between £49.1 million and £58 million. Excluding the costs of salvage and ship repairs, these costs reduce to between £23 million and £27.9 million, which includes between £2 million and £4 million on the costs of scientific studies. What proportion of these costs are associated with expenditure in Pembrokeshire is not known. However, they do relate to real resource costs.

8.5 Total Costs to Industry

A summary of the costs to industry arising from the *Sea Empress* incident is presented in Table 8.1.

Table 8.1: Summary of Costs to Industry (£1996)

Description	Lower Bound Value (£)	Upper Bound Value (£)	Comments
Costs to port-related industry	-	-	Not known.
Costs to the defence industry	17 000	25 000	
Total	**17 000**	**25 000**	

9. CONSERVATION/NON-USE RELATED EFFECTS

9.1 Overview of the Area Affected by the Oil Spill

The length of coastline affected by the *Sea Empress* oil spill is of outstanding beauty and scientific interest. Most of the coastline is within Pembrokeshire Coast National Park, the only national park in Britain primarily designated for its coastal and estuarine landscapes[56]. The main area impacted by the spill contains 35 Sites of Special Scientific Interest (SSSIs) and two National Nature Reserves at Stackpole and Skomer which are exceptional examples of wildlife habitats and geological features. In addition, the area around Skomer forms one of the UK's three Marine Nature Reserves and much of the coastline has been defined as Heritage Coast.

Parts of the area are further designated as Special Protection Areas (SPAs) under the EC Birds Directive and are thus key habitats for migratory birds or those which are rare or vulnerable. There are also plans for three Special Areas of Conservation (SACs) under the Habitats and Species Directive 1992.

9.2 The Impact of the Oil Spill

9.2.1 Marine Impacts

Immediately after the spill, eight sites in and around Milford Haven waterway were examined to assess impacts on benthic[57] animals. Effects were "surprisingly" limited, with the main species impacted being narcotised anemones and slow moving shrimps in the muddy sand off Dale Fort. However, in the weeks following the spill, large numbers of dead or moribund marine animals were washed up on beaches. Most of these animals were bivalve molluscs and other sediment dwelling species and it is believed that most strandings resulted from the spill. There was a wide range of species associated with these strandings including cockles, spiny cockles, heart urchins, common starfish, masked crabs, banded wedge shells, rayed trough shells, egg-shell razors, razorshells and venus shells. A list of strandings by species, location and date is given in Table A9.1 in Annex 9.

Over the longer-term, the effects on the offshore marine community appears to be minimal, apart for a reduction in small crustacean species such as amphipods in some locations[58]. For example, a November 1996 survey of ten sites around Skomer Marine Nature Reserve found benthic fauna to be "markedly" less diverse and abundant in 1996 compared with 1993, with there being a notable absence of small crustaceans. Similarly in June 1997, a survey of sites around the

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56 The text for Section 9.1 is based on the description of the affected area given in the SEEEC Draft Report (SEEEC, 1997). Similarly, all impacts set out in Section 9.2 are those reported in this SEEEC document.

57 Those living in or on the sea bed.

58 Impacts on commercially exploited species are not included in this statement - see Section 6.

entrance to Milford Haven waterway found very few small crustaceans such as amphipods and isopods - although these species were found at other sites, sometimes in abundance. The absence of these crustaceans in the Haven was thought to be significant as these are a favoured food species for many animals such as fish and larger crustaceans. However, it is thought that these effects are limited to within the Haven, as surveys of seabed microfauna in coastal waters between St Brides Bay and Rhosilli Bay found no such effects on amphipod fauna. In addition, the effect is expected to be of relatively short duration as amphipods, despite not having a planktonic stage, will eventually spread from unaffected areas.

9.2.2 Impacts to Rocky Shores

Rocky shores dominate much of the coastline of Pembrokeshire and the Milford Haven waterway. A large number of species live in these areas, including familiar animals such as limpets and barnacles, large brown seaweeds and a host of smaller animals and plants. Some of the species affected by the spill are nationally rare or scarce and of conservation importance.

Limpets and Other Grazers

One heavily affected species was the limpet which is particularly sensitive to the narcotising effects of fresh oil. For example, there was over 90% limpet mortality in some parts of West Angle Bay, significant reductions in limpet densities around the entrance to Milford Haven and losses at many other sites between West Angle Bay and Saundersfoot. Other herbivorous gastropods were also acutely affected including topshells and periwinkles, which were found at some heavily oiled sites.

The reduced grazing by limpets and other snails allowed algae to grow unchecked, with a resultant 'green flush' over large areas of lower and mid-shore rock surfaces. In some areas the green algae competed for space with lower shore communities of red algae and also stopped barnacle larvae from settling on the rocks. In contrast, reduced limpet grazing at West Angle Bay resulted in greater survival of brown fucoid algae sporelings, so much so that by May 1996 there was an extensive and unusually dense cover of one form of this fucoid. (Thus green and brown algae benefited from the spill. In contrast, at Manorbier and Skomer, populations of red algae were bleached following contact with oil. However, by August 1996, most populations were pink and healthy and showed little, if any, evidence of damage.)

With respect to the recovery of limpet populations, experience from other oil spills indicates that there would be a rapid recruitment and growth of limpets for a period of three to five years after the oil spill. This would be followed by a crash in populations which outgrew the available food, and then a period of smaller fluctuations until the balance of grazers and algae was restored. This could take between ten to fifteen years at West Angle Bay, with other less affected areas recovering much more quickly.

Barnacles

There were also large scale mortalities of barnacles around Dale and in a few locations around Tenby, Saundersfoot and Pendine. The mortality varied between sites and was caused by the toxicity of the oil, large scale physical smothering, or a combination of both. However, in most areas the majority of barnacles appeared to survive, with only small patches smothered by thick oil. As a result, by October 1996, densities of barnacles were either very similar to or higher than pre-spill densities.

Cryptic Fauna

There is evidence of impacts on certain small cryptic (i.e. hidden) species of rocky shore fauna which hide in crevices and algal turf. Evidence suggests that the greatest effects were limited to sites up to six kilometres (km) from the spill, but an intermediate zone of effect extended to 15 km. As for marine fauna, amphipods appear to have been particularly impacted. For example, dead amphipods were observed under upper shore stones at some oiled sites including Chapel Bay. In a survey of oarweed holdfasts[59], there was almost a complete lack of amphipods at badly oiled sites, while large numbers of such species were present at unaffected sites. However, as for marine living amphipods, rapid recovery is expected. Indeed surveys indicate that while there was a "striking" loss of amphipods and other cryptic fauna in algal turf in rockpools at West Angle Bay, there was an apparent full recovery by March 1997.

Cushion Starfish

The rockpools of West Angle Bay are one of the few UK sites where species of the cushion starfish are known to occur. As a result, the population is of scientific and conservation importance. The Bay was badly oiled and populations of both *Asterina gibbosa* and *A. phylactica* were affected. Of greatest concern are losses of *A. phylactica,* with reductions from 150 to 13 individuals as a result of the spill. Recovery has been slow and uncertain, although there is still some reproductive capacity in the population.

Other Communities

There does not appear to be any serious or long-term damage to lower shore or rockpool communities (other than the effects described above). For example, surveys in 1996 and 1997 indicate that typical communities of sponges, hydroids, anemones, byozoans, ascidians and red algae are still present and apparently healthy. However, the same cannot be said of lichens in the splash zone[60] some of which were badly oiled. An almost continuous coating of oil remains on splash zone and intertidal fringe lichen communities along a ten km stretch of north facing shores of Milford Haven and similar oiling exists at other sites. The long-term fate and recovery of oiled lichens is therefore uncertain.

9.2.3 Impacts to Sediment Shores

Sediment shores (i.e. those composed of sand or mud) make up less than a quarter of the coastline affected by the oil spill. Coarse sand beaches support a range of a few hardy species, but the muddier shores and those with a mixture of sediment sizes are immensely productive biologically

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59 The branching structure where oarweed fastens itself to rocks, which typically contains a high diversity of small animals.

60 The area just above where high tide reaches.

and form an important part of the marine ecosystem. These are particularly important as fish nurseries and feeding areas for migrant birds.

Within these areas, there appear to be no short to medium-term effects in meiofauna[61], however, there remains the possibility of long-term effects in harpacticoid copepods. The abundance and distribution of many species of macrofauna[62] was found to have changed since surveys in 1994, but not all of this reduction is thought to result from the *Sea Empress* oil spill. Again, the greatest decrease was of small crustaceans, especially amphipods, with molluscs also being impacted to some extent.

9.2.4 Impacts to Maritime Vegetation

Various maritime vegetation types came into contact with oil or were affected by the clean-up operations. Plant communities potentially at risk include those associated with sea-cliffs, saltmarshes and calcareous dunes.

It appears that while some maritime vegetation was impacted by the oil, effects have been short-lived. For example, isolated specimens of common plants such as thrift and red fescue growing on low sea-cliffs within Milford Haven waterway were killed by fuel oil, but many severely impacted common plants had regrown from their roots by Autumn 1996. Populations of the nationally scarce narrow-leaved eelgrass were also contaminated with oil, but by 1997 appeared to be healthy and little changed from pre-spill levels. This was believed to be due to the timing of the spill - which occurred before the main period of growth had commenced - and possibly a reduction in grazing pressure.

Of all maritime vegetation types, the saltmarsh in Milford Haven waterway was most directly impacted by the oil spill and studies have been initiated to map long-term effects.

9.2.5 Mammals

Although there was no evidence of any immediate impact on mammals resulting from the oil spill, a number of species were considered to be potentially at risk. However, there appears to have been no impact on these species:

- **Seals:** around 4% of the UK Atlantic grey seal population lives around the west coast of Wales. There is no convincing evidence to suggest that the spill had any short- to medium-term impact of any consequence on this population. However, had the spill occurred during the pupping season (i.e. in the autumn), some seal pups could have been killed or otherwise adversely affected;

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61 Animals less than 0.5 millimetres.

62 Animals greater than 0.5 millimetres.

- **Cetaceans:** Of the five most frequently recorded species around the coast, harbour porpoises and bottlenose dolphins were assessed as being the most at risk because of their permanent residence in the area. There appears to be no evidence of an impact on cetaceans as result of the oil spill, but longer-term observations are desirable to confirm this conclusion;

- **Otters:** Otters are widespread throughout Pembrokeshire and records suggest that they now visit estuaries and the coast more frequently. However, during the oil spill there was no evidence of coastal activity or of any adverse effect of the spill; and

- **Greater horseshoe bats:** Greater horseshoe bats are now only found in south-west England and three nursery roosts in west and south Wales. There were concerns that the 10% to 25% of the Pembrokeshire population which hibernate in sea caves on the Castlemartin coast could have been affected by oil vapour. However, exposure of the bats was found to be minimal and no adverse detrimental effects were observed.

9.2.6 Impacts on Birds

The south-west Wales coast, islands and inshore waters are of outstanding international importance for their breeding seabirds, wintering sea-duck and wintering waterfowl. The region supports about half a million breeding seabirds, including half of the UK population of Manx shearwaters, the third largest population of gannets in the world, and more than 40 000 auks (guillemots, razorbills and puffins). Many areas have been designated as SPAs or SSSIs for populations of international or national importance respectively, and two further SPAs are designated for their chough populations. During winter more than 40 000 waterfowl visit the region, including 30% to 40% of the UK's common scoter wintering population. Small numbers of three species of diver also regularly winter offshore.

The *Sea Empress* spill resulted in the oiling of large numbers of birds from a wide range of species. The first were reported on 17 February and by 1 June 1996 nearly 7 000 birds from some 36 species had been collected dead or alive. Around 85% of birds recorded came ashore between 24 February and 4 March 1996. The worst hit species was the common scoter which made up two thirds of the birds recorded. Most of the rest were auks, mainly guillemots, which together with common scoters and razorbills made up over 90% of recorded casualties. As only a small proportion of oiled birds reach the shore, the total number of birds killed will be substantially higher than the recorded totals[63]. To get a better idea of the total kill, a number of oiled corpses were neck-tagged and returned to the sea. 238 corpses were released in early March, but only 12 were eventually recovered - all in South East Ireland. On the basis of this corpse-drift experiment, it could be estimated that the total number of oiled birds was 47 600[64]. However, this may be an under- or over-estimate of the actual total as winds and currents at the time of the experiment were likely to have differed from those during the spill.

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63 Except, perhaps, for scoters in Camarthen Bay which, due to their location and prevailing winds, were more likely to have washed ashore when oiled.

64 *(7 000 birds - 4 600 scoters (see preceding footnote)) * 238 corpses released / 12 corpses recovered*

As indicated above, the impact of the spill on bird populations differed markedly between species. The common scoter, guillemot and razorbill are vulnerable to oiling as they spend long periods on the surface of the water and dive to feed. This is also true of other diver species wintering in the area and it is estimated that the number of oiled divers coming ashore was a very high proportion of those in the region at the time of the spill. In contrast, many gulls and herring gulls survived oiling (and indeed numbers of the former increased at breeding colonies). A number of important species also appear to have avoided any significant impact. In particular, puffins, Manx shearwaters and storm petrels were away from the region at the time of the spill, and the oil did not reach the important gannet population at Grassholm Island.

With respect to longer-term impacts, there were 2 600 fewer guillemots counted at affected breeding colonies than in 1995 (a decline of 13%), instead of the increase in numbers seen in nearby areas. There were also 420 fewer razorbills, a decline of 7% on 1995. The wintering population of common scoters in Camarthen bay was also badly impacted. 1997 counts show about 10 000 fewer birds than the 1996 peak, but this may be due, in part, to natural fluctuations in the population.

9.3 Payments Under the I971 Fund

We are not aware of any claims being made to the 1971 Fund for environmental damages resulting from the *Sea Empress* oil spill. However, such claims are admissible and it appears that some environmental organisations considered claiming for the costs associated with restoration of the marine environment.

The IOPC Fund's Claims Manual (IOPC, 1996b) indicates that under the 1971 Protocol, claims can be made for "impairment of the environment ... if the claimant has sustained an economic loss which can be quantified in monetary terms". However, claims will not be accepted which are only based on "abstract quantification of damage calculated in accordance with theoretical models[65]". Under the 1992 Protocol, claims for environmental damages (other than loss of profit from impairment of the environment) can only be made for the costs of "reasonable measures to reinstate the contaminated environment". (In addition, as discussed in Section 3, claims can be made for some environmental research.)

The 1996 Annual Report from the IOPC Fund (IOPC, 1996a) indicates that claims for environmental damages have only been put forward on one previous occasion. The spill in question resulted from a fire and explosion aboard the *Haven* in Genoa, Italy. Background information on the claim (which is reported to be particularly contentious) is given in Box 9.1.

65 In this regard, the Department of the Environment, Transport and the Regions has indicated that compensation for pure environmental loss "is not within the terms of the relevant international conventions. The UK has always supported the line that compensation should be paid to those that have suffered actual quantifiable losses".

Box 9.1: Claim for Damages from the 1971 Fund

Compensation has been claimed by the Italian Government for damage to the marine environment caused by the oil released from the fire and explosion aboard the *Haven* in Genoa. The Government initially quantified their claim at £32.2 million for restoration of phanerogams, wreck removal and damages to sea and atmosphere. In addition, the claim covered other impacts which were to be valued by the court on the basis of equity, namely the consequences of beach erosion caused by damage to phanerogams, and irreparable damage to the sea and atmosphere.
£15.4 million of the £32.2 million claim has been determined admissible (i.e. *statto passivo*) by the Italian court, thus the claim put to the 1971 Fund totalled some £16.8 million. Claims were also made by one Italian Region, two provinces and 14 municipalities; however, the Italian Court ruled that these authorities had no right to claim compensation.
The claim by the Italian Government has been disputed by the Fund and no monies have yet been paid. One of the reasons for disputing the claim is the approach used to estimate damages. The court took environmental damages to represent one third of clean-up costs, but the Fund's position is that it is "absurd" to contend that compensation for environmental damages should increase with the cost of clean-up.
Source: IOPC (1996a)

9.4 Valuation of Impacts

9.4.1 Introduction

Two approaches have been used to value the impacts of the *Sea Empress* oil spill on conservation. These are:

- the replacement costs approach; and
- willingness to pay values.

9.4.2 The Replacement Costs Approach

The *Sea Empress* oil spill resulted in direct losses to fauna and flora - in particular marine crustaceans and birds. These losses can be valued using the replacement costs technique which uses the actual market costs of re-instating an environmental asset in a physical sense to determine the associated loss of capital resources experienced by a nation. This technique has been adopted with varying degrees of success by those claiming compensation following oil spills in the US, and has been accepted for such cases. The reliability of the estimates of environmental damages developed using this approach depend upon the accuracy of environmental damages data, coupled with the reliability of the 'replacement cost' values attributed per organism. For example, application of the approach to damages to marine life caused by the *Amoco Cadiz* oil spill on the French coast gave values ranging between FF 7.5 million to FF 190 million (FF1996 - Grigalunas, 1986). Further examples of the application of this approach are given in Table A9.2 in Annex 9.

The replacement costs approach has been used to value strandings of marine species following the spill. The scale of losses were estimated from (mainly qualitative) reports of strandings along the coast and prices were collated from a biological supply company[66]. The results are summarised in Table 9.1 with full details given in Table A9.1 in Annex 9.

Table 9.1: Replacement Costs for Stranded Marine Species (£1998)

Species	Estimated Quantity	Value per Individual (£)	Total Value (£)
Asteria Starfish	2 000	1.48	2 960
Cockles	13 925	0.24 (per 100)	3 340
Donax	5 000	1.24	6 200
Echinocardium Heart Urchins	1 750	4.00	7 000
Ensis Razorshells	6 000	1.48	8 880
Mactra Rayed Trough Shell	10 500	1.77	18 600
Pharus Egg shell razor	5 000	1.48	7 400
Other			9 500
Total			**55 000**

Source: Table A9.1 in Annex 9

Table 9.1 indicates that strandings of marine fauna caused by the *Sea Empress* oil spill can be valued at around £55 000. In practice, the 'true' value derived through these means is likely to be much higher. This is mainly due to the fact that, unlike for seabirds, there was no protocol for reporting strandings of marine species. Thus, these were reported when seen (as opposed to a systematic search of affected beaches) and there was no requirement to quantify the number of stranded individuals (with reports using terms such as "many hundreds", "significant quantities", "some", "many", "very large numbers" and "a few"[67]). If it is assumed that only half of all stranded marine animals were reported, then the associated value could double to £110 000.

The above estimate does not taken into account losses of the most heavily affected marine animal - the amphipod - nor the most heavily affected shore-based animal - the limpets. It has been postulated that there were probably millions of amphipods killed on the seabeds and around the

66 Unfortunately, data were only readily available from a US-based company. However, it is thought that for most species there would not be large differences between US and UK prices.

67 A conservative approach was taken when convert these qualitative descriptions into quantitative estimates of strandings.

coastline, these being too small to strand. Losses of limpets were also high and approached 90% in some areas of West Angle Bay. The price of a selection of amphipods available from a biological supply company range between £1.24 and £1.78 per individual and the price of a limpet is £1.48.

If it is the case that millions of amphipods were lost, then using the replacement costs approach, the economic value of these losses would also be of the order of millions of pounds. With respect to limpets, although the scale of losses has not been quantified, the loss of tens of thousand individuals would similarly be valued at tens of thousands of pounds.

In considering these values, it should be noted that replacement would not need to actually take place for this approach to be justified. For these values to be considered sound in theoretical terms, however, there has to be an indication that society would be willing to pay such replacement costs. In the case of amphipods, evidence suggests that losses will be relatively short-lived, with some populations already at pre-spill levels. Whether a valuation of millions of pounds would be accepted for the temporary loss of these crustaceans is therefore debatable.

9.3.3 Willingness to Pay

The total economic value of an environmental asset is the sum of use values plus non-use values. The former are those associated with actual use of the environment and these have been used in monetising impacts to recreational anglers, bathers, surfers, etc. Non-use values are of three different types:

- **option values** relate to the desire to maintain the ability to use the environment at some time in the future. They reflect an individual's willingness to pay to secure the future of a good and thus express the potential benefits of that good;

- **bequest values** are attached to preservation or conservation of the environment so that future generations may also have the option of use; and

- **existence values** are those values which result from an individual's altruistic desire that an environmental asset be preserved and continue to exist into the future. These values are not associated with actual or potential use, but solely with the knowledge that the asset is being preserved.

Table 9.2 presents some relevant non-use values derived from willingness-to-pay (i.e. contingent valuation) surveys, and the results of the full literature review are presented in Table A9.2 of Annex 9. Two of these values were developed by water companies and relate to the willingness of the public to pay for protection of EC designated bathing waters from sewage pollution. The value developed by Welsh Water indicates a value of £0.14 per EC designated beach per annum. As discussed in Section 5, for the aesthetic value of a natural resource, respondents to questionnaires have found the presence of oil to be the most damaging, followed closely by the presence of sewage. There is therefore some relevance of these values to preventing oil spill related damages, although the context of these problems is different. In particular, it must be noted that the Welsh Water values relate to a continuous pollution problem as opposed to a catastrophic event.

Table 9.2: Key Non-Use Values for the *Sea Empress* Oil Spill (£1996)

Method of Valuation and Criteria	Value	Study and Comments
Household survey determining WTP for stricter controls on sewage treatment to meet new EEC standards	£0.03 /household/EC designated beach/year	South West Water from FWR Manual (1996)
Household survey determining WTP for (a) improvements to coastal sewage treatment and (b) advanced protection of bathing waters.	£0.14 /household/EC designated beach/year	Welsh Water from FWR Manual (1996), £1996, same value for both option a and b
CVM surveys to determine WTP to prevent an *Exxon Valdez* type oil spill	Median WTP of £31.66 /household/event	Carson *et al*, 1994
CVM to determine WTP estimates over five years to prevent oil spills in the Pacific Northwest. Article focuses on natural resource damages and non-use values - trying to determine how much should be spent on oil spill prevention measures in future. Estimating value to citizens of Washington and British Columbia - randomly chosen. Household values.	**Washington** All Spills £266 - £371 Large Spill £122 - £177 Moderate Spill £72 - £194 Several small spills £44 - £55 Routine very small spills £28 **British Columbia** All Spills £210 - £415 Large spill £89 - £188 Moderate £61 - £271 Several small £38 - £72 routine very small £22 - £44	Rowe and Shaw, 1992, all values are mean WTP over five years and are assumed to be per household figures.

Source: Table A9.2 in Annex 9

The remainder of the studies in Table 9.2 have quantified the non-use values associated with the prevention of natural resource damage. For example, Carson *et al* (1994) undertook a survey based on the contingent valuation method and established that households were willing to pay £31.66 to prevent an *Exxon Valdez* type oil spill[68]. This is a once-off payment for pollution prevention measures over a ten year period. Survey respondents were informed that without these measures, scientists expected there would be another large oil spill that would cause the same amount of damage to the same part of Alaska as the *Exxon Valdez* spill. With the measures, however, scientists were "virtually certain" that there would be no large spill that would cause damage to the area. On this basis, the willingness to pay value of £31.66 is taken to be a per event valuation. This can be used - via benefit transfer - to establish willingness to pay to avoid a future large oil spill in the Milford Haven area. Clearly, the *Exxon Valdez* oil spill had a greater environmental impact than the *Sea Empress*[69], but as the affected Alaskan coastline is not a

68 This is a median value. The median is preferred by Carson *et al* as it is more robust than the mean.

69 In terms of the length of coastline affected (2 400 km compared with 200 km for the *Sea Empress)*, but not in terms of spill size (37 000 t compared with 72 000 t).

common recreation site, the WTP value is unusually specific in its representation of a non-use value for avoiding large oil spills.

Another similar study found the citizens of Washington and British Columbia willing to pay up to £415 per household over a five year period to avoid natural resource damages from all future oil spills (Rowe and Shaw, 1992). For specific spills, the values range from £22 for a very small routine spill, to £188 for a large spill. In this regard, the *Sea Empress* oil spill is taken to be most closely related to a 'moderate impact' spill which would occur once every five years an kill 40 000 seabirds and kill or injure a few mammals.

Given the above value estimates, non-use values which may be associated with preventing an oil spill such as the *Sea Empress* have been estimated. The transfer values assumed and the associated results are set out in Table 9.3. The populations selected for analysis were those most appropriate to the nature of the WTP estimates, and the resultant estimates of non-use value are presented as per event values. It can be seen that the figures range from a lower bound of £22.5 million to an upper bound of £35.4 million. The lower bound figure represents the WTP of the population in Dyfed to prevent a moderate impact spill, while the upper bound value represents the WTP of the Welsh population to prevent an *Exxon Valdez* type spill along the Welsh coast.

Table 9.3: Estimates of the Non-Use Value of the *Sea Empress* Oil Spill (£1996)

Approach	**Population**		**Value❖**		**Total Value**
	Description	**Size**	**Units**	**£**	**£ million**
WTP to protect EC designated beaches	Households in Welsh Water Region	1 119 000	£/household /EC designated beach/year	0.14	30.2
WTP to avoid a moderate sized spill	Households in Dyfed	135 677	£/household /5 years	166	22.5
WTP to avoid an *Exxon Valdez* type oil spill	Households in Great Britain	1 119 000	£/household /event	31.66	35.4

❖ WTP to protect EC designated beaches: 23 EC designated beaches were impacted in the affected area. A per annum value was estimated and discounted over the event frequency (i.e. 12 years); WTP to avoid a moderate oil spill: the value is the average of the range given in Table 9.2; WTP to avoid an *Exxon Valdez* type oil spill: the value of £31.66 is a once off payment over 12 years.

10. HUMAN HEALTH EFFECTS

10.1 Introduction

The vapour cloud resulting from the *Sea Empress* oil spill had the potential to impact the health of workers involved in the clean-up and the general health of the local population. Evidence from the spills arising from the *Exxon Valdez* and the *Braer* has indicated that, for the general population, both acute and chronic physical and psychological effects could be of concern. With respect to the clean-up workers, exposure to vapour would result in similar concerns but exposure would have been limited through the use of personal protective equipment.

10.2 Acute Physical Effects of Oil Vapour on the General Population

10.2.1 The Nature of the Effects

The *Sea Empress*

The acute physical effects of the oil spill on the health of the local population have been examined in a study for Dyfed Powys Health Authority (DPHA), which is reported in Lyons *et al* (1996). The study compared the health of exposed populations (in Milford Haven, Pembroke Dock, Tenby and Saundersfoot) with those of a control group (from Aberaeron and Fishguard) over the period 16 February to 16 March 1996 (i.e. the month following the grounding of the *Sea Empress*).

The study showed an increase of acute physical symptoms in the exposed population following the oil spill, including nausea, sore throat and skin rash. The range of symptoms are set out in Table 10.1 overleaf, which also provides data on their prevalence in terms of an odds ratio. An odds ratio is a measure of how common an event is in one group compared with another. Thus, Table 10.1 reveals that while 12% of the control population experienced a headache during the period of the study, almost four times[70] as many (or 47%) of the exposed population experienced a headache during this time.

Comparison with Other Studies

There have been criticisms of the above study, with some contending that the study is flawed with respect to the survey instrument, approach and timing. For example, the eight week delay between the spill and the survey is reported to have reduced the robustness of the survey (pers. comm.). It is therefore useful to compare the findings of the *Sea Empress* study with those for other oil spills.

The short-term effects of the *Braer* oil spill have been examined by a study which questioned the exposed population about their health after the spill. In the five months after the spill, the exposed population experienced an increased rate of some symptoms when compared with the control group including weakness, eyesight problems, and breathlessness (Campbell *et al*, 1994).

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70 Using Odds Ratio A from Table 10.1.

Table 10.1: Acute Physical Health Effects Experienced by the Exposed Population

Symptom	Prevalence in Control Group	Odds Ratio A✦	Odds Ratio B⚜
Weakness	12.7%	1.9	NS✦
Headache	12.0%	3.9	2.47
Runny Nose	11.3%	1.9	NS
Sore Throat	10.5%	2.9	2.04
Cough	9.6%	1.9	NS
Generally Ill	7.3%	3.5	1.78
Nausea	5.8%	2.4	NS
Sore Eyes	4.9%	3.5	2.37
Itching Skin	4.7%	2.3	NS
Shortness of Breath	4.4%	2.3	NS
Skin Rash	2.9%	2.3	NS

✦ This column presents odds ratios which have been adjusted to account for a higher baseline rate of illness, greater level of anxiety, higher smoking rates and minor differences in age and gender between the exposed and control populations.

⚜ This column reports odds ratios which have been adjusted for a 'health belief in the effect of the oil spill'.

✦ NS indicates symptoms which are statistically non-significant when adjusted in this manner.

Source: Lyons *et al* (1996)

The odds ratios associated with these symptoms are given in Table A10.1 in Annex 10. Comparison with data for the *Sea Empress* indicates a number of differences including:

- the study of different symptoms;
- differences in the range of odds ratios: those for the *Sea Empress* range between 1.9 and 3.9, while those for the *Braer* range between 1.3 and 9.2; and
- differences in the ranking of symptoms: for example with respect to odds ratios, sore eyes are ranked second for the *Sea Empress* but last (i.e. eighth) for the *Braer* (odds ratios 3.5 and 1.28, respectively), while weakness is ranked last for the *Sea Empress* but first for the *Braer* (odds ratios 1.9 and 9.8, respectively).

The reasons for and importance of these differences are not known. However, it has been suggested that the ambient vapour concentrations following the *Braer* were higher than for the

Sea Empress. This is due to the severe weather conditions in the Shetlands which resulted in 40% of the oil being lost as a volatile fraction[71] (pers. comm.).

However, the DPHA study does present two sets of odds ratios (A and B), with the second set being adjusted to take into account a "health belief in the effects of the oil spill". This second set of odds ratios will be used to develop a lower bound estimate of the health effects of the oil spill, and thus to account for criticisms of the DPHA study.

10.2.2 The Approach to Valuation

To value the acute physical impacts of the *Sea Empress* oil spill on the general population, data are required on:

- the size of the exposed population;
- the duration of each illness;
- estimates of willingness to pay (WTP) to avoid illness;
- working days lost through illness; and
- health care costs.

10.2.3 The Size of the Exposed Population

Exposure Via Oiled Beaches

The authors of the DPHA report have indicated that the exposed population can be considered to equal those living on the coastline affected by the oil spill (from Wooltack Point in the west to the Three Rivers Estuary in the east), extending as far as one kilometre from the shore. Using this assumption and 1991 census data for the area, the exposed population has been estimated to be 25 500. This is one of the figures used to calculate the human health costs associated with the *Sea Empress* incident.

Exposure Via Vapour Cloud

A different exposed population has been estimated based on the concentration of certain volatile organic compounds (VOCs) resulting directly from the pool of oil[72] released from the *Sea Empress*. The Environment Agency commissioned a study to determine the concentration of five VOCs over the period from 15 to 22 February 1996 (Carruthers and Ellis, 1997). It has been suggested that for two of these VOCs, ethyl benzene and xylene, some symptoms can be expected to have resulted wherever the odour threshold for these compounds was reached (see Table A10.2 for details of odour thresholds and associated text). The land area over which odour threshold concentrations were detected reached as far as 13 and 17 kilometres inland (generally north and northeast of the city of Milford Haven) for ethyl benzene and xylene, respectively. Given that the larger xylene cloud completely overlapped the ethyl benzene cloud, the exposed population using

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71 In the seven days after the *Braer*, the release of volatile organic compounds (VOCs) was equivalent to 1% of the total annual release of VOCs in the UK.

72 Data on vapour concentrations resulting from oil on the beaches was not available.

this approach was based on the extent of the xylene cloud and has been estimated (again using 1991 census data) to be 37 500. This figure was also used to calculate the human health costs associated with the *Sea Empress* incident.

It is important to note, however, that exposure to VOCs is expected to result in some, but not all, of the symptoms reported in the DPHA study. For example, it is expected that headaches may result, but probably not itchy skin. It was therefore assumed that exposure to the vapour clouds resulted in only two of the symptoms identified in the DPHA study, namely headaches and nausea.

10.2.4 The Duration of Illnesses

Information on the actual duration of illnesses were collated as part of the DPHA study; however, these data are reported to be limited (pers. comm.). In the absence of these data, the Consultants approached the Department of Health for average duration figures. However, none were available. In the absence of information in the average duration of symptoms, to be conservative, it will be assumed that each symptom lasted only one day.

10.2.5 Valuation Data

'Willingness to Pay' Values

Data on WTP to avoid morbidity effects of the type experienced following the *Sea Empress* oil spill are reported in Table A10.3 of Annex 10. This presents a range of values which were derived from selected studies to indicate willingness to pay for reductions in air pollution. The values vary according to the type of symptom and, in most cases, duration of illness. As can be seen in this table, for some symptoms (e.g. headache), more than one value is given. To be conservative, values used in this analysis are the lowest values for a symptom lasting one day. For those symptoms identified in the DPHA report for which no WTP values were available (i.e. weakness, generally ill, itching skin and skin rash), the lowest value for a symptom lasting one day (£6) was applied.

It should be noted that the studies which generated these WTP values were conducted in the US, and there are problems associated with transferring these values from the US to the UK. For example, exchange rates do not always reflect purchasing power; thus, a similar study conducted in the UK may lead to significantly different values. However, in the absence of similar data generated in the UK, these values have been applied here.

Working Days Lost and Health Care Costs

In terms of the costs associated with working days lost and the provision of healthcare, the DPHA study collated information on the type of medical help sought for each of the above symptoms. However, these data have not been analysed and are not available for use in this study. In the absence of such data, the Department of Health was approached but could not assist either.

Without these data, it is not possible to estimate the costs associated with working days lost and the provision of healthcare. However, given the fairly minor nature of these symptoms, the number of days taken off work and the number of visits to the doctor should have been minimal.

10.2.6 The Value of Acute Physical Health Effects

The WTP values referred to in Section 10.2.5 were applied to the two exposed populations (those exposed via proximity to oiled beaches and those exposed via vapour clouds). Using Odds Ratio A from Table 10.1, the best estimate of the costs associated with acute physical effects is approximately £640 000 (£380 000 and £260 000 for the two exposed populations, respectively). With regard to the physical heath effects value associated with proximity to oiled beaches, some details are provided in Table 10.2 below. The full set of calculations are presented in Tables A10.4 and A10.5 of Annex 10.

Table 10.2: Acute Physical Effects (£1996)

Symptom	Estimated Exposed Population Experiencing Symptom	WTP (Low Value)	Valuation for Exposed Population
Headache	8 874	£12	£106 488
Sore Throat	5 087	£11	£55 960
Nausea	2 071	£34	£70 400
Sore Eyes	3 124	£10	£31 238
Other	-	-	£116 305
Total	-	-	£380 391

If the higher WTP values referred to in Section 10.2.5 are used instead of the lower values in calculating the costs of acute physical health effects, a higher estimate of over £1.56 million results (£600 000 and £456 000 for the two exposed populations, respectively). Similarly, by keeping the lower WTP values, and using Odds Ratio B from Table 10.1 to determine the proportion of the population experiencing a given symptom as a direct result of the *Sea Empress*, a lower estimate of £231 000 results (£151 000 and 80 000 for the two populations, respectively). Again, these calculations are presented in Tables A10.3 and A10.4 in Annex 10.

10.3 Psychological Effects on the General Population

10.3.1 The Nature of Psychological Effects

The *Sea Empress*

The DPHA study reports statistically significant psychological effects on the general population resulting from the *Sea Empress* oil spill. In particular, the exposed population scored 73.4 and the control group 77.1 in terms of SF-36 mental health scores (where scores of 0 and 100 indicate poor and good mental health respectively). In other words, the psychological health of the exposed population was 4.8% lower than that of the control group.

Comparison with Other Studies

Studies of other oil spills have also identified psychological effects. For example:

- ***Braer***: of those exposed to the *Braer* oil spill, 24% scored above the level at which a subject could be considered a "case" compared with 3% of controls (Campbell *et al*, 1994); and

- ***Exxon Valdez***: comparison of exposed and control populations indicates odds ratios of 2.0 for post-spill post-traumatic stress disorder (PTSD) and generalised anxiety disorder (GAD) and an odds ratio of 1.8 for depression following the spill[73] (Palinkas *et al*, 1993a).

Unfortunately, these studies do not use the same units of measure as that for the *Sea Empress*, thus results are not directly comparable. All that can be said is that effects such as these have been found for oil spills other than the *Sea Empress*.

10.3.2 The Approach to Valuation

Stress induced by a disastrous occurrence (flood, fire, etc.) can be related to health damaging effects such as reduced immune system response and increased susceptibility to certain illnesses. A stress model has been developed to assign a monetary value to the stress resulting from the *Sea Empress* incident. The starting point for this model is the Social Readjustment Scale (Allee *et al*, 1980). This defines stressful events in relation to other stressful events, with the mean value of 100 being the maximum level of stress (defined as 'death of a spouse'), decreasing to events such as divorce (mean value of 73), personal injury or illness (mean value of 53) and change in living conditions (mean value of 25).

The Social Readjustment Scale was applied in a subsequent study (Floyd *et al*, 1997) to determine the relative stress associated with flooding. Flooding was considered to have a relative impact on an individual's life similar to a 'change in living conditions', and was thus given the same mean value of 25. It is believed that an event such as an oil spill would rank similarly on this scale.

Department of Transport figures (DoT, 1996) suggest a casualty value of £7 170 for a minor injury, where this value reflects the human costs associated with a casualty, such as lost output, pain, grief and suffering, medical costs, and emergency services. Of this, DoT figures indicate that roughly 75% of the value relates to the human costs associated with pain, grief and suffering. No further breakdown is provided on what proportion of human costs could be attributed to a willingness to pay to avoid pain versus grief versus suffering, however. Given that pain, grief and suffering can give rise to stress, it is believed reasonable to assume that around 20% of willingness

[73] Certain social and cultural factors were found to influence the prevalence of these disorders. Factors tested were ethnic origin (i.e. Alaskan Natives or non-Natives), gender and age. Only in those over 44 were no significant associations found between exposure and any of the disorders.

to pay is stress-avoidance related. This implies that about 15% of the minor injury figure relates to stress, with this then corresponding to a value of about £1 075 per person affected.

Assuming that this figure is equal to a mean value of 53 on the Social Readjustment Scale, and that a mean value of 25 is attributed to an oil spill, the mean monetary value of the trauma resulting from an oil spill is equal to:

$$\frac{\pounds 1\ 075 \times 25}{53} = \text{roughly } \pounds 500 \text{ per person}$$

The rates of psychiatric disorders following the *Exxon Valdez* oil spill have been compared with those following other disasters. The findings with respect to floods are set out in Table 10.3. Comparison of the psychological effects arising from an oil spill with those for flooding indicates that the above approach should provide a conservative estimate of the psychological costs associated with oil spills (i.e. that the costs should not be over-estimated).

Table 10.3: Psychological Effects of Oil Spills and Floods

Event	**Prevalence in the Exposed Population**	
	Post-traumatic Stress Disorder	**Generalised Anxiety Disorder**
Exxon Valdez - High Exposure[♦]	17.2%	34.5%
Exxon Valdez - Low Exposure	9.9%	16.7%
Floods	5.2%	16.3%

♦ In this instance, exposure does not refer to exposure to oil, but to other factors considered to be indicators of psychiatric disorders - see also Section 10.3.3.

Source: Palinkas *et al*, 1993b

10.3.3 The Size of the Population

Research into the psychological effects of oil spills have indicated that these are not dependent on actual exposure to oil or oil vapour but to other factors. For example, for the *Braer* it is reported that psychiatric effects may be in response to strains on the fabric of the community (Campbell *et al*, 1994). For the *Exxon Valdez*, psychiatric effects were equated with exposure to six factors[74] relating to personal usage of the coastline, involvement in the clean-up activities and damage to property or livelihood.

It is important to note that such stress studies are applicable only to adults. In the absence of more information, it will be conservatively assumed that for the *Sea Empress* incident, the exposed

[74] Residents with high exposure were those agreeing with at least four of these six statements, while residents with low exposure were those agreeing with two or three of these statements.

population for psychological effects is 10% of adults living in the wards along the oiled coastline. This has been estimated to equal 3 800 adults.

10.3.4 The Value of Psychological Health Effects

Given that the exposed population is assumed to be 3 800 adults and that the costs associated with stress-related psychological effects is estimated at £500 per person, the total economic value of these effects is estimated at:

3 800 people x £500 = £1.9 million

A lower bound for the costs of psychological effects can be estimated by applying half the mean value from the Social Readjustment Scale, which suggests that the stress related to an oil spill is significantly less than that related to a change in living conditions (with this potentially reflecting differences in the length of time which an individual might be affected). Applying a mean value of 12.5 to the calculation presented above gives a 'per person' value of £250, which over the affected adult population of 3 800 yields a lower bound estimate of £0.95 million.

10.4 Other Effects on the General Population

To prevent injury arising from a feared gas explosion on board the *Sea Empress*, the local lighthouse and surrounding cottages were evacuated (Hooke, 1996). Fortunately, no gas explosion occurred. However, had one occurred, the costs associated with it would have increased costs of the incident.

With respect to the medium term, a study of the *Braer* oil spill found that five months after the spill, the health of the exposed and control populations was similar, though probable upper respiratory infection was detected (Campbell *et al*, 1994). This implies that any medium-term health impacts arising from the *Sea Empress* incident are likely to be minor.

There has been a follow-up to the DPHA study to identify chronic physical and psychological symptoms resulting from the *Sea Empress* oil spill. However, the results were not available within the time-frame of this analysis. Without additional information, it is not possible to draw any conclusion concerning the longer term chronic effects of the oil spill.

10.5 The Effects of the *Sea Empress* Oil Spill on the Health of Workers

10.5.1 The Clean-Up Operation

At its peak, over 1 100 workers, including contractors, council workers and volunteers, were involved in the on-shore clean-up of oil spilt from the *Sea Empress*. Risks associated with the clean-up included those associated with contact with oil, inhalation of oil vapour and the use of dispersants. With respect to the last of these, "excessive exposure" can cause irritation to the eyes, skin, nose and throat (MPCU, 1996).

The worker safety aspects of the clean-up operation were reviewed by the Health & Safety Executive (HSE) in March 1996. An HSE nurse from the Employment Medical Advisory Service (EMAS) visited the area site on 1/3/97 and reported on the findings of this visit in a letter to Pembrokeshire County Council dated 12/3/97. The letter indicated that a COSHH (Control of Substances Hazardous to Health) assessment was needed and that few health precautions were being taken, the main problems being skin contamination and ingestion (pers. comm.). For example, some sites had no washing facilities, the gloves in use were not suitable for oil, overalls were contaminated and there was little first aid provision. HSE also set out a five point plan for action which included the following requirements:

- the provision of instructional information for all workers on risk and safety;
- the use of neoprene or other suitable gloves;
- the provision of overalls suitable for intended use;
- the provision of suitable welfare facilities, such as washing facilities; and
- the provision of first aid facilities.

The above indicates that improvements could have been made to health and safety provisions for clean-up workers, at least at the start of the clean-up operation [and this is a view which is shared by a study on the effectiveness of the clean-up operations (Maritech, 1997)]. However, the situation improved at the beginning of April when Pembrokeshire County Council (the new unitary authority) appointed a consultant to undertake risk assessments of the clean-up operations (pers. comm.). After this time, there was a "noticeable improvement in the frequency and quality of risk assessments" (Maritech, 1997).

More generally, it appears that while the health and safety aspects of the clean-up were well managed at the very start of the incident, the expansion of the clean-up to many beaches resulted in a decline in standards. For example, it is reported that (pers. comm.):

- health and safety provisions were good initially, especially where controlled by the oil refineries, and particularly Texaco. Workers were protected, the clean-up was well managed and oil vapours were monitored;

- as the clean-up operations expanded and on site-control moved out of the hands of the oil refineries, health and safety standards began to decline; and

- as contractors took over the clean-up, standards declined further in some areas. For example, washing facilities were not available at every beach, thus it was difficult to ensure that adequate hygiene procedures were followed.

It is also reported that workers were not using their personal protective equipment (PPE) correctly. For example, gloves were in pockets and masks were not worn, or, if they were, visors were not down.

The deficiencies in the management of health and safety issues have been fully recognised by Government (Maritech, 1997). The experience gained as a result of the *Sea Empress* clean-up led to the Marine Pollution Control Unit (MPCU) issuing a draft Scientific, Technical and Operational

Advice Note 1/97 (i.e. a STOp Notice) on Health and Safety During Shoreline Clean-Up Following an Oil Spill.

10.5.2 Reported Effects

The Nature of Effects

Around 100 workers were included in the DPHA survey of the general public although these data have not been analysed. Further efforts have been made by DPHA to research health effects on workers. However, not enough workers came forward to provide a sufficient sample and the study was not undertaken.

With respect to the nature of effects, there is anecdotal evidence of both physical and psychological impacts to workers involved in the clean-up. For example (Gates, 1996):

- there were reports of both skin and respiratory symptoms including the development of asthma; and

- the stress of the incident is reported to have contributed to the suicide of an oil company manager involved in the clean-up (although it is thought that this individual was involved in organising part of the clean-up and was not in physical contact with the spill).

In addition, consultation has indicated symptoms such as headaches, skin irritation and rashes amongst workers.

The Cause of Effects

The question has been raised as to whether the presence of oil caused the above impacts, or whether other factors were important. Concentrations of VOCs on the beaches were monitored by Texaco at the start of the clean-up. Samples taken over 500 minutes at Kilpaison beach on 24 February 1996 indicated (pers. comm.):

- benzene levels of 0.1 mg/m^3 compared an occupational exposure limit (OEL) of 16 mg/m^3; and

- toluene levels 0.1 mg/m^3 compared with an OEL of 192 mg/m^3.

Concentrations were thus well below the OELs and, for benzene, well below the odour threshold (the odour threshold for toluene is not known). Concentrations of ethyl benzene and xylene on this date are not known; however, if these were at a similar level to the two assessed VOCs, then odour thresholds would have been exceeded. This may have been the case as "the smell of oil" was reported to be an issue associated with the clean-up in some instances.

Some contest that the presence of oil was not the problem, with illness being due more to a "hygiene breakdown" (i.e. unnecessary exposure), and perhaps to dispersants (pers. comm.). In addition, in cleaning the beaches of oil, some workers were exposed to other hazardous substances. For example, cleaning at Scotch Bay (a small rocky bay to the east of the entrance to Milford Haven docks) was stoped after workers reported ill health and blue asbestos was found in rubbish at the head of the beach (MPCU, 1996).

10.5.3 Valuing Effects

In the absence of data on the nature and number of symptoms experienced by the clean-up workers, it is not possible to value these effects using WTP values. Neither are data available on working days lost or health care costs. With respect to the former, the information available from one organisation which supplied workers for the clean-up indicates that there was no long-term sickness as a result of the *Sea Empress* incident. In addition, although there was some short-term illness amongst workers, there was a tendency not to report this or take sick leave due to an unwillingness to miss out on the opportunity of overtime work.

10.6 Summary of Health Costs

Valued and unvalued health costs are set out in Table 10.4.

Table 10.4: Summary of Health Costs (£1996; £millions)

Description	Low	Middle	High	Comment on Unvalued Costs
Acute impacts to the General population	0.23	0.64	1.06	
Psychological Effects to the General Population	0.95	1.9	1.9	
Chronic Effects to the General Population		-		Likely to be minor
Impacts to Workers		-		Costs limited due to the limited number of workers involved (i.e. 1 000 workers)
Total	1.18	2.54	2.96	

11. SUMMARY OF COSTS

11.1 Overview of Costs

The preceding sections have developed estimates of the costs of the *Sea Empress* oil spill in terms of clean-up and salvage costs and costs to tourism, recreation, commercial fisheries, recreational angling, local industry, conservation/non-use and human health. These costs are summarised in Table 11.1, with a breakdown of these costs given in Table 11.2 at the end of this section.

Table 11.1: Summary of Costs (£1996; £ million)

Category	Financial Costs		Economic Costs	
	Lower Bound Value	Upper Bound Value	Lower Bound Value	Upper Bound Value
Clean-up and Salvage Costs	49.1	58.1	49.1	58.1
Tourism	4.0	46.0	0.0	2.9
Recreation	-	-	1.0	2.8
Commercial Fisheries	6.8	10.0	0.8	1.2
Recreational Fisheries	0.1	0.1	0.8	2.7
Local Industry	0.0	0.0	0.0	0.0
Conservation/Non-Use	-	-	22.5	35.4
Human Health	-	-	1.2	3.0
Total	60.0	114.3	75.3	106.1

Note: All costs are per event costs.

The total financial costs of the *Sea Empress* incident are in the range of £60 million to £114 million, and economic costs in the range £75 million to £106 million. Either ends of these ranges represent lower and upper bound costs with the actual costs of the incident falling somewhere between. All of the costs associated with the incident are one-off costs, most of which were incurred in the year following the spill.

11.2 Comparison with Damage Compensation Payments

11.2.1 Payments Under the 1971 Fund for the *Sea Empress*

Estimates of the total size of claims under the 1971 Fund have been made by both the IOPC Fund and the UK Government. High and low estimates of claims are summarised in Table 11.3[75]. The financial and economic costs developed during this study are around a factor of two higher than these estimates. This is to be expected given that the 1971 Fund is not responsible for compensating all components of financial costs (e.g. the costs of ship repair and loss of cargo which are covered by separate insurance), nor does it compensate most economic losses (e.g. changes in consumer surplus arising from lost recreational visits).

Table 11.3: Estimates of Total Payments Under the 1971 Fund (£1996; £ million)

Category	UK Government Estimates[a]		IOPC Estimates[b]	
	Low	High	Low	High
Clean-up Operations	23	23	22	23
Preventative Measures	0	7	0	4
Fishing Industry	8	10	8	10
Tourist Industry	3	9	2	4
Total	**34**	**49**	**32**	**41**

a *Sea Empress Disaster Bill may Reach £50 million,* ENDS Report 265, February 1997, pp29-30
b IOPC (1997b): Executive Committee, 54th Session, Agenda Item 3, Incidents Involving the 1971 Fund, *Sea Empress*

11.2.2 The Application of Damage Compensation Formula

A damage compensation formula has been developed for application to spills impacting the Florida coast (as reported in Etkin, 1994). In calculating the amount of compensation payable, the formula takes into account a number of factors including the nature of the oil spilt, the nature and length of affected coastline and the presence of endangered or threatened species.

For comparative purposes, this formula has been applied to the *Sea Empress*. The formula and its application to the *Sea Empress* oil spill are set out in Annex 11. Using this formula, the oil spill is valued at £500 million for all impacts including non-use values.

75 As discussed in earlier sections, data gathering for this report ceased at the end of November 1997. Data provided by DETR since this date provides a low estimate of likely claims of £32.5 million and a high estimate of £42 million.

Annex 5 Contents:

Table 11.2: Summary of Costs (£1996; £ million)

Category	Description	Financial Costs		Economic Costs		Comment
		Lower Bound	Upper Bound	Lower Bound	Upper Bound	
Commercial Fisheries	Loss of fishing gear by Fishermen	0.04	0.05	0.04	0.05	Lower bound from 1971 Fund payments. Upper bound assumes around 20% of costs were uncompensated.
	Loss of income to fishermen arising from operation of the FEZ	6.60	9.81	0.66	0.98	Lower bound from 1971 Fund payments. Includes claims from fish/shellfish processors and some costs associated with loss of gear. MAFF's costs remain unvalued in the lower bound estimate. Upper bound estimate assumes costs are equal to upper limit of estimates of payments under the 1971 Fund minus all other costs.
	Reductions in markets	0.11	0.14	0.11	0.14	Some of the lower bound costs may be included in those for the operation of the FEZ. Upper bound assumes some costs remain uncompensated by the 1971 Fund.
Recreational Fisheries	Costs to the Owners and Leasers of Salmonid Fishing Rights	0.13	0.13	0.13	0.13	Lower bound costs are claims to the 1971 Fund for loss of income, refund of rod and membership and expenses.
	Costs to Salmonid Anglers	-	-	0.56	0.95	Estimate of change in consumer surplus.
	Costs to Bass Anglers	-	-	0.06	1.38	Estimate of change in consumer surplus.
	Costs to other Sea Anglers	-	-	0.01	0.28	Estimate of change in consumer surplus.
	Other costs	-	-	-	-	Costs to operators of charter boats and costs associated with long-term reductions in harvest rates remain unvalued.

Table 11.2: Summary of Costs (£1996; £ million)

Category	Description	Financial Costs		Economic Costs		Comment
		Lower Bound	Upper Bound	Lower Bound	Upper Bound	
Local Industry	Costs to the defence industry	0.02	0.03	0.02	0.03	
	Costs to port-related industry	-	-	-	-	Remain unvalued.
Conservation/ Non-Use	Total costs	-	-	22.52	35.43	Per event costs derived from WTP values. The lower bound figure represents the WTP of households in Dyfed to prevent a moderate impact spill. The upper bound value represents the WTP of the Welsh population to prevent an *Exxon Valdez* type spill occurring along the Welsh coast.
Human Health	Acute impacts to the general population	-	-	0.23	1.06	Valued through willingness tp pay to avoid symptoms arising from the oil spill.
	Psychological effects to the general population	-	-	0.95	1.90	Valued though a stress model which relates the stress arising from an oil spill with other events such as flooding.
	Other costs to the general public	-	-	-	-	The health care costs and costs associated with lost working time remain unvalued in the assessment as do chronic effects.
	Costs to workers	-	-	-	-	These remain unvalued.
TOTAL		**60.01**	**114.31**	**75.32**	**106.18**	Per event costs

12. MARINE TRANSPORT RISKS

12.1 Overview

Every year, over 1.5 billion tonnes of oil (crude oil and oil products) is moved by vessels ranging in size from small barges to supertankers.

Every year (on average), there is a major spill comparable to that from the *Sea Empress*. Clearly, such spills are associated with the movement of oil by large tankers of which there are about 3000 in operation. In addition, there are many more smaller spills and other incidents involving the marine transport of oil.

Data on spills and incidents are gathered by various bodies at international, national and local levels. As a broad generalisation, the larger the spill or incident, the more likely it is to be reported.

The purpose of this analysis is to review available data on reported spills and incidents in at international, national and local levels in order to determine, *inter alia*:

- the likelihood of incidents similar to that of the *Sea Empress*;
- the most likely causes of spills and other incidents;
- whether the historical record for Milford Haven is significantly different than that for the UK national waters; and
- whether the historical record for the UK national waters is significantly different than that for marine transport of oil elsewhere.

Given the results of the analysis, a range of potential risk mitigation measures has been identified which are considered further in Section 13.

At the outset, it is important to stress that the analysis has been severely hampered by a lack of available data at national and local levels. In particular:

- no information has been provided by the Milford Haven Port Authority - which is perhaps not surprising given that the Authority is to be prosecuted by the Agency;

- at a national level, although summary statistics are published annually, detailed analysis of shipping movements in UK waters by Statistics Division, DETR (at the request of the Consultants) has not been made available for "legal reasons"; and

- similarly, although some summary data were provided, details of tanker casualties in UK waters were not provided until January 1998 by the Marine Accident Investigation Branch due to "problems with the data-base".

Clearly, this lack of input from those parties responsible for the collection and analysis of data on marine transport in UK waters led to considerable difficulties in generating a robust analysis within the time-frame of the study.

Table 12.3: International Oil Spill Frequencies (Tankers, etc.)

Period	Number of Spills (per year) for Spills of:		
	7 - 700 t	>700 t	All Sizes >7 t
1970 - 75	48	24	**72**
1976 - 85	49	15	**64**
1986 - 96	27	8.5	**36**
1970 - 96	**40**	**14**	**54**

Source: based on ITOPF, 1997

From Tables 12.1 to 12.3, the following observations can be made:

- the frequency of large spills (greater than 700 t or 3400 t) has decreased in recent years;
- the overall frequency of spills of more than seven tonnes has decreased in recent years (ITOPF data), although that for spills >34 t has been broadly constant since the mid-1970s (Etkin data); and
- spills from tankers account for over half of all spills over 34 t (and have been assumed to account for all spills over 3400 t).

Analysis of Major Spills

A detailed analysis of all the major spills (taken to be those over 30 000 t) since 1960 has been undertaken based on the information from Etkin (1997), ITOPF (1997) and Hooke (1997).

The full listing of the 44 major spills (of which there were sparse data on four) analysed in depth is presented in Annex 12.

12.2.2 Casualty Data and Tankers at Risk

Casualty Data

Another key source of data at an international level is 'casualty statistics' which, for tankers, cover a wide range of incidents - which may or may not lead to a spill. Detailed information gathered by Lloyd's Register of Shipping has been analysed and summarised by the International Maritime Organisation (IMO, 1983 and IMO, 1992) and Table 12.4 summarises the numbers of 'serious casualties' over the period 1968 - 1991 where these are defined as:

12.2 Analysis at an International Level

12.2.1 Data Collation

Overview

Data on over 1700 oil spills of over 34 t in size have been reported by Etkin (1997). This comprehensive data-set has been analysed from various perspectives for the period 1966 - 1995 (*i.e.* 30 years) to determine some key parameters for the analysis which follows.

The overall spill frequencies are summarised in Table 12.1 with the corresponding data for oil spills from vessels identified as 'tankers' summarised in Table 12.2.

Table 12.1: International Oil Spill Frequencies (All Vessels)

Period	Number of Spills (per year) for Spills of:			
	34 - 3400 t	3400 - 34 000 t	>34 000 t	All Sizes >34 t
1966 - 75	23	6.5	1.7	**32**
1976 - 85	64	6.7	1.6	**73**
1986 - 95	61	2.8	0.9	**65**
1966 - 95	**50**	**5.3**	**1.4**	**56**

Source: based on Etkin, 1997

Table 12.2: International Oil Spill Frequencies (Tankers)

Period	Number of Spills (per year) for Spills of:			
	34 - 3400 t	3400 - 34 000 t[1]	>34 000 t[1]	All Sizes >34 t
1966 - 75	17	6.5	1.7	**25**
1976 - 85	28	6.7	1.6	**37**
1986 - 95	29	2.8	0.9	**33**
1966 - 95	**25**	**5.3**	**1.4**	**32**

1) Values derived on the assumption that all spills in excess of 3400 t were associated with spills from tankers.

Source: based on Etkin, 1997

Another major source of oil spill data is the International Tanker Owners Federation (ITOPF, 1997) which has reported summary data on nearly 9000 spills (excluding those resulting from military action) from tankers, combined carriers and barges. Most of the reported spills are less than seven tonnes and a summary of larger spills is presented in Table 12.3.

"a fire, explosion, collision, grounding, contact, heavy weather damage, ice damage, hull cracking or suspected hull defect resulting in:

- *structural damage rendering the ship unseaworthy such as penetration of hull underwater, immobilization of main engines, extensive accommodation damage, etc.;*
- *loss of life; and/or*
- *pollution (regardless of quantity);*

a breakdown necessitating towage or shore assistance; or
a total loss." (IMO, 1992)

Table 12.4: Serious Casualties (Tankers greater than 6 000 grt/10 000 dwt)

Period	Number of Serious Casualties per year	Number of Tankers	Serious Casualty Rate (per vessel year)
1968 - 75	71	3305	0.02
1976 - 85	76	3156	0.02
1986 - 91	63	2865	0.02
1968 - 91	**71**	**3132**	**0.02**

Source: from IMO, 1983 & 1992

From Table 12.4, it can be seen that the numbers of incidents and tankers have remained surprisingly constant over the period 1968 - 1991 with a risk of 0.02 or 1 chance in 50 per year of a particular tanker becoming a serious casualty.

As would be expected, the numbers of serious casualties exceeds the numbers of spills (*i.e.* not all serious casualties result in a spill). The 'escalation probabilities' from an incident to a spill have been derived on two bases - the long term average and the recent average (based on data post 1986) - by simply dividing the corresponding numbers of spills by the numbers of serious casualties (taken as 71 and 63 per year respectively) as summarised in Table 12.5.

Table 12.5: Escalation Probabilities for Spills resulting from Serious Casualties

Spill Size	Number of Spills per year		Derived Escalation Probability	
	long term	post 1986	long term	post 1986
>700 t	14	8.5	0.20 (1 in 5)	0.13 (1 in 7)
>3400 t	6.7	3.7	0.09 (1 in 11)	0.06 (1 in 17)
>34 000 t	1.4	0.9	0.02[1] (1 in 50)	0.014[1] (1 in 70)

1) These escalation probabilities are not strictly correct since only large tankers carrying more than 34 000 t could generate a spill of this size.

Source: derived from Tables 12.2 - 12.4

Numbers of Tankers

As indicated above, there are about 3000 registered tankers of greater than 6000 grt[76] (or 10 000 dwt). The composition of the tanker fleet has varied by size of vessel over time as shown in Table 12.6.

Table 12.6: Tanker Fleet Composition (Tankers greater than 6 000 grt/10 000 dwt)

Period	Number of Tankers	Tanker Size dwt			
		10 000 - 24 999	25 000 - 44 999	45 000 - 149 999	150 000+
1968 - 75	3305	36%	30%	24%	10%
1976 - 85	3156	24%	30%	28%	18%
1986 - 91	2865	22%	35%	29%	14%
1968 - 91	**3132**	**28%**	**31%**	**27%**	**14%**

As can be seen from Table 12.6, there has been a progressive move from the smaller tankers to mid-range (25 000 - 150 000 t) tankers accompanied by a reduction in recent years in the number of operational supertankers.

12.2.3 Data Analysis

Introduction

In order to determine the type of mitigation measures which are likely to prove most cost-effective, it is important to gain an understanding of the key factors which contribute to incidents involving tankers which could lead to a spill of the cargo.

Using the data sets outlined above, the various incidents were analysed by nature of incident, by cause, by location, by age of vessel and by size of vessel.

Analysis by Nature of Incident

All incidents which are reported are characterised by nature of the incident. Unfortunately, the precise categories vary from organisation to organisation. In this analysis, the characterisations listed in Table 12.7 have been used.

76 'grt' is the gross registered tonnage which relates to the internal volume of the vessel whilst 'dwt' is the deadweight tonnage and represents the amount of cargo which can be carried in tonnes.

Table 12.7: Characterisation of Incidents by Author/Organisation

Etkin (1997)	IMO (1983, 1992)	ITOPF (1997)	MAIB[1] (1997)
Grounding	Wrecked/Stranded	Groundings	Stranding & grounding
Collision	Collision	Collisions	Collisions & contacts
Structural Failure + Mechanical Failure	Hull Defect + Machinery Defect	Hull failures	Hull defect + Machinery
Fire/explosion	Fire/explosion	Fires & explosions	Fires & explosion
Ramming	Contact	-	*(included in collisions)*
Sinking	Foundered	-	Foundering & flooding + capsizing
Others[2]	Others	Others	Others

1) The MAIB data have been used in the analysis of incidents in UK waters and Milford Haven (see Sections 12.3 and 12.4).
2) 'Others' includes additional specified incident types (which vary from organisation to organisation) as well as incidents 'not otherwise specified'.

The results of the analysis by nature of incident are summarised in Table 12.8.

Table 12.8: Nature of Incidents

Type of Incident	Spills >34t	Spills >700 t	Spills >30 000 t	Serious Casualties
Period of Analysis	1966 - 95	1974 - 96	1960 - 96	1968 - 91
Type of Vessel	All vessels	Tankers, *etc.*	Large Tankers	Tankers >6000 grt
Number of Incidents	1690	285	40	1716
Nature of Incident (%)				
Grounding	24%	33%	28%	20%
Collision	21%	29%	17%	15%
Structural Failure + Mechanical Failure	11%	13%	25%	28%
Fire/explosion	7.6%	7.0%	23%	27%
Ramming	7.5%	-	2.5%	7.6%
Sinking	6.9%	-	0%	2.0%
Others	22%	18%	5.0%	0.8%

Sources: Etkin, 1997; ITOPF, 1997; IMO, 1983 & 1992 and Annex 12

From Table 12.8, it can be seen that there is a considerable degree of consistency between the proportions of major spills (over 30 000 t) and serious casualties associated with groundings, collisions, structural/mechanical failures and fires/explosions which together account for about 90% of all such incidents. For oil spills more generally, the figures are dominated by groundings and collisions, which together account for about half of such incidents.

Analysis by Cause

The precise cause of marine incidents is often difficult to determine not least due to issues relating to insurance payments and possible prosecutions.

In broad terms, human error is by far the most dominant cause of marine incidents although, in many cases, there may be additional factors such as poor visibility, adverse weather[77], etc.

These views are consistent with the summary information on major spills presented in Annex 12. Although heavy seas and poor visibility are specifically identified in 11 of the 40 incidents (*i.e.* 28%), human error is only specifically identified in four incidents. Nevertheless, it would appear that human error is likely to have been the root cause in most of the remaining 25 incidents.

Analysis by Location

Analysis of the data sets for major spills and serious casualties indicated that most incidents occur at sea as summarised in Table 12.9.

Table 12.9: Location of Incidents

Type of Incident		**Spills >30 000 t**	**Serious Casualties**
Period of Analysis		1960 - 96	1977 - 91
Type of Vessel		Large Tankers	Tankers >6000 grt
Number of Incidents		40	1195
Location of Incident (%):			
	At Sea	75%	58%
	(in open sea)	(33%)	
	(in coastal waters)	(42%)	
	Restricted Waters	10%	14%
	Ports	15%	28%

Sources: IMO 1983 & 1992 and Annex 12

77 By way of example, detailed analysis of nearly 700 incidents involving over 1000 vessels in the busy waters of Hong Kong found that the prime cause of half of all incidents was human error, while in a further 25% of incidents 'adverse weather' and/or 'congestion' were identified as being significant contributory factors (Au Posford *et al*, 1996).

Analysis by Age of Vessel

Analysis of the data presented in Annex 12 indicates that the average age of vessels involved in major spills is about 11 years. This is slightly younger than the average vessel involved in an oil spill of >34 t which is about 13 years - although it is worth noting that the average age of vessels involved in spills of >34 t in the decade 1986 - 95 is 15 years. It might be expected that this is due to older vessels being more prone to be involved in spills. However, in fact, such variations are directly linked to the age distribution of the world's tanker fleet which experienced a boom in the mid-1970s with a current average age of 15 years - hence more recent incidents are dominated by vessels of about 15 years in age (Fairplay, 1996).

Analysis by Vessel Size

The composition of the world's tanker fleet was presented in Table 12.4. This distribution is compared directly with that of serious casualties in Table 12.10.

Table 12.10: Serious Casualties by Tanker Size (1968 - 91)

Parameter	Tanker Size dwt			
	10 000 - 24 999	25 000 - 44 999	45 000 - 149 999	150 000+
Distribution of Tankers	28%	31%	27%	14%
Distribution of Casualties	26%	31%	30%	13%
Sources: Table 12.4 and IMO, 1983 & 1992				

Although the data on oil spills were gathered on a different basis, the corresponding distribution of spills >34 t is shown in Table 12.11.

Table 12.11: Oil Spills >34 t by Tanker Size (1960 - 95)

Parameter	Tanker Size dwt			
	<16 000	16 000 - 49 999	50 000 - 159 999	160 000+
Distribution of Spills	18%	40%	31%	11%
Source: from Etkin, 1997				

The above data show that the incidence of serious casualties is independent of tanker size and, to a first approximation at least, the same applies to the incidence of oil spills.

12.2.4 Summary

There is a considerable wealth of information on tanker incidents at an international level. Analysis of the data indicates that major spills (comparable to that from *Sea Empress*) would be expected at a rate of about once per year somewhere in the world. As would be expected, smaller spills are more frequent and a spill of more than 700 t would be expected every six weeks or so somewhere in the world.

Although the historical record indicates that there has been a significant reduction in the number of spills of more than 700 t in recent years, the numbers of accidents (and the associated accident rates) involving tankers have remained remarkably constant over the past 30 years. There is also some evidence to show that the incidence of oil spills of greater than 34 t has remained constant over the past 20 years.

In terms of the chances of an incident, the historical record shows that neither the age nor size of the tanker are significant factors (although, clearly, the maximum spill size will be limited by the size of tanker). The types of incident which are most likely to result in oil spills of tens or hundreds of tonnes are groundings and collisions which together account for about half of all such incidents. For major spills involving tens of thousands of tonnes, fires/explosions and structural failures are equally important as groundings and collisions, which together account for about 90% of all such incidents.

12.3 Analysis for UK Waters

12.3.1 Scaling Factor for UK Waters

One means to determine the number of spills and other incidents that would be expected to occur in UK waters is to apply a scaling factor to global data. This scaling factor is based on the relative amounts of oil and oil products transported at global and national levels as shown in Table 12.12.

Table 12.12: Marine Transport at Global and National Levels

Movement of:	Global	UK Waters	UK as % of Global
Crude oil	1450 million tonnes	154 million tonnes	10.5%
Oil Products	380 million tonnes	63 million tonnes	16.5%
Oil/oil products	**1830 million tonnes**	**217 million tonnes**	**12%**

Sources: Fairplay, 1996 and DoT, 1996

12.3.2 Numbers of Incidents

In recent years (1986 - 91), there have been 63 incidents per year worldwide involving tankers (>6000 grt) designated as 'serious casualties' (from Table 12.4). Using a scaling factor of 12%, it would be expected that there would be about 7.5 such incidents per year in UK waters.

In recent years (1989 - 91), 14% of serious casualties occurred in an area comprising UK waters, the Bay of Biscay and the North Sea (IMO, 1992). Although these will include both incidents not related to UK oil transport as well as incidents outside UK waters, it might be expected that the majority of the incidents covered by the 14% figure will be related to UK oil transport and, hence, would be consistent with the scaling factor of 12% derived above.

Apart from international data, data for tanker incidents in UK waters during the period 1993 - 1997 have been provided by the Marine Accident Investigation Branch[78] (MAIB, 1998).

The total number of reported incidents was 223 (*i.e.* 45 per year for the period January 1993 - December 1997). Since the scope of incidents recorded by the MAIB is much broader than 'serious casualties', the next step of the analysis was to derive the proportion of MAIB-recorded tanker incidents which would be classified as serious casualties involving tankers of 6000 grt or more.

In the absence of details of the names and sizes of tankers involved in incidents, it was difficult to determine the numbers of 'serious casualties' involving tankers of 6000 grt or more. Nevertheless, by inspection, it would appear that perhaps 20 incidents (*i.e.* four per year on average) would be so classified.

The results of the above analysis are summarised in Table 12.13

Table 12.13: Incidents in UK Waters (Tankers > 6000 grt)

Type of Incident	No. per Year	Derived from:	Source(s)
Serious Casualty in UK waters	7.5	Scale factor of 12% (based on quantities transported)	Tables 12.4 and 12.12
Serious Casualty in/ around UK waters	8.8	Serious casualty data	IMO, 1992
Serious Casualty in UK waters	4	UK tanker incident data	MAIB, 1998

From Table 12.13, it can be seen that the numbers of serious casualties in UK waters would be expected to be about six per year and that this figure is consistent with that derived from consideration of the relative quantities of oil and oil products transported at national and

[78] This analysis was originally derived from summary data provided by MAIB (MAIB, 1997) but has been reworked to account for the more detailed information provided in January 1998.

international levels. However, it is possible that a more rigorous analysis of the MAIB data would lead to a slight reduction in this figure.

In other words, there is insufficient evidence to suggest that the general level of tanker safety in UK waters is significantly better or worse than elsewhere.

12.3.3 Major UK Spills

In Table 12.5, probabilities for serious casualties to escalate to oil spills were derived. Over the past 35 years, the historical record shows that for every 50 serious casualties involving tankers of 6000 grt or more, there has been one spill of 34 000 t.

Applying this factor to an estimated serious casualty rate of six per year in UK waters over the last 35 years would lead to the view that there would have been four major oil spills during this period.

In fact, there have been three - *Torrey Canyon* (1967), *Braer* (1993) and the *Sea Empress* (1996). Indeed, against this background, it could be argued that, statistically at least, an incident similar to the *Sea Empress* was to be expected.

In recent years, the probability that a serious casualty incident escalates to a major spill has fallen to about 1 chance in 70. On this basis, for six serious casualties per year, **it would be expected that there will be another major spill (>30 000 t) in UK waters within the next 12 years.**

12.3.4 Types of Incident

Analysis of world data on spills and serious casualties indicated that such incidents were dominated by groundings, collisions, structural/mechanical failures and fires/explosions (see Table 12.8). The MAIB data for incidents in UK waters (MAIB, 1998) include both these more serious types of incidents as well as lesser incidents and 'near misses' as summarised in Table 12.14.

Table 12.14: Nature of Incidents in UK Waters (all tankers)

Type of Incident	Number (1/93 - 12/97)	Number per Year
Machinery + Hull Defects	43	8.6
Collisions & Contacts	41	8.2
Fire/explosion	15	3.0
Stranding & Grounding	23	4.6
Others	101	20
Totals:	223	45

Source: MAIB, 1998

Although the data presented in Table 12.14 cover a different range of incidents from those considered at an international level, the relative distribution of those incidents which are most likely to result in a large spill are comparable as shown in Table 12.15.

Table 12.15: Relative Contributions of Incidents Most Likely to Results in a Large Spill

Type of Incident	MAIB Data for UK waters	Spills >34t World Data	Spills >30 000 t World data
Machinery + Hull Defects	35%	15%	26%
Collisions & Contacts/Ramming	34%	40%	20%
Fire/explosion	12%	11%	24%
Stranding & Grounding	19%	34%	29%

Source: derived from Tables 12.8 and 12.14

Although the distribution does vary from data-set to data-set, it would appear that, as a first approximation, **the pattern of incidents reported by MAIB associated with those most likely to result in a major spill is not significantly different from those derived from world data.**

12.3.5 Summary

Comparisons between world data on tanker incidents and tanker incidents in and around UK waters indicate that, in terms of tanker safety, UK waters are no more and no less safe than the average.

In relation to major spills comparable to that from the *Sea Empress*, it could be argued that, statistically at least, such an incident was to be expected. Furthermore, it would be expected that **there will be another similar spill in UK waters in the next 12 years.**

12.4 Analysis of Incidents in Milford Haven

12.4.1 Port Location and Description

Milford Haven is a 'natural' harbour located on the western most tip of Wales. The seaward entrance to the Haven is from an westerly direction passing through a channel around 2.5 km in width. The branching pattern of Milford Haven and its tributary tidal creeks demonstrate a 'ria' or drowned river system (see Figure 12.1). It is some 18 km from the Haven mouth to Mill Bay in the east whereupon the Haven swings northwards to the Daugelddau (the common estuary of the rivers Cleddau).

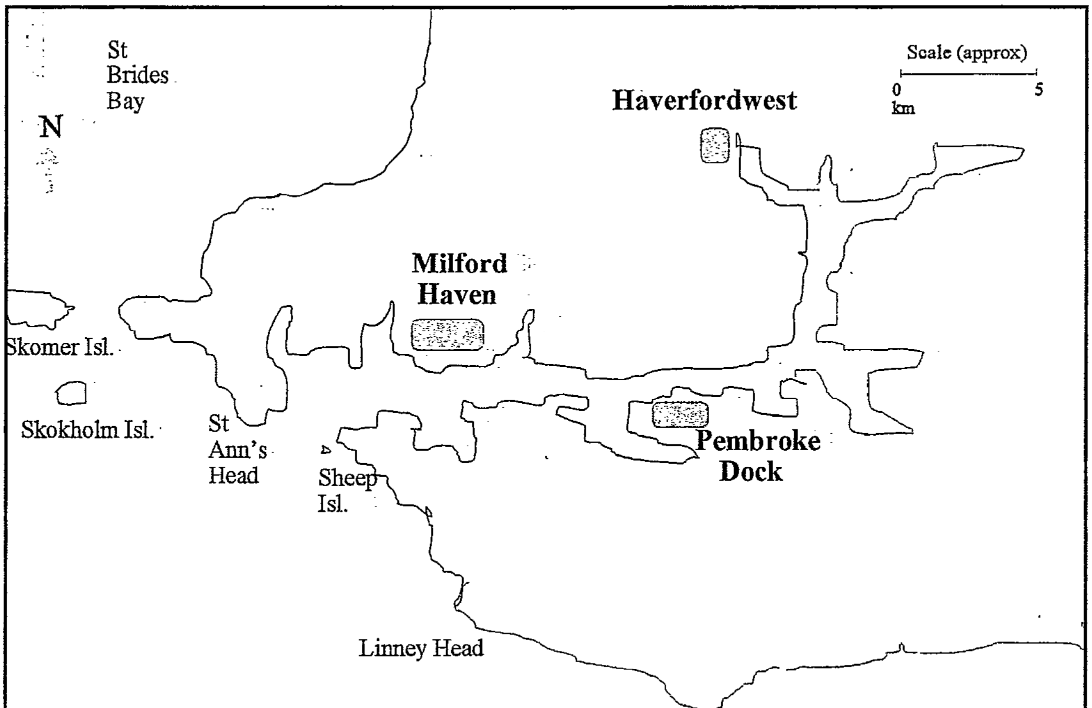

Figure 12.1: Milford Haven

The port of Milford Haven includes the whole of the Haven with the seaward outer limits extending some 11 km southeast and southwest of St. Ann's Head. The inner limits of the port are on the upper reaches of the River Cleddau. The port is one of the few UK to be openly accessible to fully laden Very Large Crude Carriers (VLCCs, >200 000 dwt) with draughts of up to 20 m.

At the time of the *Sea Empress* disaster, the Haven served three oil refineries, two on the north side and one on the south side. Milford Docks is an important centre for the fishing industry while containers and general cargo are handled at Pembroke Dock, where a roll-on roll-off (Ro-Ro) ferry terminal provides services to Ireland.

12.4.2 Port Characteristics

Port Approach

There are two entrance channels which converge to a single dredged channel some 2.5 km into the Haven (see Figure 12.2). The East Channel has a depth limit of 9.8 m while the West Channel is the deep water entrance to the harbour, having a minimum charted depth of 16.6 m at its entrance and 16.4 m at its inner end.

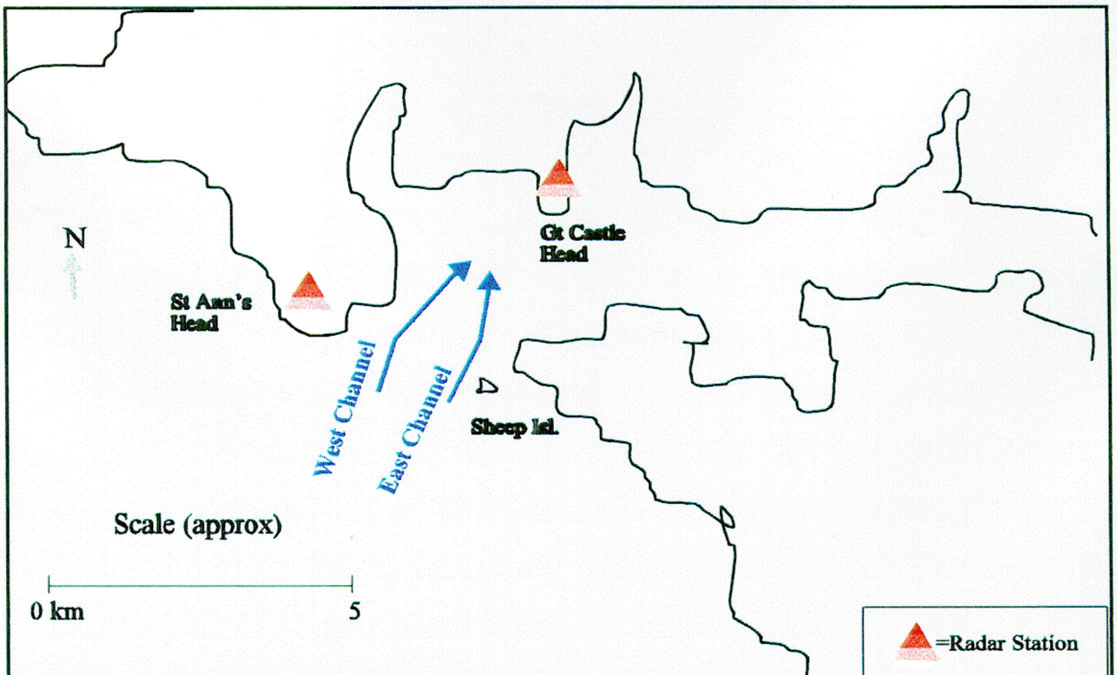

Figure 12.2: Approaches to Milford Haven

Towing and Pilotage

Except for certain exempted vessels, pilotage is compulsory for vessels over 50 m in length. For those vessels entering the harbour through the West Channel, pilots board vessels around 7 km southwest of St Ann's Head (subject to weather conditions). At the time of the grounding of the tanker *Sea Empress*, there were no standard lines of approach to the West Channel entrance except for VLCCs.

The only tugs regularly operating at the port are the harbour tugs used for berthing which usually meet inbound tankers near Chapel Buoy, around 5.5 km inside the Haven entrance. No escort tugs are provided to large tankers entering the Haven. The harbour tugs are not intended for work outside the Haven and none have the power to play an escorting role.

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14.1.36 Although more detailed work involving consultation with Milford Haven Harbour Authority and others would be required to develop an appropriately costed risk mitigation strategy, it is considered that significant improvements in traffic management, piloting standards and navigational aids could be achieved cost-effectively. In addition, many of the detailed recommendations made by MAIB with regard to the preparation and operation of an Emergency Plan could be implemented at a limited cost.

14.1.37 Once these measures had been implemented and been shown to be effective, consideration could then be given to the additional benefits that might accrue from, say, the banning of single hulled tankers and the provision of escort tugs and their likely cost-effectiveness.

14.2 Recommendations

14.2.1 The risks of another major spill involving tens of thousands of tonnes are significant. Furthermore, the costs of such spills are high. It is estimated that those associated with the *Sea Empress* were at least £60m and could have been a lot higher had the incident occurred under less favourable circumstances. It is therefore recommended that measures to reduce the chances of further such incidents are given a high priority.

14.2.2 It had been hoped that, as part of this study, it would be possible to review and analyse detailed accounts of all recent incidents and oil spills in and around Milford Haven through data provided by the various authorities. Although comprehensive data have not been forthcoming, in order to provide a more robust basis for further actions, it is recommended that such an analysis is undertaken in any event.

14.2.3 The development of an effective approach to reducing the chances of further incidents and spills will require full co-operation amongst the various authorities (both locally and nationally). It is therefore recommended that steps are taken to restore good relationships on all sides.

14.2.4 It is vital that data on further incidents and spills are collected, analysed and, as importantly, disseminated in order to monitor the cost-effectiveness of the improvement measures taken in Milford Haven.

14.2.5 At a national level, it is recommended that much greater use is made of statistics gathered at both local and national levels to analyse the causes of incidents in order to provide a robust basis for developing risk reduction strategies. Clearly, such strategies should account for the lessons from the *Sea Empress* disaster (as well as those from previous disasters such as the *Braer*).

14.1.28 It was not possible to value health costs to workers, but these are expected to be small due to the limited numbers of workers involved.

14.1.29 The costs arising from the *Sea Empress* incident are summarised in Section 11. While the financial costs arising from the spill range between £60 million and £114 million, economic costs are between £75 million and £106 million.

14.1.30 It should be noted that the costs associated with the oil spill could have been much higher. In particular, it is believed that the timing of the spill and the prevailing weather were key to limiting its impacts. Had the spill occurred later in the year, for example, impacts to tourism and recreation could have been at least two and a half times higher. Had weather conditions been less conducive to natural and chemical dispersion, the environmental effects could have been many times greater. By way of example, the *Exxon Valdez* oil spill (where conditions were not suitable for dispersant use) was half the volume but affected over ten times the length of coastline. Thus, when using the overall costs of the *Sea Empress* oil spill to examine the cost-effectiveness of various mitigation options it should be remembered that these costs are perhaps atypical of a >30 000t oil spill.

14.1.31 The analysis of tanker incidents and oil spills is presented in Section 12. Data were analysed at three levels - international, national (i.e. for UK waters) and local (i.e. for Milford Haven). Although the numbers and types of incidents in UK waters and international waters are broadly comparable, it was found that the incident rate in Milford Haven was about twice the national average, accounting for nearly one quarter of tanker incidents in UK waters.

14.1.32 Based on the historical record, the *Sea Empress* disaster was to be expected. Furthermore, it is probable that another major oil spill (involving tens of thousands of tonnes) will occur within UK waters in the next 12 years. At Milford Haven, another *Sea Empress* type disaster would be expected within the next 50 years.

14.1.33 Apart from major spills, there are many lesser incidents (which may or may not result in a spill) as well as many oil spills associated with ship-shore transfer operations. Currently, the Marine Accident Investigation Branch (MAIB) record about 10 incidents per year involving tankers in and around Milford Haven. Furthermore, Milford Haven Port Authority (MHPA) record nearly 40 oil pollution incidents per year (although 80% involve small spills of less than 160 litres).

14.1.34 Analysis of tanker incidents and associated oil spills indicates that perhaps half can be attributed to simple human error. If the likelihoods of spills (of all sizes) and their associated costs are to be reduced, it would appear that improvements should be first directed towards reducing incidents caused by simple human error.

14.1.35 In relation to Milford Haven, a review of possible mitigation measures, their practicality and likely cost-effectiveness is presented in Section 13. This review includes cross-references to the recommendations which have already been made by MAIB following the formal investigation of the *Sea Empress* incident.

locations. Applying the replacement costs approach to known losses of marine animals generates a value of £0.05 million. However, if estimates of amphipod losses are taken into account, then costs would be of the order of millions of pounds.

14.1.22 One heavily affected rocky shoreline species was the limpet and it is expected that in the worst affected areas limpet populations could take between ten to fifteen years to recover. There were also large scale mortalities of barnacles in some areas, but these effects were short-lived and by October 1996 barnacle densities were similar to those before the spill. In addition, 137 of the population of 150 cushion starfish (*Asterina phylactica*) were lost and recovery has been slow and uncertain. That aside, there does not appear to be any serious or long-term damage to lower shore or rockpool communities.

14.1.23 The oil spill also resulted in some impacts to sediment shores which are particularly important as fish nurseries and are feeding areas for migrant birds. The greatest decrease was of small crustaceans, especially amphipods, with molluscs also being impacted to some extent. With respect to maritime vegetation, while some was impacted by the oil, most effects have been short-lived. The saltmarsh in Milford Haven waterway was most directly impacted by the oil spill and studies have been initiated to map long-term effects.

14.1.24 There was no impact on mammals as a result of the *Sea Empress* incident, however, large numbers of birds were oiled. The worst hit species was the common scoter which made up two thirds of the birds recorded. Most of the rest were auks, mainly guillemots, which together with common scoters and razorbills made up over 90% of recorded casualties. These birds are vulnerable to oiling as they spend much time on the surface of the water and dive to feed. In contrast, many gulls and herring gulls survived oiling and a number of important species appear to have avoided any significant impact. In particular, puffins, Manx shearwaters and storm petrels were away from the region at the time of the spill, and the oil did not reach the important gannet population at Grassholm Island.

14.1.25 Non-use values can be applied to give a monetary valuation of the environmental impacts of the oil spill. There are three values which appear appropriate for application to the *Sea Empress*: willingness to pay (WTP) values for protecting EC designated beaches from oil pollution gives a valuation of £30 million per event; WTP values for avoiding a moderate oil spill gives a valuation of £23 million per event; and WTP values for avoiding an *Exxon Valdez* type oil spill gives a valuation of £35 million per event.

14.1.26 The valuation of costs to human health is presented in Section 10. The *Sea Empress* incident resulted in an increase in the prevalence of certain symptoms amongst the exposed population including headaches, nausea, sore eyes and itching skin. Taking into account exposure to the vapour cloud emanating from the oil spill and exposure to oil on beaches, acute physical symptoms are valued in the range £0.23 million to £1.1 million.

14.1.27 The oil spill also resulted in psychological impacts, measured in terms of a reduction in SF-36 health scores. These impacts were valued using a stress model which compared the stress arising from an oil spill with that arising from floods and other disasters. The resulting valuations are in the range £0.95 million to £1.9 million.

14.1.15 The impacts of the oil spill on recreational fisheries are presented in Section 7. The main activities affected are freshwater fishing for salmon and sea trout, and sea- and coastal-based angling for bass, cod and other marine species. As for commercial fisheries, impacts mainly stem from the operation of the FEZ.

14.1.16 The owners and leasers of fishing rights on affected rivers have claimed compensation from the IOPC Fund for loss of income and other costs. These amount to about £0.13 million. However, the operation of the FEZ also resulted in a 21% reduction in the number of angling visits by salmonid fishermen which can be valued at between £0.56 million and £0.95 million. Research also indicates that the oil spill may have adversely affected sea trout catches in the longer-term, although it has not been possible to assign a monetary value to this impact.

14.1.17 Both shore-based and boat-based sea angling were affected by the FEZ. It is estimated that 16% of all bass angling trips were affected by the ban resulting in consumer surplus losses as high as £1.7 million. Fishing for cod, plaice and other species was also affected. However, these species are less valued than bass by the sea angler, thus the upper bound of losses is less than £0.3 million. Overall, costs to recreational fisheries are valued at between £0.76 million and £2.7 million.

14.1.18 The impacts of the oil spill on other industry is discussed in Section 8. The (then) three oil refineries at Milford Haven, the ferry from Pembroke Dock to Ireland, Pembroke Power Station and the defence industry at Castlemartin and Pendine all experienced a negative impact as a result of the spill. However, it has only been possible to value the impacts on the last of these.

14.1.19 Personnel from the Pendine facility were involved in the clean-up of oiled beaches and some business was also lost. For the Castlemartin Range, costs were mainly associated with the loan of vehicles and equipment, the provision of meals for clean-up workers and staff-time. Had the spill occurred when the Castlemartin Range had been firing (March to December), the costs would have been much higher. Some costs to the defence industry were compensated by the IOPC Fund with residual costs valued at between £0.017 million and £0.025 million.

14.1.20 The environmental impacts of the oil spill are valued in Section 9. The affected coastline is of outstanding beauty and scientific interest, and most lies within Pembrokeshire Coast National Park, the only national park in Britain primarily designated for its coastal and estuarine landscapes. The main area impacted by the spill contains 35 Sites of Special Scientific Interest and two National Nature Reserves. In addition, part of the area forms one of the UK's three Marine Nature Reserves and much of the coastline has been defined as Heritage Coast. Parts of the area are further designated by the European Commission as Special Protection Areas under the EC Birds Directive and there are also plans for three Special Areas of Conservation under the Habitats and Species Directive 1992.

14.1.21 In the weeks following the spill, large numbers of dead or moribund marine animals were washed-up on beaches. Longer-term impacts on the offshore marine community appears to be minimal, apart for a reduction in small crustacean species such as amphipods in some

14.1.7 Data have allowed three estimates of financial impacts to be made. Estimates based on the IOPC Fund provide a lower and upper bound of £4 million and £18 million respectively. A higher estimate of costs was provided by the Wales Tourist Board which estimates a lower and upper bound of £20 million and £27 million respectively based on reductions in bed nights. The widest range of costs is provided by the Pembrokeshire Tourism Federation which provides information suggesting that overall tourism performance may fall between £12 million and £46 million.

14.1.8 The impacts of the oil spill on beach-based and other recreational activity are presented in Section 5. Impacts were not only limited to the time when beaches were heavily oiled, recreational activities after this time being impacted by residual oil and users' perceptions.

14.1.9 The main activities to be affected by the oil spill were general usage of beaches and swimming. With respect to the former, the incident appears to have resulted in the loss of around 450 000 visitor days valued at between £0.45 million and £2.3 million. Around 100 000 swimming visits may also have been affected at a value of £0.5 million.

14.1.10 Other affected activities include canoeing/kayaking, jet-skiing, land/sand yachting, sailing, sub-aqua diving, surfing, waterskiing and windsurfing. In total, recreational impacts have been valued at between £1 million and £2.8 million.

14.1.11 As a result of the oil spill, the Ministry of Agriculture, Fisheries and Food, placed a ban on fishing in an area covering 2000 km^2 (810 square miles) off the coast of south west Wales. These impacts and others on commercial fishermen are reported in Section 7.

14.1.12 A number of claims have been made to the IOPC Fund by commercial fishermen, with most of these arising from the implementation of the fisheries exclusion zone (FEZ). However, fishermen have also put forward claims relating to contamination of fishing gear by oil, and fish processors have claimed for loss of raw materials. A total of £6.8 million had been approved for payment by the Fund (by the end of 1997) of which almost £5.5 million compensates fishermen for the operation of the FEZ. In addition, claims of the order of £7 million had been rejected by the Fund.

14.1.13 With respect to molluscs, the FEZ had a severe impact on winkle landings and some impacts on landings of cockles, mussels and whelks. There were also impacts on landings of crustaceans. In contrast, there was little impact on landings of whitefish. Overall, catch data for the affected area indicates that 1996 catches were down on those for 1995. However, owing to higher prices in 1996, the value of catch was higher in 1996 than 1995 and indeed on a par with previous years. On this basis, payments under the IOPC Fund are surprisingly high.

14.1.14 In total, costs to commercial fisheries resulting from the oil spill are estimated to lie between £6.8 million and £10 million. These costs are mainly associated with the operation of the FEZ, with limited costs associated with long term impacts on harvest rates and reduced markets. It appears that impacts were limited by three main factors: the timing of the spill, the composition of the oil and the prevailing weather.

14. CONCLUSIONS AND RECOMMENDATIONS

14.1 Conclusions

14.1.1 This study has required an assessment of the costs arising from the *Sea Empress* incident. Social cost-benefit analysis (CBA) was chosen as the framework for assessing these costs and an overview of CBA is reported in Section 1. Valuation has required the use of a range of economic valuation techniques and has relied on the use of benefit transfer (i.e. values derived from previous studies have been transferred for application to the *Sea Empress* oil spill).

14.1.2 A brief overview of the events leading up to the *Sea Empress* oil spill and its effects are given in Section 2. In total, 72 000 tonnes of oil were spilt, and 200 kilometres of coastline were affected. However, the vast majority of oil evaporated or was dispersed following the application of chemical dispersants. In total, between 5.5% and 11.5% of the oil found its way onto the shoreline, of which about two thirds remained (as of the end of 1997).

14.2.3 The *Sea Empress* incident resulted in direct costs to those involved in the clean-up and salvage operations. These are reported in Section 3. Those involved in the clean-up operations have been able to recoup most of their costs from the International Oil Pollution Compensation (IOPC) Fund. By the end of 1997, claims of almost £9 million (all values expressed as £1996) had been made, and nearly half of these paid. However, not all claims for direct costs had been submitted and total payments under the Fund may be as high as £30 million.

14.1.4 The IOPC Fund has a set of criteria which it uses to assess compensation claims. These criteria are such that not all direct costs arising from the *Sea Empress* oil spill can be claimed for (and this is also true of claims for other types of costs). Taking into account costs such as those associated with repairs to the *Sea Empress* itself, total direct costs are estimated to range between £49 million and £58 million.

14.1.5 The impacts of the oil spill on the Pembrokeshire tourism industry is reported in Section 4. The spill occurred during the period of peak bookings for summer holidays, and for some operators bookings ceased for a period of about six weeks following the spill. However, interest increased later in the year, partly as a result of positive advertising campaigns by the industry.

14.1.6 By the end of 1997, almost 400 claims had been made to the IOPC Fund by tourism operators, and claims totalling £1.2 million had been paid. However, the Fund has estimated that total payments could equal £4 million and the UK government has put this figure as high as £9 million. In addition, some operators were unable to claim from the Fund owing to an inability to meet the Fund's claim criteria, or a lack of data to substantiate their claim. Overall, perhaps 70% of tourism businesses that experienced an impact have not claimed from the Fund.

In relation to the proposed measure to exclude tankers with inadequate cargo protection (Measure 6), the International Maritime Organisation has stated:

> *At present* (as of March 1996) *only 251 of the world's 3,500 tankers have double hulls. Calls for single hulled ships to be banned are therefore scarcely practicable from an economic point of view - there are not enough double hulled tankers .... In any case, it is generally felt that while double hulls can minimise oil spills in certain circumstances - such as low-speed grounding - they provide little protection in the event of a high speed impact or a collision with another ship.* (IMO, 1996)

Nevertheless, action has already been taken by the United States to accelerate the MARPOL requirements through the enactment of the Oil Protection Act 1990 and, more recently, Japan has been urging similar action following spills off Japan in January 1997.

In short, although the proposed exclusion of certain types of tanker may not be practical at present, it is likely that this situation will change within the next few years as more and more countries press for the phasing out of single hulled tankers. In terms of the effectiveness of such a measure, it would reduce spill probabilities although, as IMO note, not in every case.

13.4 Cost-Effectiveness of Measures

At present, it is estimated that the chances of another *Sea Empress* type spill in and around Milford Haven is about 1 chance in 50 per year (see Section 12.4.7). As outlined in Section 11, the damage costs associated with such an incident are at least £50m. In other words, the average annual damages are of the order of £1m per year.

If the incident rate was to be reduced by a factor of two, the damages avoided (*i.e.* the benefits) would be £0.5m per year. In other words, if the costs of the mitigation measures required to reduce the incident rate by a factor of two were less than £0.5 per year, then the measures would be deemed to be cost-effective (since the 'benefit/cost ratio' would be greater than 1).

Clearly, more detailed work involving consultation with Milford Haven Harbour Authority and others would be required to develop an appropriately costed strategy. However, it is considered that significant improvements in traffic management, piloting standards and navigational aids could be achieved cost-effectively. Furthermore, the effectiveness of such improvements could and should be carefully monitored through the annual numbers of incidents.

In addition, many of the detailed recommendations in the MAIB Report with regard to the preparation and operation of an Emergency Plan could be implemented at a limited cost.

Once these measures had been implemented and been shown to be effective, consideration could be given to the additional benefits that might accrue from, say, the banning of single hulled tankers and the provision of escort tugs and their likely cost-effectiveness.

13.3 Practicality and Effectiveness of Mitigation Measures

13.3.1 Measures Considered

Based on the information presented above, there are six measures under consideration as summarised in Table 13.2.

Table 13.2: Proposed Mitigation Measures

Measure	Purpose	Comment
1. Improve traffic management	Reduce numbers of all shipping incidents	Considered to be the 'first step'
2. Improve Emergency Plan	Reduce level of environmental damage in the event of a large spill	Must account for both 'technical' and 'administrative' issues
3. Improve piloting	Reduce numbers of incidents involving large tankers	A key element of the MAIB Report into the *Sea Empress*
4. Improve navigational aids	Reduce numbers of incidents - particularly for larger vessels	
5. Provide escort tugs	Reduce numbers of incidents involving large tankers	Likely to be of limited value
6. Exclude tankers with inadequate cargo protection	Reduce the chances that an incident will result in a large spill	International agreements in place to improve tanker designs (albeit slowly)

13.3.2 Practicality & Effectiveness

With reference to Table 13.2, it is considered that the Measures 1, 3 and 4 are practical and would be effective in reducing the numbers of incidents and hence the numbers of large spills.

Measure 2, the improved Emergency Plan, is clearly a practical proposition and the MAIB Report sets out a number of specific recommendations with particular regard to appropriate administrative arrangements. The effectiveness of the Emergency Plan (in reducing environmental damage) will depend on numerous factors. In earlier sections of this report, it is concluded that the level of environmental damage associated with the *Sea Empress* spill was relatively minor. It could be argued that in this particular case, there would have been little benefit (to the environment) from a 'better' plan. However, if the incident had occurred at a different time under different weather/sea conditions the outcome could have been much more dependent on the procedures followed to limit environmental damage.

Measure 5, the provision of escort tugs, is practical and, in some cases, would be effective in preventing an incident.

Table 13.1: At Sea Response Options

	Mechanical Recovery	Dispersant Application
Strategy	Enclose as much floating oil as possible and remove it from the surface of the water.	Use of chemical surfactants/solvents to accelerate the natural dispersion and dilution of oil into the water column.
Method	Deploy oil containment booms to contain all, or portions of, the spill. Oil is collected using specially designed skimmers and vacuum hoses and then deposited in storage tanks/bags. Sorbents may be used in some circumstances to collect residual oil from the water's surface.	A range of dispersants are available. These can be sprayed onto the spill at a rate of around 1:50 (by weight) from aircraft or boat. Wave action assists mixing of oil, dispersant and water allowing the dispersion of oil into the water column as small droplets.
Ideal Application	Spills in relatively calm water in sea conditions of no greater than #3 (i.e. wind moderate, >12 - 16 knots, wave height 1.0 - 1.6 m). The technique is desirable near sensitive areas.	Spills in turbulent water in sea states #4 and #5 (wind moderate-fresh breeze to fresh-strong breeze, wave height 1.7 - 3.7 m, rough-very rough). The technique is generally undesirable near sensitive areas.
Benefits	• low environmental impact; • prevents collected oil from entering water column where it may contaminate organisms by diffusion over membranes or ingestion; and • prevents oil from reaching shorelines.	• relatively inexpensive; • can be deployed on large spills very quickly; • in good conditions it is very effective at removing oil from the water's surface where it can adversely affect birds and marine mammals; • prevents oil from coming ashore; and • reduces the 'stickiness' of oil that does wash up on shore.
Dis-advantages and Limitations	• inefficient, recovery rates have rarely exceeded 15% though it should be noted that equipment provision and speed of past responses may have played a part in this low recovery rate; • time consuming and expensive when applied on a large scale; • speed of response is a crucial factor in success; and • logistical difficulties of getting large numbers of personnel and equipment deployed to a site quickly.	• as oil 'weathers' over time becoming resistant to dispersion, dispersants must be applied within the first 24 hours; • the chemicals are at least slightly toxic to marine life; • whilst oil is removed from the surface, accelerated dispersion into the water column increases the bio-availability of oil and thus increases the potential for contamination of marine organisms; and • the technique is ineffective where there is little wave action *i.e.* #2 sea state and below (wind gentle, 7 - 12 knots, wave height 0.6 - 0.8 m).

'Natural' clean up and in-situ burning do not receive any further attention in this assessment as neither are suitable for application to Milford Haven. In the case of 'natural' clean up, this technique is only really applicable to open sea spills that are unlikely to come ashore. In-situ burning is unlikely to be a practical proposition for spills in and around Milford Haven due to the proximity of populated areas. Brief details on the remaining clean up options are provided in Table 13.1.

Once oil begins to wash up on the shore, the extent of the environmental damage from an oil spill is multiplied many-fold. In addition, the clean up of the oil spill becomes significantly more difficult. In the event that it becomes inevitable that oil will wash up on shore, there are effectively three responses that can be applied, ideally in combination. These options are:

- protect sensitive areas;
- clean up the shorelines; and
- allow 'natural' cleaning.

Sensitive areas can be protected by employing containment booms along the length of sensitive shoreline. Depending on the location, these areas might include fisheries, ecologically 'valuable' sites and tourist beaches[79].

Deployment of booms with weighted 'skirts' can effectively contain oil in current under washes of up to around 1.6 km/hr. In under washes above this, oil which builds up against the 'floating wall' gets carried underneath or, in fairly extreme conditions, over the top. For this reason deployment of mechanical recovery equipment at sea at such sites can be extremely beneficial, minimising or stopping oil from coming ashore.

Oil behaves differently on different beach types. On pebble and shingle shores oil has a tendency to 'sink' into the substrate where it can gradually work its way down to form a reservoir. On such beaches re-oiling of a cleaned beach can be extremely problematic. On rocky shores oil cannot sink into the substrate. As a result it clings to rocks and associated organisms with excess remaining in the sea. On sandy shores the substrate size is small enough to prevent most oil from sinking beneath the surface.

There are a number of different methods that can be employed to clean up oil that has washed up on shore. The method employed depends on the type of beach and each method has its own drawbacks in terms its environmental effects. The options available for clean up of different beach types and their associated environmental impacts are too numerous for inclusion in this report.

In some circumstances, the best environmental option may be to leave some shorelines alone as clean up efforts may prove more damaging than the oil itself. By way of example, use of high pressure hoses or steam cleaning can effectively heat-kill or physically remove organisms from rock surfaces. Such clean up operations can effectively finish the job that the oil started.

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79 It is interesting to note that in his report *Safer Ships, Cleaner Seas* after the Braer incident, Lord Donaldson (1994) proposed a scheme of Marine Environmentally High Risk Areas (MEHRAs) that would feature not only on the Seaway Code but might also be marked on Admiralty Charts.

13.2.4 Reducing Environmental Damage

Overview

Given a large spill, environmental damage can be limited by taking appropriate action. Initially, this may be through limiting the size of the release (by lightening for example). Subsequently, the degree of environmental damage may be influenced by the use of dispersants and clean-up methods. Clearly, the appropriate strategy will depend on various factors such as prevailing weather and sea conditions, nature of cargo spill (for example, a large spill of volatile gasoline will evaporate reasonably quickly with no intervention), quantity and rate of spill, nature of receiving environment (rocky coastline versus sandy beaches), *etc.*

Such a strategy must be influenced by the results of the detailed studies undertaken into the effects of such spills as the *Sea Empress, Exxon Valdez, etc.* Of course, for the strategy to be implemented promptly and effectively it must form part of an overall emergency plan and this is reinforced by the MAIB Report (Recommendations 9, 18, and 22 refer).

An important part of implementing an Emergency Plan is the involvement of other parties and clear definitions of responsibilities. By way of example, the relationship between the salvors and those responsible for limiting the environmental damage needs to be clearly defined since there may be conflicts in determining the 'best' response to a particular situation. This matter is considered in some detail by MAIB and various recommendations for improving the administrative management of a 'disaster' (including the liaison with salvors) are put forward (Recommendations 9, 15, 19, 20, 21, 23 and 24).

Factors which affect Environmental Damage

To provide an illustration of some of the (technical) factors which need to be accounted for in the preparation of an appropriate Emergency Plan, consideration is given to a major spill of crude oil at sea.

The oil will spread out across the water's surface, typically at a speed of around 1 - 3 km/h depending on oil type. Within the first few hours of a spill, most of the more toxic lighter fraction compounds will have evaporated. After 2 days of evaporation, the spill size will have reduced by as much as 50% but typically between 35 and 45% depending on oil type. In sea conditions of #3 (moderate) and above (*i.e.* wind moderate, >12 - 16 knots, wave height 1.0 - 1.6 m) natural dispersion into the water column is at an optimum. Oil becomes attached to particulate matter and drawn into the water column. Oils with high asphaltene content often form persistent emulsions after a few days at sea.

In essence, there are four options for tackling an oil spill at sea:

- mechanical containment and recovery;
- dispersant application;
- in-situ burning; and
- 'natural' clean up (do nothing).

13.2.3 Reducing Spill Probabilities

In broad terms, it might be expected that spills can be grouped into three:

- small spills (perhaps a few hundred litres) associated with leaks during the loading/discharge operations;
- medium spills (perhaps a few tens of tonnes) associated with failures of ship-shore connections, overflows from tanks, *etc.*; and
- large spills (perhaps hundreds of tonnes or more) associated with damage to cargo tanks on tankers.

It is considered that a more detailed analysis of the 40 or so pollution incidents per year in Milford Haven would provide a robust basis on which to reduce the occurrence of small and medium spills through improved procedures and management.

Large spills will tend to be associated with a serious tanker incident (grounding, collision, fire/explosion and major structural/mechanical failure). Given the occurrence of the initiating event, there will be often be a limited amount of time in which to take prompt and effective action. By way of example, the MAIB Report notes that:

> *By the time it was recognised that the course change was inadequate, Sea Empress was already within two minutes of grounding ...*
> (para 9.3, MAIB, 1997b)

Similarly in the event of an explosion or a collision for example, the damage which results in a spill has already occurred.

With these points in mind, there has been considerable discussion at an international level on the introduction of new tanker designs. By way of example, the provision of double hull tankers is covered by the International Convention for the Prevention of Pollution from Ships (MARPOL). The MARPOL requirement for double hull (or equivalent) tankers were enacted in the UK by the Merchant Shipping (Prevention of Oil Pollution) Amendment Regulations 1993. As a result, all new tankers over 5000 dwt should be of double hull construction and all existing tankers will comply by 2026. As a result, it will be some years before a significant proportion of the shipping visiting Milford Haven will be of double hull construction. Nevertheless, the MAIB Report indicates that such regulations could be improved (Recommendations 16 and 17).

Although the annual rate for 'serious casualties' involving tankers has remained surprisingly constant for the past 30 years (see Table 12.4), the probabilities of large spills have decreased in recent years (see Table 12.5) which might reflect the gradual improvement in the degree of cargo protection provided on modern tankers.

Against this background, one possible mitigation measure would be to exclude tankers without 'appropriate' levels of cargo protection from sensitive environmental areas such as Milford Haven.

13.2.2 Reducing the Chances of an Incident

As discussed in Section 12.4.4, the incident rate (associated with incidents per tanker movement) in Milford Haven appears to be twice the national average. Furthermore, by inspection of recent incidents recorded by MAIB (see Annex 12), it would appear that many are due to simple human error.

It had been hoped that, as part of this study, it would be possible to review and analyse detailed accounts of all recent incidents in and around Milford Haven through data provided by the various authorities. In order to provide a more robust basis for further actions, it is recommended that such an analysis is undertaken in any event.

Nevertheless, the first recommended mitigation measure is to improve the monitoring, control and enforcement action. This might be termed improved traffic management through use of radar and responding pro-actively to situations which may result in vessels passing too close, vessels moving without permission, etc. At the outset, this clearly requires the provision of a fully operational radar system (which is covered by Recommendation 4 of the MAIB Report). Once potential deviations are observed from the radar, there should be prompt and effective intervention from the Milford Haven Port Authority (for example by direct communication with the vessels and/or the use of a patrol launch). For cases where there has been a disregard of appropriate procedures (for example, unauthorised vessel movements), appropriate enforcement action should be taken.

For large tankers, such as the *Sea Empress*, the MAIB Report makes a series of recommendations concerning the improvement of the standards of piloting (with particular reference to Recommendations 1, 2, 3, 5, 6, 7, 12, 13 and 14). In broad terms, it would be difficult to disagree with these recommendations. However, it is of note that in Annex 12, two dangerous occurrences are recorded in which large tankers entered Milford Haven without pilots - contrary to procedures. In other words, it is probably more important to improve the general traffic management rather than the quality of the pilots.

The third area of mitigation is to improve the level of navigational aids including designated channels, the provision of accurate charts and improved lighting. These matters are dealt with by Recommendations 8 and 11 and, as above, it would be difficult to disagree with these.

Although escort tugs have been considered, it is unlikely that their presence would be effective in preventing a disaster in all cases. There are a number of issues which are discussed in the MAIB Report (Section 9 refers) which result in the recommendation that the matter should be examined further (Recommendation 10). It is our view that in relation to the prevention of tanker incidents generally (*i.e.* not just those involving large tankers), the benefits of escort tugs will be limited and perhaps not as cost-effective as the other measures outlined above.

With improved traffic management, piloting standards and navigational aids, it might be expected that the overall tanker incident rate would be reduced by at least a factor of two (*i.e.* at least to the national average).

13. MITIGATION MEASURES

13.1 Overview

For a proposed risk mitigation measure to be implemented, there are criteria to be satisfied which include:

- the existing risk should be 'significant' - in other words, there is little merit in reducing a risk of negligible proportions;
- the proposed risk mitigation measure should be a practicable proposition;
- the proposed risk mitigation measure should reduce the overall risks - in some cases, a slight reduction in risks associated with one activity might lead to a significant increase elsewhere; and
- reductions in risk to be achieved should be compared with the associated costs to ensure that the proposed risk mitigation measure will be cost-effective.

In relation to Milford Haven, the records show that there are ten tanker incidents per year (see Table 12.18) and an oil spill of more than a 1000 t every ten years or so (see Table 12.19). Against this background, it would appear that the existing risks are 'significant' and that risk mitigation is required.

13.2 Possible Mitigation Measures

13.2.1 Overview

The *Sea Empress* disaster has been subject to a formal investigation (MAIB, 1997b) which resulted in 24 recommendations covering such topics as improving the standards of piloting, reviewing emergency plans and procedures and urging the International Maritime Organisation to review regulations for tanker design. It is not the intention of this Section to review the practicality and cost-effectiveness of each of these recommendations in detail although reference to them will be made.

Rather, the intention is to 'stand back' from the *Sea Empress* disaster and consider some of the more general issues involved. In broad terms, risk mitigation can be directed to:

- reducing the chances of an incident;
- reducing the chances that an incident will escalate to a spill; and
- reducing the chances that a spill will lead to extensive environmental damage.

These are briefly reviewed in turn below.

12.4.6 Causes of Incidents

For each of the 50 incidents which have been reported by MAIB (MAIB, 1997a), a 'probable cause' has been assigned as shown in Annex 12. It is fully accepted that this has involved a degree of judgement but it appears that 29 incidents (nearly 60%) were due to simple 'human error'. In a further two cases (*i.e.* 4%) involving collision/contact 'adverse weather' was a significant factor.

As discussed in earlier sections, large oil spills are generally associated with collisions (and contacts), stranding and grounding, fires and explosions and mechanical/structural failures. Annex 12 lists 21 such incidents and, of these, ten (48%) were considered to be due to simple 'human error' with the further two cases (10%) mentioned above in which 'adverse weather' was a significant factor.

12.4.7 Discussion

Milford Haven accounts for nearly a quarter of all incidents involving tankers reported by MAIB. By comparison with the level of oil movements, it appears that the incident rate at Milford Haven is twice the national average. However, the number of large oil spills over the last 35 years appears to be less than would be expected given the higher than average incident rate.

However, as indicated earlier, national statistics suggest that the *Sea Empress* disaster was to be expected. Furthermore, given that an incident in UK waters is more likely to occur in Milford Haven than anywhere else, it could be argued that not only was the *Sea Empress* disaster to be expected but also that it would be expected to occur in Milford Haven.

For every major spill, there are many smaller spills and many more incidents which do not result in a spill. Currently, it would be expected that another *Sea Empress* type spill would occur in the next 50 years (derived from 23% of the 1 in 12 year probability for UK waters generally). Clearly, one means to reduce the probability of another major spill is to significantly reduce the numbers of lesser spills and incidents.

With reference to those listed in Annex 12, it can be seen that quite a number involve apparent disregard of fairly basic rules (vessels passing too close, vessel movement without permission, travelling without a pilot, *etc.*). It is also apparent that such breaches are not solely associated with tankers and fishing vessels, ferries, *etc.* also bear responsibility in some cases.

From Table 12.18, it is clear that the distribution of incident types in Milford Haven is the same as for UK waters generally. Furthermore, nearly a quarter of all tanker incidents occur in and around Milford Haven - which is twice as many as would be expected from the numbers of tankers using Milford Haven.

In summary, the incident rate for tankers using Milford Haven is twice the national average.

12.4.5 Numbers of Spills

At a national level, it was estimated that there are about six serious casualties per year (see Section 12.3.2). In addition, spill probabilities have been derived from world data (see Table 12.5). Combining these figures with the 23% value for incidents in Milford Haven, the expected number of oil spills can be estimated.

Although no information has been provided by the Milford Haven Port Authority, the Authority does maintain an extensive data-base of incidents. A summary of spills over the period 1961 - 93 has been previously reported (National Power, 1994) which indicates that nearly 40 spills are reported each year (although 80% are less than 160 litres). In terms of larger spills, there have been four spills of more than 133 t (during the period 1961 - 93). These would appear to include a 2200 t spill from the *Dona Marika* in 1973 but not a 3000 t spill from the *Christos Bitas* in 1978 (both these incidents are listed in RCEP, 1981).

These results are summarised in Table 12.19 to which the *Sea Empress* has been added.

Table 12.19: Spills in Milford Haven (1961-96)

Spill Size	Number of Spills		Comment
	Expected	Reported	
All spills	-	40 per year	of which 80% are less than 160 litres
>133 t	-	6	4 reported + *Christos Bitas* + *Sea Empress*
>700 t	10	3	*Dona Marika, Christos Bitas, Sea Empress*
>3400 t	4	1	*Sea Empress*
>34 000 t	1	1	*Sea Empress*

Sources: derived from Table 12.5; National Power, 1994; and associated calculations

In summary, the incidence of large spills (say, >700 t) in Milford Haven is less than would be expected from the overall incident rate (as reported by MAIB).

In terms of the numbers and size distributions of tankers, the relevant figures are presented in Table 12.17.

Table 12.17: Marine Transport of Oil & Oil Products (1995)

Tanker Size	Number of Arrivals in 1995		As % of UK
	Milford Haven	UK Waters	
<4999 dwt	1 537	15 837	10%
5000 - 19 999 dwt	624	4 602	14%
20 000 - 99 999 dwt	341	3 155	11%
>100 000 dwt	85	674	13%
All tankers	**2 587**	**24 268**	**11%**

Source: DoT, 1996

From Tables 12.16 and 12.17, it can be seen that Milford Haven accounts for about 15% of the UK's oil throughput. Due to the relatively lower number of small tankers (less than 4999 dwt), Milford Haven accounts for only 11% of the associated tanker traffic.

12.4.4 Numbers of Incidents

It would be expected that tanker incidents in and around Milford Haven would account for about 11% of tanker incidents in UK waters. In addition to the UK tanker incident data (discussed in Section 12.3.2), MAIB provided another data set relating to all reported incidents in Milford Haven for the period June 1993 to August 1997 (MAIB, 1997a). Direct comparison with the national summary data is provided in Table 12.18.

Table 12.18: Numbers of Incidents in Milford Haven & UK Waters (all tankers)

Type of Incident	Milford Haven (6/93 - 8/97)	UK Waters (6/93 - 8/97)	As %UK
Machinery + Hull Defects	7	30	23%
Collisions & Contacts	8	35	23%
Fire/explosion	2	9	22%
Stranding & Grounding	3	20	15%
Others	25	103	24%
Totals	**45**	**197**	**23%**

Sources: derived from MAIB, 1997 & 1997a

Tides and Timing of Approach

For vessels of around 150 000 t, around 90 minutes is allotted from the embarkation of the Pilot to making fast at, for example, the Texaco refinery. Arrival is timed such that vessels are alongside not later than predicted low water. VLCCs inevitably time their arrival off the Channel when the tidal stream is running fairly strongly to the northwest. This allows them to use the Outer Leading Lights which were set up in 1971 to guide their approach.

Squat

Inbound vessels' Masters and Pilots must take account of the phenomenon of 'squat' when entering the Haven. Squat effect causes increases in a vessel's draught in conditions where the hull is close to the ground. The effect increases with increased speed and closeness of the vessel's bottom to the ground. By way of example, it has been estimated by MAIB that the *Sea Empress*'s increase in draught due to squat would have been about 0.75 m immediately prior to the grounding.

Port Radar

Since 1973, radar has provided coverage of the whole harbour area. In 1985, the system was replaced and, with upgrading, monitored the positions of entrance buoys and large tankers successfully until its operation became erratic in late 1994. In January 1995, a new system was initiated which, due to progressive failures, resulted in the loss of coverage at St Ann's Head and Great Castle Head (See Figure 12.2). Replacement of the St Ann's unit was approved in November 1995, with a tender being approved on 16 February 1996 (Day 2 of the oil spill) (MAIB, 1997b).

12.4.3 Level of Marine Traffic

The proportion of tanker traffic using Milford Haven relative to the UK as a whole has been derived from both throughput figures and the numbers of tankers. For 1995, the relevant quantities of oil and oil products are shown in Table 12.16.

Table 12.16: Marine Transport of Oil & Oil Products (1995)

Movement of:	Milford Haven	UK Waters	As % of UK
Crude oil	17 million tonnes	154 million tonnes	11%
Oil Products	15 million tonnes	63 million tonnes	24%
Oil/oil products	**32 million tonnes**	**217 million tonnes**	**15%**

Source: DoT, 1996

ANNEX 1: LIST OF CONSULTEES

A1. CONSULTEES

Activity Wales
Advisory Committee on Oil Pollution of the Sea (ACOPS)
British Mountaineering Council
British Resorts Association
British Water Ski Federation
Carmarthenshire Fishermen's Federation
Centre for Environment, Fisheries and Aquaculture Science (CEFAS)
Coastal Voyages Cardigan Bay Boat Trips
Dale Sailing (Island Odyssey)
Department of Environment, Transport and the Regions (DETR)
Department of Health
Dyfed Powys Health Authority
English Tourist Board
Environment Agency
Fishguard Chamber of Commerce
Haverford West and St Brides Bay Tourism Association
Institute of Environmental Assessment
International Maritime Organisation (IMO)
International Oil Pollution Compensation Fund (IOPC)
International Tanker Owners Pollution Fund (ITOPF)
Irish Ferries
Joint Response Centre (JRC)
L&R Leisure/Consulting
Lloyds of London Publishing Limited (LLP ltd.)
Marine Accident Investigation Branch (MAIB)
Marine Pollution Control Unit (MPCU)
Marine Safety Agency (MSA)
Milford Haven Coast Guard
Milford Haven Port Authority (MHPA)
Milford Haven Tourism Association
Ministry of Agriculture, Fisheries and Food (MAFF)
Ministry of Defence
Morgwnnyg Health Authority
Neyland Yacht Club
Oil Pollution Research Unit (OPRU)
Pembrokeshire Coast National Parks Authority (PCNPA)
Pembrokeshire County Council: various departments and individuals (PCC)
Pembrokeshire Hotels and Restaurants Association
Pembrokeshire Tourism Federation
Pembrokeshire Tourist Attractions Association
Pembrokeshire Watersports
Pembrokeshire Yacht Club
Pendine Range
Royal Society for the Prevention of Cruelty to Animals (RSPCA)
Scarborough Tourism Economic Activity Monitor (STEAM)

Sea Empress Environmental Evaluation Committee (SEEEC)
Sea Empress Fisheries Claimants Association
Sea Empress Solicitors Group
Simon Jackson Solicitors
South Wales Sea Fisheries Committee
Sports Council for Wales
St. Davids Peninsula Tourist Association
Thousand Island Expedition
Tourism South & West Wales
University of Wales, Swansea
Wales Tourist Board
Welsh Association of Sub-Aqua Clubs
Welsh Canoeing Association
Welsh Economy Business Unit, Cardiff Business School
Welsh Federation of Sea Anglers
Welsh Office
Welsh Waterskiing Association
Welsh Yachting Association
West Wales Windsurfing Centre
Wildlife Trust West Wales

In addition to these organisations, a number of individuals have been contacted for information. These have included: charter boat operators, tackle shop owners, hire operators, land yachters and paracarters and a number of other key individuals some of whom wish to remain anonymous.

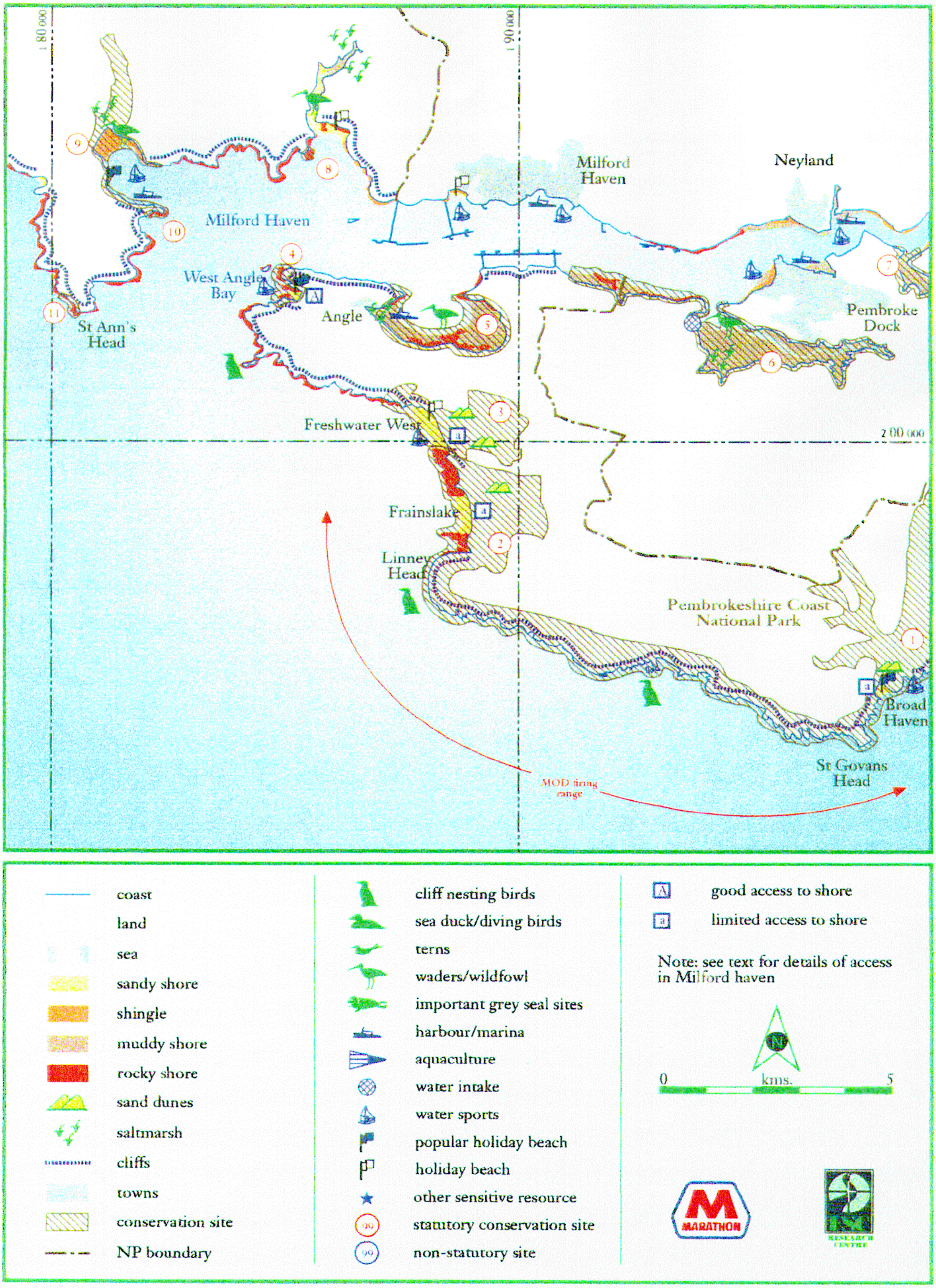
ANNEX 2: SITE SENSITIVITY MAPS

Annex 2 Contents:

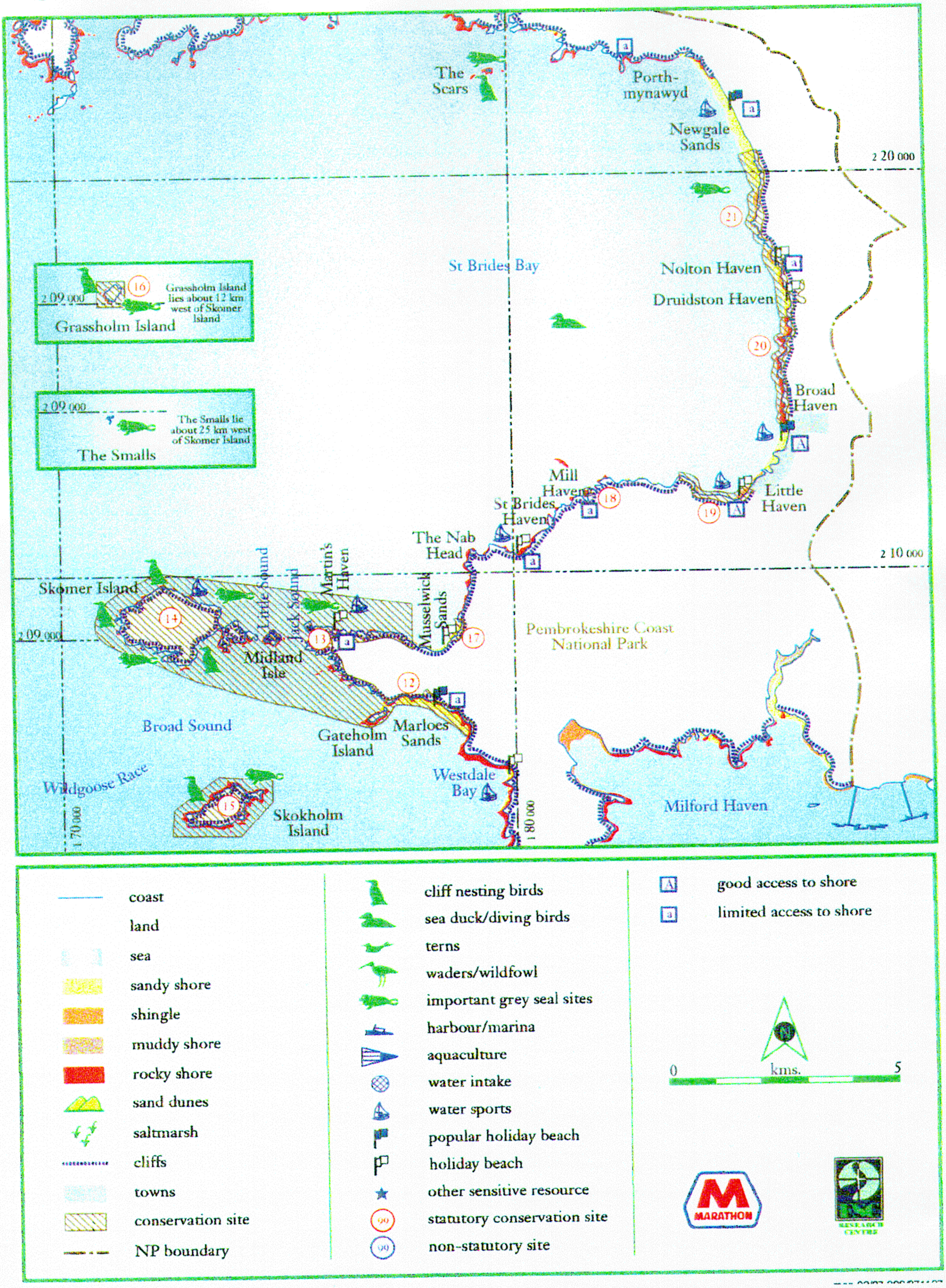
Reproduction of these maps has kindly been granted by the Oil Pollution Research Unit (OPRU) in Pembrokeshire. They are taken from:

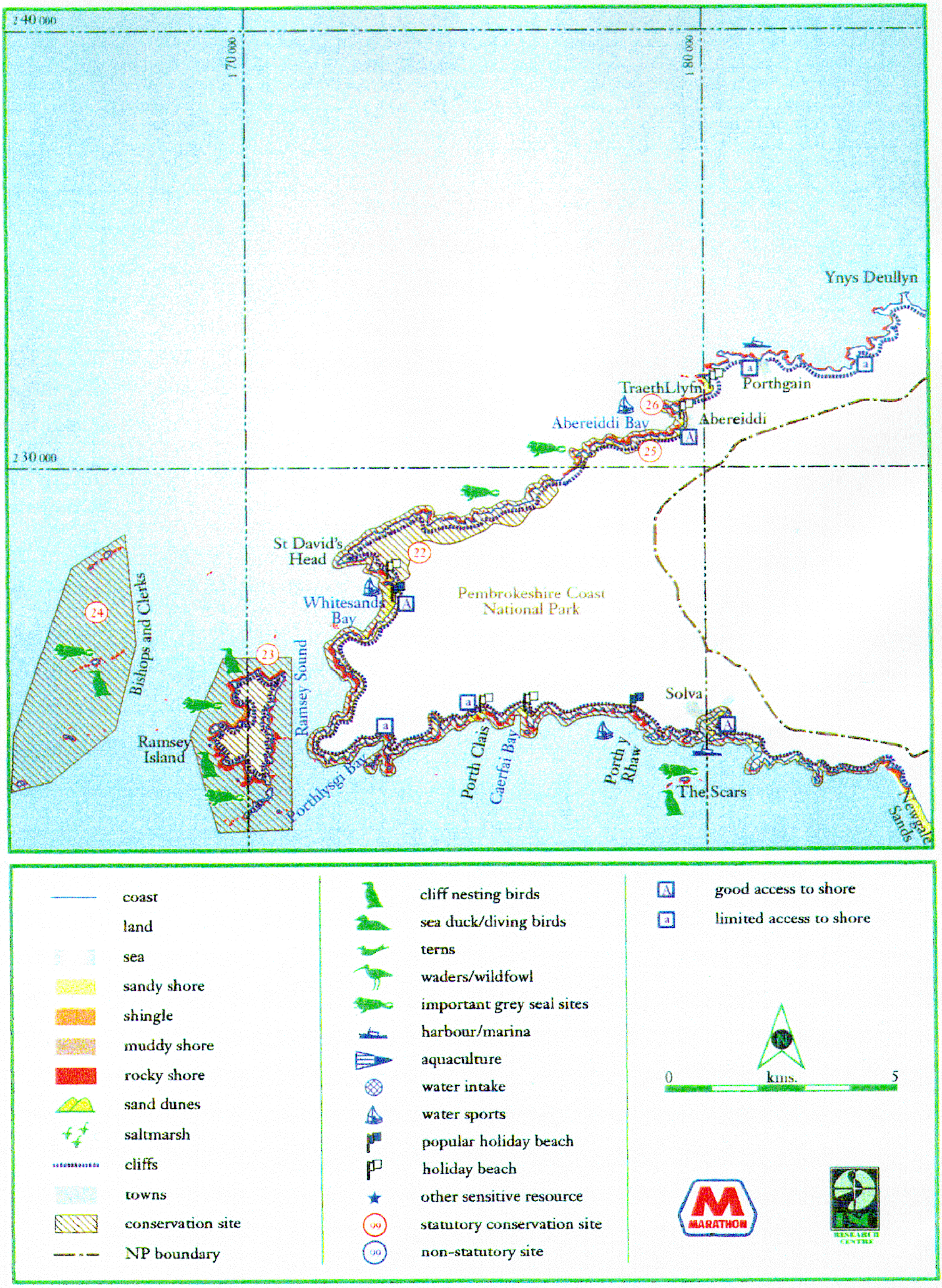
Moore J and Elliot R (1995): **Oil Spill Sensitivity Maps for the West Coast of Wales**, Second Edition. A report from the Oil Pollution Research Unit to Marathon Oil UK Ltd. Report No. FSC/RC/17/95.

Map 1. **Broad Haven to St Ann's Head**

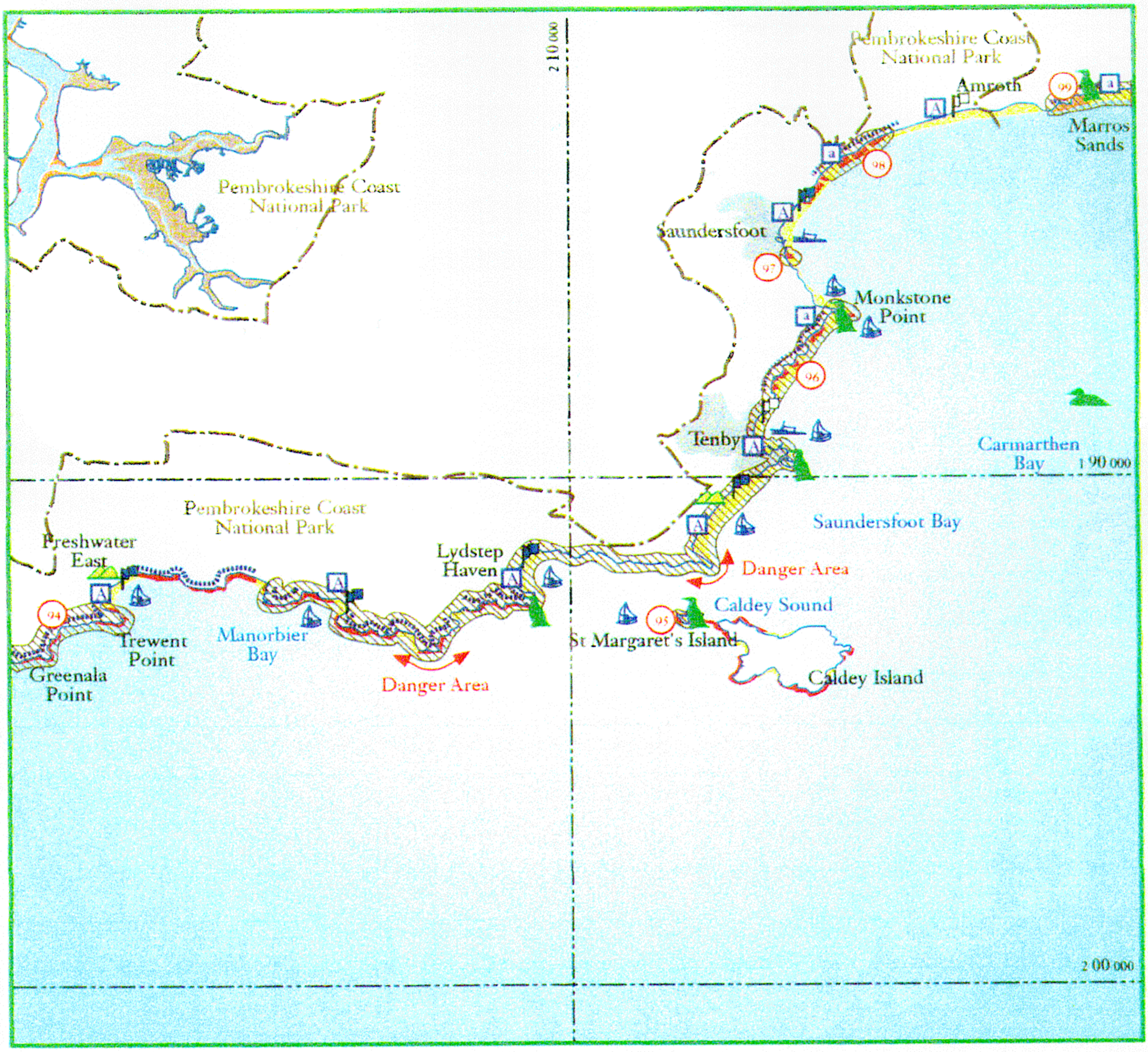


Map 2. Skokholm Island to Newgale Sands



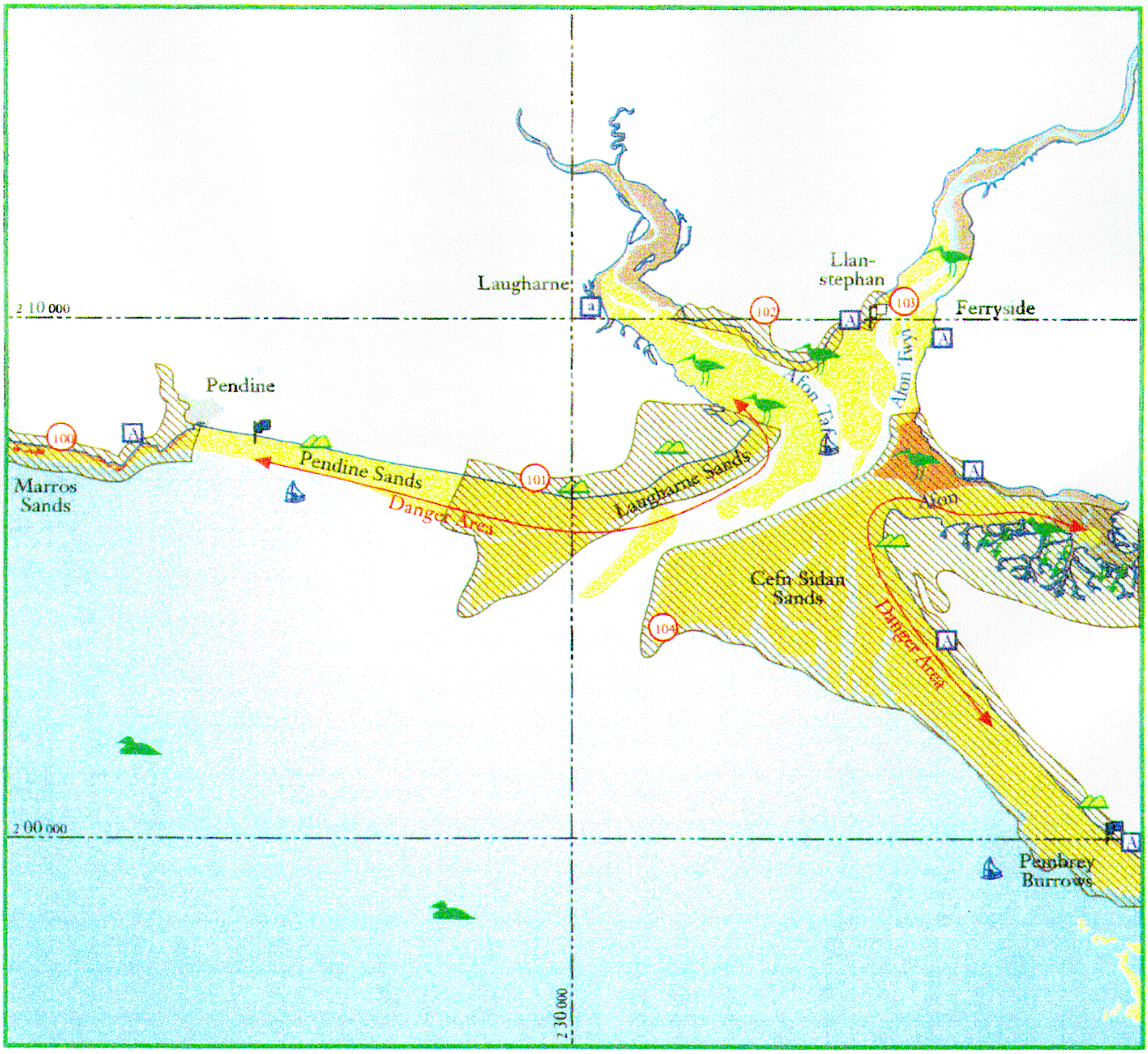

2 40 000
1 70 000
1 80 000
2 30 000
Ynys Deullyn
Porthgain
TraethLlyfn
26
Abereiddi Bay
Abereiddi
25
St David's
Head
22
Whitesands
Bay
Pembrokeshire Coast
National Park
24
Bishops and Clerks
23
Ramsey Sound
Ramsey
Island
Porthlysgi Bay
Porth Clais
Caerfai Bay
Porth y
Rhaw
Solva
The Scars
Newgale
Sands
coast
land
sea
sandy shore
shingle
muddy shore
rocky shore
sand dunes
saltmarsh
cliffs
towns
conservation site
NP boundary
cliff nesting birds
sea duck/diving birds
terns
waders/wildfowl
important grey seal sites
harbour/marina
aquaculture
water intake
water sports
popular holiday beach
holiday beach
other sensitive resource
statutory conservation site
non-statutory site
good access to shore
limited access to shore
0
kms.
5
MARATHON

Greenala Point to Marros Sands



- coast
- land
- sea
- sandy shore
- shingle
- muddy shore
- rocky shore
- sand dunes
- saltmarsh
- cliffs
- towns
- conservation site
- NP boundary
- cliff nesting birds
- sea duck/diving birds
- terns
- waders/wildfowl
- important grey seal sites
- harbour/marina
- aquaculture
- water intake
- water sports
- popular holiday beach
- holiday beach
- other sensitive resource
- statutory conservation site
- non-statutory site
- good access to shore
- limited access to shore

0 kms. 5



- coast
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- holiday beach
- other sensitive resource
- statutory conservation site
- non-statutory site
- good access to shore
- limited access to shore

0 kms. 5

ANNEX 3: CLAIMS TO THE 1971 FUND

Annex 3 Contents:

Table A3.1: Claims to the 1971 Fund for Clean-up Costs to 31/12/96 (£1996)

Claimant	Nature of Claim	Amount of Claim (£ million)	Amount Approved (£ million)	Amount Paid (£ million)
Local Authorities Clean-Up				
Camarthen County Council	Clean-up operations to end of March 1996	0.918		
	Clean-up operations after end of March 1996	0.353		
Councils in Devon	Devon County Council and two Devon District Councils	0.013	0.009	0.007
Councils in Ireland	Four County Councils intended to submit claims	0.072		
Pembrokeshire County Council	Clean-up operations by local authorities to end of March 1996	1.100	0.918	0.677
	Costs incurred by PCC April to November 1996	3.900	2.511	1.884
	Costs to be submitted for December 1996 to March 1997	0.122		
	Interest	0.300		
Total		6.778	3.438	2.568
Regulatory Bodies Clean-Up				
Environment Agency	Costs incurred by NRA (staff costs, transport and equipment hire)	0.402		
Milford Haven Standing Conference on Oil Pollution	Provision of booms, skimmers and spill response craft	1.200		
Joint Nature Conservation Committee	Cost of advisory personnel and a diving survey[a]	0.011		
Total		1.613		

Table A3.1: Claims to the 1971 Fund for Clean-up Costs to 31/12/96 (£1996)

Claimant	Nature of Claim	Amount of Claim (£ million)	Amount Approved (£ million)	Amount Paid (£ million)
Other - Clean-Up				
French Government	Two vessels associated with clean-up	0.161		
Care for the Wild	Cleaning birds	0.005		
South Devon Seabird Trust	Cleaning birds	0.001	0.001	
Total		0.167	0.001	
Total				
All		8.558	3.439	2.568

[a] Major part of the claim considered inadmissible as the studies were of a general or purely scientific character.

Source IOPC, 1996a. More recent data was also provided for the assessment, specifically IOPC, 1997a, 1997b and 1997c. Data gathering stopped at the end of November 1997.

Table A3.2: Claims to the IOPC Fund for Damages to Property to 31/12/96 (£1996)

Claimant	Nature of Claim	Amount of Claim (£ million)	Amount Approved (£ million)	Amount Paid (£ million)
Milford Haven boats owners	75 claims for the costs of cleaning oiled boats and moorings		0.126	0.123
Owners of buildings	31 claims for clean-up of buildings contaminated with wind-blown oil		0.020	0.015
Other property owners	39 claims for damage to carpets, homes, clothing, equipment, trees, shrubs and private roads	0.039		0.034
Total		0.039	0.146	0.172

Source IOPC, 1996a. More recent data was also provided for the assessment, specifically IOPC, 1997a, 1997b and 1997c. Data gathering stopped at the end of November 1997.

ANNEX 4: DATA IN SUPPORT OF TOURISM ANALYSIS

Annex 4 Contents:

A4.1 Introduction

As set out in Section 4 of the main report, various studies have attempted to value the impacts to Pembrokeshire's tourism from the *Sea Empress* oil spill and clean-up. Overall, it appears that there may have been a 7% reduction in bedstock for the year as a whole, or a 6% reduction in Pembrokeshire's performance overall compared with 1995. For completeness, a summary of the findings of studies is presented below, although a summary is also provided in the draft SEEEC report (1997).

A4.2 Findings of the Wales Tourist Board

The impacts of the *Sea Empress* oil spill on tourism performance in Pembrokeshire in 1996 have been evaluated by the Wales Tourist Board (WTB, 1997a). The study collated evidence from a number of ad-hoc and continuous surveys with the aim of identifying consistent and measurable trends in tourism. These surveys are described in Table A4.1.

As a result of this review, the WTB concluded that no consistent or measurable trends in tourism performance emerge for Pembrokeshire for 1996. That said, the *Sea Empress* incident may have had a small effect on the conversion rate of enquiries to bookings; 26.3% of those requesting a Pembrokeshire brochure after the *Sea Empress* incident took a holiday in the county, compared with 23.5% of those enquiring before the incident (WTB: Pembrokeshire Brochure Enquiries, in WTB, 1997a).

In addition, the report found that the hotel sector in south west Wales appears to have performed less well in 1996 than that in south east Wales and in Wales as a whole[1]. By applying these data to hotel bedstock data for Pembrokeshire, the WTB calculated a 7% decline in bednights sold during 1996 compared to 1995, equivalent to a loss in turnover of £2 million. If south west Wales hotels had performed at the same level as hotels across all Wales[2], then the estimate of lost turnover increases to £2.6 million. WTB also postulated that if there had been a similar 8% decline in bed nights in all other commercial accommodation sectors, then a £20 million reduction in expenditure could be estimated for Pembrokeshire for 1996 (rising to £27 million if south west Wales performed at the same level as all Wales[3]).

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1 1996 annual bedspace occupancy data compared to that for 1995: -2.5% south west Wales, +3% south east Wales, +1% all Wales.

2 i.e. if there had been a 1% increase in bedspace occupancy.

3 Other data presented by WTB indicate that this may not be a valid assumption; the United Kingdom Tourism Survey indicated that expenditure for domestic UK visitors (the core market for staying visitors) increased in overall terms in 1996 compared to 1995. WTB assumes that this implies growth in the self-catering and caravan/camping sectors and visiting friends and relatives.

Table A4.1: Surveys Reviewed by the Wales Tourist Board

Organisation and Title	Description
Cardiff Business School: The Economic Impacts of the *Sea Empress* Oil Spillage	Postal survey (May 1996) of 360 tourism businesses in west Wales to evaluate economic impact and assess options for economic regeneration
Countryside Council for Wales: The *Sea Empress* Oil Spill - A Survey of Visitor's Perceptions	Face to face survey (26 May - 6 September 1996) of 1 316 holiday and day visitors to explore awareness of the *Sea Empress* incident, perceptions of impact and effects on behaviour
Wales Tourist Board: Wales Visitor Survey 1996	Face to face survey (17 June - 20 September 1996) of 4 892 holiday and day visitors, part of which related to awareness of the *Sea Empress* incident and effects on behaviour
Wales Tourist Board: Pembrokeshire Brochure Enquiries	Postal survey of 2 000 households requesting a Pembrokeshire holiday brochure in 1996 to determine the extent to which the *Sea Empress* incident may have reduced the conversion rate of brochure enquiries to actual bookings
Wales Tourist Board: Hotel Occupancy Survey	Postal survey (monthly) to around 200 Welsh hotels to provide a measure of demand for such accommodation
United Kingdom Tourism Survey	Household interview survey (annual) with 70 000 participants to provide a continuous measure of the volume, value and characteristics of staying tourism by UK residents
Wales Tourist Board: Survey of Visitors to Attractions	Postal survey (annual) of 450 tourist attractions in Wales to provide information on annual visitor attendance
International Passenger Survey	Face to face survey (annual) of around 190 000 individuals at key points of entry/exit to provide a continuous measure of the volume, value and characteristics of international tourism to and from Great Britain
United Kingdom Day Visits Survey	Household interview survey (biannual) of around 9 000 individuals to provide a measure of the volume, value and characteristics of leisure day trips from home taken by UK residents
Wales Tourist Board: Visitors to Tourist Information Centres	Collation of data on visitors to Tourist Information Centres within Pembrokeshire

Source: WTB, 1997a

The report raises two issues of concern with respect to these (and any other) impacts. Firstly, that the *Sea Empress* incident would have been only one of a number of factors influencing a decision to visit Pembrokeshire with others including cost, weather, convenience, range and availability of accommodation, activities and attractions, accessibility and exchange rates. It was also suggested that usual early bookings were delayed by the General Election (pers. comm.), an example which clearly illustrates the complex nature of decisions to holiday. With the information available, WTB was not able to isolate the effects of the *Sea Empress* incident from those of other factors. Secondly, however, WTB notes that if it were possible to link the oil spill with a measurable downturn in tourism, then, the fact that 1995 was a strong year for tourism growth within west Wales should be taken into account (i.e. the upward trend should be considered).

With respect to the last of these points, many consultees in the tourism industry have commented that 1995 was a very strong year due to the long and hot summer. From both these anecdotal reports and other evidence, for example that provided on visits to Pembrokeshire National Park Tourist Information Centres (TICs) presented in Table A4.2 (at the end of this section), it appears that 1995 was an anomaly and that annual visits in 1996 were returning to the trends set by previous years. Consultation suggests that movement away from some TICs may suggest that recently opened attractions in the area are encouraging people away from more traditional tourist locations where TICs are located, such as Pembroke Castle (pers. comm.).

With respect to separating out the impacts of the *Sea Empress* incident, WTB does acknowledge that "for one in five of those who actively considered Pembrokeshire as a prospective holiday destination in 1996, *Sea Empress* was a significant reason which led them to reject the area"[4]. From this, the Wales Tourist Board estimate that the impact of this to the local economy may have been somewhere between £1.3 million and £5 million (pers. comm.)[5].

A4.3 Other Evidence of Impacts

The literature reviewed to date provides little additional information on impacts to tourism. Consultation with those in the industry has suggested that impacts were specific to different types of tourism providers, as such the overall impacts to the area were minimal but impacts to some individuals and companies were severe.

The weather at Easter 1996 was 'glorious', so people visited Pembrokeshire to see the spill for themselves. May and early June 1996 were relatively quiet, bookings for this period traditionally being made in February and March when the 'phones stopped ringing' due to the oil spill. In addition, 'inclement weather' may have put off 'last-minute bookers' and 'day-visitors'. With respect to the summer, there were on-going requests for literature throughout the season (which was unusual) and visitor numbers to Tourist Information Centres (TICs) indicate that the main season was on a par with 1995 which was considered good. The first of these suggests that visitors may have delayed their holiday decisions til later in the year as a result of the oil spill. With respect to the second, visit numbers will have been enhanced by events such as the Radio One Roadshow and the Celtic Watersports Festival in and around Tenby. The fact that overseas visitors to TICs were up by 50% from 1995 may have indicated that this group was not impacted, but were eager for information on the effects of the oil spill.

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4 *19% of those who did not visit Pembrokeshire agreed or strongly agreed with the statement that "the Sea Empress* oil spillage was the main reason why I decided not to holiday in Pembrokeshire in 1996" (WTB: Pembrokeshire Brochure Enquiries, in WTB, 1997a)

5 Based on 19% of the total number of enquiries for Pembrokeshire brochure in 1996, multiplied by the average expenditure per holiday trip to Wales sourced from the Wales Visitor Survey (£510) and the UKTS (£136).

There are conflicting anecdotal reports on longer-term impacts, some saying that reduced performance continued on into 1997 while some suggest that performance for Easter 1997 was very strong (pers comm).

Box A4.1 sets out additional data on the influence of the *Sea Empress* incident. As the associated respondents were already on holiday in the area, the results are considered to be of limited use in determining the extent of lost tourism to Pembrokeshire from the oil spill and clean-up.

Box A4.1: Additional Data on the Influence of the *Sea Empress* Incident

93% of respondents confirmed that the incident did not affect their decision to visit Wales (WTB: Wales Visitor Survey 1996, in WTB, 1997a).

Only 10% who holidayed in Pembrokeshire said that the *Sea Empress* had affected their decision to visit the county (WTB: Pembrokeshire Brochure Enquiries, in WTB, 1997a).

83% of respondents said that the incident had not affected their decision to visit Pembrokeshire, with figures of 87%, 80% and 86% for Welsh, other UK and overseas visitors respectively (Beaufort Research, 1996).

5% of holiday visitors said that they had hesitated or delayed their decision to come to Pembrokeshire, whilst a further 3% had made enquiries before coming. 5% said that they were already committed, in the sense that their holiday had been booked earlier. Around 1% wished to see the clean-up operation or to support the area (Beaufort Research, 1996).

For those visiting Pembrokeshire in 1996, repeat visits seem likely; 74% of visitors stated that they would definitely visit Pembrokeshire again and 19% saying probably.

Table A4.2: National Park Tourist Information Centre Throughput Figures

Centre	Comparison of First 12 Weeks of Opening Where All Centres Were Open* up to 2nd June		% Change	Totals for Year				% Change		
	1996	1997		1993	1994	1995	1996	1993-4	1994-5	1995-6
40 High Street	1 792	2 130	19							
Broad Haven	3 427	3 670	7	10 109	15 783	13 948	13 986	56	-11	-100
Haverfordwest				6 586	11 505	10 322	7 413	75	-36	-28†
Pembroke	6 149	3 576	-42	24 932	24 257	26 918	23 622	-3	-3	-100
St David's	17 166	20 444	19	51 132	68 842	68 446	70 160	35	2	-100
Newport	2 990	2 843	-5	12 903	13 854	13 673	13 461	7	-3	-100
Saundersfoot				40 417	42 577	34 683	30 641	5	-28	-100
Total	*31 524*	*32 663*	*4*	*146 079*	*176 818*	*167 990*	*159 283*	*21*	*-10*	*-100*

* i.e. excludes the four weeks after Easter except for St David's which was open throughout both years.
† open only part-time in 1996.
Source: Pembrokeshire Coast National Park Authority.

ANNEX 5: DATA IN SUPPORT OF RECREATIONAL ACTIVITY ANALYSIS

Annex 5 Contents:

Popular Sites for Specialist Recreational Interests

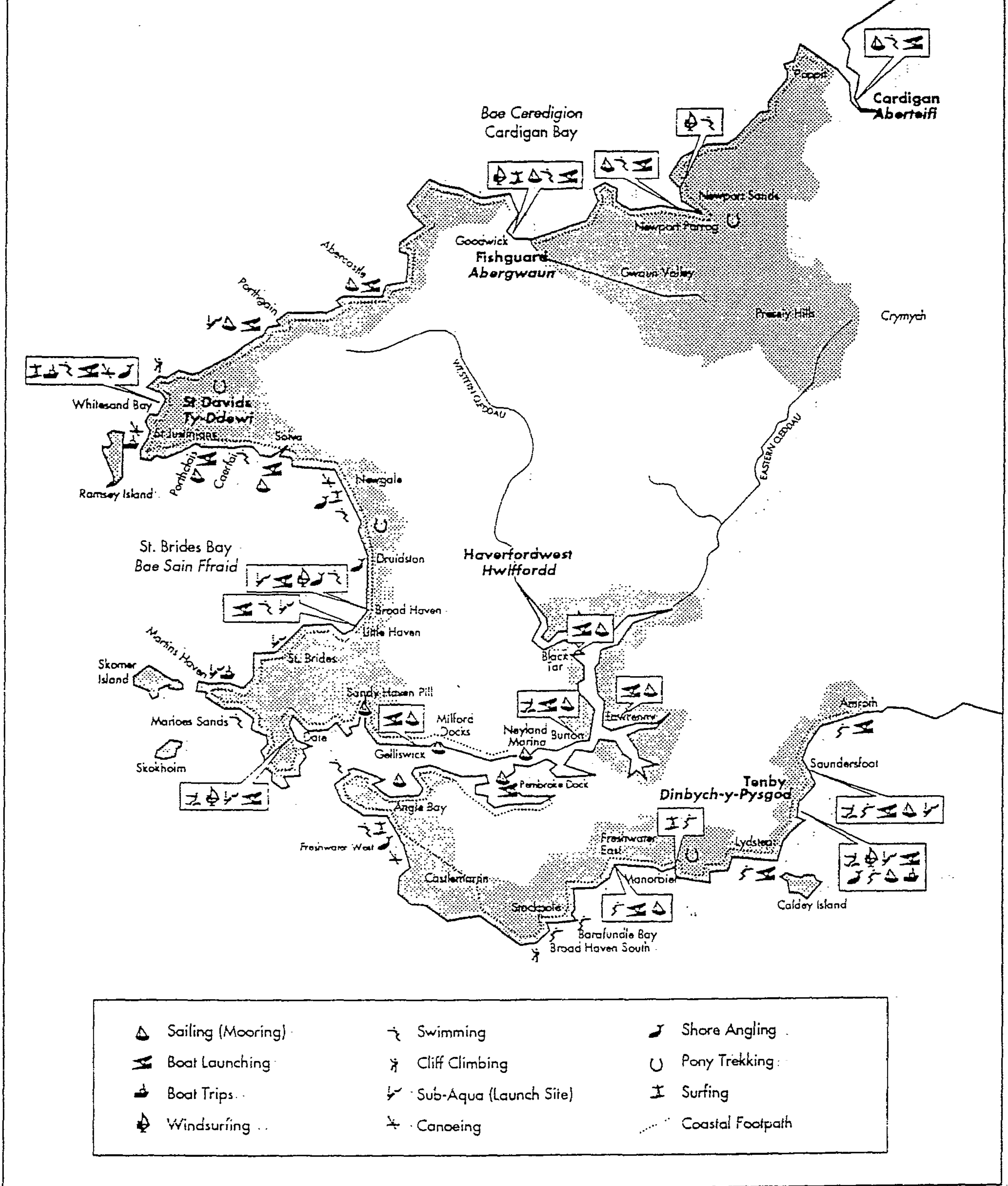

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Table A5.1: Summary of Recreational Characteristics of Pembrokeshire's Affected Beaches

Beach[1]	Rural	Resort	1997 Seaside Awards	EC Bathing Water Standard[2]	Type of beach	Recreational Pursuits	Use	Accessibility: Location	Accessibility: Parking	Site Quality/ Facilities
Abereiddy	✔		✔	G	Sand/ shingle cove	Surfing Canoeing Slipway Sub Aqua club		Near Abereiddy On Coast Path	Good	Historical background Adjacent to NT land Toilets, ice cream van
Amroth	✔		✔	M	Very large sandy/ rocky	Windsurfing Jetskiing Start of Pembrokeshire Coast Path Slipway	M	Village Promenade	Good	SSSI café, restaurant, toilets, ice cream van
Angle Bay (Kilpaison)	✔				Mud and rocks	Fishing (bass, flatfish)	L	Good Access, near Angle	Present	SSSI
Barafundle Bay	✔		✔	G	Sandy/ cobble	Fishing: mackerel (boats) bass (from rocks)	H	Along Coast Path Long walk from parking Accessed by steep steps	Good	SSSI within PCNP Owned and managed by NT Sand dunes and cliffs within Stackpole NNR 'Jewel in Crown' toilets
Broad haven South	✔		✔	G	Sheltered sandy	-		Near Bosherton Lilly Ponds	Good	Managed by NT Good for swimming toilets, ice cream van

Table A5.1: Summary of Recreational Characteristics of Pembrokeshire's Affected Beaches

Beach[1]	Rural	Resort	1997 Seaside Awards	EC Bathing Water Standard[2]	Type of beach	Recreational Pursuits	Use	Accessibility: Location	Accessibility: Parking	Site Quality/ Facilities
Broad haven Haverfordwest	✔		✔	G	Sandy	**Windsurfing** (+hire, esp. winter) Surfing (+ board hire) Canoeing Fishing (bass; autumn) 3 Slipways Diving	H	Village	Good	cafe, toilets, first aid Near important diving centre (see Dale)
Burton						*Waterskiing* *Sailing*				
Castlebeach Bay	✔						L	Pedestrian access to shore		SSSI No facilities
Conduit Point	✔				Small shingle		L local			No facilities
Coppet Hall (Saundersfoot beach)	✔		✔	M	Small sandy/ shingle	Slipway Fishing (bass; flatfish)	M	Harbour	'Excelle nt'	Historical background Owned by Head Castle Estate cafe, toilets, ice cream van
Church Doors	✔				sand/ cobbles/ boulders	-	L	Difficult access Adjacent to Skrinkle Haven; steep flight of steps		SSSI unstable coastal slopes; rock falls No facilities
Cwm yr Eglwys	✔		✔	-	*Small sandy/ rocky*	*Windsurfing* *Canoeing* *Paddleboats*		*Village site*	*Good*	*'picturesque'* *Good for families*

Table A5.1: Summary of Recreational Characteristics of Pembrokeshire's Affected Beaches

Beach[1]	Rural	Resort	1997 Seaside Awards	EC Bathing Water Standard[2]	Type of beach	Recreational Pursuits	Use	Accessibility		Site Quality/ Facilities
								Location	Parking	
Cwr Bwdy Bay	✔				Sandy/ cobble		L	Pedestrian access only		No facilities
Dale	✔		✔	M	Pebbled	**Windsurfing** (+hire +tuition) Surfing[3] Canoeing **Sailing** Diving Slipway (free) Pontoons	H	Good access Village site	Good but limited	SSSI, Dale Fort Field Centre 'Working fishing village' Mud flats rich in marine life Very ocean-centred Clean site (not littered) Historical background West Wales Diving Centre (important sub-aqua site)
Drimkin (Caldey Island)	✔				Sand and Shingle		L local	Difficult access	None	No facilities
Druidston Haven	✔					Horse riding	H	Long walk to beach	Very limited	SSSI No facilities
Freshwater East	✔		✔	G	Large sandy sweeping sheltered	Slipway Windsurfing Surfing	M	Near holiday accommodation	Good	SSSI within PCNP Overlooked by chalets and caravans toilets
Freshwater West	✔				Sandy/ rocky	**Surfing** Fishing (bass; autumn) Canoeing Windsurfing	H			SSSI within PCNP Very dangerous; quicksand; strong currents "vital amenity beach" One of main UK surf sites Venue for Welsh, British and European Surfing Championships

Table A5.1: Summary of Recreational Characteristics of Pembrokeshire's Affected Beaches

Beach[1]	Rural	Resort	1997 Seaside Awards	EC Bathing Water Standard[2]	Type of beach	Recreational Pursuits	Use	Accessibility: Location	Accessibility: Parking	Site Quality/ Facilities
Gelliswick	✔		✔	M	Large shingle	Canoeing Diving **Sailing** 'Excellent', free slipway into Haven Waterway	H	Good access Backed by 'roadway' Near to Hakin and Milford Haven	Present	Pembroke Yacht Club HQ toilets Not very good for swimming Busy during race meetings
The Glen	✔				Small Flat rock/ shingle	Fishing (bass; flatfish) Boating	L	Access difficult Paths and down steep cliffs		Between Saundersfoot/Tenby Near Gunky and Swallow Tree; No facilities
Gunky	✔				Small Flat rock/ shingle	Fishing (bass; flatfish)	L	Access difficult Paths and down steep cliffs		Between Saundersfoot/Tenby Near The Glen and Swallow Tree; No facilities
Hakin Point					shingle/ concrete sea defences		L local	Adjoins Hakin		
Lindsway Bay	✔				Two sandy coves (1 large)	Fishing	M local	One pedestrian access (steps)		Good for swimming
Little Haven	✔				Very small	Slipway Diving Fishing Rowing Sailing	H	Pubs either side of beach		Sheltered so good for watersports
Llanreath	✔				Shingle		M			

Table A5.1: Summary of Recreational Characteristics of Pembrokeshire's Affected Beaches

Beach[1]	Rural	Resort	1997 Seaside Awards	EC Bathing Water Standard[2]	Type of beach	Recreational Pursuits	Use	Accessibility		Site Quality/ Facilities
								Location	Parking	
Llanstadwell and Hazelbeach	✔				Shingle rocks mud	Boating	M local	Limited access (no vehicles)	None	Bird roosting/feeding area No facilities
Lydstep Caverns	✔				Small sandy/ rocky		L	Difficult access down 150 steep steps; Access only from Coast Path		SSSI No facilities
Lydstep Haven/Beach	✔				Wide and sandy	Slipway Boating P.W.C Sailing Canoeing	M	Good access near Lydstepp Haven	Good	SSSI; sheltered anchorage Good for swimming
Manorbier	✔		✔	G	Sandy/ rocky	Windsurfing **Surfing** ('extremely popular all year') Canoeing	H	Accessed via narrow public road and track	Good but limited	SSSI; PCNPA sand dune restoration project "vital amenity beach" Crowded surfing beach Toilets Historical background
Marloes Sands	✔		✔	G	'Spacious golden sands'	-	H	Restricted access; half mile walk away	Good	SSSI within MNR Good for swimming 'lovely offshore views' of Skomer and Stockholm Islands nature reserves
Marros Sands	✔				Sand/ shingle		L	Difficult; only accessible at very low tides	None	SSSI (Cliffs) Submerged forest No facilities

Table A5.1: Summary of Recreational Characteristics of Pembrokeshire's Affected Beaches

Beach[1]	Rural	Resort	1997 Seaside Awards	EC Bathing Water Standard[2]	Type of beach	Recreational Pursuits	Use	Accessibility: Location	Accessibility: Parking	Site Quality/ Facilities
Martin's Haven	✔		✔	-	Small pebbled cove	Landing Stage for boat trips to Skomer Island and diving support vessels Fishing Diving	H	-	Good	Wildlife Reserve (Skomer Marine Nature Reserve) toilet
Milford Beach	✔				Large shingle/ boulders		M local	Access down steep narrow path		No facilities
Milford Haven Waterway + Daugleddau estuary						Fishing Motorised Watersports 14 Slipways Kayaking Canoeing				One of major watersports sites in Wales Sheltered touring for kayaks and canoes Coast around Milford Haven one of finest sea kayaking venues in Britain
Mill Haven	✔						L	Difficult access		SSSI; No facilities
Monk Haven	✔				Pebbles/ rocky		M local	Pedestrian access only		No facilities
Monkstone	✔				Sandy	Fishing (flatfish; bass)		Difficult access down 170 steep steps from caravan park		No facilities
Morfa Bychan	✔				Small sandy	Fishing (flatfish; bass summer and winter)	L	Isolated		Between Marros and Pendine; No facilities

Table A5.1: Summary of Recreational Characteristics of Pembrokeshire's Affected Beaches

Beach[1]	Rural	Resort	1997 Seaside Awards	EC Bathing Water Standard[2]	Type of beach	Recreational Pursuits	Use	Accessibility: Location	Accessibility: Parking	Site Quality/ Facilities
Musslewick Sands	✔							Remote; Walk from Marloes Village	None	No facilities
Newgale Sands	✔		✔	G	Long, sandy and cobbles	**Windsurfing** **Surfing** (+ board hire) Canoeing Fishing (winter)	H	Village	Good	'One of the best surf beaches in Pembrokeshire' 'The longest and most sandy of beaches in Pembrokeshire' café, toilets, ice cream van, lost child centre, first aid, life guards
Newport Sands	✔		✔	-	*Large, sandy*	***Windsurfing*** *Canoeing Sailing Slipway*	*H*	*Adjoins golf course*	*Good*	*cafe, toilets, first aid, life guards, surf life saving*
Nolton Haven	✔		✔	M	Compact sheltered sand and shingle	Windsurfing Canoeing Sailing	M	Near pub and Coast Path	Good	SSSI
Penycwm	✔				Sand and boulders		L	Adjoins Newgale Sands		
Pendine Sands	✔			✔	Very large sandy	Sand-yachting Slipway Sailing Waterskiing Jetskiing Fishing	H	Good access near Pendine		SSSI

Table A5.1: Summary of Recreational Characteristics of Pembrokeshire's Affected Beaches

Beach[1]	Rural	Resort	1997 Seaside Awards	EC Bathing Water Standard[2]	Type of beach	Recreational Pursuits	Use	Accessibility: Location	Accessibility: Parking	Site Quality/ Facilities
Poppit	✔		✔	*M*	*Large sandy*	*Windsurfing* *Surfing* *Canoeing*		-	*Good*	*Start of Coast path cafe, toilets, lost child post, first aid, life guard*
Porth Clais	✔				-	Boating	M	Small harbour on Coast Path		'Very pretty'
Porthlysgi Bay	✔				Sand/ boulder		L	Limited access		
Precipe	✔				Sandy cove		L			SSSI; No facilities
Priory Bay (Caldey Island)	✔				Soft sand		L			No facilities
Sandtop Beach	✔				Soft sand		L local	Difficult farm track access	None	No facilities
Sandy Haven					Large sandy	Slipway Boating	H	Good access		'Not very suitable for bathing'
Saundersfoot				✔	Sandy/ shingle	Sailing Pleasure boat trips to islands Fishing (winter)	H	Harbour		SSSI; Sailing club 'Popular holiday beach'
Scotch Bay					Small rocky		L	Pedestrian access		Just below ship breaking yard by Milford Haven docks

Table A5.1: Summary of Recreational Characteristics of Pembrokeshire's Affected Beaches

Beach[1]	Rural	Resort	1997 Seaside Awards	EC Bathing Water Standard[2]	Type of beach	Recreational Pursuits	Use	Accessibility: Location	Accessibility: Parking	Site Quality/ Facilities
Skrinkle Haven	✔		✔	G	Sandy bay/cove	-	M	Difficult access via 150 narrow and steep steps Near National Park Youth Hostel	Present	SSSI Clean and secluded Managed by National Park Youth Hostel warden
Skomer Island (North and South Haven)	✔				Shingle/ cobble	Focus of boat trips Diving	H			NNR, SSSI within Marine Nature Reserve
Solva (Porth y Rhaw)	✔				Rocky	Fishing Sailing (to Ramsey)	M	Good access near to Solva		Natural harbour inlet
St Brides Haven	✔		✔	-	Small sand and shingle cove	Canoeing	H	On Coast Path Cottages overlook beach	Good	Good for swimming toilets
St David's, Caerfai	✔		✔	G	Sandy	Surfing Canoeing		Near St David's Limited access; very steep walk	Good	"picturesque"
St David's, Whitesands		✔	✔	*G*	*Wide and sandy*	*Windsurfing* ***Surfing** (+hire)* *Canoeing* *Slipway* *Diving* *Fishing* *'Thousand Island Boat Trip'* *Waterskiing*	*H*	*Limited vehicular access*	*Good*	*Within PCNP* *Toilets, first aid* *Crowded surfing beach*

Table A5.1: Summary of Recreational Characteristics of Pembrokeshire's Affected Beaches

Beach[1]	Rural	Resort	1997 Seaside Awards	EC Bathing Water Standard[2]	Type of beach	Recreational Pursuits	Use	Accessibility: Location	Accessibility: Parking	Site Quality/ Facilities
Swallow Tree	✔				Small Flat rock/ shingle		L	Difficult access Paths and down steep cliffs	None	Between Saundersfoot/Tenby Near The Glen and Gunky No facilities
Swanlake	✔				Sandy/ rocky		L	Pedestrian access only from Coast Path	None	No facilities
Telpyn	✔				Sand/ shingle		L	Remote; access only from Amroth and Marros	None	No facilities
Tenby, North		✔	✔	G	Long and sandy	Pedallo Hire Slipway Fishing (bass; + boat hire)		Overlooked by Tenby town and harbour Promenade	Good	Historical background Good for swimming cafe, toilets, beach huts, deckchair hire, ice cream van, first aid, life guards, no dogs on beach, pier
Tenby, South (inc Castle Beach and Paragon Beach)	✔		✔	M	Long and sandy	Windsurfing Surfing Slipway Fishing (bass; + boat hire) Boat trips to islands Scuba Diving	H	Adjoins Tenby golf course Promenade	Good	SSSI (Cliffs/sand dunes) Historical background Good for swimming cafe, toilets, deckchair hire, beach huts, ice cream van, first aid, life guard
Waterwynch Bay	✔				Small sand/ shingle		L hotel	Access only via Coast Path		Privately owned by Waterwynch Hotel

Table A5.1: Summary of Recreational Characteristics of Pembrokeshire's Affected Beaches

Beach[1]	Rural	Resort	1997 Seaside Awards	EC Bathing Water Standard[2]	Type of beach	Recreational Pursuits	Use	Accessibility: Location	Accessibility: Parking	Site Quality/ Facilities
Watwick Bay	✔				Sandy/ rocky		M	Pedestrian access only		
Westdale Bay	✔				Narrow shingle/ sand	**Surfing**	H	Limited pedestrian access down steep steps		
Wiseman's Bridge	✔		✔	M	Sand and shingle	-	M	Harbour Links Saundersfoot (Coppet Hall) and Amroth	Good	Historical background toilets, cafe Can walk from Saundersfoot over beach at low tide or through old coal railway tunnel
West Angle Bay	✔		✔	M	Small sheltered sandy/ rocky	Slipway (Watersports)	H	Short walk from Angle village	Good	SSSI; one of richest SW Wales sites for marine flora and fauna, including rare Asterina phylactica (star fish) cafe, toilets

Notes:

1 Italicised beaches may not have been affected by the oil spill or represent key alternative sites.
2 Mandatory (M); Guideline (G); No Data '-'
3 The 1997 Seaside Awards (Tidy Britain Group, 1997) list surfing as an activity undertaken here, but other sources suggest that in fact it is not (pers. comm.).

Sources:

Tidy Britain Group (1997): **The 1997 Seaside Awards**
The Environment Agency (1996): **The Aesthetic Impact of Oil on Beaches** (Draft Final) prepared by Pembrokeshire College, Technical Report P22
The Coastguard Agency (1996): **The Sea Empress Incident**
Pers. comm.

Table A5.2: Criteria for Ranking Beaches

Score: / Criteria:	1	2	3	4	5
Location/ Accessibility	Remote, Pedestrian only, Difficult	Rural, Pedestrian only	Rural, CP, Walk	Rural, CP (village)	Resort/Promenade/ Harbour
EC Designated Bathing Water	Not Designated	Not 1997 Seaside Awards but designated EC water quality (quality unknown)	Designated 1997 Seaside Awards (and so EC water quality, quality unknown)	EC Mandatory water quality	EC Guideline water quality
Facilities	None	None, SSSI, etc.	Toilets Only	Some	Lots

Table A5.3: Popularity of Affected Beaches				
Beach[1]	**Rank**	**Use**	**Known Visit Numbers Lifeguard Count Sun 17.08.97**	**Assumed Peak Visit Numbers** (i.e. hot August Sunday)
Tenby, South (inc. Castle and Paragon)	up to joint 5	Very High	3-3.5k	4k
Newgale Sands			3-3.5k	
Saundersfoot				
Dale				
Poppit	up to joint 10			3.5k
Amroth				
Broad Haven (Haverfordwest)				
Wiseman's Bridge	up to joint 15	High		3k
Freshwater East				
St David's, Whitesands			2.5-3k	
Newport Sands				
Broad Haven (South)				
Barafundle				
Manorbier				
West Angle Bay				
Abereiddy				
Gelliswick				
Nolton Haven	up to joint 20	Medium		2.5k
Marloes Sands				
Martin's Haven				
Coppet Hall			2-2.5k	
St David's, Caerfai	up to joint 25			2k
Porth Clais				
Little Haven				
Sandy Haven				
Pendine Sands				
Freshwater West				
Tenby, North[2]			1-1.5k	
Druidston Haven	up to joint 30	Medium /Low		1.5k
Lydstep Haven/Beach				
Angle Bay (Kilpaison)				
Waterwynch Bay				
Solva (Porth y Rhaw)				
Llanreath				
Priory Bay (Caldey)	up to joint 35			1k
Precipe				
Penycwm				
Llanstadwell & Hazelbeach				
Castlebeach Bay				

<table>
<tr><th colspan="5">Table A5.3: Popularity of Affected Beaches</th></tr>
<tr><th>Beach[1]</th><th>Rank</th><th>Use</th><th>Known Visit Numbers Lifeguard Count Sun 17.08.97</th><th>Assumed Peak Visit Numbers (i.e. hot August Sunday)</th></tr>
<tr><td>Westdale Bay
St Brides Haven
Conduit Point
Lydstep Caverns
Church Doors
Cwr Bwdy Bay
Monk Haven
Mill Haven
Musslewick Sands
Monkstone
Watwick Bay
Scotch Bay
Skrinkle Haven
Cwm yr Eglwys
Skomer Island (North & South Haven)
Hakin Point
Marros Sands
Swanlake
Lindsway Bay</td><td>up to joint 40</td><td>Low/Medium</td><td></td><td>0.5k</td></tr>
<tr><td>Milford Beach
Swallow Tree
Telpyn
Gunky
Porthlysgi Bay
Morfa Bychan
Drimkin (Caldey)
The Glen
Sandtop Beach</td><td>over joint 50</td><td>Low</td><td></td><td>0.2k</td></tr>
<tr><td colspan="5">Notes: 1 Italicised beaches may not have been oiled
2 Ranked 1 but known visit numbers used to rank instead (small beach limits numbers)</td></tr>
</table>

Table A5.4: Number of Visits Affected by the Oil Spill, by Month

Data in THOUSANDS of visits	**February**		**March**		**April**	**May**
	Day	**No. Day visits**	**Day**	**No. Day visits**	**Day**	**Day**
Tenby, North	0.246	3.686	0.246	5.037	0.246	0.010
Saundersfoot	0.491	7.371	0.491	10.074	0.491	0.020
Newgale Sands	0.491	7.371	0.491	10.074	0.491	0.020
Dale	0.491	7.371	0.491	10.074	0.491	0.020
Tenby, South (inc Castle and Paragon beaches)	0.491	7.371	0.491	10.074	0.491	0.020
Broad haven (Hvfdwst)	0.430	6.450	0.430	8.815	0.430	0.017
Amroth	0.430	6.450	0.430	8.815	0.430	0.017
St David's, Whitesands	0.369	5.529	0.369	7.556	0.369	0.015
Wiseman's Bridge	0.369	5.529	0.369	7.556	0.369	0.015
Freshwater E	0.369	5.529	0.369	7.556	0.369	0.015
Barafundle	0.369	5.529	0.369	7.556	0.369	0.015
Broad haven (Sth)	0.369	5.529	0.369	7.556	0.369	0.015
West Angle Bay	0.369	5.529	0.369	7.556	0.369	0.015
Manorbier	0.369	5.529	0.369	7.556	0.369	0.015
Abereiddy	0.369	5.529	0.369	7.556	0.369	0.015
Gelliswick	0.369	5.529	0.369	7.556	0.369	0.015
Nolton Haven	0.307	4.607	0.307	6.296	0.307	0.012
Marloes Sands	0.307	4.607	0.307	6.296	0.307	0.012
Martin's Haven	0.307	4.607	0.307	6.296	0.307	0.012
St Brides Haven	0.307	4.607	0.307	6.296	0.307	0.012
Coppet Hall	0.307	4.607	0.307	6.296	0.307	0.012
St David's, Caerfai	0.246	3.686	0.246	5.037	0.246	0.010
Skrinkle Haven	0.246	3.686	0.246	5.037	0.246	0.010
Porth Clais	0.246	3.686	0.246	5.037	0.246	0.010
Little Haven	0.246	3.686	0.246	5.037	0.246	0.010
Sandy Haven	0.246	3.686	0.246	5.037	0.246	0.010
Freshwater W	0.246	3.686	0.246	5.037	0.246	0.010
Pendine Sands	0.246	3.686	0.246	5.037	0.246	0.010
Angle Bay	0.184	2.764	0.184	3.778	0.184	0.007
Druidston Haven	0.184	2.764	0.184	3.778	0.184	0.007
Lydstep Haven/Beach	0.184	2.764	0.184	3.778	0.184	0.007
Waterwynch Bay	0.184	2.764	0.184	3.778	0.184	0.007
Solva	0.184	2.764	0.184	3.778	0.184	0.007
Llanreath	0.184	2.764	0.184	3.778	0.184	0.007
Priory Bay (Caldey)	0.123	1.843	0.123	2.519	0.123	0.005
Penycwm	0.123	1.843	0.123	2.519	0.123	0.005
Precipe	0.123	1.843	0.123	2.519	0.123	0.005
Llanstadwell & Hazelbeach	0.123	1.843	0.123	2.519	0.123	0.005
Castlebeach Bay	0.123	1.843	0.123	2.519	0.123	0.005
Westdale Bay	0.061	0.921	0.061	1.259	0.061	0.002
Watwick Bay	0.061	0.921	0.061	1.259	0.061	0.002
Scotch Bay	0.061	0.921	0.061	1.259	0.061	0.002
Skomer Island (N & S Haven)	0.061	0.921	0.061	1.259	0.061	0.002
Swanlake	0.061	0.921	0.061	1.259	0.061	0.002
Lindsway Bay	0.061	0.921	0.061	1.259	0.061	0.002
Hakin Point	0.061	0.921	0.061	1.259	0.061	0.002
Marros Sands	0.061	0.921	0.061	1.259	0.061	0.002
Lydstep Caverns	0.061	0.921	0.061	1.259	0.061	0.002
Conduit Point	0.061	0.921	0.061	1.259	0.061	0.002
Church Doors	0.061	0.921	0.061	1.259	0.061	0.002
Cwr Bwdy Bay	0.061	0.921	0.061	1.259	0.061	0.002
Monk Haven	0.061	0.921	0.061	1.259	0.061	0.002
Monkstone	0.061	0.921	0.061	1.259	0.061	0.002
Musslewick Sands	0.061	0.921	0.061	1.259	0.061	0.002
Mill Haven	0.061	0.921	0.061	1.259	0.061	0.002
Morfa Bychan	0.025	0.369	0.025	0.504	0.025	0.001
Porthlysgi Bay	0.025	0.369	0.025	0.504	0.025	0.001
Sandtop Beach	0.025	0.369	0.025	0.504	0.025	0.001
The Glen	0.025	0.369	0.025	0.504	0.025	0.001
Gunky	0.025	0.369	0.025	0.504	0.025	0.001
Milford Beach	0.025	0.369	0.025	0.504	0.025	0.001
Drimkin (Caldey)	0.025	0.369	0.025	0.504	0.025	0.001
Telpyn	0.025	0.369	0.025	0.504	0.025	0.001
Swallow Tree	0.025	0.369	0.025	0.504	0.025	0.001
TOTALS	***12.568***	***188.524***	***12.568***	***257.650***	***12.568***	***0.503***

Total Number of Day Visits Lost (thousands) 446.174

based on 100% of 15 days in February
and 10 days in March;
then 50% for the rest of March

Table A5.5: Impacts of Oil Spill on Specific Coastal Recreational Activities

Activity	Key Sites Affected	Number of Days Affected	Number of People Participating per Day	Total People Activity Days Lost	Comments
General Participation					
Canoeing	Whole South Pembrokeshire Coast	11 weekends (up to end of April) ½ term (one week?)	?	?	Most canoeists would have used North Pembrokeshire coast
Diving (sub aqua)	Broad Haven Little Haven St Brides Bay Martins Haven Dale Tenby Saundersfoot	None	-	None	Slight short-term visibility disturbance but cleaner now than before
Jetskiing	?	?	?	?	?
Kayaking	Some sheltered bays and caves were unpleasant due to vapours (light-headedness). Some rocks were unsightly.	None	?	None	By time season started had cleared. Programme largely unaffected - changed routes occasionally. Used same launch sites so no extra travelling.

Table A5.5: Impacts of Oil Spill on Specific Coastal Recreational Activities

Activity	Key Sites Affected	Number of Days Affected	Number of People Participating per Day	Total People Activity Days Lost	Comments
Land/Sand Yachting	*Paracarting:* Pendine Sands, Pembray Beach and Kidwelly Estuary	10 weekends (two months)	Groups of between 2 and 10	Lower bound: 20 Upper bound: 200	1 paracarter makes the kites and had international cancellations.
	Sand Yachting: Kevinsheedon (Pembray Country Park) and Pendine	4 weekends	2	Lower bound: 8 Upper bound: 16	6 weeks affected in total but 1 weekend were away at event and estimate 1 weekend would not have been suitable weather - winds were light.
Sailing	Haven Waterways Dale Gelliswick Saundersfoot	None	-	None	The season had not started. Only impacts were to attendance figures for Impaler European event and Celtic Watersports Festival, see below.
Surfing	Broadhaven (Haverfordwest) Freshwater West Manorbier Newgale Sands *Whitesands* Westdale Bay	?	?	?	Two events reorganised
Waterskiing	Particularly Milford Haven Marina	None	-	None	The season had not started. When it did, the marina looked cleaner than ever.

Table A5.5: Impacts of Oil Spill on Specific Coastal Recreational Activities

Activity	Key Sites Affected	Number of Days Affected	Number of People Participating per Day	Total People Activity Days Lost	Comments
Windsurfing	Broadhaven (Haverforwest) Dale Freshwater West Manorbier Newgale Sands *Newport Sands* Tenby *Whitesands*	?	?	?	?
Specific Events					
Impaler European Sailing event	Nayland YC	July/Aug	Expecting between 18 and 28 boats but only 9 came	About 15 boats may not have attended	Event went ahead but reduced attendance
Celtic Watersports Festival	Nayland YC	July/Aug	Disabled Sailing Teams - normally have 6 or 7 but dropped to the French, Irish (for ½ time) and Welsh only.	About 4 Disabled Sailing Teams may not have attended	Event went ahead but reduced attendance
1st round of National Series (Sand Yachting)	Pembray Beach	March	30 to 50 competitors 100 to 150 in all	Probably few	Event moved to Western Supermare at the last minute. People come from all over UK as is major National event (1st of 3 rounds in the series)

Table A5.5: Impacts of Oil Spill on Specific Coastal Recreational Activities

Activity	Key Sites Affected	Number of Days Affected	Number of People Participating per Day	Total People Activity Days Lost	Comments
Milford Haven National Ski Race (waterskiing)	Milford Haven Marina	Early May	50 skiing competitors. For each of these there are two in the boat (100). Including supporters, total number around 500.	None, same number came	Some apprehension beforehand but received letters of commendation following event. Marina cleanest ever been.

Table A5.6: General Recreation Use Values

Author and Date	Method of Valuation	Valuation Criteria	Value	Comments
Bateman et al, 1993 (Gren & Söderqvist, 1994)	CVM	Recreation value on the Broads, various question techniques were used	£108 to £226 per household per year, depending on technique	£1993 UK study
Bell and Leeworthy, 1990 (Freeman, 1995)	TC	Consumer surplus value associated with access to beach recreation	$50.40 /beach day visit	?$1990 US study Very dependent upon the accommodation chosen
Bergstrom et al, 1990 (Gren & Söderqvist, 1994)	Consumer surplus	Recreational activity along the Gulf of Mexico coast, in Louisiana	mean: $461 per recreationist per year $27 per hectare per year economic impact on recreation was $114 per hectare per year	$1993 US study
Bockstael, Hanemann and Kling, 1987 (Freeman, 1995)	RUM	Seasonal benefits to beach users for 10% reduction in oil, faecal coliform bacteria and chemical oxygen demand	$10.48 /person/year	?$1987 US study

Table A5.6: General Recreation Use Values

Author and Date	Method of Valuation	Valuation Criteria	Value	Comments
Carson RT & Mitchell RC, 1993	CVM	Mean unadjusted annual household willingness to pay amounts for different levels of national water quality by type of bid. four types of bid were given: first bid (with no other information), corrected bid (allowed to change their first bid after it was repeated to them), informed bid (told how much they currently paid in taxes) and pushed bid (told their original bid was not sufficient)	**Non-boatable to boatable**: first bid: $111 corrected bid: $106 informed bid: $125 pushed bid $141 **Boatable to fishable**: first bid: $80 corrected bid: $80 informed bid: $96 pushed bid: $108 **Fishable to swimmable**: first bid: $89 corrected bid: $89 informed bid: $102 pushed bid: $116 **Total**: first bid: $280 corrected bid: $275 informed bid: $323 pushed bid: $366	$1993 US study
Carson & Mitchell, 1993	CVM	Value for boatable and swimmable water	Boatable (mean): $93/household/yr Swimmable (mean): $78/household/ yr	$1990 (refers to freshwater quality) US study
Constanza, 1988	CVM	Value of recreation as part of an overall value for the Louisiana Wetlands	$3.07/per annum/per acre (As part of the overall value of the wetlands of $168.78 pa/acre)	$1983 US study (transferability more questionable)

Table A5.6: General Recreation Use Values

Author and Date	Method of Valuation	Valuation Criteria	Value	Comments
Devouges & Smith, 1986 (Hanley, 1989)	CVM, TC	Improving water quality from: boatable to game fishing	**Contingent Valuation** direct question $21.18 Payment card $30.88 **Travel Cost** $7.16	$1981 on Monongahela River, Pennsylvania US study
		boatable to swimming	**Contingent Valuation** direct question $31.18 Payment card $51.18 **Travel cost** $28.86	
Everett, 1978	Questionnaire and use of 'Clawson Method'	Monetary value of recreational benefits of wildlife for Dalby Forest Area (North Yorkshire Moors)	£157/ha/yr for the total recreation benefits, of which £38 is attributable to wildlife	£1976 UK study
Farber & Costanza, 1987 (Gren & Söderqvist, 1994)	TC	Recreation value of wetlands in Louisiana	Total: $155 per hectare per year, of which recreation is 14% ($21.70)	$1993 US study
Feenberg and Mills, 1980 (Freeman, 1995)	RUM	Seasonal benefits to beach users for 10% reduction in oil, total bacteria and colour	$3.23 /person/year	?$1980 US study
Fouquet et al, 1991	CVM	WTP to protect hurst Spit. Includes non-use value	£9.20 - £40.60 /visitor/year	£1991 UK study
		Lost value of enjoyment per trip from erosion	£3.72 /adult visit	

Table A5.6: General Recreation Use Values

Author and Date	Method of Valuation	Valuation Criteria	Value	Comments
Georgiou et al, 1996	CVM	WTP additional water rates to ensure that bathing water constantly passes EC standard	**Great Yarmouth** Mean £12.64 all per household £14.16 holiday per household £10.24 day trippers per household £9.33 local residents per household Median £0.00 for all per household **Lowestoft** Mean £14.32 all per household £14.49 holiday per household £14.53 day trippers per household £13.50 local residents per household Median £4.75 all per household £5.00 holiday per household £4.50 day trippers per household £0.00 local residents per household	£1996 UK study
Green and Tunstall, 1991 (Bateman et al, 1993)	CVM	WTP to protect coast - survey of residents in 5 towns	£21.90 - £25.16 /resident/year	?£1991 UK study
Green et al, 1990	CVM	WTP for day of beach recreation, survey of 6 sites around UK	Mean £7.75 /adult recreation day	£1988 UK study
		WTP for day of beach recreation, survey of 4 sites around UK	Mean £7.55 /adult recreation day	£1989 UK study

Table A5.6: General Recreation Use Values

Author and Date	Method of Valuation	Valuation Criteria	Value	Comments
		Lost value from beach erosion	Mean £1.90 /recreation day	£1989 UK study
Harley and Hanley, 1989	CVM	WTP to maintain access to three different nature reserves	£1.13 - £2.53 /visit to one reserve	£1989 UK study
Hausman, Leonard and McFadden, 1995 (Sandström, 1996)	TCM	Total loss in consumer surplus caused by Exxon Valdez oil spill	Total: $3.8m	($1995?) US study
Institute of Offshore Engineering, 1995 (FWR)	CVM	WTP to upgrade sewage system discharging into Torry Bay to reduce litter on shore, improve seawater quality, enhance recreation and benefit wildlife	£39.39 /household/year	?£1995 UK study some component is non-use but not separated out
Kaoru, 1993	CVM	WTP for coastal pond water quality improvements on island of Martha's Vineyard, Mass.	**Use value**: $33.69/respondent/year	$1989 (component of total WTP of $131.03) US study

Table A5.6: General Recreation Use Values

Author and Date	Method of Valuation	Valuation Criteria	Value	Comments
Kearney, 1991 (King, 1994)	CVM	Coastal recreational WTP per day	Values split into general (walkers, picnickers, swimmers etc.) and specialised (water sports users and anglers). General: Foreign visitor: £46.35 Out of state visitor: £4.29 Local uses: £4.29 Specialised: Foreign visitor: £66.14 Out of state: £22.92 Local users: £15.02	£1993 US study
Lant & Roberts, 1990 (Gren & Söderqvist, 1994)	CVM	Interviews to determine wtp to improve changes in river quality	Poor to fair: $42 fair to good: $52 good to excellent $53 all per household per year	$1993 US study
Leeworthy and Wiley, 1991 (Freeman, 1995)	?	Consumer surplus for visits to Island Beach State Park, New Jersey coast	$24.74 - $88.17 /person/day	?$1991 US study
Leeworthy, 1991 (Freeman, 1995)	TC	Consumer surplus associated with access to a unique state park and reef in Florida	$223 - $3,448 /person/day	?$1991 US study

Table A5.6: General Recreation Use Values

Author and Date	Method of Valuation	Valuation Criteria	Value		Comments
Maidwell, 1995 (FWR)	CVM	Valuation of bathing water quality improvement from failure to meet EEC Directive (76/160) to that safe for swimming	Mean £11.18 /household/year		?£1995 UK study
McConnell, 1986 (Freeman, 1995)	TC and Survey	Damages to beach users from PCB contamination of the harbour in New Bedford, Massachusetts	$3 - $4 /household/year		? US study
Parsons & Kealy (1992)	RUM	Value of water quality benefits in Wisconsin lakes per choice occasion; where low standard refers to improving water quality so no lakes have dissolved oxygen of zero; and high standard is water quality at all lakes is improved so dissolved oxygen is maintained at 5 ppm at all times for all lakes	**Low standard**: swimming Fishing Boating Viewing **High standard**: swimming Fishing Boating Viewing	 $0.83 $0.50 $0.19 $0.15 $4.22 $0.94 $8.15 $6.64	$1987 US study

Table A5.6: General Recreation Use Values

Author and Date	Method of Valuation	Valuation Criteria	Value	Comments
PDE, 1991	CVM	WTP for beach stabilisation	**Holiday** Beach charge: mean £1.11 per adult per visit **Day trip** Beach charge: mean £1.36 per adult per visit Car park charge: £1.46 per car per visit **Local** Beach charge: £0.88 per adult per visit Community charge: £9.31 per adult per year **Residents** Community charge: £8.97 per adult per year	£1991 UK study
Penning-Rowsell et al, 1992 in King, 1994	CVM	WTP for coastal recreation (per day)	Mean: £7.54	£1992(?). For all visitor types UK study
Penning-Rowsell et al, 1992 in Bateman et al, 1993	CVM	Recreational value of cliff tops	£1.83 - £2.83 /resident/year	?£1992 UK study

Table A5.6: General Recreation Use Values

Author and Date	Method of Valuation	Valuation Criteria	Value	Comments
Penning-Rowsell et al, 1991	CVM	Surveys of coastal recreation 1987-1990: value of enjoyment of this/today's visit (mean WTP)	**Beaches and Promenades** **1988** Scarborough £4.93 (users) Clacton £9.96 (users) Dunwich £6.87 (users) Filey £3.68 (users) Frinton £9.56 (users) Hastings £7.72 (users) Spurn Head £8.50 (users) **1989** Bridlington £5.91 (users) Clacton £10.52 (users) Hunstanton £8.74 (users) Morecambe £5.76 (users) **1990** Herne Bay £12.34 (users) Herne Bay £3.59 (residents) **Cliff Tops** **1988** Peacehaven £3.50 (residents)	UK study Values as given in year
Penning-Rowsell et al, 1989 in Bateman et al, 1993	CVM	Value of enjoyment per recreational visit to beaches in 4 conditions	£3.86, £6.57, £7.76 and £11.46 /adult visit	?£1989 UK study
Sandström, 1996	Random Utility Maximisation model	Total consumer surplus for reduction in nutrient load along entire Swedish coast	Estimated to be 240mSEK with the nested multinomial logit model and 540mSEK with the conditional logit model	SEK1995 Swedish study

Table A5.6: General Recreation Use Values

Author and Date	Method of Valuation	Valuation Criteria	Value	Comments
Sandström, 1996	Random Utility Maximisation model	Total consumer surplus for reduction in nutrient load in the Laholm Bay in south-west Sweden	Estimated to be 12mSEK with the nested multinomial logit model and 32mSEK with the conditional logit model	SEK1995 Swedish study
Silberman and Klosk, 1988 (Freeman, 1995)	CVM	Visit values for strip of ocean beach on north New Jersey shore	Mean $4.57	?$1988 US study Site suffering from erosion
Simmonds, 1976 (Bateman et al, 1993)	CVM	WTP for access to beach for beach users	£0.2 /group visit	?£1975 UK study
Thibodeau, 1979	?	Total value of recreational activity in wetlands, per acre per year	Small Game hunting $32.07 Waterfowl hunting $31.87 Nature study $102.02	US study
Turner and Brook, 1988 (Bateman et al, 1993)	CVM	Enjoyment per visit to beach	£15 /local visit £18 /non-local visit	?£1988 UK study
USDC, 1985	TC	Consumer surplus for use of site in Gulf of Mexico	$3.9 million/year	$1985 US study
	CVM	Present value of site in Gulf of Mexico (assuming 8% discount)	$5.7 million	$1985 US study
		Present value of an estuarine acre	8% discount rate $46 3% discount rate $181	$1985 US study
Willis and Benson, 1988 (Turner et al, 1992)	TCM	Consumer surplus for nature reserve recreation	Consumer surplus £0.60 to £1.70 per visit of £1.02 to £2.30 per visit depending on TC estimate	£1988. Based on three sites (n=94, 461, 463) UK study

Table A5.6: General Recreation Use Values

Author and Date	Method of Valuation	Valuation Criteria	Value	Comments
Willis, 1990 in Bateman et al, 1993	CVM	Hypothetical trust fund for SSSIs and nature reserves - option price including use and non-use values	IOB and BES members £4.54 /person Households up to 200km radius £0.82 /person	?£1990 UK study
Willis and Garrod, 1991 and 1992 (Bateman et al, 1993)	CVM	WTP to preserve the current Yorkshire Dales landscape	Mean £22.12 /visitor household/year Mean £26.03 /resident household/year	£1991 UK study
		WTP to prevent flooding and preserve the Norfolk Broads landscape	Mean £76.74 (Open Ended) £83.67 (Iterative Bidding)	£1991 UK study
Willis et al, 1995	CVM (payment card format)	WTP for benefits of ESA scheme of residents and visitors	**Somerset Levels and Moors ESA** Residents: £17.53 per year Visitors: £13.51 per year **South Downs ESA** Residents: £27.52 per year Visitors: £24.26 per year	£1993 UK study
Wiltman, 1981	Hedonic price model	Value (cost) of debris on the most popular beaches in Cape Cod (n=196)	Mean: -\$193.83 (values range between -\$383.59 and \$6.28)	\$1981. US study Loss occurs to suppliers of rented homes

ANNEX 6: DATA ON COMMERCIAL FISHERIES

Annex 6 Contents:

A6.1 Claims to the IOPC Fund

Claims to the IOPC Fund for Costs to Fisheries to 31/12/96

Claimant	Nature of Claim	Amount of Claim (£ million)	Amount Approved[a] (£ million)	Amount Paid (£ million)
10 fishermen in the area affected by the ban	Claims for lost fishing gear. Some claims were rejected on the basis that gear was not in the water or was outside the affected area.		£0.040	£0.028
148 fishermen in the area affected by the ban	Claims for loss of income due to the fishing ban, with some claims for damage to nets and loss of pots. The majority catching whelks and crustaceans with some white fish. 112 claims paid..		£5.449	£4.194
1 oyster farmer in the area affected by the ban	Stock contaminated by the spill and loss of market due to the ban. 75% payments for stock which normally would have been harvested and sold since the incident.		£0.112	£0.084
7 fishermen outside area affected by ban	Reductions in catch of squid and whitefish in the Bristol Channel, North Devon and Swansea.	£0:112		
14 fish and shellfish processors in the area affected by the ban	Claims for being deprived of raw materials during the ban. Companies trade in white fish (2), whelks (5), crustaceans (5) and cockles, whelks and mussels (4).			£1.148
3 fish and shellfish processors outside the area affected by the ban	One company based in New Quay (80km from the ban area) and one in Newport (160km from the ban area). Claims admissible in principle due to the close proximity to the ban area. One claim from a Cornish based company was rejected due to the 400km distance from the ban area.			
Total			£5.602	£5.454

Source: IOPC, 1996, 1997a and 1997c

[a] It is reported that rejected claims amount to £7 million.

A6.2 Cockles At the Burry Inlet

Table A6.2: Landings Figures for the Cockle Fishery at Burry Inlet

Year	Size of Catch		First Sale Value (£)	
	Tonnes	%❖	£	%✦
1993	2,806.5	14%	505,170	-11%
1993	2,756.0	12%	509,865	-10%
1995	2,392.0	-1%	458,135	-22%
1996	2,415.5	0%	559,272	0%

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern

Effect of the FEZ

In 1994 and 1995, cockle gathering took place all year round at the Burry inlet. However in 1996, the FEZ prevented cockle gathering between 28 February and 3 July.

Catches and Landings

Cockle landings in 1996 were down by over 10% on 1993 and 1994.

Value

Despite this, the first sales value of the cockle fishery was greater in 1996 than in the three previous years (£560 000 compared with the high in 1994 of £510 000). This was due to the high demand for cockles and the resultant high price paid to gatherers. The end-sale value of the Burry cockle fishery is though to be between four and five times higher than this (i.e. between £2.24 million and £3.35 million).

A6.3 Cockles on the Three Rivers Estuary

Table A6.3: Landings Figures for the Cockle Fishery at Three Rivers Estuary

Year	Size of Catch		First Sale Value (£)	
	Tonnes	%❖	£	%✦
1993	4,975.0	73%	895,500	65%
1994	737.0	-84%	136,713	-130%
1995	2,725.0	50%	488,931	36%
1996	1,354.0	0%	314,042	0%

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern

Effect of the FEZ

In 1996, cockle beds were closed between 1 February and 14 September. The FEZ was only partly responsible for this closure as the cockle beds are normally closed between later winter and early summer to protect spawning stocks. For example in 1995 the cockle bed was closed to commercial gathering on 26 January and re-opened on 5 August in 1995.

Catches or Landings

Cockle landings were considerably down on 1993 and 1995 but up on 1994.

Value

The change in the value of landings reflects the change in their size.

A6.4 Mussels

Table A6.4: Landings Figures for the Mussel Fishery

Year	Size of Catch		First Sale Value (£)	
	Tonnes	**%❖**	**£**	**%✦**
1993	181.0	-81%	34,390	-84%
1994	521.0	37%	36,000	-76%
1995	360.0	9%	26,600	-138%
1996	327.0	0%	63,300	0%

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern

Effect of the FEZ

The FEZ had some impact on 80% of mussels landings in 1996, but there were also other factors contributing to the poor supply of good quality mussels. This included a prohibition to gathering on the north side of the Burry Inlet under the EC Directive on Bivalve Molluscs and a shortage of adult stock.

Catches or Landings

Cockle landings were down on those of 1994 and 1995, but up on 1993.

Value

Despite this, the value of mussels landed was higher in 1996 than in the three previous years. This may have been due, in part, to a high demand in Europe in 1996.

A6.5 Winkle

Table A6.5: Landings Figures for the Winkle Fishery

Year	Size of Catch		First Sale Value (£)	
	Tonnes	%❖	£	%✦
1993	32.0		19,264	
1994	65.0		76,830	
1995	37.6		48,000	
1996	small		small	

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern

Effect of the FEZ

The FEZ was not lifted on winkles until 1997 and had a severe impact on winkle landings in 1996.

Catches or Landings

Winkle landings were expected to be minimal.

Value

The value of winkle landings is expected to match the size of landings in 1996.

A6.6 Oysters

Table A6.6: Landings Figures for the Oyster Fishery

Year	Size of Catch		First Sale Value (£)	
	Tonnes	%❖	£	%✦
1993				
1994				
1995	5.0	91%	10,200	91%
1996	0.5	0%	900	0%

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern

Effect of the FEZ

The FEZ prevented the issue of permits to dredge for oysters upstream of Neyland Bridge, Milford Haven.

Catches or Landings

1996 oyster landings were 90% down on 1995, with all of the 1995 landings coming from Neyland Bridge.

Value

The value of oyster landings reflected the size of these landings in 1996.

A6.7 Scallops

Table A6.7: Landings Figures for the Scallop Fishery

Year	Size of Catch		First Sale Value (£)	
	Tonnes	%❖	£	%✦
1993	28.0	-396%	34,071	-363%
1994	70.0	-99%	91,999	-71%
1995	28.0	-396%	43,780	-260%
1996	139.0	0%	157,611	0%

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern.

Effect of the FEZ

In 1996, the majority of scallop landings were taken from the north and west of the SWSFC District and from outside the District. The FEZ had little impact on landings of scallops.

Catches or Landings

1996 scallop landings were twice those in 1994 and four times whose in 1993 and 1995.

Value

1996 prices appear to be slightly lower then those in previous years.

A6.8 Whelks

Table A6.8: Landings Figures for the Whelk Fishery

Year	Size of Catch		First Sale Value (£)	
	Tonnes	%❖	£	%✦
1993	0.0		0	
1994	0.0		0	
1995	1,250.0	-47%	564,300	-79%
1996	1,841.0	0%	1,009,568	0%

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern

Effect of the FEZ

The two main periods for whelk fishing are spring and autumn, with fishing being hampered in the summer by the high water temperatures and in the winter due to spawning activity. The FEZ stopped fishing for whelks in Camarthen Bay in the spring peak, however, whelks were being landed by large Devon vessels fishing outside the FEZ.

Catches or Landings

The catch was dominated by the larger vessels which haul up to 2 000 pots per day. As a result, monthly catches remained relatively constant even when the FEZ was lifted and 16 local vessels resumed whelk fishing.

Catches for 1997 are reported to be up 30%.

Value

When the FEZ was lifted at the end of August, markets were supplied from elsewhere. This and the strength of the pound also reduced the price for whelks from a peak of £650/tonne in 1995 to £350-£400/tonne in September 1996. Thus the decline in value of the whelk catch was much greater than the reduction in its size (i.e. while catches reduced by almost 50% from 1995, value declined by almost 80%).

In 1997 overall earnings are reported to be similar to previous years despite the 30% increase in catch. This is due to the strength of the £ which has forced fishermen to reduce prices.

A6.9 Bass

Table A6.9: Landings Figures for the Bass Fishery

Year	Size of Catch		First Sale Value (£)	
	Tonnes	%❖	£	%✦
1993	25.0	-160%	121,253	-195%
1994	64.0	-2%	330,031	-8%
1995	109.0	40%	480,603	26%
1996	65.0	0%	357,500	0%

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern

Effect of the FEZ

The FEZ had the potential to affect in excess of 90% of bass catches, however, the FEZ was lifted in May, which allowed fishermen to take advantage of the main summer fishing season. As a result, only 5% of the catch was affected by the FEZ.

Catches or Landings

Data reveals that bass catches had been increasing from 25 t in 1993 to 109 t in 1995. Catches in 1996 were down on those in 1995, but this is though to be due to heavy fishing effort in previous years and changes in the migratory behaviour of fish. Catches in 1997 are reported to be good.

Part of the bass catch is recreational as opposed to commercial. In both 1995 and 1996, it is estimated that the recreational catch represented just over 6% of the commercial catch (i.e. 7 t and 4.2 t respectively). Catch figures are based on adjusted MAFF log book data. MAFF data only apply to vessels over 10m in length and thus underestimate total catch. In 1996 MAFF data suggested a catch of 52 t.

Value

Prices paid for fish in 1996 were up on those in previous years.

A6.10 Demersal

Table A6.10: Landings Figures for the Demersal Fishery

Year	Size of Catch		First Sale Value (£)	
	Tonnes	%❖	£	%✦
1993	2,042.0	13%	3,073,994	22%
1994	1,897.0	7%	2,684,246	10%
1995	1,657.0	-7%	1,897,662	-27%
1996	1,770.0	0%	2,406,157	0%

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern

Effect of the FEZ

Most landings of demersal fish are sourced from outside the 6 mile limit of the SWSFC District and were thus not affected by the ban.

Catches or Landings

Catches fluctuate little in terms of tonnes caught. The 1996 catch was up on that for 1995. Catches for 1997 are reported to be on a par with previous years.

Catch figures are those reported to MAFF which apply to vessels over 10m in length, thus these underestimate total catch. The scale of this underestimate is not known, although a survey of ports in the SWSFC District in 1995 identified 35 vessels over 10m and 299 less than 10m.

Value

Prices paid for fish in 1996 were up on those for 1995.

A6.11 Pelagic

Table A6.11: Landings Figures for the Pelagic Fishery

Year	Size of Catch		First Sale Value (£)	
	Tonnes	%❖	£	%✦
1993	20.0	-215%	10,000	-443%
1994	5.0	-1160%	2,000	-2613%
1995	4.6	-1270%	2,300	-2259%
1996	63.0	0%	54,267	0%

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern

Effect of the FEZ

Not known.

Catches or Landings

The 1996 catch was much higher than that in previous years. Catches for 1997 are reported to be on a par with previous years.

Catch figures are those reported to MAFF which apply to vessels over 10m in length, thus these underestimate total catch. The scale of this underestimate is not known, although a survey of ports in the SWSFC District in 1995 identified 35 vessels over 10m and 299 less than 10m.

Value

Prices paid for fish in 1996 appear to be twice those paid in previous years.

A6.12 Squid, etc.

Table A6.12: Landings Figures for the Squid, etc. Fishery

Year	Size of Catch		First Sale Value (£)	
	Tonnes	%❖	£	%✦
1993				
1994				
1995	43.0	9%	78,933	10%
1996	39.0	0%	70,919	0%

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern

Effect of the FEZ

Not known.

Catches or Landings

The Swansea squid fishery was less productive in 1996 than previous years, probably due to trawlers trialing whelk gear and thus not catching squid.

Value

The value in 1996 was similar to that for 1995.

A6.13 Lobster

Table A6.13: Landings Figures for the Lobster Fishery

Year	Size of Catch		First Sale Value (£)	
	Tonnes	%❖	£	%✦
1993	70.5	68%	575,070	61%
1994	62.5	64%	537,371	58%
1995	70.2	68%	613,298	64%
1996	22.4	0%	223,220	0%

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern

Effect of the FEZ

The FEZ affected 90% of the lobster catch. The lobster season is typically between April and September. The removal of the FEZ coincided with the normal winding down period of the lobster season.

Catches or Landings

Lobster landings in January 1996 were similar to those in 1995, however there was a rapid drop in February 1996 with catches between May and August 1996 being 80% down on those for 1995. After the FEZ was removed, catches improved to 2995 levels. Indeed by December 1996, catches were twice those for 1995. In total, lobster catches were down almost 70% on 1995 catches. Catches of lobster in 1997 are reported to be very good due to under-fishing in 1996. Catches have improved in terms of both the numbers caught and the size of individual specimens.

Landings per unit effort (LPUE) was 12.6% down on 1995 which bucks the general upward trend since 1990. This is due to lower LPUE figures for areas outside the FEZ which dominate the higher LPUE figures which were achieved inside the FEZ once it was lifted.

Value

Lobster prices were slightly up on 1995.

A6.14 Edible Crab

Table A6.14: Landings Figures for the Edible Crab Fishery

Year	Size of Catch		First Sale Value (£)	
	Tonnes	%❖	£	%✦
1993	445.0	38%	441,471	36%
1994	440.0	38%	380,010	25%
1995	528.0	48%	570,686	50%
1996	274.4	0%	284,277	0%

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern

Effect of the FEZ

The FEZ had the potential to affected 70% of the crab catch. The cock crab is mainly caught in the spring and early summer, but catches are traditionally low between January and March. The removal of the FEZ coincided with the beginning of the autumn hen crab fishery.

Catches or Landings

Between May and August 1996, catches were 75% down on 1995 and whilst these improved with the lifting of the ban, they die not increase to 1995 levels. In total, edible crab catches were down almost 50% on 1995. Catches in 1997 are reported to be average to good.

LPUE were 26% up on 1995 which continues the general upward trend since the early 1980's. However, the size of the increase is an effect of the FEZ. Fishing could only take place from September, the autumn and early winter period traditionally producing the best crab landings.

Value

Edible crab prices were slightly down on 1995.

A6.15 Spider Crab

Table A6.15: Landings Figures for the Spider Crab Fishery

Year	Size of Catch		First Sale Value (£)	
	Tonnes	%❖	£	%✦
1993	123.0	69%	108,446	69%
1994	147.0	74%	129,630	74%
1995	215.0	82%	203,442	84%
1996	38.7	0%	33,303	0%

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern

Effect of the FEZ

The normal in-shore fishery was completely interrupted by the FEZ.

Catches or Landings

Between May and August 1996, catches were over 90% down on 1995. However, 1996 spider crab catches are best compared with those for 1994 as 1995 was an "exceptional" year. 1996 catches were almost 40% down on 1994, with off-shore fishery landings (i.e. outside the 6 mile limit) boosting catches later in the season. Catches in 1997 are reported to be good.

LPUE was 25% down on 1995 which bucks the general upward trend since 1990. This is thought to be due to the FEZ which prevented fishing in the summer months when the majority of spider crab are landed.

Value

Spider crab prices were slightly down on 1995.

A6.16 Crawfish

Table A6.16: Landings Figures for Crawfish

Year	Size of Catch		First Sale Value (£)	
	Tonnes	%❖	£	%✦
1993	8.6	95%	109,017	95%
1994	1.2	67%	16,534	65%
1995	0.9	53%	10,669	46%
1996	0.4	0%	5,796	0%

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern

Effect of the FEZ

Crawfish are normally harvested from areas affected by the FEZ. The lifting of the ban allowed some fishing to resume in the autumn.

Catches or Landings

The crawfish catch was over 50% down on that in 1995, but has been steadily declining since a peak in 1992. Catches in 1994 and 1995 show a return to catch levels of the 1980's. Catches in 1997 are reported to be very low.

LPUE was 62% down on 1995 which continues the general downward trend since 1980. However, the steep decline is though to be due to the FEZ.

Value

Crawfish prices were slightly up on 1995.

A6.17 Velvet Crab

Table A6.17: Landings Figures for the Velvet Crab Fishery

Year	Size of Catch		First Sale Value (£)	
	Tonnes	%❖	£	%✦
1993	33.4	84%	44,312	84%
1994	39.4	86%	34,744	80%
1995	24.7	78%	34,296	80%
1996	5.5	0%	6,978	0%

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern

Effect of the FEZ

The FEZ contributed to a decline in catch with other factors including lower water temperatures and possibly a general decline in the fishery.

Catches or Landings

Velvet crab landings were down by nearly 80% from 1995 levels.

Value

Velvet crab prices were slightly down on 1995.

A6.18 Prawn

Table A6.18: Landings Figures for the Prawn Fishery

Year	Size of Catch		First Sale Value (£)	
	Tonnes	%❖	£	%✦
1993	32.0	94%	320,000	93%
1994	17.5	90%	175,000	87%
1995	4.1	56%	44,975	50%
1996	1.8	0%	22,294	0%

❖ (Catch in year of concern - Catch in 1996) / Catch in year of concern
✦ (Value in year of concern - Value in 1996) / Value in year of concern

Effect of the FEZ

The prawn fishery takes place mainly in the winter in the Fishguard area, thus it was not affected by the FEZ.

Figure A6.1: Prices for Mollusa

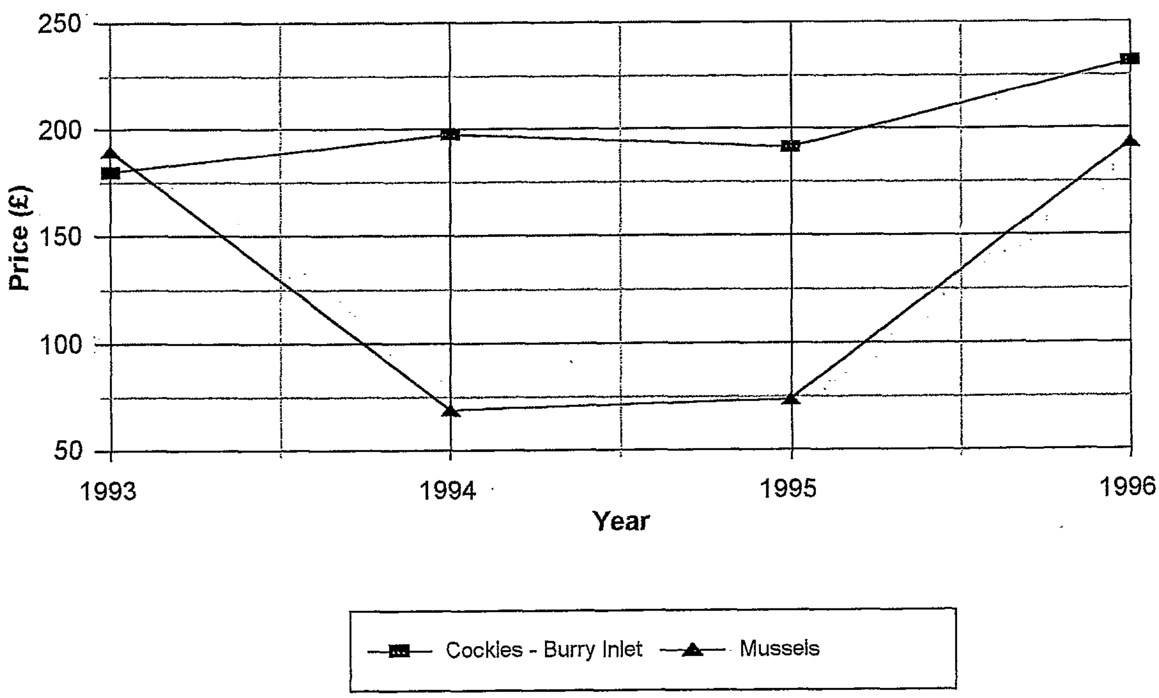


Figure A6.2: Prices for White Fish

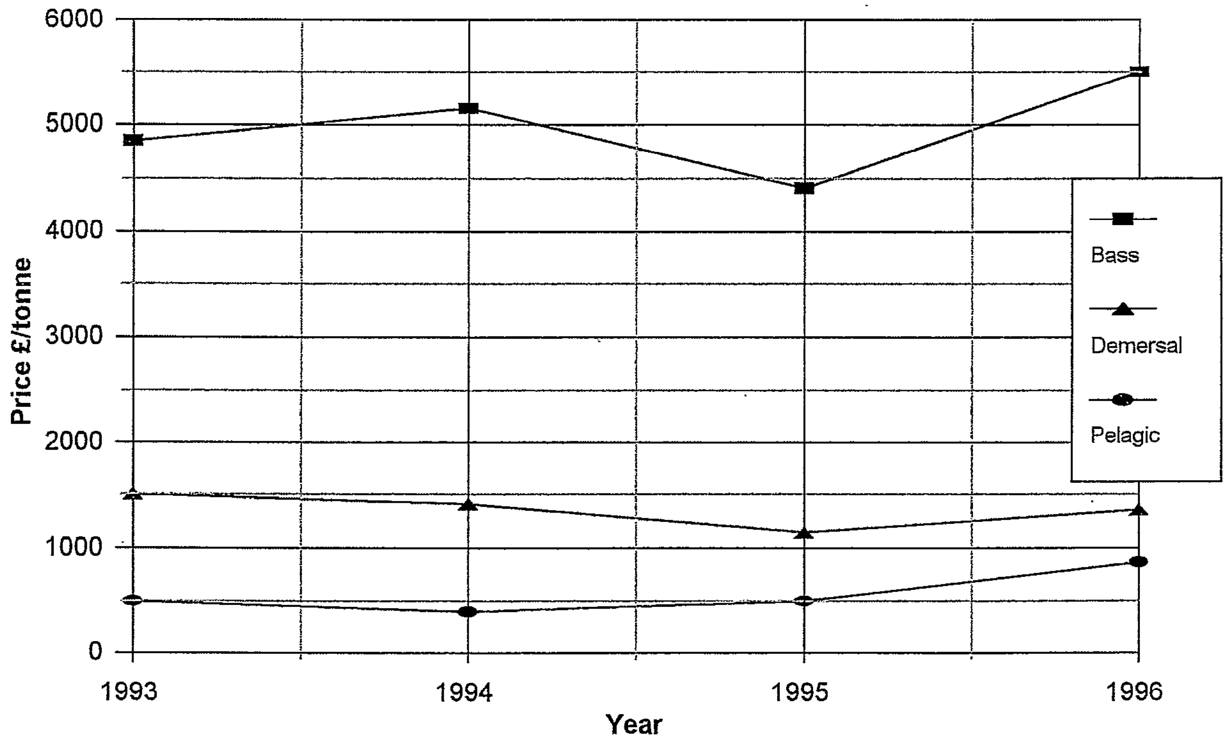
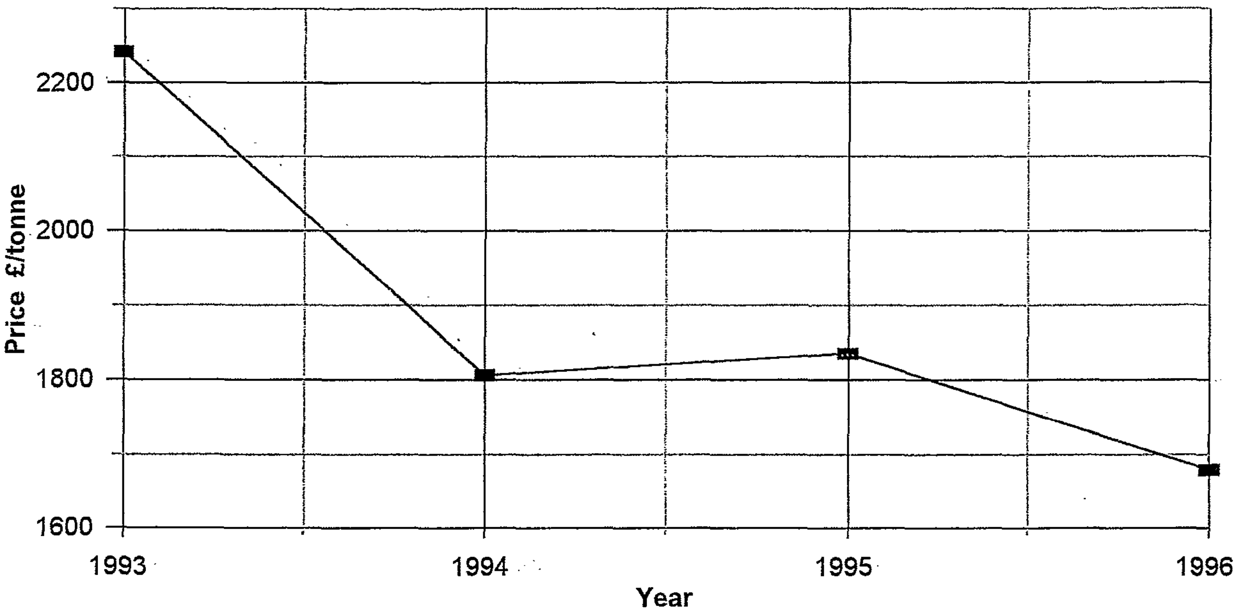


Figure A6.3: Prices for Crustaceans



ANNEX 7: DATA IN SUPPORT OF RECREATIONAL FISHERIES

Annex 7 Contents:

Table A7.1: Economic Use Values for Angling

Author and Date	Method of Valuation	Valuation Criteria	Value	Comments
Cameron, 1992 (Freeman, 1995)	TC and CVM (joint)	Per trip value to access Red Drum fishery, Texas Coast	$91	$1991
Cameron, 1988 (Freeman, 1995)	CVM	Per trip value to access Pacific Salmon fishery, British Columbia	$34.22	
Carson & Mitchell, 1993	CVM	Value for fishable water quality	Mean: $70/household/year	$1990 (refers to freshwater quality)
Dunn et al, 1989 (FWR)	CVM	Value of one-day fishing trip for sea bass angling	£2.59 /angler/trip	£1989
FWR Manual, 1996	CVM/estimates	WTP for migratory salmonoid anglers (freshwater/rivers)	£11.58/person/trip for C1 fishery £11.95/person/trip for T2 fishery £18.70/person/trip for T1 fishery £25.66/person/trip for S1 fishery	£1996
FWR Manual, 1996	CVM	Recreational sea angling unit values	£3.38/angler/trip	£1989
Green et al, 1992	?(CVM)	Value of river water improvements to a standard sufficient to support fish species	£0.57 for coarse fishing £0.65 for trout	£1992
		Presence of more desirable fish in a river	£6.10 for coarse fish £13.90 for trout £14.60 for salmon	£1992

Table A7.1: Economic Use Values for Angling

Author and Date	Method of Valuation	Valuation Criteria	Value	Comments
Huppert, 1989 (Freeman, 1995)	TC	Per trip value to access Striped Bass and Salmon fishery, San Francisco Bay	$77 (maximum likelihood)	
Leeworthy, 1990 (Freeman, 1995)	TC	Per trip value to access King Mackerel fishery, Florida	$56.40	$1991
Morey, et al, 1991 (Freeman, 1995)	RUM (random utility model)	Per trip value to access Atlantic Salmon fishery, Penobscot River, Maine	Mean $96 Median $83	$1991
Norton et al, 1983 (Freeman, 1995)	TC	Per trip value to access Striped Bass fishery	Mid Atlantic $279 South Atlantic $190 New England $142 Chesapeake $64	$1991
Parsons & Kealy (1992)	RUM	Value of water quality benefits in Wisconsin lakes per choice occasion; where low standard refers to improving water quality so no lakes have dissolved oxygen of zero; and high standard is water quality is improved so dissolved oxygen is maintained at 5 ppm at all times for all lakes	**Low standard**: Fishing $0.50 **High standard**: Fishing $0.94	$1987
Rowe et al, 1985 (Freeman, 1995)	RUM	Per trip value to access Pacific Salmon fishery	California $7.43 Oregon $6.00 Washington $0.44	

Table A7.1: Economic Use Values for Angling

Author and Date	Method of Valuation	Valuation Criteria	Value		Comments
Thibodeau, 1979	?	Total value of activity in wetlands, per acre per year	Trout fishing	$13.35	
Walsh et al, 1978 (Loomis & Walsh, 1986)	CVM	The viability of fish populations for various use and non-use categories, with existence value based on the presence of clean water	Recreational use	$56 per household	$1978
Wegge et al, 1988 (Freeman, 1995)	NRUM (Nested random utility model)	Per trip value to access Pacific Salmon fishery, Alaska	$48.50		$1991

Note: Freeman, 1995 also has multi-species fishery trip values by type of trip (shore, hire boat, etc.) For pacific, Atlantic and gulf coast. Also has values for a person annual access to a single species fishery and to a multi-species fishery and values for increases in catch rates per species.

Table A7.2: Changes in Consumer Surplus for Salmonid Anglers

Best Estimate	**1995**	**1996**	**Comments**
Number of Members	3494	3268	Derived from known membership figures for 5 out of the 21 clubs affected.
Number of Syndicate Rods	137	110	Taken to equal the number of syndicate rods for the largest (thought to be the only) syndicate in the affected area.
Private Rods	349.4	349.4	Assumed to be 10% of club membership figures in 1995 with no change in 1996
Total angling population	3980.4	3727.4	
% change in angling population		-6.4%	
Average number of trips	33.01	27.53	From EA study (Simpson, 1997)
% change		-16.6%	
Total Number Trips	131393	102615	Total angling population in that year multiplied by the average number of trips in that year - assumes all membership reductions are due to the Sea Empress
% change		-21.9%	
Total number of reduced trips		28778	
Number of Day Permits	394	934	Derived from known membership figures for 4 out of the 21 clubs affected.
% change		137%	
Lost trips		-540	i.e. there was an increase in the number of day permits sold in 1996.
Total lost trips		28238	Number of reduced trips - the increased number of day permits.
Value per trip		£25.66	From the FWR Manual for a good salmon and sea trout river (FWR, 1996)
Value lost		£724,579	
Lower Bound Estimate	1995	1996	
Total Number Trips	124879	102615	As above but with the assumption that only 22% of the reduction in members from 1995 to 1996 is due to the Sea Empress
% change		-17.8%	
Lost trips		21723	Takes account of the increased number of day permits.
Value lost		£557,425	As above using a consumer surplus figure of £25.66
Upper Bound Estimate	1995	1996	
Number of Members	4367.5	4018.1	Assumes that 1995 membership numbers are underestimated by 25% and that 1996 membership numbers are down 8% on 1995.
Number of Syndicate Rods	137	110	As for best estimate.
Private Rods	436.75	436.75	Assumed to be 10% of club membership figures in 1995 with no change in 1996
Total angling population	4941.25	4564.85	
% change in angling population		8.0%	From EA study (Simpson, 1997)
Trips	163111	125670	
Lost trips		36900	Takes account of the increased number of day permits.
Value lost		£946,863	

Table A7.3: Summary of Fishing Locations Within the Fisheries Exclusion Zone

Beach	Rural	Type of beach	Accessibility		Major Fishing Events	Species caught
			Location	Parking		
Amroth	✔	Very large sandy/ rocky	Village	Good	Competition attracting anglers from all over country (1996) Osprey SAC Pembroke Dock annual open	
Angle Bay (Kilpaison)	✔	Mud and rocks	Good access	Present		Bass, flatfish (early in year), cod, coalfish
Barafundle Bay	✔	Sandy/cobble	Along Coast Path Long walk from parking Accessed by steep steps	Good		Tope from boats; mackerel and bass from rocks
Broad Haven Haverfordwest	✔	Sandy; surf and rock fishing; stone piers and jetties	Village	Good		Bass (best summer and late autumn) pollack, skate, rays, whiting, cod, plaice, dogfish and coalfish, flounder
Burry Inlet			Near Burry Port		Annual Burry Port Fishing Festival	Bass, cod, whiting, ray, conger
Caldey Island (Tenby)	✔		Access by boat only			Mackerel (all year); tope
Carmarthen Bay					Excellent boat fishing (cod)	Bass, cod, tope
Freshwater West	✔	Sandy/ rocky	Along Coast Path, or B road	Good		Good surf fishing and rock fishing for bass (best summer and late autumn)
The Glen	✔	Small beach				Bass, flatfish
Gunky	✔	Small beach				Bass, flatfish

Table A7.3: Summary of Fishing Locations Within the Fisheries Exclusion Zone

Beach	Rural	Type of beach	Accessibility		Major Fishing Events	Species caught
			Location	Parking		
Loughor Bridge (Swansea)		Estuary				Bass, mullet, flounder, whiting
Lindsway Bay	✔	Two sandy coves (1 large)	Access by steps			Bass, mackerel
Little Haven	✔	Very small				Sheltered
Llanelli					Llanelli Sea Anglers Festival	Bass, dogfish
Llanmadoc (Swansea)						Conger, tope, thornback, monkfish, mackerel (warmer weather)
Martin's Haven	✔	Small pebbled cove	-	Good		
Milford Haven Waterway + Daugleddau estuary		Stone piers and jetties			World Championships fish off for places in the team	Pollack, skate, rays, whiting, cod, dogfish, coalfish
Monkstone						Bass, flatfish
Morfa Bychan						Flatfish, bass (summer and winter)
Nab Head	✔	Rocks	Along Coast Path			
Newgale Sands	✔	Long, sandy and cobbles	Village	Good		Bass
Pembroke Dock (Hobb's Point and Stackpole Quay)		Rocks/ Quays		Good	Permit required for docks	Conger and skate; mackerel from rocks and boats (especially Stackpole Quay)

Table A7.3: Summary of Fishing Locations Within the Fisheries Exclusion Zone

Beach	Rural	Type of beach	Accessibility: Location	Accessibility: Parking	Major Fishing Events	Species caught
Pendine Sands	✔	Very large sandy	Good access near Pendine			Bass
Rhossili Bay						Bass, flounder
Saundersfoot (Coppet Hall)		Sandy/ shingle	Harbour		Boat fishing (excellent cod)	Bass, mackerel
Solva (Porth y Rhaw)		Rocky	Good access near to Solva			Natural harbour inlet; bass, mackerel
St Brides Haven	✔	Small sand and shingle cove	On Coast Path	Good		
Tenby, North		Long and sandy; spinning from rocks	Overlooked by Tenby town and harbour Promenade	Good	Fishing boat hire	Bass, mackerel, tope, black bream
Tenby, Old Pier					European Tope Championships (1995,1996)	Whiting, pollack, bass, cod, grey mullet, tope
Tenby, South (inc Castle Beach and Paragon Beach)	✔	Long and sandy; spinning from rocks	Adjoins Tenby golf course Promenade	Good	Fishing boat hire	Bass, mackerel, tope, black bream
Whitesand Bay (St Davids)		Long, sandy beach		Good		
Worm's Head (Swansea)		Beach and rocky foreshore			Boat and beach fishing	Bass, flatfish, ray, cod, conger, flounder

Sources: Downloaded from **Where to Fish** Internet site (http://www.where-to-fish.com)

Table A7.4: Valuation of Costs to Bass Fishing

Ward	Population	% Dyfed	number anglers	nearest bass site	distance	nearest alternative s	distance	% lost (year)	% lost due to ban	wts on-site sample	wts 1987 contacts	wtp on-site sample	wtp 1987 contacts
Dyfed	578,896		16,245							£901.33	£2,138.81	£87.88	£608.84
Abergwili	1,962	0.34%	55	Pendine	19	Swansea/Gower	28	33.33%	5.47%	£2,713	£6,437	£265	£1,833
Ammanford	1,465	0.25%	41	Llanelli	14	Swansea/Gower	18	22.03%	3.61%	£1,339	£3,177	£131	£904
Amroth	114	0.02%	3	Amroth	1	Fishguard	25	96.05%	15.75%	£454	£1,078	£44	£307
Begelly	1,742	0.30%	49	Saundersfoot	3	Fishguard	23	86.49%	14.18%	£6,249	£14,830	£609	£4,221
Betws	1,759	0.30%	49	Llanelli	13	Swansea/Gower	17	21.82%	3.58%	£1,592	£3,778	£155	£1,075
Bigyn	6,180	1.07%	173	Llanelli	2	Swansea/Gower	9	75.00%	12.30%	£19,226	£45,623	£1,875	£12,987
Brawdy	1,387	0.24%	19	Newgale Sands	6	Fishguard	10	43.75%	7.18%	£1,259	£2,986	£123	£850
Brynamman	932	0.16%	26	Llanelli	20	Swansea/Gower	23	12.33%	2.02%	£477	£1,131	£46	£322
Burry Port	4,379	0.76%	123	Burry Port	1	Swansea/Gower	24	95.83%	15.72%	£17,408	£41,307	£1,697	£11,759
Burton	1,404	0.24%	39	Lindsway Bay	8	Fishguard	22	61.43%	10.07%	£3,578	£8,489	£349	£2,417
Bynea	2,808	0.49%	79	Llanelli	4	Swansea/Gower	8	52.00%	8.53%	£6,057	£14,373	£591	£4,091
Camrose	2,307	0.40%	65	Newgale Sands	3	Fishguard	15	77.55%	12.72%	£7,421	£17,610	£724	£5,013
Carew	1,291	0.22%	36	Freshwater East	3	Fishguard	25	87.34%	14.32%	£4,677	£11,099	£456	£3,159
Carmarthen	12,247	2.12%	344	Pendine	10	Swansea/Gower	26	60.98%	10.00%	£30,977	£73,506	£3,020	£20,924
Castle	816	0.14%	23	Llanelli	20	Swansea/Gower	25	20.25%	3.32%	£686	£1,627	£67	£463
Castle	1,924	0.33%	54	Newgale Sands	7	Fishguard	16	54.00%	8.86%	£4,310	£10,227	£420	£2,911
Clynderwen	1,353	0.23%	38	Amroth	11	Fishguard	17	35.19%	5.77%	£1,975	£4,686	£193	£1,334
Cross Hands	1,394	0.24%	39	Llanelli	10	Swansea/Gower	16	37.25%	6.11%	£2,154	£5,112	£210	£1,455
Dafen	2,865	0.49%	80	Llanelli	4	Swansea/Gower	10	63.64%	10.44%	£7,563	£17,946	£737	£5,109
East Williamston	1,959	0.34%	55	Saundersfoot	1	Fishguard	26	97.86%	16.05%	£7,952	£18,870	£775	£5,371
Elli	3,169	0.55%	89	Llanelli	2	Swansea/Gower	10	80.65%	13.23%	£10,601	£25,156	£1,034	£7,161
Felinfoel	2,095	0.36%	59	Llanelli	19	Swansea/Gower	23	18.67%	3.06%	£1,622	£3,849	£158	£1,096
Ffairfach	1,155	0.20%	32	Llanelli	18	Swansea/Gower	21	13.43%	2.20%	£644	£1,527	£63	£435
Garnant	2,084	0.36%	58	Broad Haven	7	Fishguard	15	53.06%	8.70%	£4,587	£10,885	£447	£3,098
Glanamman	2,160	0.37%	61	Llanelli	15	Swansea/Gower	17	10.91%	1.79%	£977	£2,319	£95	£660
Glanymor	4,534	0.78%	127	Llanelli	1	Swansea/Gower	8	87.69%	14.38%	£16,493	£39,136	£1,608	£11,141
Glyn	2,015	0.35%	57	Burry Port	6	Swansea/Gower	14	58.70%	9.63%	£4,906	£11,642	£478	£3,314
Gorslas	3,428	0.59%	96	Llanelli	12	Swansea/Gower	19	35.00%	5.74%	£4,977	£11,810	£485	£3,362
Hakin	5,030	0.87%	141	Lindsway Bay	2	Fishguard	23	90.41%	14.83%	£18,864	£44,764	£1,839	£12,743
Hendy	2,735	0.47%	77	Llanelli	9	Swansea/Gower	13	33.33%	5.47%	£3,782	£8,974	£369	£2,554
Hengoed	3,682	0.64%	103	Burry Port	3	Swansea/Gower	12	72.97%	11.97%	£11,145	£26,447	£1,087	£7,529
Hundleton	1,163	0.20%	33	Angle Bay	2	Fishguard	26	93.90%	15.40%	£4,530	£10,750	£442	£3,060
Johnston	2,149	0.37%	60	Broad Haven	3	Fishguard	19	82.26%	13.49%	£7,333	£17,400	£715	£4,953
Kidwelly	3,183	0.55%	89	Burry Port	6	Swansea/Gower	18	64.91%	10.65%	£8,571	£20,338	£836	£5,789
Lampeter Velfry	1,342	0.23%	38	Amroth	5	Fishguard	22	76.81%	12.60%	£4,276	£10,146	£417	£2,888
Laugharne Township	1,272	0.22%	36	Freshwater East	2	Fishguard	27	91.76%	15.05%	£4,842	£11,489	£472	£3,271
Letterston	1,944	0.34%	55	Pendine	2	Swansea/Gower	25	91.25%	14.97%	£7,358	£17,461	£717	£4,970
Lamphey	1,646	0.28%	46	Newgale Sands	6	Fishguard	9	33.33%	5.47%	£2,276	£5,401	£222	£1,537
Llanboidy	1,675	0.29%	47	Amroth	9	Fishguard	19	52.46%	8.60%	£3,645	£8,649	£355	£2,462
Llanddarog	1,872	0.32%	53	Burry Port	14	Swansea/Gower	21	35.29%	5.79%	£2,741	£6,503	£267	£1,851
Llanddowror	1,646	0.28%	46	Amroth	5	Fishguard	26	80.95%	13.28%	£5,527	£13,116	£539	£3,734
Llandeilo	850	0.15%	24	Llanelli	19	Swansea/Gower	24	19.48%	3.19%	£687	£1,630	£67	£464
Llandybie	3,537	0.61%	99	Llanelli	16	Swansea/Gower	19	16.67%	2.73%	£2,445	£5,803	£238	£1,652
Llandyfaelog	1,256	0.22%	35	Pendine	10	Swansea/Gower	21	53.73%	8.81%	£2,799	£6,643	£273	£1,891
Llanegwad	1,740	0.30%	49	Burry Port	20	Swansea/Gower	26	25.00%	4.10%	£1,804	£4,282	£176	£1,219
Llanfihangel Aberbythych	1,560	0.27%	44	Llanelli	17	Swansea/Gower	23	25.00%	4.10%	£1,618	£3,839	£158	£1,093
Llangadog	1,747	0.30%	49	Llanelli	24	Swansea/Gower	27	12.64%	2.07%	£916	£2,174	£89	£619
Llangennech	4,003	0.69%	112	Llanelli	3	Swansea/Gower	10	66.67%	10.93%	£11,070	£26,268	£1,079	£7,478
Llangunnor	2,348	0.41%	66	Burry Port	13	Swansea/Gower	23	43.06%	7.06%	£4,193	£9,951	£409	£2,833
Llangwm	1,947	0.34%	55	Broad Haven	9	Fishguard	19	54.84%	8.99%	£4,429	£10,510	£432	£2,992

Table A7.5: Valuation of Costs to Cod Fishing

Ward	Population	% Dyfed	number anglers	nearest site	distance	nearest alternative site	distance	% lost (year)	% lost due to ban	wts	wts	wtp	wtp
Dyfed	578,896		10,568							£100.95	£239.55	£9.84	£68.19
Abergwili	1,962	0.34%	36	Pendine	19	Swansea/Gower	28	33.33%	5.47%	£198	£469	£19	£134
Ammanford	1,465	0.25%	27	Llanelli	14	Swansea/Gower	18	22.03%	3.61%	£98	£232	£10	£66
Amroth	114	0.02%	2	Amroth	1	Fishguard	25	96.05%	15.75%	£33	£79	£3	£22
Begelly	1,742	0.30%	32	Saundersfoot	3	Fishguard	23	86.49%	14.18%	£455	£1,080	£44	£308
Betws	1,759	0.30%	32	Llanelli	13	Swansea/Gower	17	21.82%	3.58%	£116	£275	£11	£78
Bigyn	6,180	1.07%	113	Llanelli	2	Swansea/Gower	9	75.00%	12.30%	£1,401	£3,324	£137	£946
Brawdy	1,387	0.24%	13	Newgale Sands	6	Fishguard	10	43.75%	7.18%	£92	£218	£9	£62
Brynamman	932	0.16%	17	Llanelli	20	Swansea/Gower	23	12.33%	2.02%	£35	£82	£3	£23
Burry Port	4,379	0.76%	80	Burry Port	1	Swansea/Gower	24	95.83%	15.72%	£1,268	£3,010	£124	£857
Burton	1,404	0.24%	26	Lindsway Bay	8	Fishguard	22	61.43%	10.07%	£261	£619	£25	£176
Bynea	2,808	0.49%	51	Llanelli	4	Swansea/Gower	8	52.00%	8.53%	£441	£1,047	£43	£298
Camrose	2,307	0.40%	42	Newgale Sands	3	Fishguard	15	77.55%	12.72%	£541	£1,283	£53	£365
Carew	1,291	0.22%	24	Freshwater East	3	Fishguard	25	87.34%	14.32%	£341	£809	£33	£230
Carmarthen	12,247	2.12%	224	Pendine	10	Swansea/Gower	26	60.98%	10.00%	£2,257	£5,356	£220	£1,525
Castle	816	0.14%	15	Llanelli	20	Swansea/Gower	25	20.25%	3.32%	£50	£119	£5	£34
Castle	1,924	0.33%	35	Newgale Sands	7	Fishguard	16	54.00%	8.86%	£314	£745	£31	£212
Clynderwen	1,353	0.23%	25	Amroth	11	Fishguard	17	35.19%	5.77%	£144	£341	£14	£97
Cross Hands	1,394	0.24%	25	Llanelli	10	Swansea/Gower	16	37.25%	6.11%	£157	£372	£15	£106
Dafen	2,865	0.49%	52	Llanelli	4	Swansea/Gower	10	63.64%	10.44%	£551	£1,308	£54	£372
East Williamston	1,959	0.34%	36	Saundersfoot	1	Fishguard	26	97.86%	16.05%	£579	£1,375	£56	£391
Elli	3,169	0.55%	58	Llanelli	2	Swansea/Gower	10	80.65%	13.23%	£772	£1,833	£75	£522
Felinfoel	2,095	0.36%	38	Llanelli	19	Swansea/Gower	23	18.67%	3.06%	£118	£280	£12	£80
Ffairfach	1,155	0.20%	21	Llanelli	18	Swansea/Gower	21	13.43%	2.20%	£47	£111	£5	£32
Garnant	2,084	0.36%	38	Broad Haven	7	Fishguard	15	53.06%	8.70%	£334	£793	£33	£226
Glanamman	2,160	0.37%	39	Llanelli	15	Swansea/Gower	17	10.91%	1.79%	£71	£169	£7	£48
Glanymor	4,534	0.78%	83	Llanelli	1	Swansea/Gower	8	87.69%	14.38%	£1,202	£2,851	£117	£812
Glyn	2,015	0.35%	37	Burry Port	6	Swansea/Gower	14	58.70%	9.63%	£357	£848	£35	£241
Gorslas	3,428	0.59%	63	Llanelli	12	Swansea/Gower	19	35.00%	5.74%	£363	£860	£35	£245
Hakin	5,030	0.87%	92	Lindsway Bay	2	Fishguard	23	90.41%	14.83%	£1,374	£3,261	£134	£928
Hendy	2,735	0.47%	50	Llanelli	9	Swansea/Gower	13	33.33%	5.47%	£276	£654	£27	£186
Hengoed	3,682	0.64%	67	Burry Port	3	Swansea/Gower	12	72.97%	11.97%	£812	£1,927	£79	£549
Hundleton	1,163	0.20%	21	Angle Bay	2	Fishguard	26	93.90%	15.40%	£330	£783	£32	£223
Johnston	2,149	0.37%	39	Broad Haven	3	Fishguard	19	82.26%	13.49%	£534	£1,268	£52	£361
Kidwelly	3,183	0.55%	58	Burry Port	6	Swansea/Gower	18	64.91%	10.65%	£624	£1,482	£61	£422
Lampeter Velfry	1,342	0.23%	24	Amroth	5	Fishguard	22	76.81%	12.60%	£312	£739	£30	£210
Laugharne Township	1,272	0.22%	23	Freshwater East	2	Fishguard	27	91.76%	15.05%	£353	£837	£34	£238
Letterston	1,944	0.34%	35	Pendine	2	Swansea/Gower	25	91.25%	14.97%	£536	£1,272	£52	£362
Lamphey	1,646	0.28%	30	Newgale Sands	6	Fishguard	9	33.33%	5.47%	£166	£393	£16	£112
Llanboidy	1,675	0.29%	31	Amroth	9	Fishguard	19	52.46%	8.60%	£266	£630	£26	£179
Llanddarog	1,872	0.32%	34	Burry Port	14	Swansea/Gower	21	35.29%	5.79%	£200	£474	£19	£135
Llanddowror	1,646	0.28%	30	Amroth	5	Fishguard	26	80.95%	13.28%	£403	£956	£39	£272
Llandeilo	850	0.15%	16	Llanelli	19	Swansea/Gower	24	19.48%	3.19%	£50	£119	£5	£34
Llandybie	3,537	0.61%	65	Llanelli	16	Swansea/Gower	19	16.67%	2.73%	£178	£423	£17	£120
Llandyfaelog	1,256	0.22%	23	Pendine	10	Swansea/Gower	21	53.73%	8.81%	£204	£484	£20	£138
Llanegwad	1,740	0.30%	32	Burry Port	20	Swansea/Gower	26	25.00%	4.10%	£131	£312	£13	£89
Llanfihangel Aberbythych	1,560	0.27%	28	Llanelli	17	Swansea/Gower	23	25.00%	4.10%	£118	£280	£11	£80
Llangadog	1,747	0.30%	32	Llanelli	24	Swansea/Gower	27	12.64%	2.07%	£67	£158	£7	£45
Llangennech	4,003	0.69%	73	Llanelli	3	Swansea/Gower	10	66.67%	10.93%	£807	£1,914	£79	£545
Llangunnor	2,348	0.41%	43	Burry Port	13	Swansea/Gower	23	43.06%	7.06%	£306	£725	£30	£206
Llangwm	1,947	0.34%	36	Broad Haven	9	Fishguard	19	54.84%	8.99%	£323	£766	£31	£218
Llangyndeyrn	2,983	0.52%	54	Burry Port	9	Swansea/Gower	18	52.54%	8.62%	£474	£1,124	£46	£320

Table A7.5: Valuation of Costs to Cod Fishing

Lliedi	5,247	0.91%	96	Pendine	7	Swansea/Gower	24	72.73%	11.93%	£1,153	£2,737	£112	£779
Llwynhendy	4,494	0.78%	82	Llanelli	3	Swansea/Gower	10	74.19%	12.17%	£1,008	£2,391	£98	£681
Llynfell	940	0.16%	17	Llanelli	3	Swansea/Gower	8	70.37%	11.54%	£200	£474	£19	£135
Maenclochog	1,580	0.27%	29	Fishguard	13	Fishguard	13	0.00%	0.00%	£0	£0	£0	£0
Manorbier	1,887	0.33%	34	Freshwater East	2	Fishguard	27	93.10%	15.27%	£531	£1,260	£52	£359
Manordeilo	1,496	0.26%	27	Llanelli	22	Swansea/Gower	26	14.46%	2.37%	£65	£155	£6	£44
Martletwy	1,280	0.22%	23	Freshwater East	11	Fishguard	19	41.67%	6.83%	£161	£382	£16	£109
Merlin's Bridge	1,871	0.32%	34	Lindsway Bay	8	Fishguard	8	0.00%	0.00%	£0	£0	£0	£0
Milford	8,619	1.49%	157	Lindsway Bay	4	Fishguard	22	81.82%	13.42%	£2,131	£5,057	£208	£1,440
Myddfai	640	0.11%	12	Llanelli	29	Swansea/Gower	31	8.00%	1.31%	£15	£37	£2	£10
Myddnfych	1,184	0.20%	22	Llanelli	14	Swansea/Gower	18	21.05%	3.45%	£75	£179	£7	£51
Narberth	2,965	0.51%	54	Amroth	6	Fishguard	20	71.88%	11.79%	£644	£1,528	£63	£435
Newchurch	1,169	0.20%	21	Pendine	13	Swansea/Gower	28	51.69%	8.48%	£183	£433	£18	£123
Neyland	3,966	0.69%	72	Lindsway Bay	6	Fishguard	23	72.22%	11.84%	£866	£2,054	£84	£585
Pantyffynnon	1,215	0.21%	22	Llanelli	13	Swansea/Gower	18	26.32%	4.32%	£97	£229	£9	£65
Pembrey	3,679	0.64%	67	Burry Port	4	Swansea/Gower	15	74.47%	12.21%	£828	£1,965	£81	£559
Pembroke & Pembroke Dock	15,881	2.74%	290	Pembroke Dock	1	Fishguard	25	96.00%	15.74%	£4,608	£10,934	£449	£3,112
Penally	1,421	0.25%	26	Tenby beaches	3	Fishguard	28	90.11%	14.78%	£387	£918	£38	£261
Penygroes	2,203	0.38%	40	Llanelli	13	Swansea/Gower	18	27.59%	4.52%	£184	£436	£18	£124
Pontamman	1,289	0.22%	24	Llanelli	15	Swansea/Gower	18	17.24%	2.83%	£67	£159	£7	£45
Pontyberem	2,797	0.48%	51	Burry Port	9	Swansea/Gower	17	47.17%	7.74%	£399	£946	£39	£269
Prendergast	1,790	0.31%	33	Broad Haven	9	Fishguard	15	42.86%	7.03%	£232	£550	£23	£157
Priory	2,530	0.44%	46	Broad Haven	6	Fishguard	17	64.15%	10.52%	£491	£1,164	£48	£331
Quarter Bach	1,093	0.19%	20	Llanelli	21	Swansea/Gower	23	8.11%	1.33%	£27	£64	£3	£18
Rudbaxton	2,107	0.36%	38	Newgale Sands	9	Fishguard	15	38.78%	6.36%	£247	£586	£24	£167
Saron	3,222	0.56%	59	Llanelli	13	Swansea/Gower	17	25.93%	4.25%	£252	£599	£25	£171
Saundersfoot	2,666	0.46%	49	Saudersfoot	1	Fishguard	16	93.75%	15.38%	£755	£1,792	£74	£510
Solva	1,743	0.30%	16	Solva	1	Fishguard	13	92.00%	15.09%	£242	£575	£24	£164
St Clears	3,014	0.52%	55	Pendine	8	Fishguard	25	66.25%	10.87%	£603	£1,432	£59	£408
St Davids	1,959	0.34%	36	Solva	6	Fishguard	16	62.50%	10.25%	£370	£878	£36	£250
St Ishmaels	1,493	0.26%	27	Lindsway Bay	3	Fishguard	24	89.47%	14.67%	£404	£958	£39	£273
Stackpole	693	0.12%	13	Stackpole Quay	2	Fishguard	29	94.57%	15.51%	£198	£470	£19	£134
Swiss Valley	2,592	0.45%	47	Llanelli	5	Swansea/Gower	12	56.76%	9.31%	£445	£1,055	£43	£300
Tenby	4,809	0.83%	88	Tenby beaches	2	Fishguard	37	94.59%	15.51%	£1,375	£3,262	£134	£929
The Havens	1,439	0.25%	26	Broad Haven	2	Fishguard	19	91.94%	15.08%	£400	£949	£39	£270
Trelech	1,520	0.26%	28	Pendine	15	Fishguard	22	32.39%	5.31%	£149	£353	£15	£101
Trimsaran	2,696	0.47%	49	Burry Port	4	Swansea/Gower	11	63.89%	10.48%	£521	£1,235	£51	£352
Tumble	3,688	0.64%	67	Llanelli	9	Swansea/Gower	15	41.67%	6.83%	£464	£1,102	£45	£314
Tycroes	2,228	0.38%	41	Llanelli	10	Swansea/Gower	15	29.79%	4.89%	£201	£476	£20	£135
Tyisha	4,235	0.73%	77	Llanelli	2	Swansea/Gower	9	82.14%	13.47%	£1,051	£2,495	£103	£710
Whitland	1,518	0.26%	28	Amroth	7	Fishguard	22	67.14%	11.01%	£308	£731	£30	£208
Wiston	1574	0.27%	29	Fishguard	13	Fishguard	13	0.00%	0.00%	£0	£0	£0	£0
	236,670		**4,292**							**£43,774**	**£103,873**	**£4,268**	**£29,569**
DISTRICTS													
Carmarthen	39,263		717							£6,408	£15,206	£625	£4,329
Dinefwr	33,087		604							£2,278	£5,405	£222	£1,539
Llanelli	74,698		1,364							£14,856	£35,253	£1,449	£10,035
Preseli Pembrokeshire	48,763		862							£9,357	£22,203	£912	£6,320
South Pembrokeshire	40,859		746							£10,875	£25,807	£1,060	£7,346
	236,670		**4,292**							**£43,774**	**£103,873**	**£4,268**	**£29,569**

Table A7.6: Valuation of Costs to Whiting Fishing

Ward	Population	% Dyfed	number anglers	nearest site	distance	nearest alternative site	distance	% lost (year)	% lost due to ban	wts	wts	wtp	wtp
Dyfed	578,896		8,068							£41.46	£98.39	£4.04	£28.01
Abergwili	1,962	0.34%	27	Pendine	19	Swansea/Gower	28	33.33%	5.47%	£62	£147	£6	£42
Ammanford	1,465	0.25%	20	Llanelli	14	Swansea/Gower	18	22.03%	3.61%	£31	£73	£3	£21
Amroth	114	0.02%	2	Amroth	1	Fishguard	25	96.05%	15.75%	£10	£25	£1	£7
Begelly	1,742	0.30%	24	Saundersfoot	3	Fishguard	23	86.49%	14.18%	£143	£339	£14	£96
Betws	1,759	0.30%	25	Llanelli	13	Swansea/Gower	17	21.82%	3.58%	£36	£86	£4	£25
Bigyn	6,180	1.07%	86	Llanelli	2	Swansea/Gower	9	75.00%	12.30%	£439	£1,042	£43	£297
Brawdy	1,387	0.24%	10	Newgale Sands	6	Fishguard	10	43.75%	7.18%	£29	£68	£3	£19
Brynamman	932	0.16%	13	Llanelli	20	Swansea/Gower	23	12.33%	2.02%	£11	£26	£1	£7
Burry Port	4,379	0.76%	61	Burry Port	1	Swansea/Gower	24	95.83%	15.72%	£398	£944	£39	£269
Burton	1,404	0.24%	20	Lindsway Bay	8	Fishguard	22	61.43%	10.07%	£82	£194	£8	£55
Bynea	2,808	0.49%	39	Llanelli	4	Swansea/Gower	8	52.00%	8.53%	£138	£328	£13	£93
Camrose	2,307	0.40%	32	Newgale Sands	3	Fishguard	15	77.55%	12.72%	£170	£402	£17	£115
Carew	1,291	0.22%	18	Freshwater East	3	Fishguard	25	87.34%	14.32%	£107	£254	£10	£72
Carmarthen	12,247	2.12%	171	Pendine	10	Swansea/Gower	26	60.98%	10.00%	£708	£1,679	£69	£478
Castle	816	0.14%	11	Llanelli	20	Swansea/Gower	25	20.25%	3.32%	£16	£37	£2	£11
Castle	1,924	0.33%	27	Newgale Sands	7	Fishguard	16	54.00%	8.86%	£98	£234	£10	£67
Clynderwen	1,353	0.23%	19	Amroth	11	Fishguard	17	35.19%	5.77%	£45	£107	£4	£30
Cross Hands	1,394	0.24%	19	Llanelli	10	Swansea/Gower	16	37.25%	6.11%	£49	£117	£5	£33
Dafen	2,865	0.49%	40	Llanelli	4	Swansea/Gower	10	63.64%	10.44%	£173	£410	£17	£117
East Williamston	1,959	0.34%	27	Saundersfoot	1	Fishguard	26	97.86%	16.05%	£182	£431	£18	£123
Elli	3,169	0.55%	44	Llanelli	2	Swansea/Gower	10	80.65%	13.23%	£242	£575	£24	£164
Felinfoel	2,095	0.36%	29	Llanelli	19	Swansea/Gower	23	18.67%	3.06%	£37	£88	£4	£25
Ffairfach	1,155	0.20%	16	Llanelli	18	Swansea/Gower	21	13.43%	2.20%	£15	£35	£1	£10
Garnant	2,084	0.36%	29	Broad Haven	7	Fishguard	15	53.06%	8.70%	£105	£249	£10	£71
Glanamman	2,160	0.37%	30	Llanelli	15	Swansea/Gower	17	10.91%	1.79%	£22	£53	£2	£15
Glanymor	4,534	0.78%	63	Llanelli	1	Swansea/Gower	8	87.69%	14.38%	£377	£894	£37	£255
Glyn	2,015	0.35%	28	Burry Port	6	Swansea/Gower	14	58.70%	9.63%	£112	£266	£11	£76
Gorslas	3,428	0.59%	48	Llanelli	12	Swansea/Gower	19	35.00%	5.74%	£114	£270	£11	£77
Hakin	5,030	0.87%	70	Lindsway Bay	2	Fishguard	23	90.41%	14.83%	£431	£1,023	£42	£291
Hendy	2,735	0.47%	38	Llanelli	9	Swansea/Gower	13	33.33%	5.47%	£86	£205	£8	£58
Hengoed	3,682	0.64%	51	Burry Port	3	Swansea/Gower	12	72.97%	11.97%	£255	£604	£25	£172
Hundleton	1,163	0.20%	16	Angle Bay	2	Fishguard	26	93.90%	15.40%	£103	£246	£10	£70
Johnston	2,149	0.37%	30	Broad Haven	3	Fishguard	19	82.26%	13.49%	£168	£398	£16	£113
Kidwelly	3,183	0.55%	44	Burry Port	6	Swansea/Gower	18	64.91%	10.65%	£196	£465	£19	£132
Lampeter Velfry	1,342	0.23%	19	Amroth	5	Fishguard	22	76.81%	12.60%	£98	£232	£10	£66
Laugharne Township	1,272	0.22%	18	Freshwater East	2	Fishguard	27	91.76%	15.05%	£111	£262	£11	£75
Letterston	1,944	0.34%	27	Pendine	2	Swansea/Gower	25	91.25%	14.97%	£168	£399	£16	£114
Lamphey	1,646	0.28%	23	Newgale Sands	6	Fishguard	9	33.33%	5.47%	£52	£123	£5	£35
Llanboidy	1,675	0.29%	23	Amroth	9	Fishguard	19	52.46%	8.60%	£83	£198	£8	£56
Llanddarog	1,872	0.32%	26	Burry Port	14	Swansea/Gower	21	35.29%	5.79%	£63	£149	£6	£42
Llanddowror	1,646	0.28%	23	Amroth	5	Fishguard	26	80.95%	13.28%	£126	£300	£12	£85
Llandeilo	850	0.15%	12	Llanelli	19	Swansea/Gower	24	19.48%	3.19%	£16	£37	£2	£11
Llandybie	3,537	0.61%	49	Llanelli	16	Swansea/Gower	19	16.67%	2.73%	£56	£133	£5	£38
Llandyfaelog	1,256	0.22%	18	Pendine	10	Swansea/Gower	21	53.73%	8.81%	£64	£152	£6	£43
Llanegwad	1,740	0.30%	24	Burry Port	20	Swansea/Gower	26	25.00%	4.10%	£41	£98	£4	£28
Llanfihangel Aberbythych	1,560	0.27%	22	Llanelli	17	Swansea/Gower	23	25.00%	4.10%	£37	£88	£4	£25
Llangadog	1,747	0.30%	24	Llanelli	24	Swansea/Gower	27	12.64%	2.07%	£21	£50	£2	£14
Llangennech	4,003	0.69%	56	Llanelli	3	Swansea/Gower	10	66.67%	10.93%	£253	£600	£25	£171
Llangunnor	2,348	0.41%	33	Burry Port	13	Swansea/Gower	23	43.06%	7.06%	£96	£227	£9	£65
Llangwm	1,947	0.34%	27	Broad Haven	9	Fishguard	19	54.84%	8.99%	£101	£240	£10	£68
Llangyndeyrn	2,983	0.52%	42	Burry Port	9	Swansea/Gower	18	52.54%	8.62%	£149	£352	£14	£100

Table A7.6: Valuation of Costs to Whiting Fishing

Lliedi	5,247	0.91%	73	Pendine	7	Swansea/Gower	24	72.73%	11.93%	£362	£858	£35	£244
Llwynhendy	4,494	0.78%	63	Llanelli	3	Swansea/Gower	10	74.19%	12.17%	£316	£750	£31	£213
Llynfell	940	0.16%	13	Llanelli	3	Swansea/Gower	8	70.37%	11.54%	£63	£149	£6	£42
Maenclochog	1,580	0.27%	22	Fishguard	13	Fishguard	13	0.00%	0.00%	£0	£0	£0	£0
Manorbier	1,887	0.33%	26	Freshwater East	2	Fishguard	27	93.10%	15.27%	£166	£395	£16	£112
Manordeilo	1,496	0.26%	21	Llanelli	22	Swansea/Gower	26	14.46%	2.37%	£20	£49	£2	£14
Martletwy	1,280	0.22%	18	Freshwater East	11	Fishguard	19	41.67%	6.83%	£51	£120	£5	£34
Merlin's Bridge	1,871	0.32%	26	Lindsway Bay	8	Fishguard	8	0.00%	0.00%	£0	£0	£0	£0
Milford	8,619	1.49%	120	Lindsway Bay	4	Fishguard	22	81.82%	13.42%	£668	£1,586	£65	£451
Myddfai	640	0.11%	9	Llanelli	29	Swansea/Gower	31	8.00%	1.31%	£5	£12	£0	£3
Myddnfych	1,184	0.20%	17	Llanelli	14	Swansea/Gower	18	21.05%	3.45%	£24	£56	£2	£16
Narberth	2,965	0.51%	41	Amroth	6	Fishguard	20	71.88%	11.79%	£202	£479	£20	£136
Newchurch	1,169	0.20%	16	Pendine	13	Swansea/Gower	28	51.69%	8.48%	£57	£136	£6	£39
Neyland	3,966	0.69%	55	Lindsway Bay	6	Fishguard	23	72.22%	11.84%	£271	£644	£26	£183
Pantyffynnon	1,215	0.21%	17	Llanelli	13	Swansea/Gower	18	26.32%	4.32%	£30	£72	£3	£20
Pembrey	3,679	0.64%	51	Burry Port	4	Swansea/Gower	15	74.47%	12.21%	£260	£616	£25	£175
Pembroke & Pembroke Dock	15,881	2.74%	221	Pembroke Dock	1	Fishguard	25	96.00%	15.74%	£1,445	£3,428	£141	£976
Penally	1,421	0.25%	20	Tenby beaches	3	Fishguard	28	90.11%	14.78%	£121	£288	£12	£82
Penygroes	2,203	0.38%	31	Llanelli	13	Swansea/Gower	18	27.59%	4.52%	£58	£137	£6	£39
Pontamman	1,289	0.22%	18	Llanelli	15	Swansea/Gower	18	17.24%	2.83%	£21	£50	£2	£14
Pontyberem	2,797	0.48%	39	Burry Port	9	Swansea/Gower	17	47.17%	7.74%	£125	£297	£12	£84
Prendergast	1,790	0.31%	25	Broad Haven	9	Fishguard	15	42.86%	7.03%	£73	£173	£7	£49
Priory	2,530	0.44%	35	Broad Haven	6	Fishguard	17	64.15%	10.52%	£154	£365	£15	£104
Quarter Bach	1,093	0.19%	15	Llanelli	21	Swansea/Gower	23	8.11%	1.33%	£8	£20	£1	£6
Rudbaxton	2,107	0.36%	29	Newgale Sands	9	Fishguard	15	38.78%	6.36%	£77	£184	£8	£52
Saron	3,222	0.56%	45	Llanelli	13	Swansea/Gower	17	25.93%	4.25%	£79	£188	£8	£53
Saundersfoot	2,666	0.46%	37	Saudersfoot	1	Fishguard	16	93.75%	15.38%	£237	£562	£23	£160
Solva	1,743	0.30%	12	Solva	1	Fishguard	13	92.00%	15.09%	£76	£180	£7	£51
St Clears	3,014	0.52%	42	Pendine	8	Fishguard	25	66.25%	10.87%	£189	£449	£18	£128
St Davids	1,959	0.34%	27	Solva	6	Fishguard	16	62.50%	10.25%	£116	£275	£11	£78
St Ishmaels	1,493	0.26%	21	Lindsway Bay	3	Fishguard	24	89.47%	14.67%	£127	£300	£12	£86
Stackpole	693	0.12%	10	Stackpole Quay	2	Fishguard	29	94.57%	15.51%	£62	£147	£6	£42
Swiss Valley	2,592	0.45%	36	Llanelli	5	Swansea/Gower	12	56.76%	9.31%	£139	£331	£14	£94
Tenby	4,809	0.83%	67	Tenby beaches	2	Fishguard	37	94.59%	15.51%	£431	£1,023	£42	£291
The Havens	1,439	0.25%	20	Broad Haven	2	Fishguard	19	91.94%	15.08%	£125	£297	£12	£85
Trelech	1,520	0.26%	21	Pendine	15	Fishguard	22	32.39%	5.31%	£47	£111	£5	£32
Trimsaran	2,696	0.47%	38	Burry Port	4	Swansea/Gower	11	63.89%	10.48%	£163	£387	£16	£110
Tumble	3,688	0.64%	51	Llanelli	9	Swansea/Gower	15	41.67%	6.83%	£146	£346	£14	£98
Tycroes	2,228	0.38%	31	Llanelli	10	Swansea/Gower	15	29.79%	4.89%	£63	£149	£6	£42
Tyisha	4,235	0.73%	59	Llanelli	2	Swansea/Gower	9	82.14%	13.47%	£330	£782	£32	£223
Whitland	1,518	0.26%	21	Amroth	7	Fishguard	22	67.14%	11.01%	£97	£229	£9	£65
Wiston	1574	0.27%	22	Fishguard	13	Fishguard	13	0.00%	0.00%	£0	£0	£0	£0
	236,670		**3,277**							**£13,726**	**£32,570**	**£1,338**	**£9,271**
DISTRICTS													
Carmarthen	39,263		547							£2,009	£4,768	£196	£1,357
Dinefwr	33,087		461							£714	£1,695	£70	£482
Llanelli	74,698		1,041							£4,658	£11,054	£454	£3,147
Preseli Pembrokeshire	48,763		658							£2,934	£6,962	£286	£1,982
South Pembrokeshire	40,859		569							£3,410	£8,092	£332	£2,303
	236,670		**3,277**							**£13,726**	**£32,570**	**£1,338**	**£9,271**

Table A7.7: Valuation of Costs to Mackerel Fishing

Ward	Population	% Dyfed	number anglers	nearest site	distance	nearest alternative site	distance	% lost (year)	% lost due to ban	wts	wts	wtp	wtp
Dyfed	578,896		7,221							£14.42	£34.22	£1.41	£9.74
Abergwili	1,962	0.34%	24	Pendine	19	Swansea/Gower	28	33.33%	5.47%	£19	£46	£2	£13
Ammanford	1,465	0.25%	18	Llanelli	14	Swansea/Gower	18	22.03%	3.61%	£10	£23	£1	£6
Amroth	114	0.02%	1	Amroth	1	Fishguard	25	96.05%	15.75%	£3	£8	£0	£2
Begelly	1,742	0.30%	22	Saundersfoot	3	Fishguard	23	86.49%	14.18%	£44	£105	£4	£30
Betws	1,759	0.30%	22	Llanelli	13	Swansea/Gower	17	21.82%	3.58%	£11	£27	£1	£8
Bigyn	6,180	1.07%	77	Llanelli	2	Swansea/Gower	9	75.00%	12.30%	£137	£324	£13	£92
Brawdy	1,387	0.24%	9	Newgale Sands	6	Fishguard	10	43.75%	7.18%	£9	£21	£1	£6
Brynamman	932	0.16%	12	Llanelli	20	Swansea/Gower	23	12.33%	2.02%	£3	£8	£0	£2
Burry Port	4,379	0.76%	55	Burry Port	1	Swansea/Gower	24	95.83%	15.72%	£124	£294	£12	£84
Burton	1,404	0.24%	18	Lindsway Bay	8	Fishguard	22	61.43%	10.07%	£25	£60	£2	£17
Bynea	2,808	0.49%	35	Llanelli	4	Swansea/Gower	8	52.00%	8.53%	£43	£102	£4	£29
Camrose	2,307	0.40%	29	Newgale Sands	3	Fishguard	15	77.55%	12.72%	£53	£125	£5	£36
Carew	1,291	0.22%	16	Freshwater East	3	Fishguard	25	87.34%	14.32%	£33	£79	£3	£22
Carmarthen	12,247	2.12%	153	Pendine	10	Swansea/Gower	26	60.98%	10.00%	£220	£523	£21	£149
Castle	816	0.14%	10	Llanelli	20	Swansea/Gower	25	20.25%	3.32%	£5	£12	£0	£3
Castle	1,924	0.33%	24	Newgale Sands	7	Fishguard	16	54.00%	8.86%	£31	£73	£3	£21
Clynderwen	1,353	0.23%	17	Amroth	11	Fishguard	17	35.19%	5.77%	£14	£33	£1	£9
Cross Hands	1,394	0.24%	17	Llanelli	10	Swansea/Gower	16	37.25%	6.11%	£15	£36	£1	£10
Dafen	2,865	0.49%	36	Llanelli	4	Swansea/Gower	10	63.64%	10.44%	£54	£128	£5	£36
East Williamston	1,959	0.34%	24	Saundersfoot	1	Fishguard	26	97.86%	16.05%	£57	£134	£6	£38
Elli	3,169	0.55%	40	Llanelli	2	Swansea/Gower	10	80.65%	13.23%	£75	£179	£7	£51
Felinfoel	2,095	0.36%	26	Llanelli	19	Swansea/Gower	23	18.67%	3.06%	£12	£27	£1	£8
Ffairfach	1,155	0.20%	14	Llanelli	18	Swansea/Gower	21	13.43%	2.20%	£5	£11	£0	£3
Garnant	2,084	0.36%	26	Broad Haven	7	Fishguard	15	53.06%	8.70%	£33	£77	£3	£22
Glanamman	2,160	0.37%	27	Llanelli	15	Swansea/Gower	17	10.91%	1.79%	£7	£16	£1	£5
Glanymor	4,534	0.78%	57	Llanelli	1	Swansea/Gower	8	87.69%	14.38%	£117	£278	£11	£79
Glyn	2,015	0.35%	25	Burry Port	6	Swansea/Gower	14	58.70%	9.63%	£35	£83	£3	£24
Gorslas	3,428	0.59%	43	Llanelli	12	Swansea/Gower	19	35.00%	5.74%	£35	£84	£3	£24
Hakin	5,030	0.87%	63	Lindsway Bay	2	Fishguard	23	90.41%	14.83%	£134	£318	£13	£91
Hendy	2,735	0.47%	34	Llanelli	9	Swansea/Gower	13	33.33%	5.47%	£27	£64	£3	£18
Hengoed	3,682	0.64%	46	Burry Port	3	Swansea/Gower	12	72.97%	11.97%	£79	£188	£8	£54
Hundleton	1,163	0.20%	15	Angle Bay	2	Fishguard	26	93.90%	15.40%	£32	£76	£3	£22
Johnston	2,149	0.37%	27	Broad Haven	3	Fishguard	19	82.26%	13.49%	£52	£124	£5	£35
Kidwelly	3,183	0.55%	40	Burry Port	6	Swansea/Gower	18	64.91%	10.65%	£61	£145	£6	£41
Lampeter Velfry	1,342	0.23%	17	Amroth	5	Fishguard	22	76.81%	12.60%	£30	£72	£3	£21
Laugharne Township	1,272	0.22%	16	Freshwater East	2	Fishguard	27	91.76%	15.05%	£34	£82	£3	£23
Letterston	1,944	0.34%	24	Pendine	2	Swansea/Gower	25	91.25%	14.97%	£52	£124	£5	£35
Lamphey	1,646	0.28%	21	Newgale Sands	6	Fishguard	9	33.33%	5.47%	£16	£38	£2	£11
Llanboidy	1,675	0.29%	21	Amroth	9	Fishguard	19	52.46%	8.60%	£26	£62	£3	£18
Llanddarog	1,872	0.32%	23	Burry Port	14	Swansea/Gower	21	35.29%	5.79%	£19	£46	£2	£13
Llanddowror	1,646	0.28%	21	Amroth	5	Fishguard	26	80.95%	13.28%	£39	£93	£4	£27
Llandeilo	850	0.15%	11	Llanelli	19	Swansea/Gower	24	19.48%	3.19%	£5	£12	£0	£3
Llandybie	3,537	0.61%	44	Llanelli	16	Swansea/Gower	19	16.67%	2.73%	£17	£41	£2	£12
Llandyfaelog	1,256	0.22%	16	Pendine	10	Swansea/Gower	21	53.73%	8.81%	£20	£47	£2	£13
Llanegwad	1,740	0.30%	22	Burry Port	20	Swansea/Gower	26	25.00%	4.10%	£13	£30	£1	£9
Llanfihangel Aberbythych	1,560	0.27%	19	Llanelli	17	Swansea/Gower	23	25.00%	4.10%	£12	£27	£1	£8
Llangadog	1,747	0.30%	22	Llanelli	24	Swansea/Gower	27	12.64%	2.07%	£7	£15	£1	£4
Llangennech	4,003	0.69%	50	Llanelli	3	Swansea/Gower	10	66.67%	10.93%	£79	£187	£8	£53
Llangunnor	2,348	0.41%	29	Burry Port	13	Swansea/Gower	23	43.06%	7.06%	£30	£71	£3	£20
Llangwm	1,947	0.34%	24	Broad Haven	9	Fishguard	19	54.84%	8.99%	£31	£75	£3	£21
Llangyndeyrn	2,983	0.52%	37	Burry Port	9	Swansea/Gower	18	52.54%	8.62%	£46	£110	£5	£31

Table A7.7: Valuation of Costs to Mackerel Fishing

Lliedi	5,247	0.91%	65	Pendine	7	Swansea/Gower	24	72.73%	11.93%	£113	£267	£11	£76
Llwynhendy	4,494	0.78%	56	Llanelli	3	Swansea/Gower	10	74.19%	12.17%	£98	£233	£10	£66
Llynfell	940	0.16%	12	Llanelli	3	Swansea/Gower	8	70.37%	11.54%	£20	£46	£2	£13
Maenclochog	1,580	0.27%	20	Fishguard	13	Fishguard	13	0.00%	0.00%	£0	£0	£0	£0
Manorbier	1,887	0.33%	24	Freshwater East	2	Fishguard	27	93.10%	15.27%	£52	£123	£5	£35
Manordeilo	1,496	0.26%	19	Llanelli	22	Swansea/Gower	26	14.46%	2.37%	£6	£15	£1	£4
Martletwy	1,280	0.22%	16	Freshwater East	11	Fishguard	19	41.67%	6.83%	£16	£37	£2	£11
Merlin's Bridge	1,871	0.32%	23	Lindsway Bay	8	Fishguard	8	0.00%	0.00%	£0	£0	£0	£0
Milford	8,619	1.49%	108	Lindsway Bay	4	Fishguard	22	81.82%	13.42%	£208	£494	£20	£141
Myddfai	640	0.11%	8	Llanelli	29	Swansea/Gower	31	8.00%	1.31%	£2	£4	£0	£1
Myddnfych	1,184	0.20%	15	Llanelli	14	Swansea/Gower	18	21.05%	3.45%	£7	£17	£1	£5
Narberth	2,965	0.51%	37	Amroth	6	Fishguard	20	71.88%	11.79%	£63	£149	£6	£42
Newchurch	1,169	0.20%	15	Pendine	13	Swansea/Gower	28	51.69%	8.48%	£18	£42	£2	£12
Neyland	3,966	0.69%	49	Lindsway Bay	6	Fishguard	23	72.22%	11.84%	£85	£201	£8	£57
Pantyffynnon	1,215	0.21%	15	Llanelli	13	Swansea/Gower	18	26.32%	4.32%	£9	£22	£1	£6
Pembrey	3,679	0.64%	46	Burry Port	4	Swansea/Gower	15	74.47%	12.21%	£81	£192	£8	£55
Pembroke & Pembroke Dock	15,881	2.74%	198	Pembroke Dock	1	Fishguard	25	96.00%	15.74%	£450	£1,067	£44	£304
Penally	1,421	0.25%	18	Tenby beaches	3	Fishguard	28	90.11%	14.78%	£38	£90	£4	£26
Penygroes	2,203	0.38%	27	Llanelli	13	Swansea/Gower	18	27.59%	4.52%	£18	£43	£2	£12
Pontamman	1,289	0.22%	16	Llanelli	15	Swansea/Gower	18	17.24%	2.83%	£7	£16	£1	£4
Pontyberem	2,797	0.48%	35	Burry Port	9	Swansea/Gower	17	47.17%	7.74%	£39	£92	£4	£26
Prendergast	1,790	0.31%	22	Broad Haven	9	Fishguard	15	42.86%	7.03%	£23	£54	£2	£15
Priory	2,530	0.44%	32	Broad Haven	6	Fishguard	17	64.15%	10.52%	£48	£114	£5	£32
Quarter Bach	1,093	0.19%	14	Llanelli	21	Swansea/Gower	23	8.11%	1.33%	£3	£6	£0	£2
Rudbaxton	2,107	0.36%	26	Newgale Sands	9	Fishguard	15	38.78%	6.36%	£24	£57	£2	£16
Saron	3,222	0.56%	40	Llanelli	13	Swansea/Gower	17	25.93%	4.25%	£25	£58	£2	£17
Saundersfoot	2,666	0.46%	33	Saudersfoot	1	Fishguard	16	93.75%	15.38%	£74	£175	£7	£50
Solva	1,743	0.30%	11	*Solva*	1	*Fishguard*	13	92.00%	15.09%	£24	£56	£2	£16
St Clears	3,014	0.52%	38	Pendine	8	Fishguard	25	66.25%	10.87%	£59	£140	£6	£40
St Davids	1,959	0.34%	24	Solva	6	Fishguard	16	62.50%	10.25%	£36	£86	£4	£24
St Ishmaels	1,493	0.26%	19	Lindsway Bay	3	Fishguard	24	89.47%	14.67%	£39	£94	£4	£27
Stackpole	693	0.12%	9	Stackpole Quay	2	Fishguard	29	94.57%	15.51%	£19	£46	£2	£13
Swiss Valley	2,592	0.45%	32	Llanelli	5	Swansea/Gower	12	56.76%	9.31%	£43	£103	£4	£29
Tenby	4,809	0.83%	60	Tenby beaches	2	Fishguard	37	94.59%	15.51%	£134	£318	£13	£91
The Havens	1,439	0.25%	18	Broad Haven	2	Fishguard	19	91.94%	15.08%	£39	£93	£4	£26
Trelech	1,520	0.26%	19	Pendine	15	Fishguard	22	32.39%	5.31%	£15	£34	£1	£10
Trimsaran	2,696	0.47%	34	Burry Port	4	Swansea/Gower	11	63.89%	10.48%	£51	£121	£5	£34
Tumble	3,688	0.64%	46	Llanelli	9	Swansea/Gower	15	41.67%	6.83%	£45	£108	£4	£31
Tycroes	2,228	0.38%	28	Llanelli	10	Swansea/Gower	15	29.79%	4.89%	£20	£46	£2	£13
Tyisha	4,235	0.73%	53	Llanelli	2	Swansea/Gower	9	82.14%	13.47%	£103	£244	£10	£69
Whitland	1,518	0.26%	19	Amroth	7	Fishguard	22	67.14%	11.01%	£30	£71	£3	£20
Wiston	1574	0.27%	20	Fishguard	13	Fishguard	13	0.00%	0.00%	£0	£0	£0	£0
	236,670		**2,933**							**£4,273**	**£10,139**	**£417**	**£2,886**
DISTRICTS													
Carmarthen	39,263		490							£626	£1,484	£61	£423
Dinefwr	33,087		413							£222	£528	£22	£150
Llanelli	74,698		932							£1,450	£3,441	£141	£980
Preseli Pembrokeshire	48,763		589							£913	£2,167	£89	£617
South Pembrokeshire	40,859		510							£1,062	£2,519	£104	£717
	236,670		**2,933**							**£4,273**	**£10,139**	**£417**	**£2,886**

Table A7.8: Valuation of Costs to Plaice Fishing

Ward	Population	% Dyfed	number anglers	nearest site	distance	nearest alternative site	distance	% lost (year)	% lost due to ban	wts	wts	wtp	wtp
Dyfed	578,896		6,941							£115.37	£273.77	£11.25	£77.93
Abergwili	1,962	0.34%	24	Pendine	19	Swansea/Gower	28	33.33%	5.47%	£148	£352	£14	£100
Ammanford	1,465	0.25%	18	Llanelli	14	Swansea/Gower	18	22.03%	3.61%	£73	£174	£7	£49
Amroth	114	0.02%	1	Amroth	1	Fishguard	25	96.05%	15.75%	£25	£59	£2	£17
Begelly	1,742	0.30%	21	Saundersfoot	3	Fishguard	23	86.49%	14.18%	£342	£811	£33	£231
Betws	1,759	0.30%	21	Llanelli	13	Swansea/Gower	17	21.82%	3.58%	£87	£207	£8	£59
Bigyn	6,180	1.07%	74	Llanelli	2	Swansea/Gower	9	75.00%	12.30%	£1,052	£2,495	£103	£710
Brawdy	1,387	0.24%	8	Newgale Sands	6	Fishguard	10	43.75%	7.18%	£69	£163	£7	£46
Brynamman	932	0.16%	11	Llanelli	20	Swansea/Gower	23	12.33%	2.02%	£26	£62	£3	£18
Burry Port	4,379	0.76%	53	Burry Port	1	Swansea/Gower	24	95.83%	15.72%	£952	£2,259	£93	£643
Burton	1,404	0.24%	17	Lindsway Bay	8	Fishguard	22	61.43%	10.07%	£196	£464	£19	£132
Bynea	2,808	0.49%	34	Llanelli	4	Swansea/Gower	8	52.00%	8.53%	£331	£786	£32	£224
Camrose	2,307	0.40%	28	Newgale Sands	3	Fishguard	15	77.55%	12.72%	£406	£963	£40	£274
Carew	1,291	0.22%	15	Freshwater East	3	Fishguard	25	87.34%	14.32%	£256	£607	£25	£173
Carmarthen	12,247	2.12%	147	Pendine	10	Swansea/Gower	26	60.98%	10.00%	£1,694	£4,020	£165	£1,144
Castle	816	0.14%	10	Llanelli	20	Swansea/Gower	25	20.25%	3.32%	£37	£89	£4	£25
Castle	1,924	0.33%	23	Newgale Sands	7	Fishguard	16	54.00%	8.86%	£236	£559	£23	£159
Clynderwen	1,353	0.23%	16	Amroth	11	Fishguard	17	35.19%	5.77%	£108	£256	£11	£73
Cross Hands	1,394	0.24%	17	Llanelli	10	Swansea/Gower	16	37.25%	6.11%	£118	£280	£11	£80
Dafen	2,865	0.49%	34	Llanelli	4	Swansea/Gower	10	63.64%	10.44%	£414	£981	£40	£279
East Williamston	1,959	0.34%	23	Saundersfoot	1	Fishguard	26	97.86%	16.05%	£435	£1,032	£42	£294
Elli	3,169	0.55%	38	Llanelli	2	Swansea/Gower	10	80.65%	13.23%	£580	£1,376	£57	£392
Felinfoel	2,095	0.36%	25	Llanelli	19	Swansea/Gower	23	18.67%	3.06%	£89	£211	£9	£60
Ffairfach	1,155	0.20%	14	Llanelli	18	Swansea/Gower	21	13.43%	2.20%	£35	£84	£3	£24
Garnant	2,084	0.36%	25	Broad Haven	7	Fishguard	15	53.06%	8.70%	£251	£595	£24	£169
Glanamman	2,160	0.37%	26	Llanelli	15	Swansea/Gower	17	10.91%	1.79%	£53	£127	£5	£36
Glanymor	4,534	0.78%	54	Llanelli	1	Swansea/Gower	8	87.69%	14.38%	£902	£2,140	£88	£609
Glyn	2,015	0.35%	24	Burry Port	6	Swansea/Gower	14	58.70%	9.63%	£268	£637	£26	£181
Gorslas	3,428	0.59%	41	Llanelli	12	Swansea/Gower	19	35.00%	5.74%	£272	£646	£27	£184
Hakin	5,030	0.87%	60	Lindsway Bay	2	Fishguard	23	90.41%	14.83%	£1,032	£2,448	£101	£697
Hendy	2,735	0.47%	33	Llanelli	9	Swansea/Gower	13	33.33%	5.47%	£207	£491	£20	£140
Hengoed	3,682	0.64%	44	Burry Port	3	Swansea/Gower	12	72.97%	11.97%	£610	£1,446	£59	£412
Hundleton	1,163	0.20%	14	Angle Bay	2	Fishguard	26	93.90%	15.40%	£248	£588	£24	£167
Johnston	2,149	0.37%	26	Broad Haven	3	Fishguard	19	82.26%	13.49%	£401	£952	£39	£271
Kidwelly	3,183	0.55%	38	Burry Port	6	Swansea/Gower	18	64.91%	10.65%	£469	£1,112	£46	£317
Lampeter Velfry	1,342	0.23%	16	Amroth	5	Fishguard	22	76.81%	12.60%	£234	£555	£23	£158
Laugharne Township	1,272	0.22%	15	Freshwater East	2	Fishguard	27	91.76%	15.05%	£265	£628	£26	£179
Letterston	1,944	0.34%	23	Pendine	2	Swansea/Gower	25	91.25%	14.97%	£402	£955	£39	£272
Lamphey	1,646	0.28%	20	Newgale Sands	6	Fishguard	9	33.33%	5.47%	£124	£295	£12	£84
Llanboidy	1,675	0.29%	20	Amroth	9	Fishguard	19	52.46%	8.60%	£199	£473	£19	£135
Llanddarog	1,872	0.32%	22	Burry Port	14	Swansea/Gower	21	35.29%	5.79%	£150	£356	£15	£101
Llanddowror	1,646	0.28%	20	Amroth	5	Fishguard	26	80.95%	13.28%	£302	£717	£29	£204
Llandeilo	850	0.15%	10	Llanelli	19	Swansea/Gower	24	19.48%	3.19%	£38	£89	£4	£25
Llandybie	3,537	0.61%	42	Llanelli	16	Swansea/Gower	19	16.67%	2.73%	£134	£317	£13	£90
Llandyfaelog	1,256	0.22%	15	Pendine	10	Swansea/Gower	21	53.73%	8.81%	£153	£363	£15	£103
Llanegwad	1,740	0.30%	21	Burry Port	20	Swansea/Gower	26	25.00%	4.10%	£99	£234	£10	£67
Llanfihangel Aberbythych	1,560	0.27%	19	Llanelli	17	Swansea/Gower	23	25.00%	4.10%	£88	£210	£9	£60
Llangadog	1,747	0.30%	21	Llanelli	24	Swansea/Gower	27	12.64%	2.07%	£50	£119	£5	£34
Llangennech	4,003	0.69%	48	Llanelli	3	Swansea/Gower	10	66.67%	10.93%	£605	£1,437	£59	£409
Llangunnor	2,348	0.41%	28	Burry Port	13	Swansea/Gower	23	43.06%	7.06%	£229	£544	£22	£155
Llangwm	1,947	0.34%	23	Broad Haven	9	Fishguard	19	54.84%	8.99%	£242	£575	£24	£164
Llangyndeyrn	2,983	0.52%	36	Burry Port	9	Swansea/Gower	18	52.54%	8.62%	£356	£844	£35	£240

Table A7.8: Valuation of Costs to Plaice Fishing

Lliedi	5,247	0.91%	63	Pendine	7	Swansea/Gower	24	72.73%	11.93%	£866	£2,054	£84	£585
Llwynhendy	4,494	0.78%	54	Llanelli	3	Swansea/Gower	10	74.19%	12.17%	£756	£1,795	£74	£511
Llynfell	940	0.16%	11	Llanelli	3	Swansea/Gower	8	70.37%	11.54%	£150	£356	£15	£101
Maenclochog	1,580	0.27%	19	Fishguard	13	Fishguard	13	0.00%	0.00%	£0	£0	£0	£0
Manorbier	1,887	0.33%	23	Freshwater East	2	Fishguard	27	93.10%	15.27%	£399	£946	£39	£269
Manordeilo	1,496	0.26%	18	Llanelli	22	Swansea/Gower	26	14.46%	2.37%	£49	£116	£5	£33
Martletwy	1,280	0.22%	15	Freshwater East	11	Fishguard	19	41.67%	6.83%	£121	£287	£12	£82
Merlin's Bridge	1,871	0.32%	22	Lindsway Bay	8	Fishguard	8	0.00%	0.00%	£0	£0	£0	£0
Milford	8,619	1.49%	103	Lindsway Bay	4	Fishguard	22	81.82%	13.42%	£1,600	£3,796	£156	£1,081
Myddfai	640	0.11%	8	Llanelli	29	Swansea/Gower	31	8.00%	1.31%	£12	£28	£1	£8
Myddnfych	1,184	0.20%	14	Llanelli	14	Swansea/Gower	18	21.05%	3.45%	£57	£134	£6	£38
Narberth	2,965	0.51%	36	Amroth	6	Fishguard	20	71.88%	11.79%	£483	£1,147	£47	£327
Newchurch	1,169	0.20%	14	Pendine	13	Swansea/Gower	28	51.69%	8.48%	£137	£325	£13	£93
Neyland	3,966	0.69%	48	Lindsway Bay	6	Fishguard	23	72.22%	11.84%	£650	£1,542	£63	£439
Pantyffynnon	1,215	0.21%	15	Llanelli	13	Swansea/Gower	18	26.32%	4.32%	£73	£172	£7	£49
Pembrey	3,679	0.64%	44	Burry Port	4	Swansea/Gower	15	74.47%	12.21%	£622	£1,475	£61	£420
Pembroke & Pembroke Dock	15,881	2.74%	190	Pembroke Dock	1	Fishguard	25	96.00%	15.74%	£3,459	£8,207	£337	£2,336
Penally	1,421	0.25%	17	Tenby beaches	3	Fishguard	28	90.11%	14.78%	£290	£689	£28	£196
Penygroes	2,203	0.38%	26	Llanelli	13	Swansea/Gower	18	27.59%	4.52%	£138	£327	£13	£93
Pontamman	1,289	0.22%	15	Llanelli	15	Swansea/Gower	18	17.24%	2.83%	£50	£120	£5	£34
Pontyberem	2,797	0.48%	34	Burry Port	9	Swansea/Gower	17	47.17%	7.74%	£299	£710	£29	£202
Prendergast	1,790	0.31%	21	Broad Haven	9	Fishguard	15	42.86%	7.03%	£174	£413	£17	£118
Priory	2,530	0.44%	30	Broad Haven	6	Fishguard	17	64.15%	10.52%	£368	£874	£36	£249
Quarter Bach	1,093	0.19%	13	Llanelli	21	Swansea/Gower	23	8.11%	1.33%	£20	£48	£2	£14
Rudbaxton	2,107	0.36%	25	Newgale Sands	9	Fishguard	15	38.78%	6.36%	£185	£440	£18	£125
Saron	3,222	0.56%	39	Llanelli	13	Swansea/Gower	17	25.93%	4.25%	£190	£450	£18	£128
Saundersfoot	2,666	0.46%	32	Saudersfoot	1	Fishguard	16	93.75%	15.38%	£567	£1,345	£55	£383
Solva	1,743	0.30%	10	Solva	1	Fishguard	13	92.00%	15.09%	£182	£432	£18	£123
St Clears	3,014	0.52%	36	Pendine	8	Fishguard	25	66.25%	10.87%	£453	£1,075	£44	£306
St Davids	1,959	0.34%	23	Solva	6	Fishguard	16	62.50%	10.25%	£278	£659	£27	£188
St Ishmaels	1,493	0.26%	18	Lindsway Bay	3	Fishguard	24	89.47%	14.67%	£303	£719	£30	£205
Stackpole	693	0.12%	8	Stackpole Quay	2	Fishguard	29	94.57%	15.51%	£149	£353	£14	£100
Swiss Valley	2,592	0.45%	31	Llanelli	5	Swansea/Gower	12	56.76%	9.31%	£334	£792	£33	£225
Tenby	4,809	0.83%	58	Tenby beaches	2	Fishguard	37	94.59%	15.51%	£1,032	£2,449	£101	£697
The Havens	1,439	0.25%	17	Broad Haven	2	Fishguard	19	91.94%	15.08%	£300	£712	£29	£203
Trelech	1,520	0.26%	18	Pendine	15	Fishguard	22	32.39%	5.31%	£112	£265	£11	£75
Trimsaran	2,696	0.47%	32	Burry Port	4	Swansea/Gower	11	63.89%	10.48%	£391	£927	£38	£264
Tumble	3,688	0.64%	44	Llanelli	9	Swansea/Gower	15	41.67%	6.83%	£349	£827	£34	£235
Tycroes	2,228	0.38%	27	Llanelli	10	Swansea/Gower	15	29.79%	4.89%	£151	£357	£15	£102
Tyisha	4,235	0.73%	51	Llanelli	2	Swansea/Gower	9	82.14%	13.47%	£789	£1,873	£77	£533
Whitland	1,518	0.26%	18	Amroth	7	Fishguard	22	67.14%	11.01%	£231	£549	£23	£156
Wiston	1574	0.27%	19	Fishguard	13	Fishguard	13	0.00%	0.00%	£0	£0	£0	£0
	236,670		**2,819**							**£32,858**	**£77,970**	**£3,204**	**£22,195**
DISTRICTS													
Carmarthen	39,263		471							£4,810	£11,414	£469	£3,249
Dinefwr	33,087		397							£1,710	£4,057	£167	£1,155
Llanelli	74,698		896							£11,151	£26,461	£1,087	£7,533
Preseli Pembrokeshire	48,763		566							£7,023	£16,666	£685	£4,744
South Pembrokeshire	40,859		490							£8,163	£19,371	£796	£5,514
	236,670		**2,819**							**£32,858**	**£77,970**	**£3,204**	**£22,195**

Table A7.9: Valuation of Costs to Ray Fishing

Ward	Population	% Dyfed	number anglers	nearest site	distance	nearest alternative site	distance	% lost (year)	% lost due to ban	wts	wts	wtp	wtp
Dyfed	578,896		2,499							£91.03	£216.02	£8.88	£61.49
Abergwili	1,962	0.34%	8	Pendine	19	Swansea/Gower	28	33.33%	5.47%	£42	£100	£4	£28
Ammanford	1,465	0.25%	6	Llanelli	14	Swansea/Gower	18	22.03%	3.61%	£21	£49	£2	£14
Amroth	114	0.02%	0	Amroth	1	Fishguard	25	96.05%	15.75%	£7	£17	£1	£5
Begelly	1,742	0.30%	8	Saundersfoot	3	Fishguard	23	86.49%	14.18%	£97	£230	£9	£66
Betws	1,759	0.30%	8	Llanelli	13	Swansea/Gower	17	21.82%	3.58%	£25	£59	£2	£17
Bigyn	6,180	1.07%	27	Llanelli	2	Swansea/Gower	9	75.00%	12.30%	£299	£709	£29	£202
Brawdy	1,387	0.24%	3	Newgale Sands	6	Fishguard	10	43.75%	7.18%	£20	£46	£2	£13
Brynamman	932	0.16%	4	Llanelli	20	Swansea/Gower	23	12.33%	2.02%	£7	£18	£1	£5
Burry Port	4,379	0.76%	19	Burry Port	1	Swansea/Gower	24	95.83%	15.72%	£270	£642	£26	£183
Burton	1,404	0.24%	6	Lindsway Bay	8	Fishguard	22	61.43%	10.07%	£56	£132	£5	£38
Bynea	2,808	0.49%	12	Llanelli	4	Swansea/Gower	8	52.00%	8.53%	£94	£223	£9	£64
Camrose	2,307	0.40%	10	Newgale Sands	3	Fishguard	15	77.55%	12.72%	£115	£274	£11	£78
Carew	1,291	0.22%	6	Freshwater East	3	Fishguard	25	87.34%	14.32%	£73	£172	£7	£49
Carmarthen	12,247	2.12%	53	Pendine	10	Swansea/Gower	26	60.98%	10.00%	£481	£1,142	£47	£325
Castle	816	0.14%	4	Llanelli	20	Swansea/Gower	25	20.25%	3.32%	£11	£25	£1	£7
Castle	1,924	0.33%	8	Newgale Sands	7	Fishguard	16	54.00%	8.86%	£67	£159	£7	£45
Clynderwen	1,353	0.23%	6	Amroth	11	Fishguard	17	35.19%	5.77%	£31	£73	£3	£21
Cross Hands	1,394	0.24%	6	Llanelli	10	Swansea/Gower	16	37.25%	6.11%	£33	£79	£3	£23
Dafen	2,865	0.49%	12	Llanelli	4	Swansea/Gower	10	63.64%	10.44%	£118	£279	£11	£79
East Williamston	1,959	0.34%	8	Saundersfoot	1	Fishguard	26	97.86%	16.05%	£124	£293	£12	£83
Elli	3,169	0.55%	14	Llanelli	2	Swansea/Gower	10	80.65%	13.23%	£165	£391	£16	£111
Felinfoel	2,095	0.36%	9	Llanelli	19	Swansea/Gower	23	18.67%	3.06%	£25	£60	£2	£17
Ffairfach	1,155	0.20%	5	Llanelli	18	Swansea/Gower	21	13.43%	2.20%	£10	£24	£1	£7
Garnant	2,084	0.36%	9	Broad Haven	7	Fishguard	15	53.06%	8.70%	£71	£169	£7	£48
Glanamman	2,160	0.37%	9	Llanelli	15	Swansea/Gower	17	10.91%	1.79%	£15	£36	£1	£10
Glanymor	4,534	0.78%	20	Llanelli	1	Swansea/Gower	8	87.69%	14.38%	£256	£608	£25	£173
Glyn	2,015	0.35%	9	Burry Port	6	Swansea/Gower	14	58.70%	9.63%	£76	£181	£7	£51
Gorslas	3,428	0.59%	15	Llanelli	12	Swansea/Gower	19	35.00%	5.74%	£77	£183	£8	£52
Hakin	5,030	0.87%	22	Lindsway Bay	2	Fishguard	23	90.41%	14.83%	£293	£695	£29	£198
Hendy	2,735	0.47%	12	Llanelli	9	Swansea/Gower	13	33.33%	5.47%	£59	£139	£6	£40
Hengoed	3,682	0.64%	16	Burry Port	3	Swansea/Gower	12	72.97%	11.97%	£173	£411	£17	£117
Hundleton	1,163	0.20%	5	Angle Bay	2	Fishguard	26	93.90%	15.40%	£70	£167	£7	£48
Johnston	2,149	0.37%	9	Broad Haven	3	Fishguard	19	82.26%	13.49%	£114	£270	£11	£77
Kidwelly	3,183	0.55%	14	Burry Port	6	Swansea/Gower	18	64.91%	10.65%	£133	£316	£13	£90
Lampeter Velfry	1,342	0.23%	6	Amroth	5	Fishguard	22	76.81%	12.60%	£66	£158	£6	£45
Laugharne Township	1,272	0.22%	5	Freshwater East	2	Fishguard	27	91.76%	15.05%	£75	£179	£7	£51
Letterston	1,944	0.34%	8	Pendine	2	Swansea/Gower	25	91.25%	14.97%	£114	£271	£11	£77
Lamphey	1,646	0.28%	7	Newgale Sands	6	Fishguard	9	33.33%	5.47%	£35	£84	£3	£24
Llanboidy	1,675	0.29%	7	Amroth	9	Fishguard	19	52.46%	8.60%	£57	£134	£6	£38
Llanddarog	1,872	0.32%	8	Burry Port	14	Swansea/Gower	21	35.29%	5.79%	£43	£101	£4	£29
Llanddowror	1,646	0.28%	7	Amroth	5	Fishguard	26	80.95%	13.28%	£86	£204	£8	£58
Llandeilo	850	0.15%	4	Llanelli	19	Swansea/Gower	24	19.48%	3.19%	£11	£25	£1	£7
Llandybie	3,537	0.61%	15	Llanelli	16	Swansea/Gower	19	16.67%	2.73%	£38	£90	£4	£26
Llandyfaelog	1,256	0.22%	5	Pendine	10	Swansea/Gower	21	53.73%	8.81%	£43	£103	£4	£29
Llanegwad	1,740	0.30%	8	Burry Port	20	Swansea/Gower	26	25.00%	4.10%	£28	£67	£3	£19
Llanfihangel Aberbythych	1,560	0.27%	7	Llanelli	17	Swansea/Gower	23	25.00%	4.10%	£25	£60	£2	£17
Llangadog	1,747	0.30%	8	Llanelli	24	Swansea/Gower	27	12.64%	2.07%	£14	£34	£1	£10
Llangennech	4,003	0.69%	17	Llanelli	3	Swansea/Gower	10	66.67%	10.93%	£172	£408	£17	£116
Llangunnor	2,348	0.41%	10	Burry Port	13	Swansea/Gower	23	43.06%	7.06%	£65	£155	£6	£44
Llangwm	1,947	0.34%	8	Broad Haven	9	Fishguard	19	54.84%	8.99%	£69	£163	£7	£46
Llangyndeyrn	2,983	0.52%	13	Burry Port	9	Swansea/Gower	18	52.54%	8.62%	£101	£240	£10	£68

Table A7.9: Valuation of Costs to Ray Fishing

Lliedi	5,247	0.91%	23	Pendine	7	Swansea/Gower	24	72.73%	11.93%	£246	£584	£24	£166
Llwynhendy	4,494	0.78%	19	Llanelli	3	Swansea/Gower	10	74.19%	12.17%	£215	£510	£21	£145
Llynfell	940	0.16%	4	Llanelli	3	Swansea/Gower	8	70.37%	11.54%	£43	£101	£4	£29
Maenclochog	1,580	0.27%	7	Fishguard	13	Fishguard	13	0.00%	0.00%	£0	£0	£0	£0
Manorbier	1,887	0.33%	8	Freshwater East	2	Fishguard	27	93.10%	15.27%	£113	£269	£11	£76
Manordeilo	1,496	0.26%	6	Llanelli	22	Swansea/Gower	26	14.46%	2.37%	£14	£33	£1	£9
Martletwy	1,280	0.22%	6	Freshwater East	11	Fishguard	19	41.67%	6.83%	£34	£82	£3	£23
Merlin's Bridge	1,871	0.32%	8	Lindsway Bay	8	Fishguard	8	0.00%	0.00%	£0	£0	£0	£0
Milford	8,619	1.49%	37	Lindsway Bay	4	Fishguard	22	81.82%	13.42%	£454	£1,078	£44	£307
Myddfai	640	0.11%	3	Llanelli	29	Swansea/Gower	31	8.00%	1.31%	£3	£8	£0	£2
Myddnfych	1,184	0.20%	5	Llanelli	14	Swansea/Gower	18	21.05%	3.45%	£16	£38	£2	£11
Narberth	2,965	0.51%	13	Amroth	6	Fishguard	20	71.88%	11.79%	£137	£326	£13	£93
Newchurch	1,169	0.20%	5	Pendine	13	Swansea/Gower	28	51.69%	8.48%	£39	£92	£4	£26
Neyland	3,966	0.69%	17	Lindsway Bay	6	Fishguard	23	72.22%	11.84%	£185	£438	£18	£125
Pantyffynnon	1,215	0.21%	5	Llanelli	13	Swansea/Gower	18	26.32%	4.32%	£21	£49	£2	£14
Pembrey	3,679	0.64%	16	Burry Port	4	Swansea/Gower	15	74.47%	12.21%	£177	£419	£17	£119
Pembroke & Pembroke Dock	15,881	2.74%	69	Pembroke Dock	1	Fishguard	25	96.00%	15.74%	£983	£2,332	£96	£664
Penally	1,421	0.25%	6	Tenby beaches	3	Fishguard	28	90.11%	14.78%	£83	£196	£8	£56
Penygroes	2,203	0.38%	10	Llanelli	13	Swansea/Gower	18	27.59%	4.52%	£39	£93	£4	£26
Pontamman	1,289	0.22%	6	Llanelli	15	Swansea/Gower	18	17.24%	2.83%	£14	£34	£1	£10
Pontyberem	2,797	0.48%	12	Burry Port	9	Swansea/Gower	17	47.17%	7.74%	£85	£202	£8	£57
Prendergast	1,790	0.31%	8	Broad Haven	9	Fishguard	15	42.86%	7.03%	£49	£117	£5	£33
Priory	2,530	0.44%	11	Broad Haven	6	Fishguard	17	64.15%	10.52%	£105	£248	£10	£71
Quarter Bach	1,093	0.19%	5	Llanelli	21	Swansea/Gower	23	8.11%	1.33%	£6	£14	£1	£4
Rudbaxton	2,107	0.36%	9	Newgale Sands	9	Fishguard	15	38.78%	6.36%	£53	£125	£5	£36
Saron	3,222	0.56%	14	Llanelli	13	Swansea/Gower	17	25.93%	4.25%	£54	£128	£5	£36
Saundersfoot	2,666	0.46%	12	Saudersfoot	1	Fishguard	16	93.75%	15.38%	£161	£382	£16	£109
Solva	1,743	0.30%	4	Solva	1	Fishguard	13	92.00%	15.09%	£52	£123	£5	£35
St Clears	3,014	0.52%	13	Pendine	8	Fishguard	25	66.25%	10.87%	£129	£305	£13	£87
St Davids	1,959	0.34%	8	Solva	6	Fishguard	16	62.50%	10.25%	£79	£187	£8	£53
St Ishmaels	1,493	0.26%	6	Lindsway Bay	3	Fishguard	24	89.47%	14.67%	£86	£204	£8	£58
Stackpole	693	0.12%	3	Stackpole Quay	2	Fishguard	29	94.57%	15.51%	£42	£100	£4	£29
Swiss Valley	2,592	0.45%	11	Llanelli	5	Swansea/Gower	12	56.76%	9.31%	£95	£225	£9	£64
Tenby	4,809	0.83%	21	Tenby beaches	2	Fishguard	37	94.59%	15.51%	£293	£696	£29	£198
The Havens	1,439	0.25%	6	Broad Haven	2	Fishguard	19	91.94%	15.08%	£85	£202	£8	£58
Trelech	1,520	0.26%	7	Pendine	15	Fishguard	22	32.39%	5.31%	£32	£75	£3	£21
Trimsaran	2,696	0.47%	12	Burry Port	4	Swansea/Gower	11	63.89%	10.48%	£111	£263	£11	£75
Tumble	3,688	0.64%	16	Llanelli	9	Swansea/Gower	15	41.67%	6.83%	£99	£235	£10	£67
Tycroes	2,228	0.38%	10	Llanelli	10	Swansea/Gower	15	29.79%	4.89%	£43	£101	£4	£29
Tyisha	4,235	0.73%	18	Llanelli	2	Swansea/Gower	9	82.14%	13.47%	£224	£532	£22	£151
Whitland	1,518	0.26%	7	Amroth	7	Fishguard	22	67.14%	11.01%	£66	£156	£6	£44
Wiston	1574	0.27%	7	Fishguard	13	Fishguard	13	0.00%	0.00%	£0	£0	£0	£0
	236,670		**1,015**							**£9,335**	**£22,150**	**£910**	**£6,305**
DISTRICTS													
Carmarthen	39,263		169							£1,366	£3,243	£133	£923
Dinefwr	33,087		143							£486	£1,153	£47	£328
Llanelli	74,698		322							£3,168	£7,517	£309	£2,140
Preseli Pembrokeshire	48,763		204							£1,995	£4,735	£195	£1,348
South Pembrokeshire	40,859		176							£2,319	£5,503	£226	£1,567
	236,670		**1,015**							**£9,335**	**£22,150**	**£910**	**£6,305**

Table A7.10: Valuation of Costs to Pollack Fishing

Ward	Population	% Dyfed	number anglers	nearest site	distance	nearest alternative site	distance	% lost (year)	% lost due to ban	wts	wts	wtp	wtp
Dyfed	578,896		3,628							£98.25	£233.13	£9.58	£66.36
Abergwili	1,962	0.34%	12	Pendine	19	Swansea/Gower	28	33.33%	5.47%	£66	£157	£6	£45
Ammanford	1,465	0.25%	9	Llanelli	14	Swansea/Gower	18	22.03%	3.61%	£33	£77	£3	£22
Amroth	114	0.02%	1	Amroth	1	Fishguard	25	96.05%	15.75%	£11	£26	£1	£7
Begelly	1,742	0.30%	11	Saundersfoot	3	Fishguard	23	86.49%	14.18%	£152	£361	£15	£103
Betws	1,759	0.30%	11	Llanelli	13	Swansea/Gower	17	21.82%	3.58%	£39	£92	£4	£26
Bigyn	6,180	1.07%	39	Llanelli	2	Swansea/Gower	9	75.00%	12.30%	£468	£1,111	£46	£316
Brawdy	1,387	0.24%	4	Newgale Sands	6	Fishguard	10	43.75%	7.18%	£31	£73	£3	£21
Brynamman	932	0.16%	6	Llanelli	20	Swansea/Gower	23	12.33%	2.02%	£12	£28	£1	£8
Burry Port	4,379	0.76%	27	Burry Port	1	Swansea/Gower	24	95.83%	15.72%	£424	£1,006	£41	£286
Burton	1,404	0.24%	9	Lindsway Bay	8	Fishguard	22	61.43%	10.07%	£87	£207	£8	£59
Bynea	2,808	0.49%	18	Llanelli	4	Swansea/Gower	8	52.00%	8.53%	£147	£350	£14	£100
Camrose	2,307	0.40%	14	Newgale Sands	3	Fishguard	15	77.55%	12.72%	£181	£429	£18	£122
Carew	1,291	0.22%	8	Freshwater East	3	Fishguard	25	87.34%	14.32%	£114	£270	£11	£77
Carmarthen	12,247	2.12%	77	Pendine	10	Swansea/Gower	26	60.98%	10.00%	£754	£1,789	£74	£509
Castle	816	0.14%	5	Llanelli	20	Swansea/Gower	25	20.25%	3.32%	£17	£40	£2	£11
Castle	1,924	0.33%	12	Newgale Sands	7	Fishguard	16	54.00%	8.86%	£105	£249	£10	£71
Clynderwen	1,353	0.23%	8	Amroth	11	Fishguard	17	35.19%	5.77%	£48	£114	£5	£32
Cross Hands	1,394	0.24%	9	Llanelli	10	Swansea/Gower	16	37.25%	6.11%	£52	£124	£5	£35
Dafen	2,865	0.49%	18	Llanelli	4	Swansea/Gower	10	63.64%	10.44%	£184	£437	£18	£124
East Williamston	1,959	0.34%	12	Saundersfoot	1	Fishguard	26	97.86%	16.05%	£194	£459	£19	£131
Elli	3,169	0.55%	20	Llanelli	2	Swansea/Gower	10	80.65%	13.23%	£258	£612	£25	£174
Felinfoel	2,095	0.36%	13	Llanelli	19	Swansea/Gower	23	18.67%	3.06%	£39	£94	£4	£27
Ffairfach	1,155	0.20%	7	Llanelli	18	Swansea/Gower	21	13.43%	2.20%	£16	£37	£2	£11
Garnant	2,084	0.36%	13	Broad Haven	7	Fishguard	15	53.06%	8.70%	£112	£265	£11	£75
Glanamman	2,160	0.37%	14	Llanelli	15	Swansea/Gower	17	10.91%	1.79%	£24	£56	£2	£16
Glanymor	4,534	0.78%	28	Llanelli	1	Swansea/Gower	8	87.69%	14.38%	£401	£953	£39	£271
Glyn	2,015	0.35%	13	Burry Port	6	Swansea/Gower	14	58.70%	9.63%	£119	£283	£12	£81
Gorslas	3,428	0.59%	21	Llanelli	12	Swansea/Gower	19	35.00%	5.74%	£121	£287	£12	£82
Hakin	5,030	0.87%	32	Lindsway Bay	2	Fishguard	23	90.41%	14.83%	£459	£1,090	£45	£310
Hendy	2,735	0.47%	17	Llanelli	9	Swansea/Gower	13	33.33%	5.47%	£92	£218	£9	£62
Hengoed	3,682	0.64%	23	Burry Port	3	Swansea/Gower	12	72.97%	11.97%	£271	£644	£26	£183
Hundleton	1,163	0.20%	7	Angle Bay	2	Fishguard	26	93.90%	15.40%	£110	£262	£11	£74
Johnston	2,149	0.37%	13	Broad Haven	3	Fishguard	19	82.26%	13.49%	£178	£424	£17	£121
Kidwelly	3,183	0.55%	20	Burry Port	6	Swansea/Gower	18	64.91%	10.65%	£209	£495	£20	£141
Lampeter Velfry	1,342	0.23%	8	Amroth	5	Fishguard	22	76.81%	12.60%	£104	£247	£10	£70
Laugharne Township	1,272	0.22%	8	Freshwater East	2	Fishguard	27	91.76%	15.05%	£118	£280	£11	£80
Letterston	1,944	0.34%	12	Pendine	2	Swansea/Gower	25	91.25%	14.97%	£179	£425	£17	£121
Lamphey	1,646	0.28%	10	Newgale Sands	6	Fishguard	9	33.33%	5.47%	£55	£131	£5	£37
Llanboidy	1,675	0.29%	10	Amroth	9	Fishguard	19	52.46%	8.60%	£89	£211	£9	£60
Llanddarog	1,872	0.32%	12	Burry Port	14	Swansea/Gower	21	35.29%	5.79%	£67	£158	£7	£45
Llanddowror	1,646	0.28%	10	Amroth	5	Fishguard	26	80.95%	13.28%	£135	£319	£13	£91
Llandeilo	850	0.15%	5	Llanelli	19	Swansea/Gower	24	19.48%	3.19%	£17	£40	£2	£11
Llandybie	3,537	0.61%	22	Llanelli	16	Swansea/Gower	19	16.67%	2.73%	£60	£141	£6	£40
Llandyfaelog	1,256	0.22%	8	Pendine	10	Swansea/Gower	21	53.73%	8.81%	£68	£162	£7	£46
Llanegwad	1,740	0.30%	11	Burry Port	20	Swansea/Gower	26	25.00%	4.10%	£44	£104	£4	£30
Llanfihangel Aberbythych	1,560	0.27%	10	Llanelli	17	Swansea/Gower	23	25.00%	4.10%	£39	£93	£4	£27
Llangadog	1,747	0.30%	11	Llanelli	24	Swansea/Gower	27	12.64%	2.07%	£22	£53	£2	£15
Llangennech	4,003	0.69%	25	Llanelli	3	Swansea/Gower	10	66.67%	10.93%	£269	£639	£26	£182
Llangunnor	2,348	0.41%	15	Burry Port	13	Swansea/Gower	23	43.06%	7.06%	£102	£242	£10	£69
Llangwm	1,947	0.34%	12	Broad Haven	9	Fishguard	19	54.84%	8.99%	£108	£256	£11	£73
Llangyndeyrn	2,983	0.52%	19	Burry Port	9	Swansea/Gower	18	52.54%	8.62%	£158	£376	£15	£107

Table A7.10: Valuation of Costs to Pollack Fishing

Lliedi	5,247	0.91%	33	Pendine	7	Swansea/Gower	24	72.73%	11.93%	£385	£914	£38	£260
Llwynhendy	4,494	0.78%	28	Llanelli	3	Swansea/Gower	10	74.19%	12.17%	£337	£799	£33	£227
Llynfell	940	0.16%	6	Llanelli	3	Swansea/Gower	8	70.37%	11.54%	£67	£158	£7	£45
Maenclochog	1,580	0.27%	10	Fishguard	13	Fishguard	13	0.00%	0.00%	£0	£0	£0	£0
Manorbier	1,887	0.33%	12	Freshwater East	2	Fishguard	27	93.10%	15.27%	£177	£421	£17	£120
Manordeilo	1,496	0.26%	9	Llanelli	22	Swansea/Gower	26	14.46%	2.37%	£22	£52	£2	£15
Martletwy	1,280	0.22%	8	Freshwater East	11	Fishguard	19	41.67%	6.83%	£54	£128	£5	£36
Merlin's Bridge	1,871	0.32%	12	Lindsway Bay	8	Fishguard	8	0.00%	0.00%	£0	£0	£0	£0
Milford	8,619	1.49%	54	Lindsway Bay	4	Fishguard	22	81.82%	13.42%	£712	£1,690	£69	£481
Myddfai	640	0.11%	4	Llanelli	29	Swansea/Gower	31	8.00%	1.31%	£5	£12	£1	£3
Myddnfych	1,184	0.20%	7	Llanelli	14	Swansea/Gower	18	21.05%	3.45%	£25	£60	£2	£17
Narberth	2,965	0.51%	19	Amroth	6	Fishguard	20	71.88%	11.79%	£215	£511	£21	£145
Newchurch	1,169	0.20%	7	Pendine	13	Swansea/Gower	28	51.69%	8.48%	£61	£145	£6	£41
Neyland	3,966	0.69%	25	Lindsway Bay	6	Fishguard	23	72.22%	11.84%	£289	£686	£28	£195
Pantyffynnon	1,215	0.21%	8	Llanelli	13	Swansea/Gower	18	26.32%	4.32%	£32	£77	£3	£22
Pembrey	3,679	0.64%	23	Burry Port	4	Swansea/Gower	15	74.47%	12.21%	£277	£656	£27	£187
Pembroke & Pembroke Dock	15,881	2.74%	100	Pembroke Dock	1	Fishguard	25	96.00%	15.74%	£1,539	£3,653	£150	£1,040
Penally	1,421	0.25%	9	Tenby beaches	3	Fishguard	28	90.11%	14.78%	£129	£307	£13	£87
Penygroes	2,203	0.38%	14	Llanelli	13	Swansea/Gower	18	27.59%	4.52%	£61	£146	£6	£41
Pontamman	1,289	0.22%	8	Llanelli	15	Swansea/Gower	18	17.24%	2.83%	£22	£53	£2	£15
Pontyberem	2,797	0.48%	18	Burry Port	9	Swansea/Gower	17	47.17%	7.74%	£133	£316	£13	£90
Prendergast	1,790	0.31%	11	Broad Haven	9	Fishguard	15	42.86%	7.03%	£77	£184	£8	£52
Priory	2,530	0.44%	16	Broad Haven	6	Fishguard	17	64.15%	10.52%	£164	£389	£16	£111
Quarter Bach	1,093	0.19%	7	Llanelli	21	Swansea/Gower	23	8.11%	1.33%	£9	£21	£1	£6
Rudbaxton	2,107	0.36%	13	Newgale Sands	9	Fishguard	15	38.78%	6.36%	£82	£196	£8	£56
Saron	3,222	0.56%	20	Llanelli	13	Swansea/Gower	17	25.93%	4.25%	£84	£200	£8	£57
Saundersfoot	2,666	0.46%	17	Saudersfoot	1	Fishguard	16	93.75%	15.38%	£252	£599	£25	£170
Solva	1,743	0.30%	5	Solva	1	Fishguard	13	92.00%	15.09%	£81	£192	£8	£55
St Clears	3,014	0.52%	19	Pendine	8	Fishguard	25	66.25%	10.87%	£202	£478	£20	£136
St Davids	1,959	0.34%	12	Solva	6	Fishguard	16	62.50%	10.25%	£124	£293	£12	£84
St Ishmaels	1,493	0.26%	9	Lindsway Bay	3	Fishguard	24	89.47%	14.67%	£135	£320	£13	£91
Stackpole	693	0.12%	4	Stackpole Quay	2	Fishguard	29	94.57%	15.51%	£66	£157	£6	£45
Swiss Valley	2,592	0.45%	16	Llanelli	5	Swansea/Gower	12	56.76%	9.31%	£149	£353	£14	£100
Tenby	4,809	0.83%	30	Tenby beaches	2	Fishguard	37	94.59%	15.51%	£459	£1,090	£45	£310
The Havens	1,439	0.25%	9	Broad Haven	2	Fishguard	19	91.94%	15.08%	£134	£317	£13	£90
Trelech	1,520	0.26%	10	Pendine	15	Fishguard	22	32.39%	5.31%	£50	£118	£5	£34
Trimsaran	2,696	0.47%	17	Burry Port	4	Swansea/Gower	11	63.89%	10.48%	£174	£413	£17	£117
Tumble	3,688	0.64%	23	Llanelli	9	Swansea/Gower	15	41.67%	6.83%	£155	£368	£15	£105
Tycroes	2,228	0.38%	14	Llanelli	10	Swansea/Gower	15	29.79%	4.89%	£67	£159	£7	£45
Tyisha	4,235	0.73%	27	Llanelli	2	Swansea/Gower	9	82.14%	13.47%	£351	£834	£34	£237
Whitland	1,518	0.26%	10	Amroth	7	Fishguard	22	67.14%	11.01%	£103	£244	£10	£70
Wiston	1574	0.27%	10	Fishguard	13	Fishguard	13	0.00%	0.00%	£0	£0	£0	£0
	236,670		**1,473**							**£14,625**	**£34,705**	**£1,426**	**£9,879**
DISTRICTS													
Carmarthen	39,263		246							£2,141	£5,080	£209	£1,446
Dinefwr	33,087		207							£761	£1,806	£74	£514
Llanelli	74,698		468							£4,964	£11,778	£484	£3,353
Preseli Pembrokeshire	48,763		296							£3,126	£7,418	£305	£2,112
South Pembrokeshire	40,859		256							£3,634	£8,622	£354	£2,454
	236,670		**1,473**							**£14,625**	**£34,705**	**£1,426**	**£9,879**

Fig. A7.1: Tywi, Gwili & Cothi Catches
Ten Year Average: 1986 to 1995

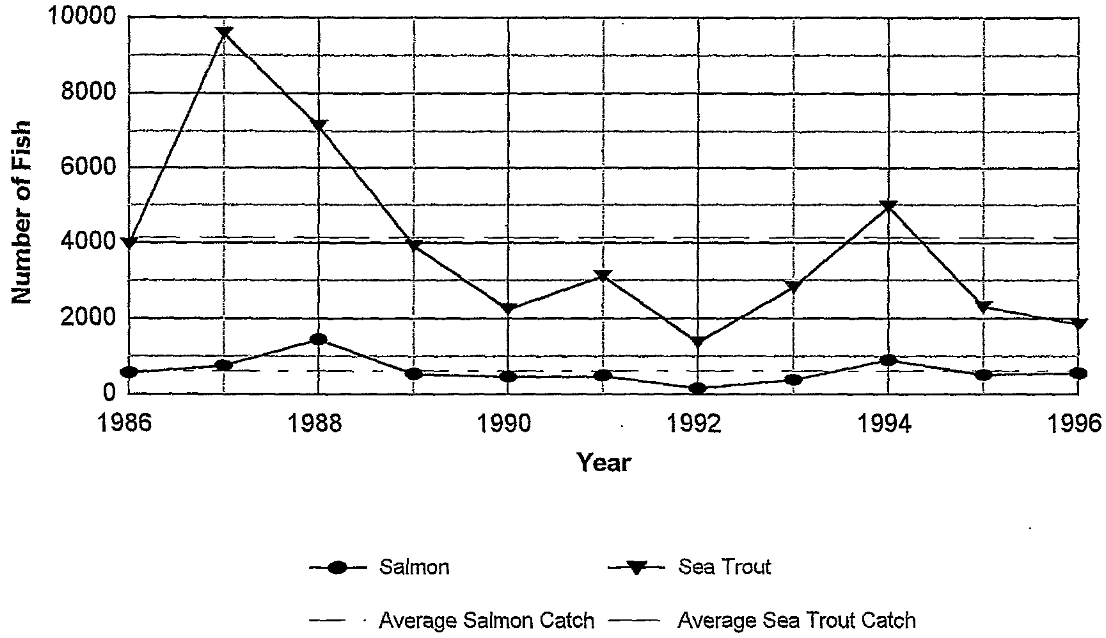


Figure A7.2: Catches on the Taf
Ten Year Average: 1986 to 1995

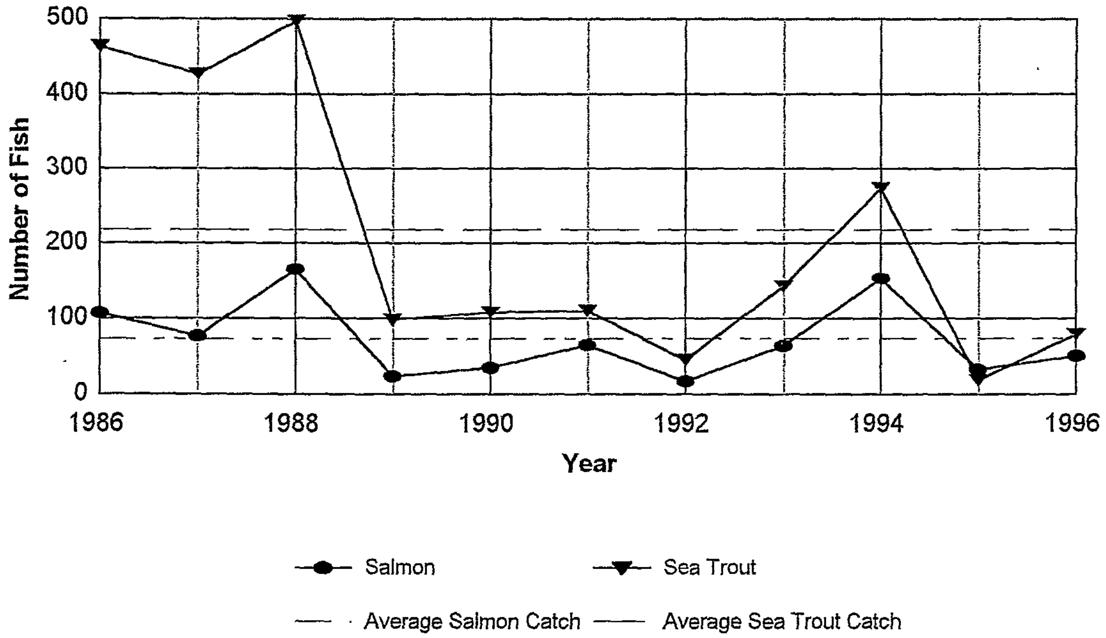


Figure A7.3: Catches on E & W Cleddau
Ten Year Average: 1986 to 1995

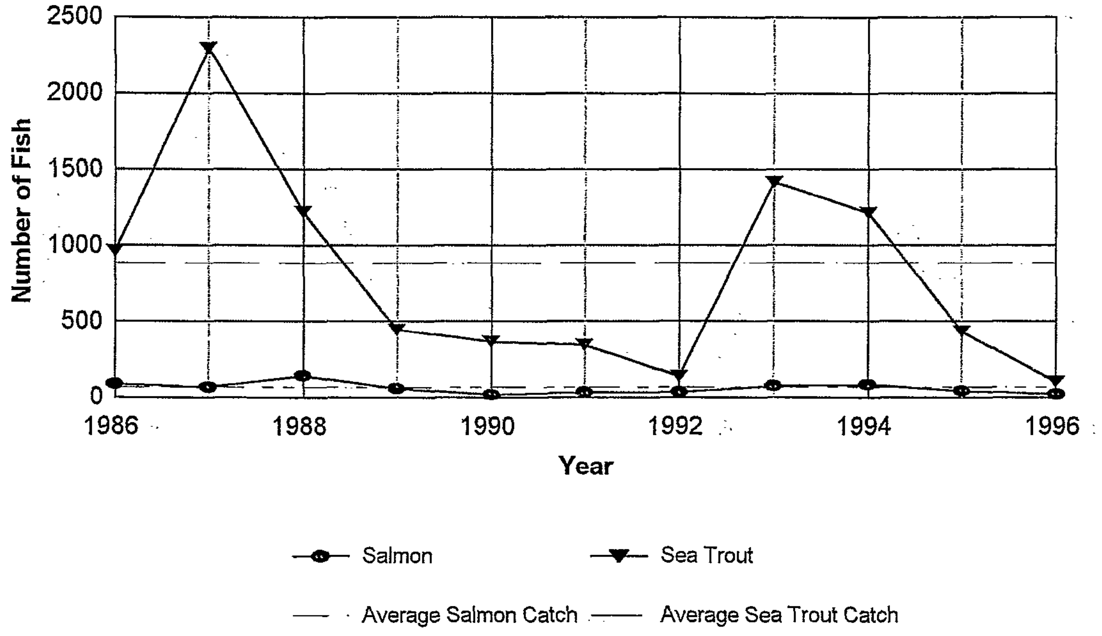


Figure A7.4: Gwendraeths Catches
Ten Year Average: 1986 to 1995

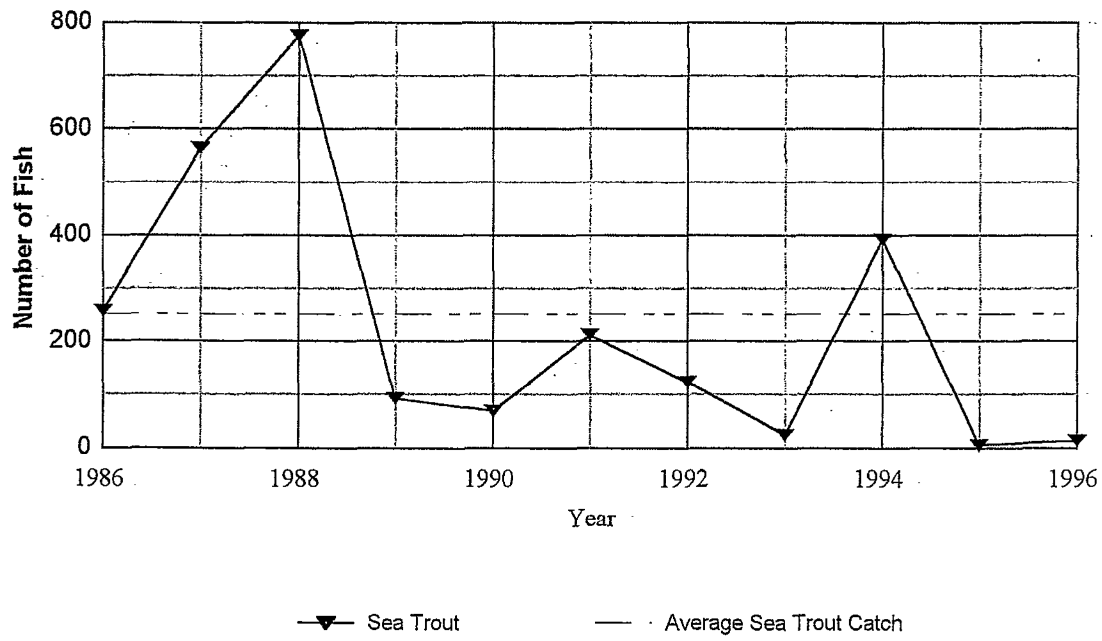
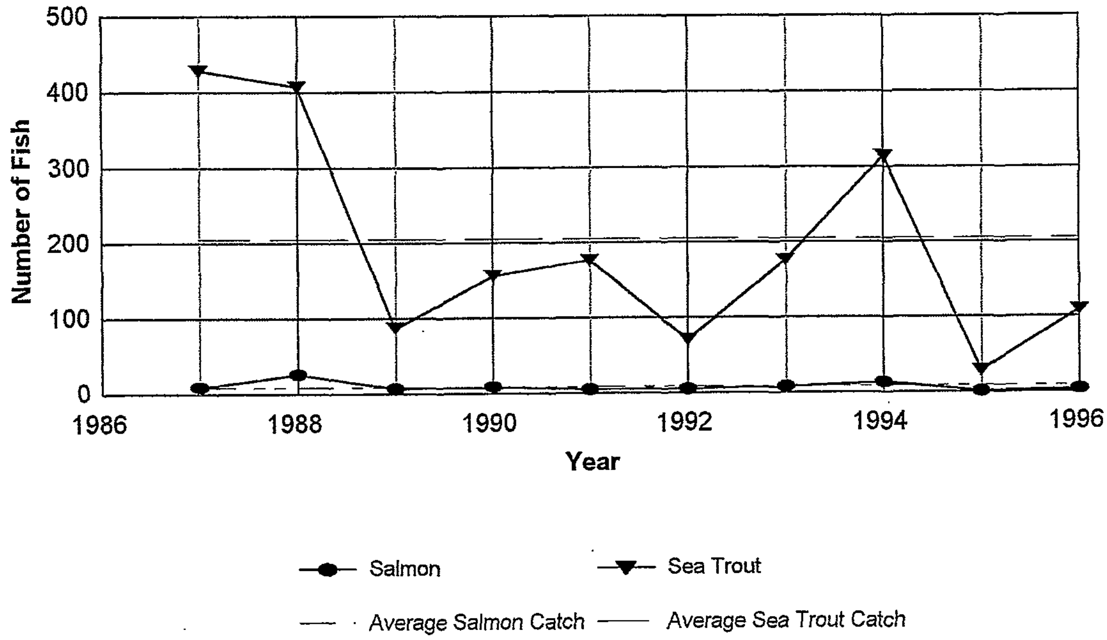


Figure A7.5: Loughour Catches
Nine Year Average: 1987 to 1995



ANNEX 8: DATA IN SUPPORT OF ANALYSIS OF IMPACTS ON INDUSTRY

There are no additional data to support the analysis of impacts on local industry.

ANNEX 9: DATA IN SUPPORT OF ANALYSIS OF CONSERVATION EFFECTS

Annex 9 Contents:

Table A9.1: Costs of Replacing Species Stranded After *Sea Empress* Incident (total costs are given to no more than three significant figures)

Species	Estimated Quantity	Location	Date	Value per individual	Total for Stranding Event	Total for Species
Asteria Starfish	1,500	Tenby South Beach	2/3 March	\$2.50 £1.48 (from MBL)	£2,220	
	500	Wisemans Bridge/Coppet Hall	14/17 March		£740	£2,960
Blenny	1	Amroth/Wisemans Bridge	29 February	in price list about £4	£4	
	1	Tenby Gosker Rock Area	2 March	about £4	£4	£8
Chamelea gallina Striped venus	500	Pendine	25 February	\$2.10 £1.24 (from MBL)	£620	£620
Cockles	200	Angle Bay	23 February	24 p per kg wholesale value (assuming 100 per kg)	£48	
	25	Dale Beach	24 February		£6	
	500	Pendine	25 February		£120	
	200	Saundersfoot & Tenby	27 February		£48	
	1,000	Sandy Haven	3 March		£240	
	500	Amroth/Wisemans Bridge	5 March		£120	
	5,000	Saundersfoot	9 March		£1,200	
	5,000	Wisemans Bridge/Coppet Hall	10 March		£1,200	
	500	Tenby (North and South)	11 March		£120	
	500	Kilpaison	1 May		£120	
	500	Saundersfoot	mid May		£120	£3,340

Table A9.1: Costs of Replacing Species Stranded After *Sea Empress* Incident (total costs are given to no more than three significant figures)

Species	Estimated Quantity	Location	Date	Value per individual	Total for Stranding Event	Total for Species
Corystes	125	Monkstone	3 May	estimated at £1.24 (compared to other species)	£155	£155
Crabs	50	Newgale	26 February	£0.60 per kg (assume 2 per kg)	£15	
	2	Amroth/Wisemans Bridge	2 March		£0.60	
	50	Wisemans Bridge/Coppet Hall	14/17 March		£15	
	50	Wisemans Bridge	27 April		£15	
	50	Kilpaison	1 May		£15	
	150	Monkstone	3 May		£45	£106.00
Donax	5,000	Wisemans Bridge/Coppet Hall	10 March	\$2.10 £1.24 (from MBL)	£6,200	£6,200
Echinocardium Heart Urchins	500	Dale Beach	5 March	£4 per urchin	£2,000	
	500	Tenby South Beach	6 March		£2,000	
	550	Priory Bay, Caldey	early March		£2,200	
	200	Tenby North Beach	16 March		£800	£7,000
Gobies	5	Tenby Gosker Rock Area	2 March	in price list £3	£15	£15
Mactra Rayed Trough Shell	500	Wisemans Bridge/Coppet Hall	10 March	\$3.00 £1.77 (from MBL)	£885	
	10,000	Rhossili Bay, Gower	to end of April		£17,700	£18,600

Table A9.1: Costs of Replacing Species Stranded After *Sea Empress* Incident (total costs are given to no more than three significant figures)

Species	Estimated Quantity	Location	Date	Value per individual	Total for Stranding Event	Total for Species
Periwinkles	5,000	Wisemans Bridge	17 March	£0.70 per kg 100 per kg	£35	£35
Pharus Egg shell razor	5,000	Tenby North Beach to Wisemans Bridge	9 to 14 March	$2.50 £1.48 (MBL)	£7,400	£7,400
Pipefish	1	Amroth/Wisemans Bridge	29 February	in price list £5	£5	£5
Ragworms	20	West Angle Bay	25 February	$2.50 £1.48 MBL	£29.60	
	10	Wisemans Bridge	27 April		£14.80	£44.40
Razorshells *Ensis*	1	Newgale	26 February	$2.50 £1.48 MBL	£1.48	
	5,000	Wisemans Bridge/Coppet Hall	10/14 March		£7,400	
	500	Dale Beach	19 February		£740	
	500	Saundersfoot	December		£740	£8,880
Scad	10	Saundersfoot	29 August	55p per kg about 5 per kg	£2.20	£2.20
Sea potato	1	Nolton Haven	26 February	estimate of £1.24 (from other species)	£1.24	£1.24
Sprat	1	Newgale	26 February	£300 per tonne (50 fish per kg, 50,000 per tonne)	The low numbers stranded gives costs of practically zero £0.02	
	2	Druidstone	26 February			
	1	Marloes	10 March			£0
Tellins	100	Broad Haven (N)	25 February	$2.10 £1.24 MBL	£124	£124

Table A9.1: Costs of Replacing Species Stranded After *Sea Empress* Incident (total costs are given to no more than three significant figures)

Species	Estimated Quantity	Location	Date	Value per individual	Total for Stranding Event	Total for Species
Whitebait	10	Saundersfoot	29 August	£1,051 per tonne (25 per kg, 25,000 per tonne)	£0.42	£0.42
				TOTAL COSTS TO REPLACE STRANDED SPECIES:		**£55,500**

Sources: Price list downloaded from **MRC** Internet site (http://www.mbl.edu/html/MRC/HTML/phylum.html); price list from Tropical Marine Centre, Hertfordshire.

Table A9.2 : Non-Use Values

Source	Method of Valuation	Valuation Criteria	Value	Comments
Anglian Water (FWR)	Household survey	WTP to improve quality of effluent for improved bathing water quality in East Anglia	£0.10 /household/EC designated beach/year	£1996
Bateman et al. (1995)	CVM	National survey to collect non-use values related to conserving the Norfolk Broads.	Nearby zone: £12.45 Households further away: £4.08; aggregate estimate of £32.5 million and £7.3 million, respectively	£1995
California Department of Fish and Game cited in Sorensen, 1976 in Mattson, 1979	Compensation costs	Santa Barbara Channel oil Spill, compensation costs for the death of 14,000 sea gulls. Replacement cost (final compensation not split down - not all costs met)	$17 /dead sea gull	?$1976
Carson et al, 1992	CVM	WTP to prevent another Exxon Valdez type spill	Median WTP of $31 per household	$1990 (WTP value deemed a conservative lower bound)
Carson et al, 1992 in Harrison and Lesley, 1996	CVM	Damages arising from environmental injury caused by Exxon Valdez	$2.8bn	$1992(?) - considered a 'conservative estimate'
Carson et al, 1994	CVM	WTP to prevent an Exxon Valdez type oil spill	Adjusted median $49 /household	$1994
Cited in Mattson, 1979	Compensation Costs	1.5 million gallon *Zoe Colocotroni* spill in Puerto Rico in 1973 destroyed 23 acres of coastal mangroves. Due to modification of the habitat, the Commonwealth of Puerto Rico was awarded compensatory damages. Replacement costs theory accepted in court.	$6.2 million = $0.27 million/acre	?$1978

Table A9.2 : Non-Use Values

Source	Method of Valuation	Valuation Criteria	Value	Comments
ERM Economics, 1997	CVM	WTP for one additional beach to meet EC standard on cleanliness (from General Public Survey undertaken by BMRB in South West)	£1.30 - £1.43 /respondent/beach	£1997 'respondent' appears to be 'household'
Fouquet et al, 1992	CVM	WTP to protect Hurst Spit. Includes non-use value	£9.20 - £40.60 /visitor/year	£1991
Garrod and Willis, 1994	CVM	WTP for an additional coastal sand dune and salt marsh reserve - respondents were members of the Northumberland Wildlife Trust	Mean £1.662 /respondent/year Standard Deviation £4.56 /respondent/year	£1994
Georgiou et al, 1996	CVM	WTP additional water rates to ensure that bathing water constantly passes EC standard	**Great Yarmouth** Mean £12.64 all £9.33 local residents Median £0.00 for all **Lowestoft** Mean £14.32 all £13.50 local residents Median £4.75 all £0.00 local residents	£1996 Must be some element of non-use for local residents
Green and Tunstall, 1991 in Bateman et al, 1993	CVM	WTP to protect coast - survey of residents in 5 towns. Includes non-use value	£21.90 - £25.16 /resident/year	?£1991

Table A9.2 : Non-Use Values

Source	Method of Valuation	Valuation Criteria	Value	Comments
Grigalunas, 1986	Opportunity cost	Social costs of clean-up of Amoco Cadiz to France	FF430-475m	FF1978
Grigalunas, 1986	Replacement costs	Social costs of losses to oyster culturing caused by Amoco Cadiz to France	FF107m	FF1978
Grigalunas, 1986	Cost data	Cost of treating oiled birds living after 2 years	$1,300 per bird	$1980/1979. Original sources referenced in article
Grigalunas, 1986	Replacement values	Estimated damage to marine life caused by Amoco Cadiz to France	FF2.4-60m	FF1978
Gupta, 1973	Model	Inland freshwater wetland assessment model	Value of wildlife $10 - $70/acre/year Visual-Cultural $30 - $270/acre/year	$1973
Gupta and Foster, 1976 in Shabman and Batie, 1988	Hypothetical return from investment to buy open space	The authors analysed the prices paid for open-space land by conservation commissions in Massachusetts in 1972. The average price per acre was $1,608. The highest was $5,769 per acre. The authors chose $5,000 per acre and, using a 5.375% capitalisation rate, calculated the annual 'return'. The authors conclude that this is equivalent to maximum WTP for high-quality wetland visual-cultural values.	$270 /acre/year	
Hammack J & Brown GM Jr, (1974)	Consumer Surplus and Marginal Value	Survey of wildfowl hunters marginal value of a waterfowl was calculated over the whole sample of 1,511 hunters	from $247 to $257 per year $3.35 to $5.21 per year	$1968

Table A9.2 : Non-Use Values

Source	Method of Valuation	Valuation Criteria	Value	Comments
Hanley, 1991 in Turner et al, 1992	CVM	Heathland conservation in Dorset	WTP: £0.74/visit with entry fee WTP: £9.73/year with annual payment WTP: £25.57/once off payment	£1991
Hanley, 1991 in Turner et al, 1992	CVM	Preservation benefits: flow country (Scotland)	Mean WTP: £16.8 per capita as a once-off payment	£1991
Hanley et al 1991 in Turner et al, 1992	CVM	Heathland preservation/woodland loss	WTP per capita according to different information categories. No information - £21.54 Info on heath loss - £20.60 Info on species loss - £21.52 Info on both losses - £30.59	£1991
Institute of Offshore Engineering, 1995 (FWR)	CVM	WTP to upgrade sewage system discharging into Torry Bay to reduce litter on shore, improve seawater quality, enhance recreation and benefit wildlife	£39.39 /household/year	?£1995 some component is non-use but not separated out

Table A9.2 : Non-Use Values

Source	Method of Valuation	Valuation Criteria	Value	Comments
Kaoru, 1993	CVM	WTP for coastal pond water quality improvements on island of Martha's Vineyard, Mass.	**Option Value**: $19.41/respondent/year **Existence value**: $77.59/respondent/year	$1989 (components of total WTP of $131.03)
Lant & Roberts, 1990 in Gren & Söderqvist, 1994	CVM	WTP estimates from interviews with households from selected towns in Iowa and Illinois for changes in river quality	Poor to fair $42 Fair to good: $52 Good to excellent: $53	$1993
North West Water (FWR)		Improve treatment of coastal discharges so beaches compare with 'blue flag' status	£0.09 /household/EC designated beach/year	£1996
PMM, 1990 in Bateman et al, 1991	?	Alternative site for bird due to construction of Cardiff Barrage	£4m	£1990

Table A9.2 : Non-Use Values

Source	Method of Valuation	Valuation Criteria	Value	Comments
Rowe and Shaw, 1992	CVM	WTP estimates over five years to prevent oil spills in the Pacific Northwest. Article focuses on natural resource damages and non-use values - trying to determine how much should be spent on oil spill prevention measures in future. Estimating value to citizens of Washington and BC - randomly chosen. Household values.	**Washington** All Spills $240 - $335 Large Spill $110 - $160 Moderate Spill $65 - $175 Several small spills $40 - $50 Routine very small spills $25 **BC** All Spills $190 - $375 Large spill $80 - $170 Moderate $55 - $245 Several small $35 - $65 routine very small $20 - $40	Very complex article - exploring adjustments. These values are resulting computations
Sculze et al, 1983 in Randall, 1994 in Eds: Braden & Kolstad, 1994	CVM	Visibility preservation in SW parklands	Preservation: $2.89 to $4.50 per household per year	$1994
Sorensen, 1978 in Mattson, 1979	Replacement Costs (from biological supply firms)	Evidence as Commonwealth of Puerto Rico's expert witness in trial of *Zoe Colocotroni* spill. Found damaged bay had 1,138 less organisms per square metre than unaffected site	$0.06 - $4.50 /individual organism killed. Court accepted lower bound of $0.06 per organism 'lost'.	?$1978

Table A9.2 : Non-Use Values

Source	Method of Valuation	Valuation Criteria	Value	Comments
Sorensen, 1976 in Mattson, 1979	Replacement Costs (from biological supply firms)	Refined following Santa Barbara Channel oil spill replacement costs theory	Deep subtidal organisms (molluscs, brittle stars, worms) $0.25 each Hydroids $0.2 Red worms $0.2 Barnacles $0.1 Sand crab $0.03 Orchestoidea $0.03 Polychaete worms $0.16 Limpets $0.375 Mussels $0.3 High intertidal amphipods $0.25 Sea lion $75 Algae and surf grass $319 /ton	?$1976
South West Water (FWR)	Household survey	WTP to provide sewage treatment for more coastal areas in addition to the present programme to eliminate sewage pollution of the sea	£0.04 /household/EC designated beach/year	£1996
		Aim for stricter controls on sewage treatment to meet new EEC standards	£0.03 /household/EC designated beach/year	£1996
Sutherland & Walsh in Randall, 1994 in Eds: Braden & Kolstad, 1994	CVM	Distance and water preservation values at Flathead Lake, Montana. Willingness to pay is aggregated over the 1,000 household sampled.	$8,183.70 per 1000 household per year	$1994

Table A9.2 : Non-Use Values

Source	Method of Valuation	Valuation Criteria	Value	Comments
US Department of the Interior's Fish and Wildlife Service reported in Mattson, 1979	'Fair market Value' or 'Replacement Cost'	Replacement for birds lost in the Chesapeake Bay oil spill of 1976, assuming that two birds were missed for each one counted as being killed	Grebes, Loons and Sea Gulls $10 - Whistling Swan $200	?$1976
Walsh et al, 1978 in Loomis & Walsh, 1986	CVM	The viability of fish populations for various use and non-use categories, with existence value based on the presence of clean water	Non-use $34 per non-user household and $34 for user households for existence value Bequest value of $17 per non-user household and $33 per user household	$1978
Welsh Water (FWR)	Household survey	Improvements to coastal sewage treatment	£0.14 /household/EC designated beach/year	£1996
		Advanced protection of bathing waters (disinfection)	£0.14 /household/EC designated beach/year	£1996
Willis, 1990 in Bateman et al, 1993	CVM	Hypothetical trust fund for SSSIs and nature reserves - option price including use and non-use values	IOB and BES members £4.54 /person Households up to 200km radius £0.82 /person	?£1990
Willis et al, 1995	CVM (payment card format)	WTP of benefits of ESA scheme of general public who are not visitors	South Downs ESA mean annual household WTP of £36.65 to maintain ESA scheme	£1993

Table A9.2 : Non-Use Values

Source	Method of Valuation	Valuation Criteria	Value	Comments
Yorkshire Water (FWR)		Improve discharges into North Sea: 1) meet today's standard 2) meet higher standards 3) meet higher standards sooner	 £0.03 £0.06 £0.06 /household/EC designated beach/year	£1996

ANNEX 10: DATA ON HUMAN HEALTH EFFECTS

Annex 10 Contents:

Table A10.1: Onset of Symptoms in the Five Months Following the *Braer* Oil Spill

Symptom	Odds Ratio
Weakness	9.18
Wheezing	4.84
Breathlessness on exercise	3.08
Unsteadiness	2.83
Cramps	2.14
Breathlessness at rest	1.63
Infections	1.52
Eyesight Problems	1.28

Source: Campbell *et al* (1994): *Later Effects of Grounding of Tanker* Braer *on Health in Shetland*, BMJ, Volume 309, 24 September 1994.

Table A10.2: Occupational Exposure Limits, Assessment Levels and Odour Thresholds

Compound	Occupational Exposure Limits		Assessment Levels		Odour Thresholds	
	ppm	mg/m^3	ppm	mg/m^3	ppm	mg/m^3
Benzene	5	16	0.125	0.4	61	197
1-3 butadiene	10	22	0.25	0.56		
Toluene	50	192	1.25	4.8		
Ethyl Benzene	100	435	2.5	11	0.05	0.22
Xylene	100	435	2.5	11	0.1	0.43

Source: Carruthers and Ellis (1997): *Prediction of Ambient Concentration of Volatile Organic Compounds (VOCs) from the Sea Empress Oil Spill using Vapour and Oil Property Models*, a report to the Environment Agency, September 1997.

Concentrations of five VOCs were derived from modelling and compared with 'assessment levels' for the general population. The assessment levels, which can be seen as the equivalent of occupational exposure limits (OELs) for the general public, were derived from maximum exposure limits and worker OELs divided by a factor of 40 to take account of the sensitivity of sectors of the population and the continuous nature of exposure compared with exposure in the workplace. These are presented in Table A10.1 along with OELs and odour thresholds.

In general terms, the highest concentrations of VOCs occurred over the sea and exceeded assessment levels for all compounds. With respect to mean hourly average concentrations over land, only those for benzene were above the assessment levels for areas other than West Blockhouse Point which was the area adjacent to the spill. The areas affected were the headland east of the spill and South Hook Point. However, the hourly average concentrations during light wind conditions indicate that the area in which benzene concentration exceeded assessment levels could have been significantly greater.

For maximum hourly average concentrations, concentrations of both benzene and toluene exceeded assessment levels for what appear to be large areas of land to the south east of the spill. In addition, it appears that the odour thresholds for ethyl benzene and xylene will have also been exceeded over land to the north east of the spill. With respect to assessment levels, the calculated concentrations are reported to be significant, especially in the case of benzene (Carruthers and Ellis, 1997).

Table A10.3: Value of Health Effects (£1996)

Symptom	Length of Illness (days)	Willingness-to-Pay Value (£ per day)	Source
Weakness	-	-	-
Headache	1	12	Dickie *et al* (1987/88)
	1	27	Tolley *et al* (1986)
	30	11	Tolley *et al* (1986)
Runny Nose	1	6	Dickie *et al* (1987/88)
Sore Throat (throat congestion)	1	11	Dickie *et al* (1987/88)
	1	19	Tolley *et al* (1986)
	30	5	Tolley *et al* (1986)
Cough	1	7	Dickie *et al* (1987/88)
	1	17	Tolley *et al* (1986)
	30	4	Tolley *et al* (1986)
Generally Ill	-	-	-
Nausea	1	34	Tolley *et al* (1986)
	30	4	Tolley *et al* (1986)
Sore Eyes	1	10	Dickie *et al* (1987/88)
	1	18	Tolley *et al* (1986)
	30	5	Tolley *et al* (1986)
Itching Skin	-	-	-
Shortness of Breath (mild)	1	17	Loehman (1979)
	7	42	Loehman (1979)
	90	114	Loehman (1979)
Shortness of Breath (severe)	1	34	Loehman (1979)
	7	103	Loehman (1979)
	90	241	Loehman (1979)
Skin Rash	-	-	-

Source: Environment Agency (1996): **The Feasibility of Cost Benefit Analysis for Integrated Pollution Control**, a report prepared by ERM Economics on behalf of the Environment Agency.

Table A10.4: Valuation of Physical Impacts from Proximity to Oiled Beaches (Page 1 of 2)

Symptom	Prevalence in Control Group	Odds Ratio A**	Odds Ratio B**	Estimated % of Population Experiencing Symptom Because of Sea Empress (Adjusted Using Odds Ratio A)	Estimated % of Population Experiencing Symptom Because of Sea Empress (Adjusted Using Odds Ratio B)
*weakness	12.70%	1.9	-	11.43%	
headache	12.00%	3.9	2.47	34.80%	17.64%
runny nose	11.30%	1.9	-	10.17%	
sore throat	10.50%	2.9	3.04	19.95%	21.42%
cough	9.60%	1.9	-	8.64%	
*generally ill	7.30%	3.5	2.78	18.25%	12.99%
nausea	5.80%	2.4	-	8.12%	
sore eyes	4.90%	3.5	2.37	12.25%	6.71%
*itching skin	4.70%	2.3	-	6.11%	
shortness of breath	4.40%	2.3	-	5.72%	
*skin rash	2.90%	2.3	-	3.77%	
Total Valuation					

Notes:

* No WTP values available for marked symptoms, so the lowest available value for any symptom (£6) was applied.

** See Section 10.2.1 and Table 10.1 for details of these odds ratios.

*** See Table A10.1 for a range of WTP values. Only values for symptoms lasting one day were used here.

Table A10.4: Valuation of Physical Impacts from Proximity to Oiled Beaches (Page 2 of 2)

Symptom	Estimated Exposed Population 25,500 Experiencing Symptom (Using Odds Ratio A)	Estimated Exposed Population 25,500 Experiencing Symptom (Using Odds Ratio B)	WTP Value (high) ***	WTP Value (low) ***	Valuation of Physical Impacts on Exposed Population (low) (Using Odds Ratio B and Low WTP Values)	(medium) (using Odds Ratio A and Low WTP Values)	(high) (Using Odds Ratio A and High WTP Values)
*weakness	2915	0	6	6	£0	£17,488	£17,488
headache	8874	4498	27	12	£53,978	£106,488	£239,598
runny nose	2593	0	6	6	£0	£15,560	£15,560
sore throat	5087	5462	19	11	£60,083	£55,960	£96,658
cough	2203	0	17	7	£0	£15,422	£37,454
*generally ill	4654	3313	6	6	£19,881	£27,923	£27,923
nausea	2071	0	34	34	£0	£70,400	£70,400
sore eyes	3124	1712	18	10	£17,118	£31,238	£56,228
*itching skin	1558	0	6	6	£0	£9,348	£9,348
shortness of breath	1459	0	17	17	£0	£24,796	£24,796
*skin rash	961	0	6	6	£0	£5,768	£5,768
					£151,060	$\boxed{£380,391}$	£601,221

Table A10.5: Valuation of Physical Impacts from the Xylene Vapour Cloud (Page 1 of 2)

Symptom	Prevalence in Control Group	Odds Ratio A**	Odds Ratio B**	Estimated % of Population Experiencing Symptom Because of Sea Empress (Adjusted Using Odds Ratio A)	Estimated % of Population Experiencing Symptom Because of Sea Empress (Adjusted Using Odds Ratio B)
*weakness	12.70%	-	-		
headache	12.00%	3.9	2.47	34.80%	17.64%
runny nose	11.30%	-	-		
sore throat	10.50%	-	-		
cough	9.60%	-	-		
*generally ill	7.30%	-	-		
nausea	5.80%	2.4	-	8.12%	0.00%
sore eyes	4.90%	-	-		
*itching skin	4.70%	-	-		
shortness of breath	4.40%	-	-		
*skin rash	2.90%	-	-		
Total Valuation					

Notes:

* No WTP values available for marked symptoms, so the lowest available value for any symptom (£6) was applied.

** See Section 10.2.1 and Table 10.1 for details of these odds ratios.

*** See Table A10.1 for a range of WTP values. Only values for symptoms lasting one day were used here.

Table A10.5: Valuation of Physical Impacts from the Xylene Vapour Cloud (Page 2 of 2)

Symptom	Estimated Exposed Population 37500 Experiencing Symptom (Using Odds Ratio A)	Estimated Exposed Population 37500 Experiencing Symptom (Using Odds Ratio B)	WTP Value (high) ***	WTP Value (low) ***	Valuation of Physical Impacts on Exposed Population (low) (Using Odds Ratio B and Low WTP Values)	(medium) (Using Odds Ratio A and Low WTP Values)	(high) (Using Odds Ratio A and High WTP Values)
*weakness	0	0	6	6	£0	£0	£0
headache	13050	6615	27	12	£79,380	£156,600	£352,350
runny nose	0	0	6	6	£0	£0	£0
sore throat	0	0	19	11	£0	£0	£0
cough	0	0	17	7	£0	£0	£0
*generally ill	0	0	6	6	£0	£0	£0
nausea	3045	0	34	34	£0	£103,530	£103,530
sore eyes	0	0	18	10	£0	£0	£0
*itching skin	0	0	6	6	£0	£0	£0
shortness of breath	0	0	17	17	£0	£0	£0
*skin rash	0	0	6	6	£0	£0	£0
Total Valuation					£79,380	$\boxed{£260,130}$	£455,880

ANNEX 11: FLORIDA'S DAMAGE COMPENSATION FORMULA

Annex 11 Contents:

Box A11.1: Florida's Damage Compensation Formula

Formula: Damages = (PCF*($1/gallon*gallons spilled*LDF*SMAF)+(CIH*HF)))+CDES+CDA

Variable	Value	Meaning
PCF		Pollutant Category Factor
	8	Bunker and residual fuels
	4	waste oil, crude oil, lubricating oil, asphalt and tars
	1	hydraulic fuels, numbers 1 and 2 diesel fuels, heating oil, jet aviation fuel, gasoline and kerosine
LDF		Location of Discharge Factor
	8	Discharges that originate inshore
	5	Discharges that originate nearshore
	1	Discharges that originate offshore
SMAF		Special Management Area Factor
	2	Location designated as a particularly sensitive area
	1	Location not designated as a particularly sensitive area
CHI	CHI	Coverage of impacted area (linear or areal)
HF		Habitat factor
	$10/sq. foot	Coral reef
	$1/sq. foot	Mangrove or sea grass
	$1/foot	Sandy beach
	$0.50/sq. foot	Live bottom, oyster reefs, worm rock, perrenial algae, saltmarsh, freshwater tidal marsh
CDES		Compensation for Death of Endangered Species
	$10,000	Death of each endangered animal
	$5,000	Death of each threatened aanimal
CDA		Cost of conducting damage assessment

Table A11.1: Application of the FDCF to the Sea Empress

Variable	Value	Comment
Gallons spilled	21176471	72 000 tonnes spilt with 0.0034 gallons per tonne
PCF	4	Oil spilt was Forties crude
LDF	5	Discharge originated inshore
SMAF	2	The Pembrokeshire coast is taken to be a sensitive area
CHI and HF		Impacted area is of two main types: sandy beach and live bottom
CHI (SB)	46000	Metres of sandy beach impacted, taken to be equivalent to sand (see note 1)
HF (SB)	£1.95	Value for one metre of sandy beach (£) - see note 2
CHI(SB)*HF(SB)	£89,619	£
CHI(LB)	60000	Area of live bottom impacted (sq. m), taken as equivalent to mudflats and saltmarshes (see note 1)
HF(LB)	£3.20	Value for one square metre of live bottom (£) - see note 2
CHI(LB)*HF(LB)	£191,756	£
CDES	£406,770	Valuation of losses of Asterina phylactica (£) (see note 3)
CDA	0	Not included as costs of SEEEC study and other research included in estimates of clean up and salvage costs
Damages	£503,692,197	Monetary estimate of total damages from application of the FDCF (£)
	£6,996	Monetary estimate of damages in £/tonne

Note 1: Data on the lenght of affected coastline from the SEEEC DFR

%	m	sq.m	Description
103%	200000		Total length of shoreline impacted (m)
58%	116000		rocky cliffs, wavecut boulders and immobile boulders
23%	46000		sand
2%	4000	40000	mudflats (area estimated assuming 10m width)
19%	38000		shingle, mobile boulders, cobbles and pebbles
1%	2000	20000	saltmarshes (area estimated assuming 10m width)

Note 2: Conversion rates for HF

US value	UK Value		Description
$10/sq. foot	63.92	£/sq.m	Coral reef
$1/sq. foot	6.39	£/sq.m	Mangrove or sea grass
$1/foot	1.95	£/m	Sandy beach
$0.50/sq. foot	3.20	£/sq.m	Live bottom, saltmarsh, etc.
£1	1.684	$	conversion rate for dollars to pounds
1foot	0.3048	m	conversion for feet to meters

Note 3: Death of Asterina phylactica

$5,000	£2,969	Value given in FDCF for death of each threatened animal
	£406,770	Value for deaths of 137 Asterina phylactica (assumed to be threatened)

ANNEX 12: INTERNATIONAL OIL SPILLS OVER 30,000t AND INCIDENTS INVOLVING TANKERS IN MILFORD HAVEN SINCE JUNE 1993

Annex 12 Contents:

Table A12.1: Details of Spills over 30,000t since 1960

Date of spill Name of Vessel Year Vessel Built	Deadweight Tonnes Spill Size (t) Location	Incident Description and Brief Spill Details (all money values in £ - 1997)	Lives Lost
6 Dec 1960 *Sinclair Petrole* 1955	56,089 56,000 480 km off Brazil	Explosion - fire - sank.	
23 May 1965 *Heimvard* 1964	*26,771* 26,771 Muroran	The vessel struck a refinery jetty at speed at Muroran, Japan. The vessel began spilling oil into the harbour which was subsequently ignited by a flame on the berthing tug. The fire caused a massive explosion in the leaking tank ripping a 15m square hole in her side. The fire spread to the other tanks, engulfing the vessel in fire. The blazing vessel drifted across the harbour until coming to rest on a sandbank, with three further explosions tearing more holes in her. Flames were reported to be over 30m in height with ash falling on the surrounding area. 235 residents were evacuated. Firefighting efforts failed and the vessel continued to burn for 27 days before finally being extinguished. The vessel was scrapped.	10
18 Mar 1967 *Torrey Canyon* 1959	118,285 119,000 Off Isles of Scilly	While en route from Kuwait to Milford Haven the vessel struck the Pollard Rock and ran aground on the Seven Stones Reef midway between Land's End and the Isles of Scilly at a speed of 30 km/h. Having been instructed to reach Milford Haven in time for a particular tide the Master of the vessel had changed his course from one that would take the vessel west of the Scilly Isles to one that would pass to the east. This course change was made to save half an hour on the journey time. In the event the vessel grounded and leaking oil from all tanks. Attempts at removing the vessel failed as she was pivoting amidships. She broke first in half and then in three. With the salvage operation now impossible, the vessel was bombarded with a series of bombs and incendiary devices to burn the remaining oil. The first pollution of mainland Britain came 10 days after the spill. Many parts of the coast between the Lizard and Newquay were polluted with clean-up costs of around £30.3m. The spill remains the biggest oil pollution problem to have threatened the coasts of Britain.	1
28 Feb 1968 *Mandoil II* 1958	42,074 41,000 540 km off Oregon	Vessel collided with Japanese vessel *Suwaharu Maru* in dense fog about 540 km west of the Columbia River estuary. A fierce fire broke out on the vessel. Half of her cargo spilled from the ruptured tanks. The vessel was subsequently scrapped.	11

Table A12.1: Details of Spills over 30,000t since 1960

Date of spill Name of Vessel Year Vessel Built	Deadweight Tonnes Spill Size (t) Location	Incident Description and Brief Spill Details (all money values in £ - 1997)	Lives Lost
14 Jun 1968 *World Glory* 1959	47,179 46,000 140 km off Durban	During heavy weather the vessel broke in two some 140km off the Durban coast. Survivors reported that the breakup had happened very suddenly and very quickly. The resulting oil slick was some 100 km long and 3 km wide. However, favourable winds and currents carried the spill out to sea. Clean-up cost around £1.3m.	25
11 Feb 1969 *Julius Schindler*	96,390 Pota Delgardo, Azores	No details available.	
20 Mar 1970 *Othello*	61,200 Tralhavet Bay	No details available.	
1 Jun 1970 *Ennerdale* 1963	*41,500* 41,500 11 km off Port Victoria, Seychelles	Royal fleet Auxiliary vessel carrying furnace oil struck submerged object, badly holing her starboard side. There was a heavy leakage of oil and the vessel was reported to have been destroyed by a Royal Naval Submarine.	0
27 Feb 1971 *Wafra* 1956	50,560 40,000 off Cape Agulhas	While en route to Cape Town the vessel's engine room flooded causing the vessel to be immobilised. She was taken in tow but the towrope subsequently broke and the vessel drifted aground in heavy swell on a reef 8 km E of Cape Agulhas. This resulted in heavy leakage of oil which became a slick of some 50 km long and 8 km wide. Listing heavily to port with her aft deck almost awash it was feared that she was breaking up. However she was finally refloated and towed out to sea where she was bombed and finally sank some 320 km out to sea. The initial spill oiled coastlines between Cape Agulhas and Gansbaai. Dead seabirds and fish also washed up along this area of coastline.	0
7 Dec 1971 *Texaco Denmark*	107,100 Belgium	No details available.	

Table A12.1: Details of Spills over 30,000t since 1960

Date of spill Name of Vessel Year Vessel Built	Deadweight Tonnes Spill Size (t) Location	Incident Description and Brief Spill Details (all money values in £ - 1997)	Lives Lost
11 Jun 1972 *Trader* 1957	34,545 34,000 off SW Greece	The vessel sank off the SW coast of Greece after severe engine room flooding. The resulting spill was reported to cover some 100 km^2, covering the Mediterranean between Greece and Sicily.	0
19 Dec 1972 *Sea Star* 1968	122,230 121,000 Gulf of Oman	The vessel was in collision with the Brazilian motor tanker *Horta Barbosa* in the Gulf of Oman. The vessel burst into flames with fire spreading to the Brazilian ship (which was travelling in ballast). The fire was brought under control later the same day but the vessel was still blazing and listing to port. However, several huge explosions oil spillage was noted through the 12m collision hole, leaving the vessel and sea on fire from end to end. She continued to drift until finally sinking after another massive explosion.	12
9 Jun 1973 *Napier* 1957	39,180 37,000 Chile	The vessel grounded in stormy weather and broke in two off Guablin Island on the west coast of Chile. The vessel was deliberately bombed with incendiary devices to prevent pollution.	0
9 Aug 1974 *Metula* 1968	210,719 53,000 Strait of Magellan	While negotiating the narrow Magellan straits a navigational error caused the vessel to run aground at the eastern end of the narrows at almost full speed. Crude oil leaked from two badly holed cargo tanks forming a large slick around the tanker. Heavy seas overnight caused the vessel to swivel, puncturing and hence flooding the engine room The vessel remained fast aground on a rock ledge until lightered and towed off rocks by six tugs. Over 2,600 km^2 of water and coastline were blanketed in oil. Extensive areas of Chilean coastline were thickly covered in an oil containing hundreds of dead penguins and sea birds.	0
10 Jan 1975 *British Ambassador* 1958	45,650 45,000 West of Iwojima	Vessel abandoned in a flooded and leaking condition. Vessel taken in tow but subsequently released due to heavy seas. Vessel sank.	0

Table A12.1: Details of Spills over 30,000t since 1960

Date of spill Name of Vessel Year Vessel Built	Deadweight Tonnes Spill Size (t) Location	Incident Description and Brief Spill Details (all money values in £ - 1997)	Lives Lost
29 Jan 1975 *Jacob Maersk* 1966	89,412 88,000 off Leixoes	While manoeuvring to berth with the assistance of tugs the vessel struck the bottom causing explosions in her engine room which ripped through the vessel causing it to ignite. The Port of Leixoes was quickly closed. After further explosions the vessel broke in two and sank some 2 days later, spilling more burning cargo into the sea. Clouds of poisonous fumes from the burning cargo caused scores of casualties to local inhabitants throughout the area. The oil polluted some 32 km of beaches and fishing beds.	6
31 Jan 1975 *Corinthos* 1963	54,988 36,000 Philadelphia	Whilst discharging its cargo of Algerian crude at Marcus Hook on the Delware River, the vessel was struck by the American oil/chemical Tanker *Edgar M Queeny* which was manoeuvring out of the dock. Explosions ripped through the *Corinthos* with resultant fires. Flames were reported to be 150m tall and a 75 t section of the *Corinthos* was blown into the air, landing on the American vessel. The explosions were felt some 30 km away. The *Corinthos* broke in two, the forward part drifting, in flames, down river. Blazing oil also drifted down river.	26
13 May 1975 *Epic Coloctronis* 1965	65,673 58,000 100 km NW of Puerto Rico	Vessel was en route from Venezuela to New York when she was abandoned about 100 km NW of Puerto Rico due to an uncontrollable fire in her engine room and large cracks in her hull. The blazing vessel continued to drift, eventually settling lower in the water. The fire burnt itself out, whereupon the vessel was towed for scrapping.	0

Table A12.1: Details of Spills over 30,000t since 1960

Date of spill Name of Vessel Year Vessel Built	Deadweight Tonnes Spill Size (t) Location	Incident Description and Brief Spill Details (all money values in £ - 1997)	Lives Lost
12 May 1976 *Urquiola* 1973	111,225 110,000 Corunna	While entering the port of Corunna through the normal channel to discharge her cargo the vessel struck bottom. The Master reported that the vessel was leaking and, once a pilot arrived, the vessel was turned round with tug assistance so that the vessel could proceed seawards. However, she agin struck bottom in the same position and, beginning to sink, she ran aground between the two entrance channels with her bow in 30 m of water. When she listed to 50 degrees the crew, with the exception of the Master and the Pilot, abandoned ship and all machinery was shut down. 2 or 3 hours later there were explosions from the forepart followed by a massive fire. Black smoke from the fire covered the port, which was closed to all traffic. The half submerged tanker continued to burn with further explosions shattering windows along the Corunna seafront. 10 days later the vessel broke up after further explosions, fire and heavy swell The oil spill spread throughout the harbour and also out to sea towards the shores of NW Spain. A number of tugs, helicopters and other vessels used detergent in an effort to disperse the spill. The spill broke into several massive slicks. The Spanish government declared the coast around Corunna a disaster area. The cost of cleanup and pollution damage were in the region of £115m	1
7 Feb 1977 *Borag* 1958	*33,068* 33,068 between Keelung Tao and Yeh-Liu	Vessel ran aground on rocks. Engine room and amidships flooded. Subsequent heavy weather conditions caused pounding damage and the vessel sank. 70 km of coastline were affected by the spill costing around £4.5m in clean-up costs.	0
23 Feb 1977 *Hawaiian Patriot* 1965	99,447 95,000 480 km W of Hawaii	While en route to Honolulu from Brunei, the vessel sustained a large 30m crack in her hull in a storm while some 500 km W of Honolulu. There was a severe leakage of oil, with some 17,500 t leaking before the oil ignited causing an enormous explosion that engulfed the vessel in flames. The huge oil slick also caught fire. The vessel subsequently broke in two and sank. The resulting 80 km oil slick was carried away from Hawaii by the currents, thus preventing major pollution of shorelines.	1

Table A12.1: Details of Spills over 30,000t since 1960

Date of spill Name of Vessel Year Vessel Built	Deadweight Tonnes Spill Size (t) Location	Incident Description and Brief Spill Details (all money values in £ - 1997)	Lives Lost
16 Mar 1978 *Amoco Cadiz* 1974	237,439 223,000 off Brittany	When 13 km N of Ushant the vessel's steering engine failed causing total loss of vessel steerage. Became clear that repair at sea was not possible and Master called for tug assistance. After 3 hours of tug assistance in severe NW storm force 10 conditions, the line parted. Further attempts to tow the vessel away from the coast failed. Vessel grounded and subsequently broke in two and then three. Large stretches of coastline severely affected by oil. £589m were claimed in damages by the French government as total cost but only £73.6m were awarded. Clean-up costs were around £388.6m.	0
7 Dec 1978 *Tadotsu*	44,860 Strait of Malacca, Indonesia	No details available.	
31 Dec 1978 *Andros Patria* 1970	222,173 48,000 off NW Spain	Vessel developed a 15m crack in hull in heavy seas and near gale force winds. Some 2 hours later an explosion occurred and a fire in the split tank. The vessel was abandoned. Salvors were refused permission to tow the ship into Spanish, Portuguese, French or British waters so the vessel was towed out to sea where the oil was pumped out and the vessel brought back for scrapping. 100 km of NW Spain's coastline were affected by a slick some 80 km long and 500m wide.	30
19 Jul 1979 *Atlantic Empress* 1974	297,361 287,000 off Tobago and subsequently off Barbados	Vessel collided with the fully loaded 210,257 dwt tanker *Aegean Captain* during a rainstorm 16 km off the coast of Tobago. Holed, on fire and with heavy leakage, the vessel was completely engulfed in flames. Oil spill from both tankers covered 65 km^2, threatening the beaches of Tobago. Vessel towed further out to sea with 10 of its 15 tanks in tact. Fire and explosion eventually sank the tanker.	29

Table A12.1: Details of Spills over 30,000t since 1960

Date of spill Name of Vessel Year Vessel Built	Deadweight Tonnes Spill Size (t) Location	Incident Description and Brief Spill Details (all money values in £ - 1997)	Lives Lost
1 Nov 1979 *Burmah Agate* 1963	62,663 41,000 Galveston Bay	While en route from the Bahamas to Houston carrying Nigerian light and blended crude, vessel collided with the bulk carrier *Mimosa* which was at anchor 6 km outside Galveston Bay. Both vessels burst into flames, igniting the ever increasing oil slick. The vessel was put aground some 9 km south of Galveston Bay where she continued to burn. More explosions spilled more oil. The fire burned itself out some 10 weeks after the collision and the vessel was towed off for scrapping. 250 km of Texan coastline were affected by oil pollution costing around £10.3m in clean-up.	32
15 Nov 1979 *Independenta* 1978	152,408 95,000 Bosphorus, Turkey	The vessel was involved in a catastrophic collision with the Greek motor vessel *Evrialy* off Istanbul. The vessel exploded and burst into flames killing 42 of the 45 crew. The force of the explosions smashed windows some 6 km inland. Still blazing and pouring oil, the vessel drifted out of control until she ran aground and broke in two only 1.5km from the crowded Kadikoy district of Istanbul. The fire was allowed to burn itself out. However, some 3 days after the collision, a new, fiercer fire came to life. Some 19 days later there was another huge explosion sending flames over 300m into the sky and raining burning debris onto the shore while a burning slick spread across the water. The fire stopped one month after the initial collision. The oil slick was said to have caused immense ecological damage, having drifted south into the sea of Maramara. Thousands of dead fish washed up on the coast. Thick black tar balls washed up along the shore of resort and residential districts on the Sea of Maramara. A thick, acrid black smoke covered the city of Istanbul for a number of days.	42
23 Feb 1980 *Irenes Serenade* 1965	105,460 82,000 off Pylos, Greece	While anchoring to take on supplies and fuel at Navarino, an explosion occurred in the forecastle area of the vessel. A fire enveloped the whole vessel in 30 minutes. The vessel sank some 12 hours later. A large volume of burning oil had been spilled into the sea, causing pollution and burning vegetation on the eastern coastline of Sfaktiria Island. Little pollution was reported in the bay as the winds and current had taken the 30 km by 6 or 7 km wide slick out to sea. Clean-up costs were around £439,000.	2

Table A12.1: Details of Spills over 30,000t since 1960

Date of spill Name of Vessel Year Vessel Built	Deadweight Tonnes Spill Size (t) Location	Incident Description and Brief Spill Details (all money values in £ - 1997)	Lives Lost
28 Dec 1980 *Juan A. Lavalleja* 1975	131,663 38,000 Arzew	Grounded.	
7 Jan 1983 *Assimi* 1964	59,032 53,000 off Muscat	Engine room fire spread to whole vessel including cargo tanks. Vessel abandoned and later towed away from shipping lanes to be sunk. Vessel broke up before this could be done and sank after an explosion.	0
8 Jun 1983 *Castillo de Bellver* 1979	271,540 252,000 off Cape Town	En route from UEA to Spain, the vessel suddenly burst into flames amidships on the port side, rapidly spreading along the entire length of the tanker. The vessel and surrounding sea was quickly engulfed by the fire, being fed by blazing oil from a crack in the hull. The vessel broke in two after massive explosions released more of her cargo. A steady SW wind of 30 km/h pushed the 155 km^2 slick away from the coast, thus preventing pollution of South African coastline. The two halves were subsequently sunk. No major pollution of coast due to wind direction. However, a major problem was experienced with a black oily rain from smoke given off by the fire. This fell on large areas of Cape Province farmland damaging crops and freshly shorn sheep	3
9 Dec 1983 *Pericles GC* 1967	60,044 44,000 320 km off Doha	A fire in the engine room when about 320 km off Doha. The vessel was abandoned when fire and explosions ripped through the vessel. The blazing vessel drifted in the Gulf until capsizing, coming to rest upside down with 9m of hull visible above the water.	0
6 Dec 1985 *Nova* 1975	239,435 70,000 off Kharg Island	Collision.	
22 Apr 1988 *Athenian Venture* 1975	31,016 30,000 1,200 km SE of Nova Scotia	Two blazing halves of vessel found 3 km apart in Atlantic Ocean. Vessel appeared to have been blown apart suddenly by explosions.	25

Table A12.1: Details of Spills over 30,000t since 1960

Date of spill Name of Vessel Year Vessel Built	Deadweight Tonnes Spill Size (t) Location	Incident Description and Brief Spill Details (all money values in £ - 1997)	Lives Lost
10 Nov 1988 *Odyssey* 1974	138,392 132,000 mid-Atlantic	While on route from Sullom Voe to Newfoundland, the vessel broke in two in heavy weather conditions in the North Atlantic some 1,100 km off the coast of Nova Scotia. The stern section caught fire and sank the same day, while the bow section remained afloat until subsequently sinking. The spill was reported to be one foot thick and 16 km by 5 in size. The spill was probably naturally dispersed in the force 7 to 8 winds and high seas and swell.	27
24 Mar 1989 *Exxon Valdez* 1986	214,861 37,000 Prince William Sound Alaska	While avoiding ice growlers the vessel grounded at a speed of 22 km/h on Bligh Reef, some 35 km south of the Valdez oil terminal from which the vessel had just been piloted. The vessel ran aground due to a failure to make a turn that would bring the vessel back into the approved shipping lane. Eight cargo holds and 3 ballast tanks were ruptured in the incident. 2,500 km of coastline. At least 580,000 birds and 5,500 sea otters killed. 11,000 workers were engaged in the cleanup which lasted 3 summers. Clean-up cost around £3,419m.	0
19 Dec 1989 *Khark 5* 1975	284,632 80,000 off Morocco	Hull damage - fire - explosion.	
11 Apr 1991 *Haven* 1973	232,164 144,000 Genoa Roads	Having discharged some 90,000 t of its 220,000 t cargo at Genoa, the vessel proceeded to Genoa Roads to await further orders. While at anchor the vessel proceeded to wash out an empty tank. During this activity petroleum gas was ignited in the tank causing a massive explosion shortly after crude oil residues had been pumped out. The vessel was surrounded by a burning slick of oil but was towed to shallower water. The fire continued for some 3 days before further explosions caused the vessel to sink on the fourth day, causing severe pollution.	6

Table A12.1: **Details of Spills over 30,000t since 1960**

Date of spill Name of Vessel Year Vessel Built	Deadweight Tonnes Spill Size (t) Location	Incident Description and Brief Spill Details (all money values in £ - 1997)	Lives Lost
28 May 1991 *ABT Summer* 1974	287,801 260,000 1,400 km W of Luanda	Explosion and fire occurred some 1,400 km off the coast of Angola. Vessel abandoned. Spill of over 200 km^2 with oil around tanker burning fiercely. Subsequent search found no sign of the tanker.	5
17 Apr 1992 *Katina P* 1966	69,992 69,992 9 km from Maputo bay	A freak wave caused the disablement of the vessel while carrying heavy fuel oil to Fujairah. The vessel was beached on a sandbar some 9 km from the coast, however there was severe damage to the amidships area causing oil to gush into the Indian Ocean. To avoid further pollution the vessel was refloated and towed away from shore. She broke in two and sank some 160 km off the coast of Mozambique, a substantial amount of oil escaping in the process. Pollution of the Mozambican coast and possible damage to prawn and other sea fisheries. Clean-up costs around £103,000.	0
3 Dec 1992 *Aegean Sea* 1973	114,036 74,000 Corunna	Vessel grounded in its approaches to the Port of Corunna, NW Spain before rendez-vous with pilot. Conditions said to be 6m swell, force 9 gales and zero visibility due to squall. Vessel began to spill oil - began to break up with explosions and fire spreading. 3 km radius pool fire. A fire raged for 5 days causing severe problems for the 250,000 inhabitants of Corunna Costs to the local fishing industry were estimated to be £31.4m - £44m. Clean-up costs were around £11.2m.	0
5 Jan 1993 *Braer* 1975	89,730 86,825 off Sumburgh Head, Shetland	Vessel sustained an engine failure en-route from Norway to Quebec when seawater from heavy seas entered her fuel supply. A force 10 storm caused the vessel to drift some 16 km back towards the coast of Mainland Shetland in 12m waves where she ran aground. The entire cargo was spilled and the vessel broke up due to battering of heavy seas. The fuel lines were said to have been damaged by steel pipes that had broken loose from the deck during the storm. The master was accused of serious dereliction of duty as he failed to take action to examine the damage caused, or the potential for damage to be caused. By end 1995 around £46m in damage claims had been paid out by IOPC.	0

Table A12.1: Details of Spills over 30,000t since 1960

Date of spill Name of Vessel Year Vessel Built	Deadweight Tonnes Spill Size (t) Location	Incident Description and Brief Spill Details (all money values in £ - 1997)	Lives Lost
21 Oct 1994 *Thanassis* 1976	38,877 37,060 630 km SE of Hong Kong	The vessel was carrying a cargo of fuel oil from Eastern Russia to Singapore when she broke in two during typhoon Teresa. Winds were force 9 with wave heights of 7m.	16
15 Feb 1996 *Sea Empress* 1993	147,273 72,000 off Milford Haven	While entering the Port of Milford Haven with Pilot the vessel grounded a number of times. The initial grounding was at full speed. Despite the efforts of the pilot and crew to slow the listing vessel, she struck up on rocks, finally coming to rest. Already with extensive to the bottom and with ruptured starboard tanks, the vessel was refloated. However her increased draft and list meant that she was trapped in a 'saucer' shaped basin. Despite efforts to maintain her position the vessel grounded several more times in bad weather spilling more of her cargo.	0

Table A12.2: Incidents in Milford Haven since June 1993 (after MAIB, 1997)

Date	Probable Cause	Incident Classification	Description of Incident	IMO Serious Casualty?
27/08/93	NS	Dangerous occurrences	No Description Available.	
27/10/94	Mech.	Dangerous occurrences	Jammed air start valve prevented main engine starting.	
20/11/94	Mech.	Fire or explosion	Tanker discharging at Texaco Berth. Pump room fire alarm went off. Smoke found but no apparent fire. Cause, fractured unsupported gauge and pipe spraying product onto hot bearing of adjacent pump.	
27/11/94	Mech.	Mechanical or structural failure	Engines failed to start, Water in fuel system.	
26/06/95	Mech.	Dangerous occurrences	Vessel suffered engine/engine control failure. Anchored and repaired.	Yes
01/07/95	HE	Dangerous occurrences	Overtaking tanker allegedly failed to keep clear.	
07/08/95	Mech.	Dangerous occurrences	Total engine failure during berthing.	Yes
26/08/95	HE	Grounding	Briefly grounded whilst waiting in channel for clearance to berth.	
28/08/95	Mech.	Dangerous occurrence	Engine failure.	Possibly
15/09/95	Mech.	Mechanical or structural failure	main engine governor drive failed. Vessel returned to port.	
11/10/95	HE	Dangerous occurrences	Fishing vessel passed dangerously close to tanker.	
29/10/95	HE	Grounding	Tanker 123,665 dwt. Whilst inward bound loaded vessel suddenly turned to port and grounded. Refloated after 6 hours. Cause was inherent characteristic of vessel - when astern power applied, high speed turns to port, low speed turns to starboard. Vessel slightly off course, narrow channel, astern applied before vessel could respond resulting in vessel turning to port irrespective of rudder position.	Possibly

Table A12.2: Incidents in Milford Haven since June 1993 (after MAIB, 1997)

Date	Probable Cause	Incident Classification	Description of Incident	IMO Serious Casualty?
09/11/95	HE	Dangerous occurrences	Close pass between inbound fishing vessel and outbound tanker.	
27/11/95	HE	Dangerous occurrences	Inbound fishing vessel on wrong side of channel. Close pass with outbound tanker.	
29/11/95	NS	Mechanical or structural failure	A hole in number 5 tank caused some oil pollution in Milford Haven. DNV detected a crack in the hull plate but the cause was unknown.	Yes
30/11/95	HE	Dangerous occurrences	Vessel left with only back springs fast because of shortage of mooring party ashore. Wind gusting to 35 knots. Mooring later completed without incident.	
09/12/95	HE	Dangerous occurrences	Vessel started to leave berth without clearance while another was leaving the next berth with clearance. Mooring gang had cast-off without instructions. Tide pushed vessel away from berth.	
05/01/96	HE	Dangerous occurrences	Close pass between outbound tanker and inbound fishing vessel.	
20/01/96	HE+W	Ramming	Landed heavily alongside dolphin when berthing in strong winds. Damage to forecastle spaces. Minor damage to dolphin.	
09/02/96	HE	Dangerous occurrences	Pilot aborted attempts to board a tanker due to swell. Vessel re-booked but on second attempt pilot again could not board. The vessel continued inwards without a pilot - who eventually boarded at Chapel Buoy.	
15/02/96	HE	Grounding	Sea Empress.	Yes
22/02/96	HE	Dangerous occurrences	Close quarters situation off Angle Buoy. Inward ferry did not comply with request to wait for outbound tanker.	
12/03/96	HE	Grounding	Dragged anchor and grounded on mud when manoeuvring alongside jetty. Refloated after an hour with tug assistance.	Possibly
13/03/96	Mech.	Ramming	Contact with jetty after alleged loss of engine control and power.	Yes

Table A12.2: Incidents in Milford Haven since June 1993 (after MAIB, 1997)

Date	Probable Cause	Incident Classification	Description of Incident	IMO Serious Casualty?
30/03/96	HE	Dangerous occurrences	Inbound fishing vessel confused with shore lights and unsure of position. Caused outbound tanker to take evasive action.	
03/04/96	Mech.	Ramming	Vessel made contact when berthing due to CPP control being stuck in half ahead position.	
04/04/96	Mech.	Dangerous occurrences	While inbound engine problems occurred due to dirty oil filters. Vessel proceeding to Anchorage at slow speed with tugs in attendance.	
21/04/96	HE	Dangerous occurrences	Close passing between 2 tankers under pilotage. Cause - lack of communication.	
09/05/96	Mech.	Dangerous occurrences	Whilst leaving port the CP propeller went to zero pitch due to faulty fuel valve to main engine cut off fuel supply.	
13/05/96	HE	Ramming	Poor unberthing procedures on the part of the pilot caused vessel to land heavily alongside heading in the opposite direction.	
02/06/96	Mech.	Dangerous occurrences	Problems with main engine turbo charger resulted in reduced engine power. Tugs in attendance to berth vessel.	
11/06/96	HE	Dangerous occurrences	Ship entered Haven by East channel without pilot after a misunderstanding between SIG station and ship.	
21/06/96	HE	Dangerous occurrences	Yacht obstructed ship manoeuvring to berth.	
14/07/96	HE	Dangerous occurrences	Outbound fishing vessel used wrong channel and hazarded the passage of an inbound tanker.	
14/08/96	Mech.	Dangerous occurrences	Main engine cooling water overheated and engine shut down in response.	
09/09/96	HE	Dangerous occurrences	Close pass between fishing vessel and tanker.	
12/10/96	HE+W	Ramming	Master lost control of vessel while attempting to go alongside Texaco berths. Unable to complete approach turn and drifted towards a ship moored at the next berth. This vessel was avoided but the vessel fetched up in the corner of the jetty.	

Table A12.2: Incidents in Milford Haven since June 1993 (after MAIB, 1997)

Date	Probable Cause	Incident Classification	Description of Incident	IMO Serious Casualty?
05/11/96	HE	Collision	Vessel sustained unreported engine failure on arrival. No remedial action taken. Departure pilot assured by the master that there were no engine defects. Engine did not perform to standard and the pilot retained the tug. While tug was manoeuvring into position, engine failed and despite the use of anchors drifted onto another tanker berthed at the Elf terminal.	Yes
24/11/96	HE	Ramming	Light contact with buoy. Pilot reported poor steerage.	
14/12/96	HE	Dangerous occurrences	Fishing vessel passed tanker about to swing without permission from VTS.	
09/01/97	Mech.	Mechanical or structural failure	Vessel's main engine control system suffered electrical fault. Vessel re-berthed for repairs.	Yes
23/01/97	Mech.	Mechanical or structural failure	Vessel needed engine repair including exhaust valve before entering port.	Possibly
14/02/97	Mech.	Dangerous occurrences	Engine control failure resulted in vessel not being able to start astern when berthing.	Possibly
20/05/97	HE	Dangerous occurrences	Jetty supervisor complained that ferry (under pilotage) passed too close causing tanker to range at berth.	
25/05/97	HE	Ramming	Contacted jetty while manoeuvring off berth. Texaco work boat to assist in future.	
27/05/97	HE	Fire or explosion	Fire in bunker tank due to flame cutting of shell plate in dry dock.	
28/05/97	HE	Ramming	Manoeuvring to berth contacted small boat pontoon. Anchor dropped too late and inadequate engine movements.	
19/06/97	Mech.	Mechanical or structural failure	Tug in attendance but suffered temporary but complete loss of thrusters.	
20/06/97	HE	Dangerous occurrences	Pleasure craft impeded safe passage of tanker.	
11/08/97	HE	Dangerous occurrences	2 Tankers had a close quarters situation.	

ANNEX 13: ANNEX REFERENCES

A.13 ANNEX REFERENCES

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