Maritime Ireland / Wales
INTERREG 1994-1999

Marine Mammal Strandings

A collaborative study for the Irish Sea

December 2001

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Marine
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Monitoring

Maritime Ireland / Wales INTERREG Report NO.8
Measure 1.3: Protection of the Marine and Coastal Environment and Marine Emergency Planning

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Maritime (Ireland / Wales) INTERREG Programme- Building Bridges.

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Maritime (Ireland/Wales) INTERREG Programme 1994 - 1999

The EU Maritime (Ireland /Wales) INTERREG II Programme (1994 — 1999) was established to:

1. promote the creation and development of networks of co-operation across the common maritime border.
2. assist the eligible border region of Wales and Ireland to overcome development problems which arise from its relative isolation within the European Union.

These aims are to be achieved through the upgrading of major transport and other economic linkages in a way that will benefit the constituent populations and in a manner compatible with the protection and sustainability of the environment. The Maritime INTERREG area includes the coastlines of counties Meath, Dublin, Wicklow, Wexford and Waterford on the Irish side and Gwynedd, Ceredigion, Pembrokeshire and Carmarthenshire on the Welsh side and the sea area in between.

In order to achieve its strategic objectives the programme is divided into two Areas:

Sub-Programme 1: **Maritime Development:** transport, environment and related infrastructure (59 mEuro)

Sub-Programme 2: **General Economic Development:** Economic growth, tourism, culture, human resource development (24.9 mEuro)

The Marine and Coastal Environment Protection and Marine Emergency Planning Measure (1.3) has a total budget of 5.33 mEuro of which 3.395 mEuro is provided under the European Development Fund. EU aid rates are 75% (Ireland) and 50% (Wales).

The specific aims of Sub-Programme 1.3 are:

- to promote the transfer of information between the designated areas.
- to establish an in-depth profile of marine/coastal areas for conservation of habitat/species.
- to explore, survey, investigate, chart the marine resource to provide a management framework.
- to develop an integrated coastal zone management system.
- to improve marine environmental contacts and co-operation.
- to promote the sustainable development of the region.
- to improve nature conservation.

Joint Working Group

The Joint Working Group, established to oversee the implementation of Measure, consists of 5 Irish and 5 Welsh representatives.

Irish representation: Department of the Marine & Natural Resources, Department of the Environment & Local Government, Department of Transport, Energy & Communications, Local Authority and Marine Institute.

Welsh representation: National Assembly for Wales, Countryside Council for Wales, National Trust, Local Authority (Dyfed), Local Authority (Gwynedd).

This Report series is designed to provide information on the results of projects funded under Measure 1.3. Protection of the Marine & Coastal Environment and Marine Emergency Planning.

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1. Introduction

Since the 1980s, there has been growing concern about the health of marine mammal populations in coastal waters and in particular with respect to a decline in harbour porpoise (*Phocoena phocoena*) numbers. A variety of possible causes have been proposed including infectious diseases, changes in food supply, pollution and entanglement in fishing gear.

Recent studies linking contaminant data with disease levels in cetaceans suggest that higher contaminant levels are generally found in animals with a higher number of diseases i.e. that chronic exposure to PCBs or trace metals negatively influences the health status of some cetacean species by predisposing individuals to mortality associated with infectious disease (Jepson *et al*., 1999; Siebert *et al*., 1999). The reverse may also be true, that high levels of disease may disable the animal to the extent that coping with contaminants is not possible and toxins accumulate.

The potentially serious role of infectious disease was demonstrated by the phocine distemper epidemic of 1987, which killed approximately 18,000 common seals (*Phoca vitulina*) in the North Sea and adjacent waters (Kennedy, 1990) and by the subsequent morbillivirus epidemic in striped dolphins (*Stenella coeruleoalba*) in the Mediterranean sea (Domingo *et al.,* 1990). Rejinders (1986) and Brouwer *et al.* (1989) demonstrated that feeding captive common seals with fish caught in highly polluted waters had deleterious effects on their health and there was speculation that pollution may have been a factor in the severity of these epidemics (Aguilar and Raga, 1990, Aguilar and Borrell, 1994, deSwart *et al*., 1994).

Relatively little work on the health status and contaminant loadings in cetacean and pinniped populations in the Irish Sea has been undertaken to date (e.g., Morris *et al*., 1989, Law *et al*., 1995, Berrow *et al*., 1998a). Given the need for such data from relatively "high-medium" polluted waters (e.g., the Irish Sea) such a data collection programme is highly desirable.

For a large number of cetacean and seal species, the only way to assess their health status and contaminant loadings, bar live capture and/or killing them, is through a Strandings Programme. Such programmes involve the recording and recovering of beach cast animals. Strandings programmes allow for some definition of the distribution of different species, but are primarily used to examine health status and to determine population parameters necessary for management decisions. Such programmes are imperative, as they allow top mammalian predators to be monitored and increase our knowledge of a number of biological parameters (for example, age, reproductive status, diet), parasites and contaminant loadings. Cause of death can reflect disease status and in the absence of observer programmes, can indicate fishing associated mortalities (by-catch).

Between 1992 and 1996 a study of small cetaceans was carried out by the Department of Zoology, National University of Ireland, Cork, funded by the National Heritage Council. The study examined stranded and by-caught animals from all Irish coasts and where feasible post-mortem examinations carried out to determine cause of death. Most of the stranded animals were from the West Coast of Ireland, with a much smaller number reported from the Irish Sea.

In England and Wales, a similar study, the Collaborative UK Marine Mammal Project, co-ordinated by The Natural History Museum and the Institute of Zoology, London, has been operating since 1990. Stranded animals reported are recovered on an *ad-hoc* basis, with some regions, e.g. Cornwall, well covered.

The current INTERREG project aims to increase the number of reported strandings in the INTERREG-II areas on the east coast of Ireland and west coast of Wales, making information on the disease status and biology of marine mammals in that region available. In addition, seals will be routinely collected and examined in Ireland for the first time. The collaboration between Marine Environmental Monitoring, representing the UK Collaborative project, and the National University of Ireland, Cork, will provide a better and combined understanding of the marine mammals in the Irish Sea and add to the Irish Strandings project and the UK Collaborative project.

1.1 Specific Objectives of the Project

The specific aims of the INTERREG Marine Mammal Strandings Project are:

- to intensify the use of regional co-ordinators and volunteer assistance in recording marine mammal strandings along the East coast of Ireland and the coast of Wales.
- to develop a greater understanding of the incidence and epizoology of disease in marine mammals.
- to increase understanding of the effects of human pollution and other human influence on the environment and the physiology and pathology of marine mammals.
- to establish joint systems for long term monitoring of marine mammals in the Irish Sea.
- to highlight coastal areas important for conservation and as habitat for marine mammals.
- to improve marine environmental contacts and co-operation within the INTERREG area, and
- to contribute to wider international studies and programmes.

This report covers the period 1997 — 1999 for Ireland and 1996 - 1999 for Wales (some additional data from 1994/5 are included).

2 Materials and Methods

2.1 Post-mortem examination of stranded & incidentally caught cetaceans & pinnipeds

The Irish Whale and Dolphin Group records and co-ordinates cetacean strandings in Ireland with the help of a network of volunteers. The National Parks and Wildlife Service, Local Authorities, the Garda and the Royal National Lifeboat Institute also report strandings. In Wales, a network of volunteers established by Marine Environmental Monitoring, responds to all calls in relation to strandings, and records and recovers marine mammals. Leaflets and posters have been produced to publicise the project and increase general public awareness. These leaflets and posters contain information on contact names and addresses, for both dead strandings and live strandings of cetaceans and pinnipeds.

Reported (dead) cetaceans or pinnipeds were collected or examined on site. The degree of post-mortem examination of each specimen depended on the condition of the carcass. Whenever possible, full post-mortem examinations were carried out according to guidelines recommended by the European Cetacean Society (Kuiken and Garcia Hartmann, 1991). Examinations were carried out on animals stranded in good condition and those landed by fishermen. Animals in very poor condition were identified, measured and occasionally skin, teeth and other samples were taken. Photographic records have been made of all strandings visited.

Measurements taken include total body length and blubber thickness (as an index of nutritive condition). The animals were sexed and teeth extracted for ageing. Samples were taken for histology, genetic and contaminant studies. Parasitological status was evaluated and stomach contents were sorted for dietary analysis.

Post-mortem examinations were carried out at the National University of Ireland, Cork for animals stranded in Ireland, and at the Institute of Zoology, London or the University of Liverpool for those stranded in Wales.

2.2 Morphometrics

Upon recovery, each animal was identified, photographed, measured and sex determined. A standard check sheet was used to record twenty external body measurements whenever possible (Appendix 1). On occasion, disfigured or mutilated body parts, whether due to entanglement in fishing gear or scavenger damage prevented the full range of external measurements being taken. In such cases, a record was made of the location and extent of the damage. Other external markings recorded in cetaceans were often observed in the form of toothrakes and pox marks. Toothrakes are characteristically a series of parallel lines or scratches caused by the teeth of other animals. The location, area, length and distance between the rakes were recorded. The position and prevalence of tattoo-like pox marks were also recorded.

In the case of pinniped strandings three external measurements and mid-sternal blubber thickness were recorded (Appendix 2).

2.3 Age Determination (after Lockyer, 1995)

Teeth were removed from each cetacean and stored frozen. Prior to sectioning, the teeth were allowed to thaw and excess tissue was removed. Fixing took place in 10% neutral formalin over several hours. After washing in running water (preferably overnight) the teeth were put into a commercially available decalcifying reagent ©RDO for between 8-10 hours, depending on the size of the animal. Teeth were then sectioned into 25-39µm sections using a sledge microtome with a CO_2-freezing stage. Sections were cut parallel to their orientation in the jaw and stained in Erlich's haematoxylin, counter-stained in alkaline water and then mounted on 5% gelatin-coated, warm, histological slides under water. Growth layers were examined under a binocular microscope (x25/x100).

Age determination was achieved by examining the growth layer groups (GLGs) in the dentine or cementum of the teeth. A growth layer is approximately equivalent to one year's growth and is analogous to annual rings laid down in trees. Once the neonatal line is detected, growth layer groups can be counted (the neonatal line is a particularly well-defined growth layer of the orthodentine that separates prenatal from post-natal dentine). The neonatal line is believed to be a product of disturbances in the nutrition of the animal in the immediate post-partum period. A GLG can be defined as a repeating or semi-repeating pattern of adjacent groups of incremental growth layers within the dentine, centum or bone, which is defined as a countable unit. Such a unit must involve at least one change i.e. dark to light or intensely stained to lightly stained bands.

Pinniped teeth were also removed during each post-mortem examination, and are currently in frozen storage awaiting processing for age determination.

2.4 Reproduction

For both sexes of any species, it is important for management purposes, to have data on variables such as age at sexual maturity, reproductive seasonality, calving period and inter-birth interval. The reproductive history of female cetaceans can be identified by the presence of scar formations in the ovaries. Two types of corpora were found in cetacean ovaries, *corpus luteum* (CL) and *corpus albicans* (CA). CL develop after ovulation has occurred, and after a period of time regresses to form the scar known as CA. CA are indicative of regressing *corpus luteum* and can be defined as either CL of pregnancy or CL of ovulation. The ovaries of cetaceans are unusual in that CA scars resulting from ovarian events persist for years and probably indefinitely in at least some species. Usually only one ovary is active, the right one often being immature in appearance and non-functional. Both ovaries from individual animals were looked at during this study.

Both ovaries were removed and preserved in 10% neutral formalin prior to sectioning. They were then thinly sectioned and the number and types of *corpora* counted. These data give information on time of conception and age at sexual maturity for each species.

In males, the most common method used to measure sexual maturity is the ratio between length (_L) and weight (_W) of the testes. Both length and weight of testes increase exponentially with total body weight. Depending on the species, testes weight in smaller animals measures ≤10g increasing to ≥2kg in larger animals. As harbour porpoises formed the largest dataset within the species stranded, an attempt was made to estimate length at sexual maturity. Due to small sample sizes, it was not possible to repeat this for other species recovered.

2.5 Dietary analysis

During the course of post-mortem examinations on both cetaceans and pinnipeds, stomachs were removed and stored frozen for inspection at a later date. The oesophagus was severed transversely as close to the anterior as possible and the third stomach was severed at its junction with the duodenum. For dietary analysis the stomachs were allowed to thaw before dissection. All three stomachs (pinnipeds have one stomach chamber, the same procedure was followed) were opened in a standard way by a midline incision that followed its curvature. In turn, any food items, squid beaks or fish otoliths were removed from each stomach compartment, which was then washed into a fine sieve (200 m). Prey items were subsequently sorted and preserved according to standard methods. Squid beaks were stored in 70% alcohol whilst otoliths were left to dry before being stored in plastic bags to await species identification with the use of a binocular microscope fitted with an ocular micrometer. Presence or absence of food items in cetacean or pinniped stomachs was recorded. In an attempt to quantify the amount of prey items consumed, a number of different approaches were considered and compared.

A binocular microscope was used to examine the fish sagittal otoliths. Otoliths were identified to the lowest taxonomic level using reference collections and guides (Harkonen, 1986). Otolith length (from the rostrum to the posterior edge of the otolith, parallel to the sulcus (Bowen *et al*., 1993)) was measured using a micrometer. The lengths were measured to back calculate the total body lengths of fish consumed using regression equations. Degree of erosion was determined by comparing the surface and the edge features of the recovered otoliths with reference collections and guides.

In order to count the number of fish consumed by the predators, left and right otoliths for each fish species were separated. Using characteristics, such as size, colour, similar features and degree of wear, the left and right otoliths were paired and counted (each pair representing an individual fish). It was decided that a length difference of two micrometer units (0.106mm) was an acceptable error between a left and right otolith, in order to match a pair. Those otoliths that were not paired were counted as individual fish. Maximum and minimum counts were also carried out. The total number of otoliths represented a maximum count i.e. all otoliths represented an individual fish. The highest number of either right or left otoliths represented a minimum count (after Bowen *et al*. (1993) and Robertson and Chivers (1997)). This study deemed the paired count as the most accurate estimate and it was this total that was used in all further analysis.

Cephalopod beaks, except the transparent growing part, are not readily dissolved by digestive juices, and are useful for dietary analysis. Both the lower and upper mandible can be used for identification, however in most instances it is only necessary to identify and measure one, as both will give the same information (Clarke, 1986).

Lower and upper beaks of each type were sorted. The beaks were also measured. The rostral length (tip of the rostrum to the jaw angle) of decapod lower beaks was measured, while the Hood length was measured in octopod lower beaks. In cases, where only squid pens were present in the stomach compartment, cephalopods were recorded as present only.

O Sullivan (1999) used the number of lower beaks as the minimum probable estimate of total cephalopods eaten. Robertson and Chivers (1997) and Bowen *et al*. (1993) both used the highest number of either lower or upper beaks as their best estimate for total cephalopods consumed. In this study, as cephalopods were identified from lower beaks all further analysis will use the lower beak count as the best estimate.

The importance of different prey items can be expressed in a number of ways and three indices of importance were used during this study: percentage occurrence (%F), a coefficient of prey numerical abundance (%N) and % importance.

Percentage occurrence (%F), which is an index of the frequency of occurrence of a single prey type is calculated as follows:

$$\% \text{ Occurrence} = (N_{si}/N_{sf}) * 100$$

where N_{si} = number of stomachs (e.g. harbour porpoise) containing prey group (type) i
N_{sf} = number of stomachs (of all harbour porpoises) containing prey remains

Coefficient of prey numerical abundance (%N), is an index of the numerical abundance of a prey type and is calculated as follows:

$$\% \text{ Number} = (N_i/N_t) * 100$$

where N_i = number of prey of each group (prey type) i
N_t = total number of prey items

Percentage importance, which is an index of prey numerical abundance, is obtained from the results of the two previous parameters:

$$\% \text{ Importance} = (\%N*\%F)^{0.5} *100$$

2.6 Parasite Burden

All major organs were examined for the presence of parasites, including tympanic bulla and blowhole (cetaceans), heart, lungs, liver, kidney, intestines and stomach. Blubber was also sectioned longitudinally for parasitic cysts. All parasites were removed and stored in 70% alcohol to await identification and enumeration. Presence or absence of parasites within specific organs was recorded.

2.7 Contaminants

Samples of blubber, kidney and liver were taken during post-mortem and stored frozen for heavy metal and organochlorine analysis at a later date. For harbour porpoises, a small number of samples were sent to the Radiological Protection Institute of Ireland for Cs-137 determination and to Plymouth University for PCB analysis.

2.8 Genetics

Tissue samples for DNA analysis were taken during post-mortem from stranded and bycaught animals and sent to various labs for analysis or archived (see Appendix 3).

3 Results

During the study, a total of 112 marine mammals were recorded stranded along the East coast of Ireland. These comprised 61 cetaceans and 45 pinnipeds. The counties covered by the strandings project were Louth, Dublin, Wicklow, Wexford, Waterford and east Cork. The majority of cetaceans reported were harbour porpoises *P. phocoena* (48%) followed by common dolphins *Delphinus delphis* (21%) and Risso s dolphins *Grampus griseus* (13%). Within the pinnipeds, forty two grey seals *Halichoerus grypus,* one common seal *Phoca vitulina* and two unidentified seals were reported. In addition, two leatherback turtles *Dermochelys coriacea* were also reported. In Wales during the period 1994 — 1999, 985 animals were reported stranded. Of these, 406 were cetaceans and the remaining 579 were grey seals. The harbour porpoise was the most commonly stranded cetacean species (76%), followed by common (8%) and striped dolphins (*S. coeruleoalba*) (4%). In the whole region, 12 cetacean species and two pinniped species were recorded. Table 1 illustrates the number and species of marine mammals reported in both Ireland and Wales during the study period.

More individuals were stranded on the Welsh coast than on the Irish coast. Although there is some inter-annual variation (see Figure 1) the annual stranding rate in Wales is 164 animals/annum, in comparison to 36 animals/year in Ireland. This may be as a result of the water circulation systems in the Irish sea, in conjunction with prevailing wind direction, depositing more animals on the Welsh coastline. In addition, the Welsh coastline is larger than the Irish coastline and the sampling period is longer.

Over the years of the study period there has been a general trend towards an increase in the number of stranded animals being reported (see Figure 1). Since 1997, in both Ireland and Wales, the number of reported strandings has increased. In Wales in 1996, a large number of grey seals were reported and collected as part of an intensive sampling programme. This high number obscures the upward trend in strandings recorded in subsequent years (see Figure 2), whereas no seals were routinely collected in this region in Ireland. Since then the number of seals reported in Ireland has increased.

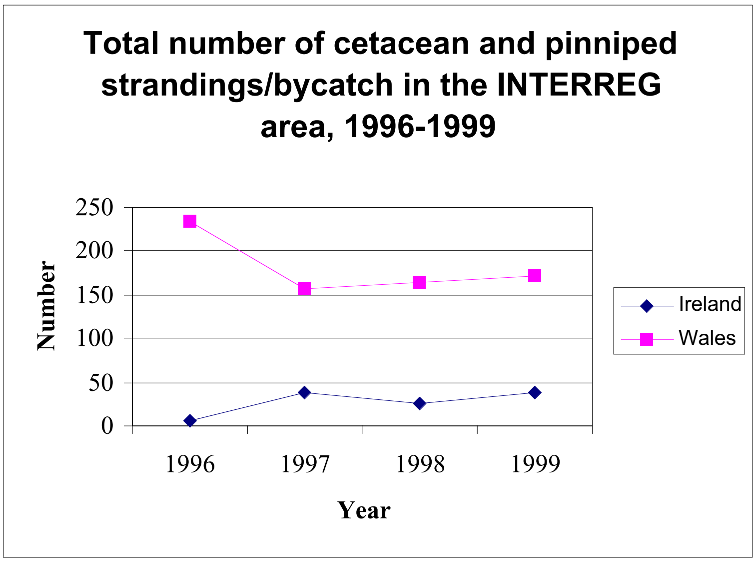

Figure 1 Total marine mammal strandings in the *INTERREG* region

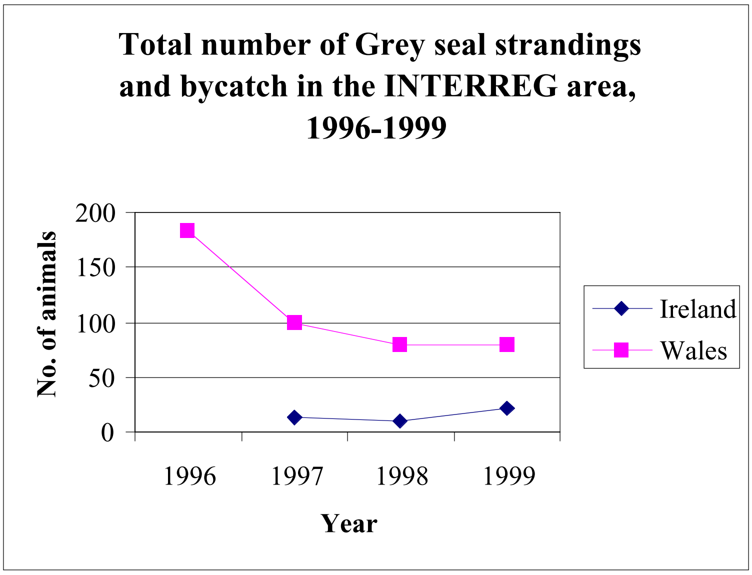

Figure 2 Seal strandings in the *INTERREG* region

There are some differences in the species composition that strand in both areas. Common seals have only been reported from the Irish coastline, reflecting a different use of coastline by this species. In contrast, more grey seals have been recorded in Wales, reflecting a different distribution and abundance of this species. A greater diversity of species was recorded from the Welsh coastline. For example, bottlenose dolphins were recorded on seven occasions. Striped dolphins (*S. coeruleoalba*) are the 3rd most commonly recorded cetacean species on the Welsh coastline, while it has not been reported on the eastern Irish coastline during this period. Distribution maps of the strandings locations for a number of the cetacean species are given in Figure 3. For some species, such as harbour porpoise, strandings occurred repeatedly in the same area, and this species is represented on a different map showing frequency of strandings.

Live and multiple strandings

On the Irish coastline, a number of strandings were either multiple strandings or live strandings. Eight live-stranding incidences were reported, comprising 12.5% of the total strandings. These included a common (*D. delphis*) and white-sided (*Lagenorhynchus acutus*) dolphin that were subsequently euthanased and a Risso s dolphin (*G. griseus*) that travelled 30km upstream towards Kilkenny. This young Risso’s dolphin spent two days in a pool at Inistige, Co. Kilkenny - it was eventually returned to sea with the help of the National Parks and Wildlife Service, Garda , Army, Customs and Excise officials, the Marine Mammal Rescue Team and dive clubs.

In Wales, 21 incidences of live strandings were reported, comprising 5% of all cetacean strandings. For both coastlines, species included harbour porpoise, common dolphin, Risso s dolphin (Ireland), white-sided dolphins, striped dolphin (Wales) and northern bottlenose whale (*Hyperoodon ampullatus*).

There were a number of multiple or mass strandings in the INTERREG area during the study period. These included three Risso s dolphins that were successfully refloated in east Cork (see Plate 1), and three northern bottlenose whales live stranded in Wexford and were subsequently refloated

Table 1 Number and species of stranded and bycaught marine mammals in the *INTERREG* area. * numbers in brackets denote possible further bycatch.

		Ireland (1996-1999)					Wales (1994 – 1999)			
Common name	***Species***	**Stranded**	**Bycatch**	**Stranded/ Bycatch**	**Live stranded**	**Total**	**Stranded**	***Stranded /Bycatch**	**Live stranded**	**Total**
Harbour porpoise	*Phocoena phocoena*	20	4	4	1	29	298	23 (18)	12	310
Common dolphin	*Delphinus delphis*	11	0	2	2	15	29	1 (1)	3	31
Risso's dolphin	*Grampus griseus*	3	2	1	3	9	7	0	0	7
Fin whale	*Balaenoptera physalus*	1	0	0	0	1	2	0	0	2
Minke whale	*B. acutorostrata*	2	0	0	0	2	0	0	0	0
Striped dolphin	*Stenella coeruleoalba*	0	0	0	0	0	11	0 (3)	4	15
Bottlenose dolphin	*Tursiops truncatus*	0	0	0	0	0	7	0	0	7
White-sided dolphin	*Lagenorhynchus acutus*	0	0	0	2	2	0	0	1	1
Pygmy sperm whale	*Kogia breviceps*	0	0	0	0	0	1	0	0	1
Pilot whale	*Globicephala melas*	2	0	0	0	2	5	0	0	5
N. bottlenose whale	*Hyperoodon ampullatus*	0	0	0	3	3	0	0	1	1
Cuvier's beaked whale	*Ziphius cavirostris*	1	0	0	0	1	1	0	0	1
Unidentified cetacean		1	0	0	0	1	23	0	0	23
Unidentified dolphin		2	0	0	0	2	2	0	0	2
Grey seal	*Halichoerus grypus*	19	23	-	-	42	579	NR	0	579
Common seal	*Phoca vitulina*	1	-	-	-	1	0	0	0	0
Unidentified seal		2	-	-	-	2	0	0	0	0
TOTAL		**65**	**29**	**7**	**11**	**112**	**964**		**21**	**985**

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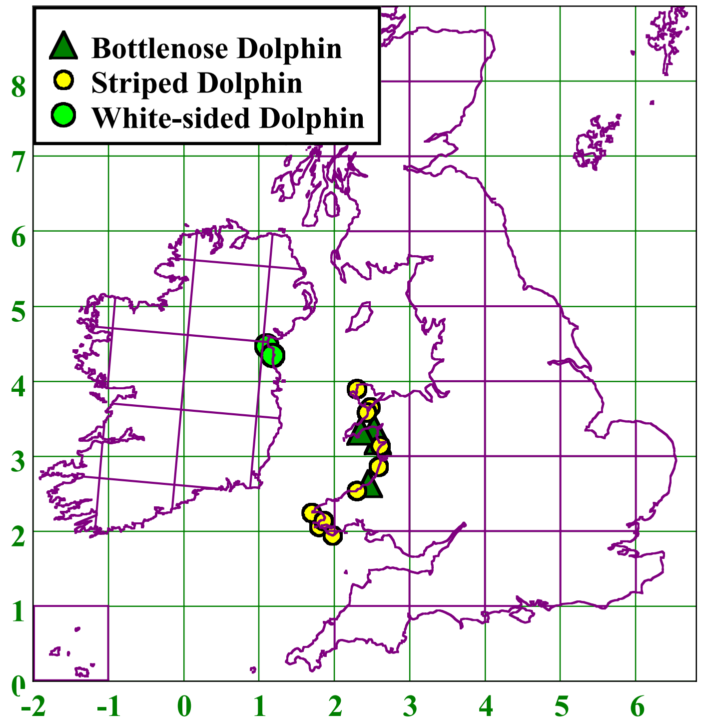


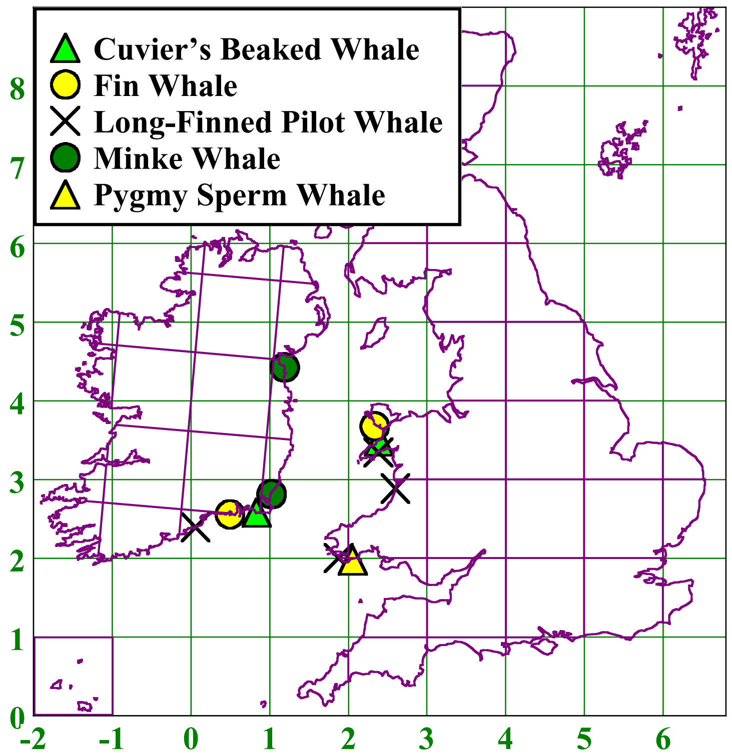
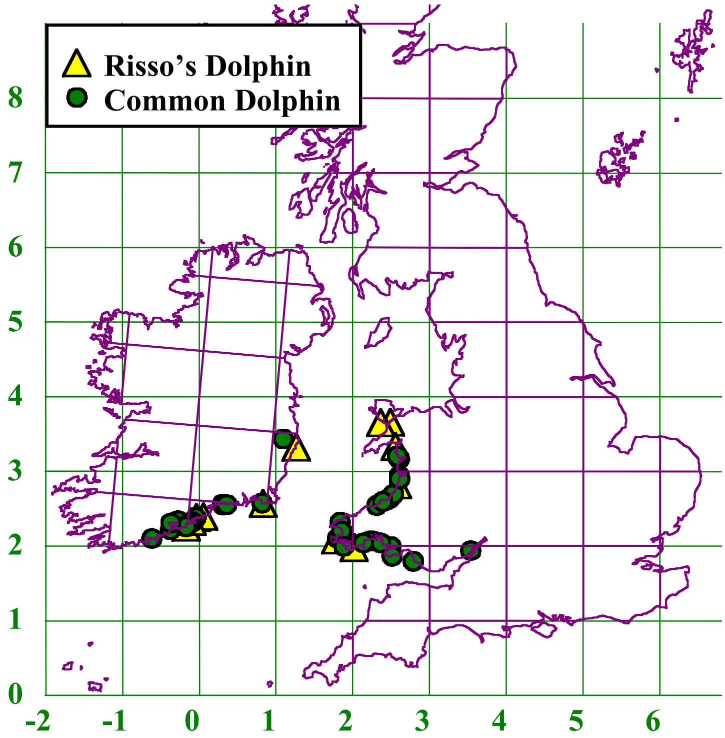


Figure 3a Strandings distributions of cetacean species in the *INTERREG* area.



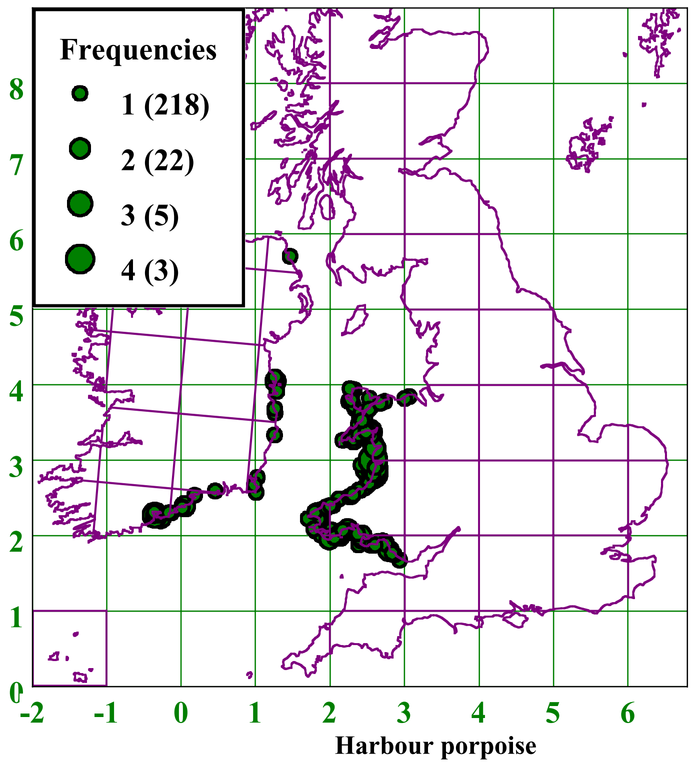


Figure 3b Strandings distributions of cetacean species in the *INTERREG* area.

Plate 1 Rescue of live stranded Risso's dolphins in east Cork (photo M. Mackey)

3.1 Seasonal distribution of strandings

3.1.1 Cetaceans

Examining the seasonal distribution of strandings shows different patterns for Ireland and Wales. In Ireland, there is no distinct seasonal trend although more strandings are reported in the winter months. In contrast, in Wales, there is a very distinct peak in strandings reported during the summer months (see Figure 4).

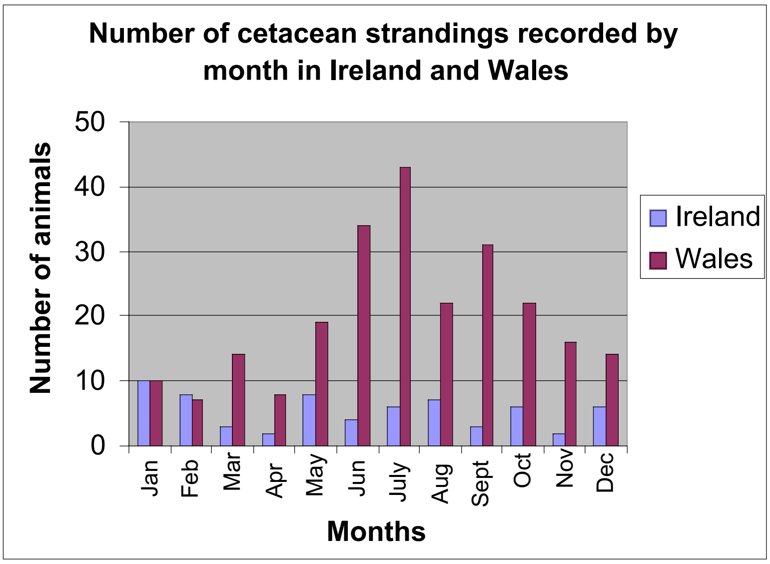


Figure 4. Monthly cetacean strandings in Ireland and Wales

3.1.2 Pinnipeds

The seasonal pattern of grey seals shows a different trend to that of Cetacea. Over the period 1997 — 1999 in Wales there is a distinct seasonal peak in September/October. In Ireland, the largest numbers of seals reported are in the period January — March.

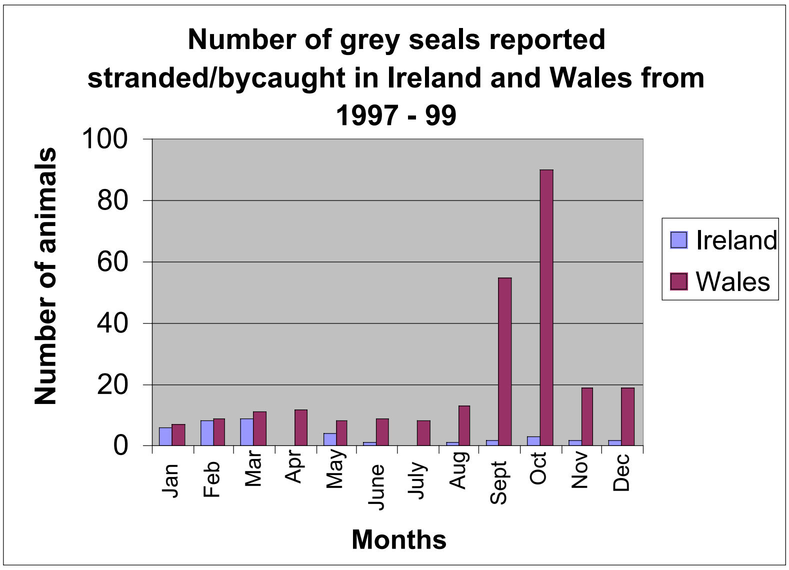


Figure 5. Monthly seal strandings in Ireland and Wales

3.2 Biological data

While biological data were collected for all animals collected in the Irish programme, it is only possible to interpret the data from species with a large data set. The Welsh data went into the national UK strandings programme. In this section, detailed results are presented for three species; harbour porpoise, grey seals and common dolphins.

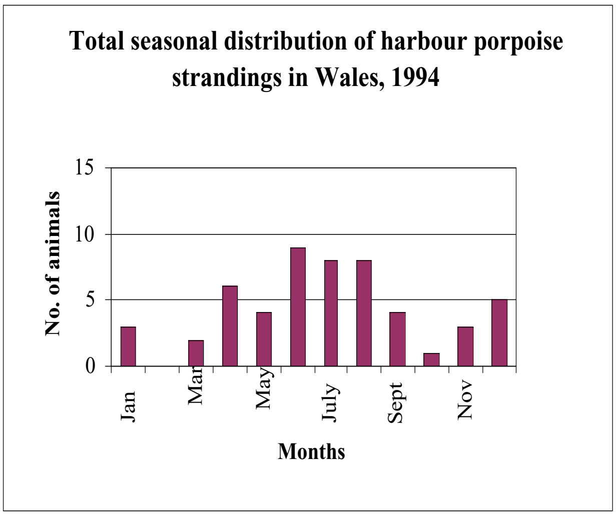
3.2.1 Harbour porpoise

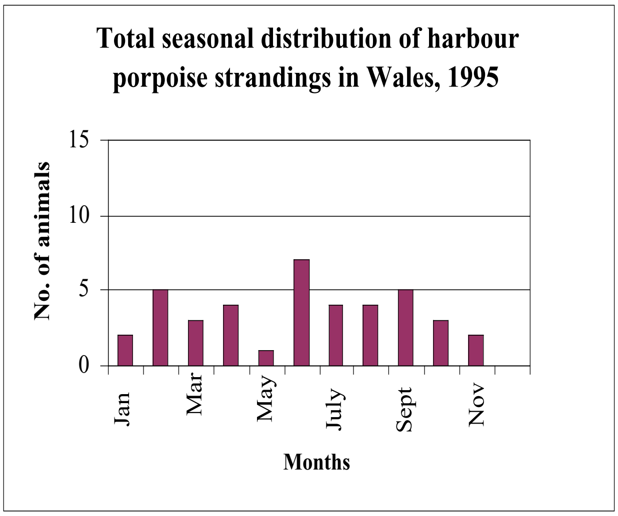
Of all the cetaceans recorded from this region, the most frequently recorded is the harbour porpoise (see Plate 2). The harbour porpoise is a species found throughout the North Atlantic, from Senegal to Northern Norway on the eastern Atlantic and from Maine to Newfoundland on the western Atlantic. It is an Annex II species under the EU Habitats Directive, meaning that its habitat requires protection. It is considered a coastal species; although there is growing evidence that this species is also found is deeper oceanic water. In recent years, some research has been undertaken on various aspects of its life history, ecology, population estimation and stock structure (see Read, 1999 for review).

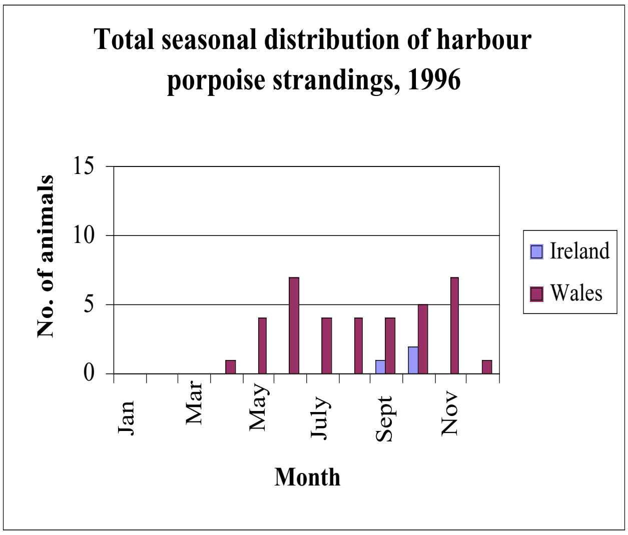
During the present study, 339 harbour porpoises were recorded from the period 1994 — 1999. Harbour porpoises were recorded in all months of the year, but with a peak in strandings in the summer time, especially in Wales (see Figures 6a - f). On the east coast of Ireland, most of the strandings/bycatch are from the winter months.

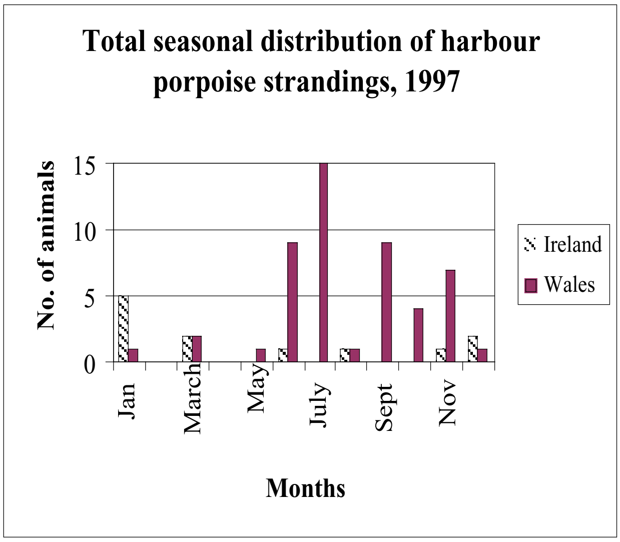
Plate 2 Harbour porpoise, *Phocoena phocoena*

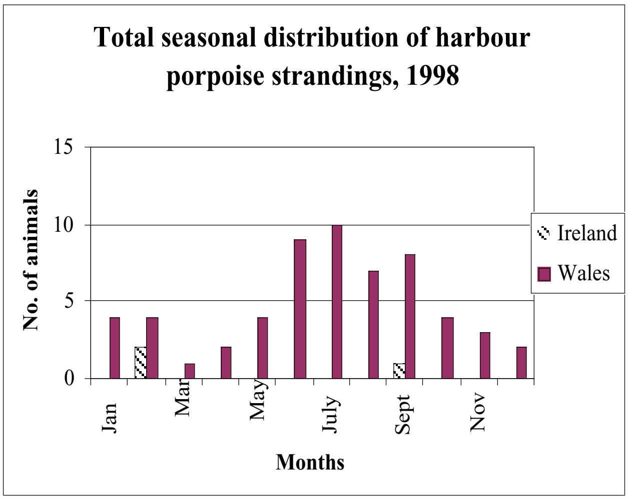
Figure 6. Seasonal distribution of harbour porpoise strandings from 1994 - 1999.

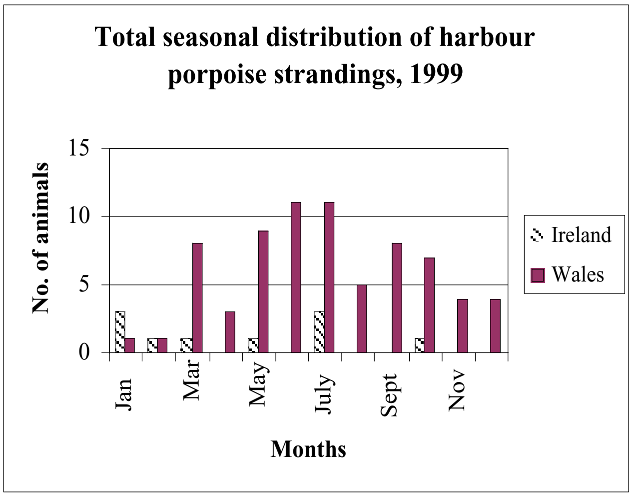












During the period 1996 — 1999, 106 harbour porpoises were examined. The sex ratio was 1:1 male to female. Examining the length/frequency distributions for this species in the period where data are in common to both Ireland and Wales shows that porpoises were recorded from 70 — 199cm in length, with a modal length between 120 — 129cm (see Figure 7).

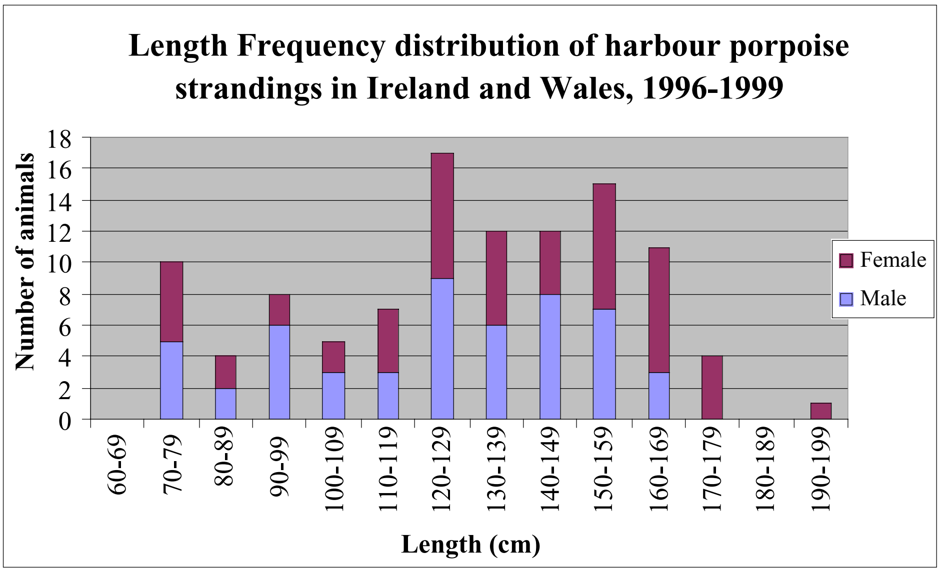


Figure 7 Length frequency distributions for male and female harbour porpoises.

This suggests that there is a high juvenile/sub-adult mortality in this species, for both sexes, especially in males. From the literature, newly born animals (neonates) are considered to have a body length of <90cm and animals between 91 and 110cm are considered calves. Examining the data of the distribution of strandings for these length categories (Figure 8), it can be seen that a high neonate mortality occurs in the summer time, with calve mortality occurring in autumn/winter, consistent with a seasonal (summer) breeding period.
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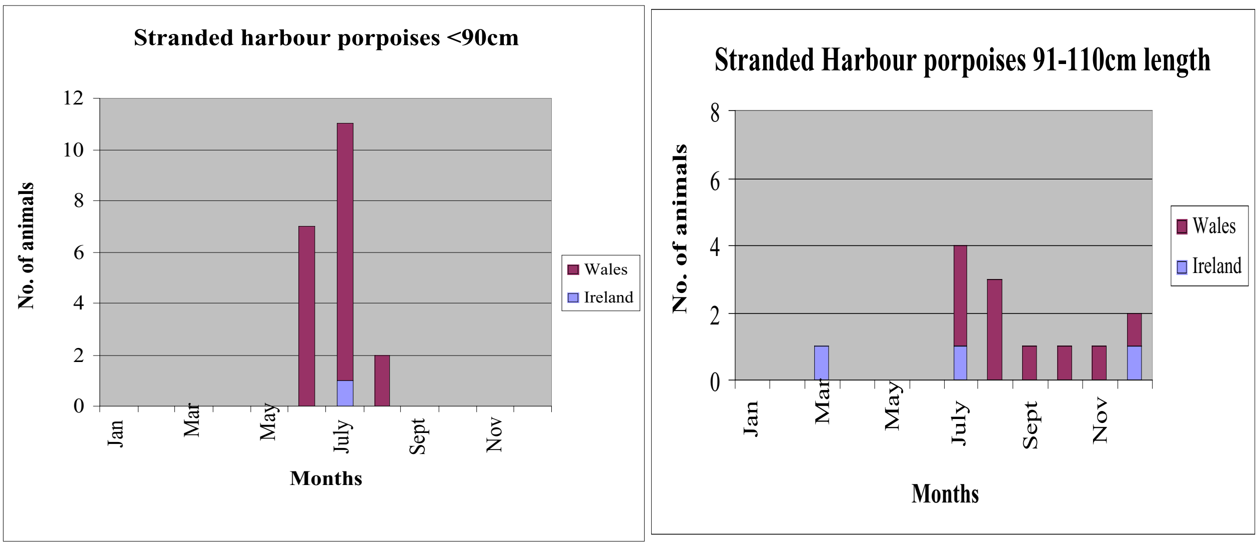


Figure 8 Seasonal occurrences of stranded neonates and juvenile harbour porpoises

The stranding of a juvenile in March, however, may suggest that while breeding/birthing may be highly seasonal, some birthing occurs outside of this period. The data also very clearly show that the Irish Sea, and in particular the area close to Wales, is an important breeding area for harbour porpoises.

3.2.1.1 Reproduction in harbour porpoises

Of the animals examined in detail in Ireland, seventeen of the harbour porpoises were female and seven were male. There are many indices for estimating length at sexual maturity for males, including examining length and weight of testes and length:weight ratio of the testes. In this study, all three methods were used and from the data available, sexual maturity in males occurs at a length of approximately 150cm (see Figure 9).

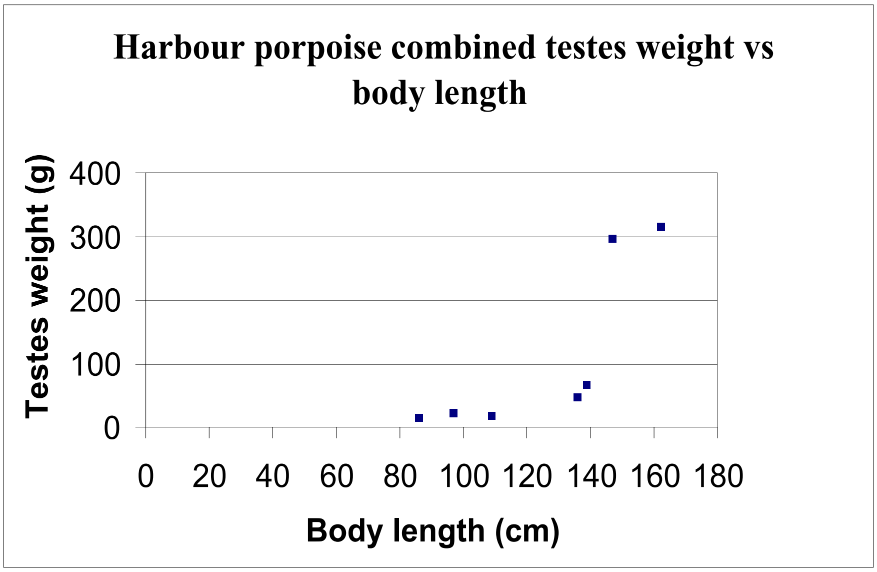


Figure 9. Testes weight as a function of total body length

For females, ovaries were examined to reveal the number of *corpora* associated with ovulation/pregnancy. During this period, 17 females were examined — of these, four females had ovaries with *corpora*, one was pregnant and lactating and a second female was lactating. Before 3 years of age (140cm) there was no discernible difference between left and right ovaries of each individual. In the length categories between 155 — 159cm, 50% of females are sexually mature.

3.2.1.2 Contaminants

Levels of 13 PCB congeners were determined from the livers of a number of individuals (see Table 2)

PCB levels ranged from 0.43 — 14.42µg/g and were highest in sexually mature individuals. In comparison, PCBs (from 10 co-geners) measured from harbour porpoises on the west coast of Ireland were found to range from 0.004 - 0.008µg/g (Smyth *et al*., 2000), suggesting that PCB levels in the Irish Sea are higher than in the Atlantic.

Code	Sum of PCB concentrations (151, 52, 121, 101, 86, 153, 141, 138, 185, 170, 199, 194 and 206)
9/99	11.40
8/99	2.24
13/97	5.21
6/97	1.56
4/97	ND
1/97	14.42
K/98	0.74
16/97	3.99
3/97	0.43
3/96	0.88

Table 2. Sum of concentrations in the liver (µg/g) of 13 PCB congeners (after Riley, 1999)

3.2.1.3 Radionuclides

Samples of muscle from three Harbour porpoises were sent to the Radiological Protection Institute, Dublin for analysis. ^{137}Cs and ^{40}K were detected and ranged from 95.8–14.3 to 124 –11.4 to Bq/kg wet weight for ^{40}K and from 10.3 –1.0 to <17 Bq/kg wet weight for ^{137}Cs (Long, pers. comm.). These values are within the ranges for both radionuclides reported previously from the Irish Sea for harbour porpoises (Berrow *et al*., 1998a)

3.2.1.4 Other contaminants

Organotin compounds have been examined from harbour porpoise and grey seals collected through the stranding programme in Wales and the results recently published (Law *et al*., 1998). Tributyltin (TBT) compounds have been used extensively as the active component of antifouling paints for ships and marine structures since the 1960s. The presence of low levels of this compound in top predators is of note. However, the significance of these results is harder to assess and further study is needed of the possible toxic effects of these compounds and the risk that their accumulation poses to these mammals.

3.2.1.5 Diet of harbour porpoise

All stomachs were examined for food remains. The number of prey items recorded, the frequency of occurrence and an index of importance are calculated and given in Table 3.

Seven species of teleosts and cephalopods were recorded. Whiting (*Merlangius merlangus*) was the most abundant (numerically) prey item found, followed by pollack. However, herring (*Clupea harengus*) and whiting were the most frequently recorded prey items, with poor cod (*Trisopterus minutus*) also important.

Species	No of Prey	% Number of Prey	Frequency of Occurrence	% Frequency of Occurrence	Index of Importance
Clupidae *Clupea harengus* Herring	99	19.4	12	52.2	31.8
Gadidae *Merlangius merlangus* Whiting	171	33.5	12	52.2	41.8
Trisopterus minutus Poor cod	69	13.5	11	47.8	25.4
Melanogrammus aeglefinus Haddock	44	8.6	3	13.0	10.6
Pollachius pollachius Pollack	105	20.6	4	17.4	18.9
Merlucidae *Merluccius merluccius* Hake	22	4.3	3	13.0	7.5
Cephalopoda *Eledone cirrhosa*	1	0.2	1	4.4	0.9

Table 3. Prey remains in harbour porpoises (from Browne, 1999).

Fish length was back-calculated from otolith length using equations derived in Harkonen (1986). Herring ranged in length from 10 — 97.9cm, with two groups being dominant, one between 1 — 19.9cm and the second between 30 — 39.9cm. Whiting ranged from 10 — 49.9cm, with 85% of this species less than 30cm in length. Of the poor cod consumed, 77% ranged in length from 5 — 14.9cm and the majority of pollack and haddock were found to be between 10 — 19.9cm. The overall modal class for all fish species was between 10 — 20cm.

Calculating weights of fish consumed, using otolith length-weight equations, herring was found to comprise 47%, whiting 23%, pollack 19%, poor cod 4%, haddock 2% and hake 1% of the total biomass consumed.

3.2.1.6 Parasites and other conditions

Cranial sinuses

Of the 29 cranial sinuses examined for nematode parasites, 22 animals were found to harbour worms, giving an overall prevalence of 76%. These worms were identified as *Stenurus minor*. No significant difference was found between the number of parasites found in the left or right bulla and the number of parasites ranged from 38 - 4,296, with an average intensity (of those infected) of 1,454 worms. The variance was greater than the mean for this sample, indicating that the parasites were over dispersed - a small number of hosts had large burdens of parasites. Parasite burden was not seen to increase with the length of the animal and there was no difference found between the number of worms present and the sex of the host (Wynne, 1999).

Respiratory tract and circulatory system.
Twenty six porpoises were found to have nematode worms in their lungs, giving an overall prevalence of 90%. These worms comprised four different species: *Pseudalius inflexus, Torynorus convolutus*, *Halocerus invaginatus* and *H. taurica*. The overall parasite burden ranged from 0 - 3,717 parasites, with *T. convolutus* contributing the most to the overall intensity. As with other helminth communities, the distribution was found to be clumped. *P. inflexus* and *T. convolutus* tend to occupy the main bronchus and bronchii while the smaller *Halocercus* spp. are found within the lung parenchyma.

Nematodes were only found in the heart of one animal (HP 12/99) that stranded in Wicklow, although it is considered that these worms were displaced from the lungs.

Stomach parasites
Of the 29 stomachs examined, 11 animals harboured nematode parasites in their 1st stomach, giving a prevalence of 38%. These nematodes were identified as *Anisakis simplex*. Ulcers were recorded from the stomachs of 12 animals, and of these animals, nine also had parasites. In these nine cases, larval stages of *Anisakis* were associated with the ulcers, but in some cases, no worms could be found. Burdens of *A. simplex* can be very varied and were found to range from 2 to > 2,000. This is within the range recorded from previous studies in this species (e.g. O'Leary 1996).

Anisakis was also found to occur in the 2nd stomach of some animals (n = 7) and in the 3rd stomach (n = 4). Clearly the 1st stomach is the main area of aggregation, but it would appear that the worms can live and survive in the 2nd and 3rd stomachs as well, unless there is extensive post-mortem migration into these areas. Ulcers were also found in the 2nd and 3rd stomachs of some porpoises (n = 3 and n = 4) respectively. These were not considered to be worm associated and further, more detailed histology needs to be carried out on these ulcers.

Liver flukes were recorded from four porpoises during the study period. While the identification of these worms has not been confirmed, they are thought to be *Campula* sp., a fluke identified in harbour porpoises in other studies (Baker and Martin, 1992)

Overall, harbour porpoises carry moderate to heavy parasite burdens, especially in organs such as the lungs and stomachs. While not apparently directly responsible for mortality in any one of the individuals examined, they may have exacerbated other health problems.

3.2.1.7 Bottlenose dolphin interactions

During this study period, nine harbour porpoises off the Welsh coast were found, by post-mortem examination, to have died of injuries consistent with attack by one or more bottlenose dolphins (Jepson and Baker, 1998). Injuries consisted of extensive bruising and haemorrhage in the musculature and a separation of the blubber from the muscle (see Plate 3), multiple skeletal fractures, including broken ribs (see Plate 4) and damaged internal organs. This unusual violent interaction between these species was first recorded and documented in the Moray Firth, Scotland by Ross and Wilson (1996).

The first harbour porpoise found dead in Wales diagnosed as killed by bottlenose dolphin attack was at Llanon, Cardigan Bay in 1995. A subsequent search through post-mortem examination reports revealed no prior evidence of other porpoises exhibiting any of these unique injuries found on these carcasses. Eight of the porpoises killed by bottlenose dolphins were found within Cardigan Bay, an accepted home area for one of the few resident UK bottlenose dolphin groups. The ninth porpoise was found north of Cardigan Bay at Trefor, Gwynedd north Wales. The reason for these killings is unclear and the present dataset although small, shows an even distribution between male and female porpoises and includes all age classes except for calves.

Plate 3. Cavity within the blubber of a harbour porpoise killed by a bottlenose dolphin indicating point of impact of ramming. Dark areas show associated bruising.

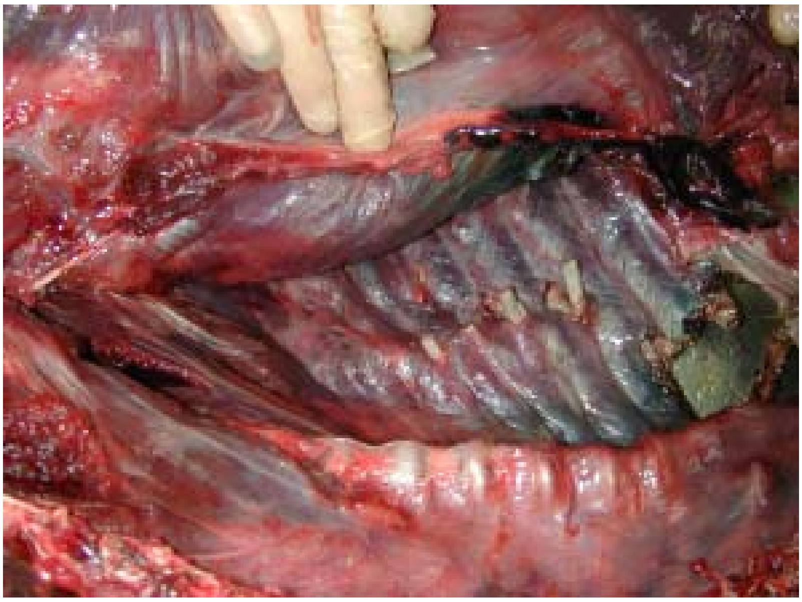


Plate 4. Broken ribs of a harbour porpoise killed by a bottlenose dolphin protruding through into the thoracic cavity.

In Ireland, during the same period, one harbour porpoise had injuries consistent with those described in Wales as having died from attacks from bottlenose dolphins.

3.2.2 *Common dolphins*

The second most frequently reported cetacean species is the common dolphin, *Delphinus delphis* (see Plate 5). This species is common along the west coast of Ireland and Scotland, but little is known from this species in the Irish Sea. However, a mass mortality of this species occurred in 1992 in Cornwall, with over 118 dolphin carcasses reported, of which 54 were positively identified as common dolphins (Kuiken *et al*., 1994). At the same time, 23 animals were also reported from the south east coast of Ireland (Berrow and Rogan, 1997). These animals were also thought to have died due to incidental capture in fishing gear. More recently (February 2000) a very large stranding of common dolphins has been reported from the Atlantic coast of France. Again, mortality is thought to be associated with entanglement in pelagic trawls (Collet, pers. comm.).

Plate 5. Common dolphin *Delphinus delphis*

During the study period, 15 common dolphins were recorded along the Irish coastline and 23 were recorded in Wales (a total of 31 from 1994 — 1999 in Wales). In Ireland, these ranged in length from 140 — 220cm, with a skewed sex ratio of 11 males: 2 females. Sex could not be determined for two animals, due to decomposition/scavenger damage. The skewed sex ratio is curious, as for other parts of Ireland, the sex ratio is equal (Rogan, unpublished data). Strandings occurred in all months of the year, with a peak in August in both regions (see Figure 10).

For the animals examined in Ireland, two animals were diagnosed as being bycaught and one was live stranded. In Wales, two animals were diagnosed as being either definitely or possibly bycaught. In addition, in the combined area, five animals live stranded.

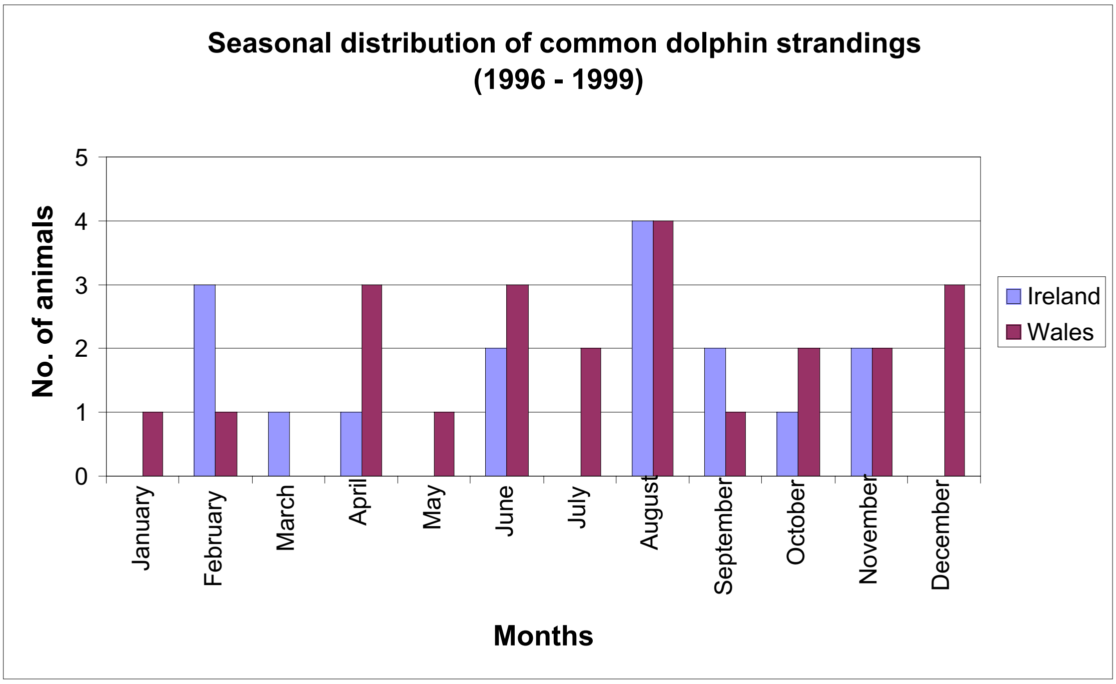


Figure 10. Seasonal distribution of common dolphin strandings in the *INTERREG* region

3.2.3 Other cetacean species

Of the other cetacean species that were recorded, Risso s dolphin (*Grampus griseus*) was the next most frequently reported species, after harbour porpoises and common dolphins, with nine animals reported from Ireland and seven from Wales. Risso s dolphins are large dolphins, primarily squid eating and are frequently seen around deep coastal waters, especially in the summer time. For example, Merne (1991, 1995) reported a group of five Risso's dolphins on three separate occasions off the Great Saltee Island, Co. Wexford. Strandings during this reporting period occurred in January, February, May and July in Ireland and June through to October and December in Wales. Many of the animals that stranded in Wales were badly decomposed and not suitable for post-mortem examination. Within the Irish sample, two animals were known bycatches and three animals live-stranded but were successfully refloated. In addition, as mentioned previously, one young Risso s swam 30km upriver, but was successfully guided back out to sea. Of interest among the stranded animals was the presence of mammary slits in a large male (325cm). In all cetacean species, mammary slits are usually only seen in females. In addition, one of these animals was a pregnant female (288cm) with a small foetus (61cm) stranded in January.

Of the remaining animals recorded, the two white-sided dolphins (*Lagenorhynchus acutus*) reported from County Louth, were a first for this species, for the County (see Plate 6). Similarly, a single white-sided dolphin live stranded in Wales. Again, this species is frequently reported from the west and south of Ireland and Scotland (Rogan *et al*., 1997, Rogan *et al*., in press) and only a small number have been reported stranded from the east coast of Ireland.

The stranding of two Cuvier s beaked whales (*Ziphius cavirostris*) in Ireland and Wales, northern bottlenose whales (*Hyperoodon ampullatus*) on each coastline and a pygmy sperm whale (*Kogia breviceps*) in Wales are of note. All these species are considered rare and infrequently reported. The Cuvier s beaked whale is the 23rd record from Irish waters since 1901 and northern bottlenose whales have only been reported stranded on 11 occasions, with four more animals standing along the west coast of Ireland in 1998/1999 (Rogan, unpublished data). All four standings of northern bottlenose whale were live strandings — one group of three in Ireland and one single animal in Wales. This species was once commercially harvested for blubber and spermaceti but little is known regarding their current status in the north east Atlantic.

Only two records of pygmy sperm whales have been reported from Ireland since 1901 (Berrow and Rogan, 1997), with a third animal stranding on the west coast of Ireland in 1998 and a forth in 2000 (Mackey, in press; Murphy and Rogan, in press). *Kogia* is considered a pelagic species and very little is known about the distribution and abundance of this species in the eastern Atlantic.

A fin whale (*Balenoptera physalus*) stranding in Co. Waterford was only the 14th published stranding record of this species since 1901 in Ireland. Similarly, two fin whales were reported stranded in Wales.

Plate 6. Atlantic white-sided dolphin *Lagenorhynchus acutus*.

3.2.4. *Grey seals*

As noted previously, a large number of strandings of grey seals were recorded over the study period (see Figures 2, 5). In Wales, numbers peaked in 1996 when 180 seals were recovered (see Figure 11). Between 1994 and 1996, post-mortems were carried out on these animals. Since 1996, no post-mortems have been carried out, but strandings still continue to be recorded.

During the period 1997 — 1999, grey seals were recovered for post-mortem and detailed examination in Ireland (Plate 7).

Plate 7. Juvenile grey seal *Halichoerus grypus*

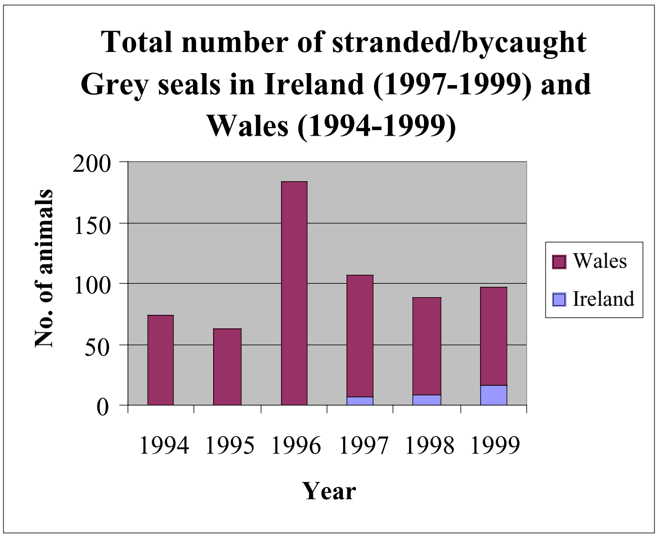
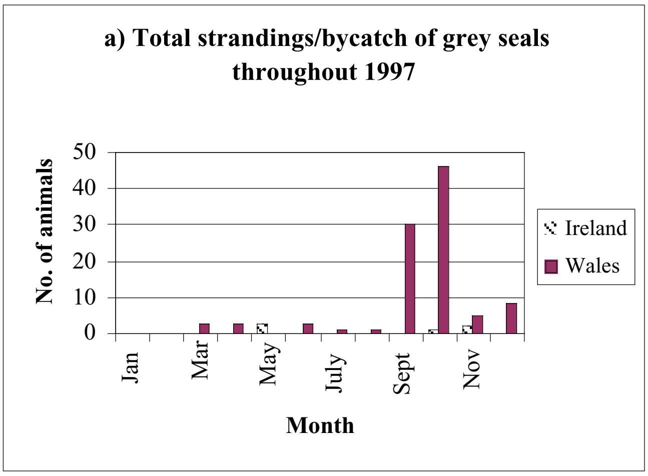
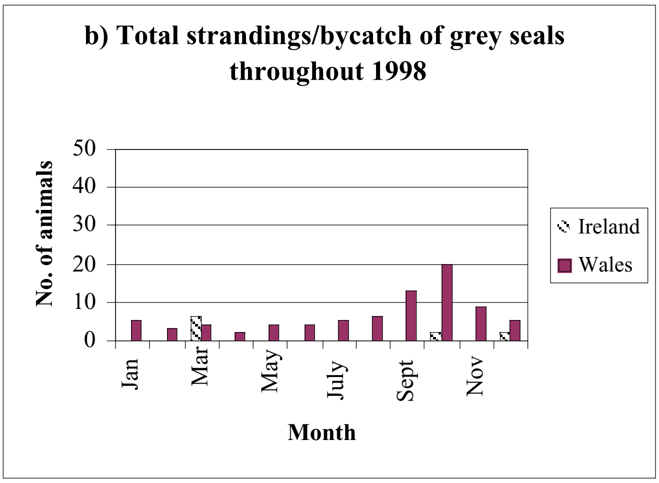


Figure 11. Number of seals recorded annually in the *INTERREG* area

As with harbour porpoises, there is inter-annual variation in the number of animals stranded and the seasonal distribution of the strandings (see Figures 12a - c). In Wales, while strandings are recorded from all months of the year, the peak in strandings occurs in the autumn, whereas in Ireland, most of the animals recorded are during winter/spring. Examination of the lengths of animals recorded from Wales shows that a large number of stranded seals are pups, corresponding with the peak pupping period in October at these latitudes.





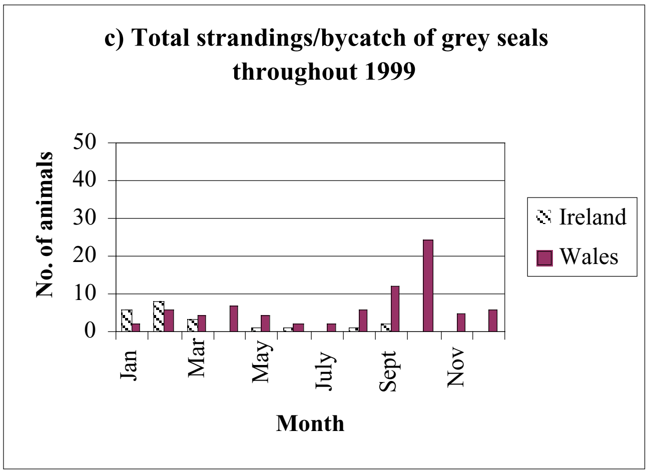


Figure 12. Number of strandings of grey seals from a) 1997, b) 1998 and c) 1999.

If length frequency distributions are plotted for the Irish data, it can be seen that most of the stranded/bycaught animals were between 120 and 130cm in length, with the majority of animals between 115 — 150cm, indicating that these animals were mostly juvenile or young of the year (Figure 13).

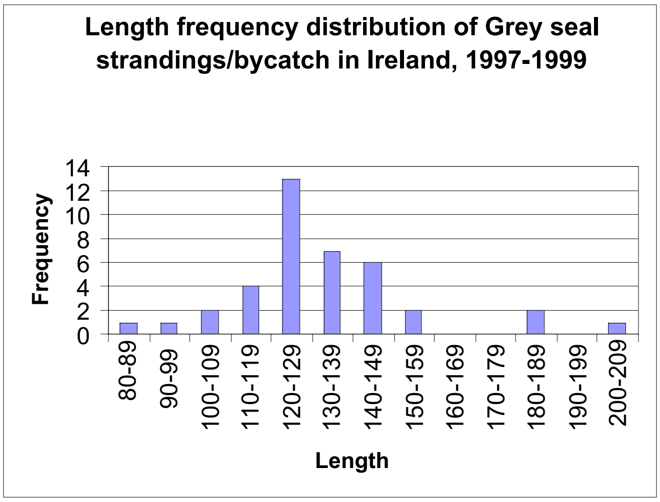


Figure 13. Length frequency distribution of grey seals recorded in Ireland.

Of the animals examined in Ireland, a high proportion of animals were known by-caught animals, landed by fishermen. All of these seals were by-caught in either set nets or tangle nets, fishing for monkfish (*Lophius piscatorius*) or rays. The fact that a high proportion of seals in this study were known bycatch animals skewed the "seasonality" profile towards winter/spring, when these fisheries are in operation (see Figure 14).

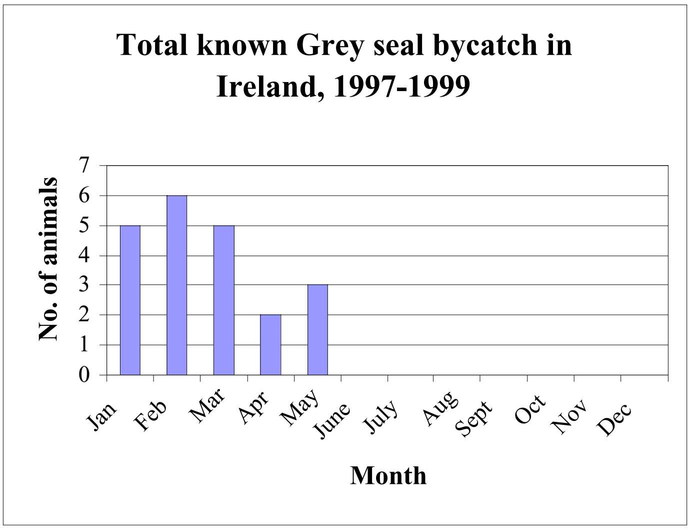


Figure 14. Occurrence of reported bycatch of grey seals

The majority of seals by-caught were juveniles, suggesting that these animals were na ve and more vulnerable to being caught in fishing gear (see Figure 15). Some of these seals were by-caught within a few miles of the coast in the Cork Harbour area. One of these animals had been "marked" with Rhodomine dye by researchers in another INTERREG study (Kiely *et al*., 2000) in the Saltee islands (Lidgard, pers. comm.), showing dispersal westwards from this breeding colony (see Plate 7).

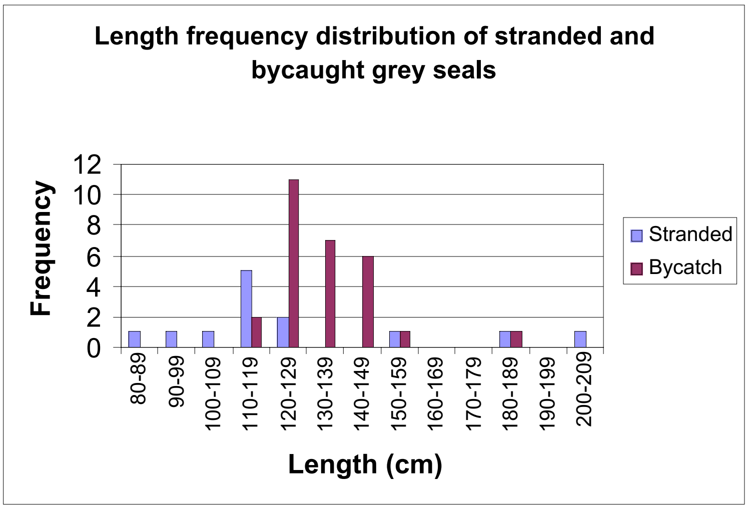


Figure 15. Length frequency of stranded and bycaught seals

The sex ratio of stranded or by-caught animals was 1:1 males to females, and there was no difference in the rate of stranding/bycatch between the sexes for this species over the annual cycle (see Figure 16).

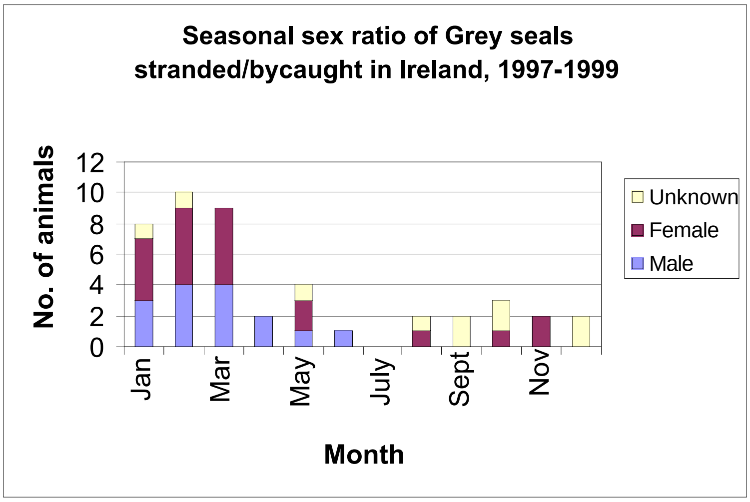


Figure 16. Seasonal variation in sex ratios of grey seals

3.2.4.1 Diet

Over the study period, stomachs from 54 seals were examined (McKibbon, 2000; Philpott, 2000). Of these, 39 were from bycaught animals and 34 had prey remains in their digestive tracts, including two animals with milk in their stomachs. Table 5 shows the number of prey items recorded and the frequency of occurrence is shown in Figure 17.

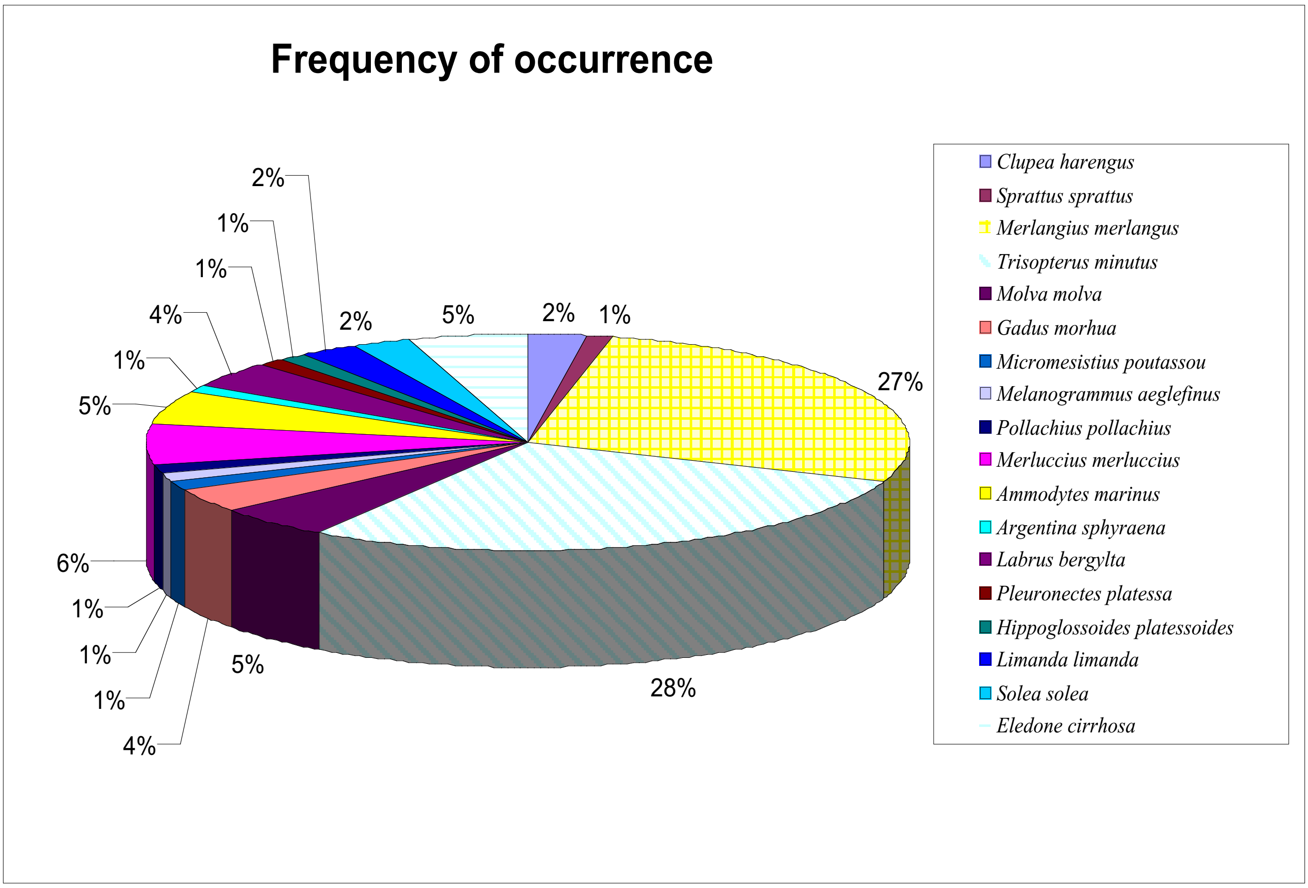


Figure 17. Frequency of occurrence of main prey items in stomachs of grey seals

Five hundred and eighty one individual prey items were recorded from eighteen different species; of these the majority were teleost fish species, with a very small proportion of cephalapod remains recorded. The Gadidae, whiting (*Merlangius merlangus*) and poor cod (*Trisopterus minutus*) were the most numerous of the prey species recorded and were also the prey items that occurred most frequently, occurring in 65% of the stomachs.

Cephalopods, represented by the squid species *Eledone cirrhosa* was found in 11.8% of the stomachs examined and overall, represented 5% of the overall frequency of occurrence of prey items (see Figure 17).

Species	No of Prey	% Number of Prey	Frequency of Occurrence	% Frequency of Occurrence
Clupidae *Clupea harengus* Herring	7	1.2	2	5.9
Sprattus sprattus Sprat	1	0.2	1	2.9
Gadidae *Merlangius merlangus* Whiting	215	37.0	22	64.7
Trisopterus minutus Poor cod	279	48.0	23	67.6
Molva molva Ling	6	1.0	4	11.8
Gadus morhua Cod	7	1.2	3	8.8
Micromesistius poutassou Blue whiting	2	0.3	1	2.9
Melanogrammus aeglefinus Haddock	2	0.3	1	2.9
Pollachius pollachius Pollack	2	0.3	1	2.9
Merlucidae *Merluccius merluccius* Hake	10	1.7	5	14.7
Ammodytidae *Ammodytes marinus* Sand eel	4	0.7	4	11.8
Argentinidae *Argentina sphyraena*	3	0.5	1	2.9
Labridae *Labrus bergylta* Ballan wrasse	5	0.9	3	8.8
Pleuronectidae *Pleuronectes platessa* Plaice	1	0.2	1	2.9
Hippoglossoides platessoides Long rough dab	1	0.2	1	2.9
Limanda limanda Dab	6	1.0	2	5.9
Soleidae *Solea solea* Sole	2	0.3	2	5.9
Cephalopoda *Eledone cirrhosa*	28	4.8	4	11.8
Milk			2	

Table 5. Prey remains in grey seal stomachs

3.2.4.2 Parasites and other conditions

Lungs were examined from 46 seals on the Irish coastline. Nematodes were extracted from 26 animals and identified as *Otostrongylus circumlitus* Raillet 1899 (Clayton, 1999). Only one species of nematode was recorded. These nematodes were also found in the heart, pulmonary artery and trachea. *O. circumlitus* was observed in the bronchi and bronchioles, with the head embedded in the lung parenchyma, while the tail projected upwards, sometimes reaching the trachea. Thick, yellow mucous was observed in the surrounding airways. Overall prevalence was 56.5%. A maximum intensity of 48 worms was recorded. Data from elsewhere on the Irish coastline gave a maximum intensity of 199 worms (Clayton, 1999). However, this parasite seems to be more prevalent in young seals, ranging from 100 - 150cm in length. By combining these data with a larger data set, it was found that a significant negative relationship was found between parasite intensities and seal body condition (calculated using three indices, following Gosselin (1995)), particularly in stranded seals. However, a strong inverse correlation does not establish that parasite intensity is the cause of poor body condition. In addition, highest burdens were seen in the early months of the year (January - March). Seals born in the previous breeding season (September - December) have started feeding for themselves and presumably encounter infected prey, resulting in the high intensities of infection in these months.

Overall Species Composition and Abundance of Gut Helminths.

Three species of anisakine nematode — *Contracaecum osculatum*, *Anisakis simplex* and *Pseudoterranova decipiens* were found in the stomach of 12 of the 16 seals examined (75% prevalence). One species of Acanthocephala —*Corynosoma strumosum* was found in the intestines of 12 of 16 seals (75% prevalence). Figure 18 shows the composition of all helminths found in the stomach and intestine of the grey seals examined (after Musgrave, 2000).

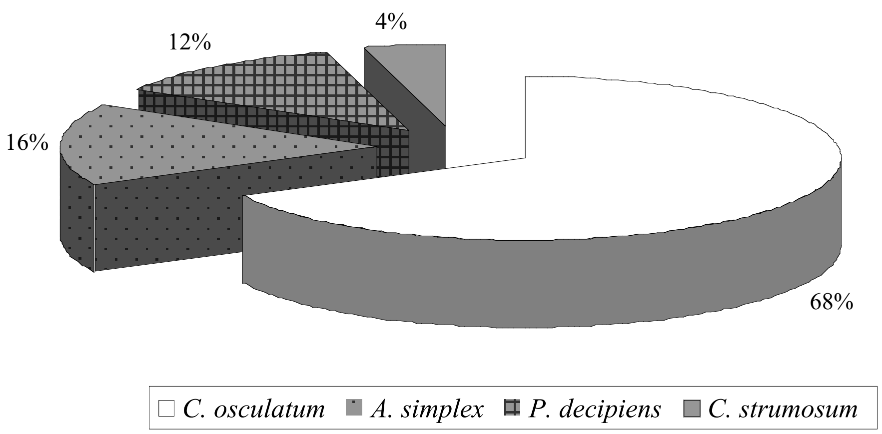


Figure 18. The species composition of gut helminths in the seal population sample.

Twelve of the sixteen seals harboured stomach parasites giving an overall nematode prevalence of 75%. Individual total burdens ranged from 45 to 3,775 parasites.

C. osculatum was the most numerous species with an overall mean number of 637.1 (including uninfected seals). The overall means for *A. simplex* and *P. decipiens* were 161.9 and 119.7 respectively (including uninfected seals). Nine of the sixteen seals examined had ulcers along the stomach wall. Nematodes of each stage were associated with these ulcers and were often deeply embedded in them.

Intestinal Parasites

Twelve of the sixteen seals harboured *Corynosoma strumosum* giving an overall Acanthocephala prevalence of 75%. Individual total burdens ranged from 1 to 117 worms, and the total burden for all seals was 681.

3.2.5 Turtles

A number of leatherback turtles, *Dermochelys coriacea*, were reported during this study. On average, nine animals are recorded in Wales/annum whereas throughout the duration of the study, two leatherbacks were recorded on the east coast of Ireland. Where possible, location, condition, measurements and species were recorded (Godley *et al*., 1998). Various samples were also taken including skin for DNA analysis and local authorities informed for safe disposal of carcass. Some of these animals were stranded but others were sightings reports. Most of the strandings/sightings occurred from July — October, suggesting a seasonal movement of this species into the Irish Sea.

Of great interest is one animal, a 2.27m female, found stranded at Pembroy, West Wales on the 8th September 1997 that had been tagged in French Guyana, South America.

4. **Discussion**

Over the study period, 1,097 marine mammals have been reported as either stranded or bycaught from the Irish Sea coastlines, comprising 12 species of cetacean and two species of pinniped. This compares with a total of 23 species recorded from the entire Irish coastline (Berrow and Rogan, 1997) and 25 recorded from the UK coast and shows that the Irish Sea is an important area for marine mammals.

Of the 12 species of cetaceans recorded, the harbour porpoise was the most frequently stranded — with 339 individuals recorded over the study period. This was followed by common dolphins (46), Risso s dolphins (16), striped dolphins (15), bottlenose dolphins (7) and pilot whales (7), with smaller numbers of the larger and rarer whale species being recorded (northern bottlenose whale (4), white-sided dolphin (3), fin whale (3), minke whale (2), Cuvier's beaked whale (2) and pygmy sperm whale (1)). Within the pinniped species, grey seals were the most frequently recorded (621), with only one common seal recorded. The numbers of animals recorded are probably indicative of the size of the populations, and/or the seasonal use of the area by the species concerned.

Cetaceans

While the majority of cetacean strandings are of dead animals, 32 individuals (6.7%) live-stranded, with most of these animals being successfully re-floated. This volume of live-strandings illustrates the need for a rapid response to live stranding incidents and the need for an increase in training of volunteers to deal with live animals. All pinnipeds were stranded dead.

If the numbers of animals that are by-caught (either known by-caught or diagnosed as by-caught on post-mortem examination) are compared to overall strandings totals, it can be seen that accidental entanglement accounts for 8.9% of cetacean strandings and 51% of pinnipeds reported in Ireland. In Wales, bycatch was diagnosed as a cause of death in 6 - 11% of the cetaceans examined; data are not available for pinnipeds. Within the cetaceans, most of the animals diagnosed as bycatch or landed were harbour porpoise, also the most frequently stranded cetacean.

Seasonal aspects of incidental by-catch have been suggested, for example Smiddy (1984, 1985) reported seasonal peaks of harbour porpoise strandings that reflected the distribution of herring fishing effort off the Cork coast. However, Berrow *et al.* (1998b) recorded no incidence of harbour porpoise by-catch in the Celtic Sea herring fishery during the 1994/1995 fishing season. A high by-catch of harbour porpoises has been reported from observer programmes in the Celtic Sea (Tregenza *et al.*, 1997), where it was estimated that the total annual by-catch in this bottom set gillnet fishery of 2,200 porpoises (95% C.I. 900 - 3,500) was 6.2% of the estimated number of porpoises in the area in 1994 (Hammond *et al.*, 1995). This level of removal may exceed natural population replacement and is not thought to be sustainable (IWC, 1996).

A comparable stranding study conducted by Kirkwood *et al.* (1997) in English and Welsh waters over a five year period found that the largest single cause of death, for those animals for which a cause had been established, was entanglement in fishing gear. Entanglement (bycatch) was diagnosed as the cause of death of 66 out of 234 harbour porpoise (28.2%) and 86 out of 138 common dolphins (62.8%). Other causes of death included neonatal starvation, pneumonia and generalised infections. In previous studies of cetacean deaths along the Welsh coast, Baker (1992) and Baker & Martin (1992) reported that of 41 harbour porpoises and 18 other cetaceans, 24% and 22%, respectively, died as a result of bycatch. Similarly, on the east coast of the US, Cox *et al*. (1998) reported that of 40 porpoises, where cause of death could be determined on the Maryland, Virginia and North Carolina coastline, 25 displayed definitive evidence of entanglement in fishing gear. Kirkwood *et al.* (1997) also noted that the proportion of harbour porpoise deaths attributed to by-catch increased over the five-year study period from 22% in 1990 to 65% in 1995. Possible reasons given for this were changes in fishing effort, technique or location, or perhaps a change in the distribution or abundance of harbour porpoise populations.

The mortality associated with interactions with bottlenose dolphins, while on a small scale, is of note. On the Welsh coastline, most of the harbour porpoises that stranded and were diagnosed to have been killed by bottlenose dolphins were in the Cardigan Bay area, which is home to a resident group of bottlenose dolphins (Arnold, 1993). It is possible that these killings have occurred as a result of competition for food, but if this were the case previous evidence of this practice would have been found, unless prey items are in decline.

As stated previously, more individuals were reported stranded on the Welsh coast than on the Irish coast. Although there is some inter-annual variation, the annual stranding rate in Wales is 164 animals/year, in comparison to 36 animals/year in Ireland. This may be as a result of the water circulation systems in the Irish Sea, in conjunction with prevailing wind direction, depositing more animals on the Welsh coastline. In addition, the Welsh coastline is larger than the Irish coastline and the sampling period is longer. However, over the years of the study there has been a general trend towards an increase in the number of stranded animals being reported in both countries (see Figure 4), which can be attributed to an increase in public awareness as a result of the programme. This is an important outcome of the study, which has improved the knowledge of marine mammals in the Irish Sea and has provided baseline data for monitoring change. In addition, it has increased the number of people reporting strandings and, consequently, the interest in marine mammals is greater. The production of brochures and posters has greatly publicised the programme and the educational component within the brochure and feedback on post-mortem examination results has put the programme into a better perspective.

Information on the reproductive biology of harbour porpoises suggests that males become sexually mature at 150cm (approximately 4 years old) and females become sexually mature at 140cm (approximately 3 years old). This is consistent with findings elsewhere (Read and Hohn, 1995, Lockyer, 1995). The high incidence of summer strandings of neonates suggests that breeding is highly seasonal and synchronous with calving occurring in the summer months. However, the strandings of a neonate in January and a juvenile in March are either an anomaly or may indicate that the season is extended. A larger sample size is necessary to examine this further.

Dietary analysis of this species reveals that harbour porpoise consume mainly clupeoid and gadoid fishes and cephalopods. Only eight different prey items were recorded, of which whiting and pollack were most abundant, while herring and whiting were most frequently recorded. Data from back calculations of the fish prey items suggest that fish between 10 — 20 cm are consumed. These results are similar to results from elsewhere (e.g. in the Bay of Fundy, harbour porpoises feed primarily on juvenile herring and silver hake (Recchia and Read, 1989; Gannon *et al*., 1998) although the species composition varies by area.

Parasite analysis revealed a high diversity of species in most of the organs examined. As with all wild mammals, parasite levels are high in comparison to domestic animals. Typical components of the helminth fauna include: the nematodes *Pseudalius*, *Stenurus*, *Halocercus* and *Torynurus* in the air passages and sinuses, the nematode *Anisakis* in the stomach and the trematode *Campula* in the liver. For all parasites found within the cranial sinuses, lungs and stomach, no relationship could be established between parasite abundance and the sex, age or length of the animal.

S. minor, which occasionally occurs in the lungs of porpoises, clearly has the ability to infect the head sinuses and inner ear bullae, and can be tightly packed in the tympanic bullae in the absence of inflammation. Geraci and St. Aubin (1986) suggest that parasites of the cranial sinuses probably elicit low-grade inflammation of the mucous membranes and rarely sinusitis, which are likely to cause discomfort, but are unlikely to affect the health of the host.

Four species of nematode were found in the lungs of the porpoises, with the numbers ranging from 0 — 3,717. Heavy lung worm infestation has been cited as a cause of death in harbour porpoise (e.g. Kirkwood *et al*., 1997), especially if associated with secondary bacterial pneumonia, however while in some animals the burdens were high in this study, they were not considered to have contributed directly to the death of the animals.

The nematode *Anisakis simplex* is a common nematode, infecting many marine mammal species. It has a complex lifecycle involving two stages in crustacean and fish hosts, with a final host in a marine mammal. It is responsible for anisakisias — a condition that occurs in humans who have eaten raw infected fish. Within the harbour porpoise host there are usually three stages (Larval stage 3 (L3) and 4 (L4) and adult males and females) and the first stomach in usually the main site. Within the stomach, numbers can range from 0 - > 2,000 and in some cases, ulcers form where the worms attach to the stomach lining. Histological examination of the ulcers show clearly points of attachment for the L3 and L4 worms, adults appear to be free living. It is difficult to assess the effect of these worms on digestion, for example, and while undoubtedly causing discomfort for the animals, probably have no lethal effects. Baker (1992) described an ulcer in the stomach of one common dolphin where the parasites had bored straight through the stomach wall, causing the ulcer to bleed and attributed this as a cause of death. However, no such incidences were recorded during this study.

From the parasite data it can be seen that most adult harbour porpoises carry heavy loads of parasites. Even in the absence of disease or health problems, it is generally thought that these heavy parasite loads may exacerbate other health problems, but are unlikely to cause significant risk to robust animals (Read, 1999).

The strandings programme shows that the Irish Sea area is an important for harbour porpoises. The high number of strandings clearly indicates that large numbers of harbour porpoises use this area. More importantly, the large neonatal and calf mortality (especially on the Welsh coastline) clearly indicates that this is a very important breeding and calving area. This is further reinforced by the proportionally higher number of sexually mature females recorded on the east coast of Ireland than on the rest of the Irish coastline. The number of calves stranded in the *INTERREG* area has been compared with strandings of calves from elsewhere in the UK and in Ireland (Penrose and Pierpoint, 1999). Penrose and Pierpoint (1999) showed that the overall proportion of neonate strandings compared to those of adults was higher on the Welsh coast (20%) than in England (12%), Scotland (12%) or Ireland (8%). This suggests that the coastal waters of the *INTERREG* area, and in particular the Welsh region, are of importance for this species.

There is some evidence of geographical sub-structure of harbour porpoises in the Irish Sea. Samples from this study have been used by Walton (1997) and are currently being analysed and compared with Icelandic samples (Duke *et al*., 2000). Walton (1995) looked at the genetic structure of harbour porpoises in the seas around UK, Ireland and the Netherlands, using mtDNA. Nineteen distinct haplotypes were identified with the most common occurring in 60% of the samples. The next most common haplotype occurred ten times and nine of these were in samples from the Irish Sea suggesting some degree of sub-structure. In another study, Walton (1997) suggests that there is considerable gene flow among these populations but that there was a significant difference ($p < 0.005$) between porpoises from the northern and southern North Sea and between the northern North Sea and Celtic/Irish Sea. The differences were predominately due to variation among the females.

Further evidence of sub-structure comes from contaminant data. Previous studies have shown that ^{137}Caesium levels were found to be higher in Irish Sea porpoises, suggesting a degree of residency (Berrow *et al*., 1998a) and levels measured during this sampling period are comparable to those reported previously. In addition, the limited data on PCBs suggests that levels are slightly higher in Irish Sea porpoises than along the west coast of Ireland, again indicating a degree of residency.

If female porpoises form local populations, they will not necessarily re-populate an area where numbers have become depleted (e.g. English Channel (IWC, 1996)). The consequences of mortality due to fishing effort in an area of apparent importance could be potentially serious. Clearly, some cetaceans are being caught in fishing gear in the Irish Sea and it would be useful to establish observer programmes in this region to identify fisheries and gear types that may contribute to cetacean mortality. Quantifying this mortality will help in management and conservation efforts for harbour porpoises in the *INTERREG* area.

Common dolphins were the second most frequently recorded cetacean species in the *INTERREG* area. This is consistent with strandings patterns for all of Ireland and the UK. As common dolphins have been recorded stranded in all months of the year it would suggest that there is no distinct inshore movement, although more common dolphins were found to strand in August than in other months. In both regions, bycatch was determined to be the cause of death of three and possibly four animals (9%) and one animal that live stranded was euthanased.

There is a very skewed sex ratio in the sample recorded, with more males recorded than females. In addition, the lengths of these animals suggest that these are young males. Sexual maturity in common dolphins occurs at 200cm in length (Collet and St-Girons, 1984) in males and at 10 years of age (Rogan unpublished data). It has been suggested that social or population segregation occurs in this species in the Atlantic (Rogan and Mackey, 1999), with large groups of sexually mature adults and juveniles recorded off the west coast of Ireland. Nothing is known about the social structure in this species, but it may be that the sexually immature and sub-adults may move closer inshore and use the Irish Sea as part of their habitat. A larger sample size and genetic analysis, currently in progress, of these samples may better elucidate this.

The second smaller odontocete, the striped dolphin, was only recorded stranded along the Welsh coastline. Striped dolphins have been described from tropical and temperate waters worldwide (Perrin *et al.*, 1994). Forcada *et al.* (1990) examined sightings from records from the north-eastern Atlantic and found that this species was most abundant in temperate waters and that sightings north of 50ßN were rare. However, data from this strandings programme suggest that they have a more northerly distribution. Interestingly, while no strandings of this species occurred on the east coast of Ireland, the striped dolphin is one of the eleven species that commonly strand on the southwest and west coast. This species is a good example of how a co-operative and regional approach to strandings can produce a much better distribution map for the species, which is imperative for good management.

A second species that was recorded stranded only on the Welsh coast was the bottlenose dolphin, *Tursiops truncatus*. This is a cosmopolitan species, found throughout the temperate and tropical oceans of the world (Leatherwood and Reeves, 1983), and Cardigan Bay is home to one of only six resident groups in Europe (Arnold, 1993). Like harbour porpoise, this species is an Annex II species under the EU Habitats Directive. While sightings records suggest that bottlenose dolphins occur on the east coast of Ireland, off Wexford and Cork, no strandings have been documented in this region.

A total of 12 species of cetaceans has been recorded in the *INTERREG* area during the study period, including some rare species of beaked whale. While some species have only stranded on few occasions, the fact that such a rich diversity of species is found in this region suggests that the Irish Sea and Celtic Sea are much more complex and diverse ecosystems than were considered heretofore and deserve more attention, both from researchers and management.

Pinnipeds

The Irish Sea area is also an important area for grey seals, as indicated by the large numbers of stranded animals recorded, especially on the Welsh coast. Whereas the other seal species, the common seal, was only found stranded along the Irish coastline, reflecting the habitat use of this species within the Irish Sea. While there is some inter-annual variation in grey seal strandings, on average 70 seals per year in Wales and approximately 14 seals per year in Ireland are reported. Parturition is highly seasonal and females congregate in colonies to give birth to nurse their offspring, usually from September — November in these regions (Kiely *et al.*, 2000). In Wales, strandings peak in October/November and this is associated with a very high pup mortality and in Ireland, the peak in mortality is in early January/February. Most of the animals examined in Ireland were bycaught juveniles.

As mentioned earlier, these juvenile seals were caught in tangle nets set inshore and landed by co-operating fishermen. Operationally, these nets have long soak times and it is possible that juvenile seals are more vulnerable to this type of gear, or more na ve and not as adept at avoiding being caught. However, it should also be noted that small seals are relatively easy to recover from the nets and that if larger seals are being caught, it would be more difficult to bring them on board. Small inshore boats are not required to keep log books and it is difficult to extrapolate to the whole inshore fleet operating in this area or to comment on the effect this type of fishing has on the population.

Data from another Irish Sea seal population study (Kiely *et al.*, 2000) suggests that the *INTERREG* region of the Irish and Celtic Seas is home to between 5,198 and 6,976 breeding grey seals, approximately 90% of which are associated with the Welsh breeding population.

Photo-identification from that study also suggests that seals move across the southern part of the Irish Sea but that there is some evidence of site fidelity by breeding females. Results from this study show that the population size of grey seals in the Irish Sea *INTERREG* area is relatively small. Over a two year period the all-age population has been estimated at between 172 — 221 on the east coast and 448 and 576 for the south east coast of Ireland. In addition, pup production has been estimated in the east coast group of islands — Lambey, Rockabill, St. Patrick s Point to be 41 in 1997 and 49 in 1998 and was found to vary between 100 and 128 in the south-east coast of Ireland (Saltee islands area). Pup mortality for the east coast group was 7.3% and 2.0% and 3.0% and 8.6% for the south-east group in 1997 and 1998, respectively (Lidgard *et al*., 2001).

Unlike other east Atlantic populations, recent estimates from the main grey seal Irish breeding colonies at the Inishkea island group, Co. Mayo and Blasket Islands, Co. Kerry on the west coast of Ireland suggest that there has been no increase in the size of the grey seal population since 1983 (Kiely and Myers, 1998). While there are no historical data to compare the south-east population to, it would seem unlikely that the population in this region will increase either. This is because: i) there is relatively high pup mortality (3 — 8.6%) for the south-east group, ii) the almost certainly high by-catch of juveniles in at least one fishery and iii) the high natural juvenile mortality (see below). In addition, there is adult seal bycatch in the winter herring fishery along the south coast of Ireland (Berrow *et al*., 1998b). On average 0.05 seals were caught per tow, which extrapolated to 60 seals removed in that year. Those authors did not believe that this would have a significant impact on the population. However, this conclusion was made in the absence of any recent abundance estimate.

Whether the population can maintain this degree of bycatch from the combined removal remains to be seen. Clearly more data are needed, especially on fishing effort in inshore fisheries and by-catch rates in other fisheries before management decisions can be made. In addition, more information on distribution and movement of seals into the area would be useful.

Dietary (stomach content) analysis for this species suggests that they are primarily piscivores, consuming only a small amount of crustaceans and cephalopods. Eighteen prey species were recorded in the diet, suggesting that grey seals are catholic feeders, consuming what is locally abundant. The main species recorded in the diet were the gadoids, whiting and poor cod, although a number of flat fish species were also recorded, suggesting that seals feed on the bottom as well as in the water column. However, the data set is not yet large enough to look at seasonality of feeding behaviour or to examine the prey preferences for the different stages, for example, juveniles versus adults.

In a small number of juveniles, milk was found in the stomachs. Previous studies of grey seal behaviour suggest that weaning of pups is abrupt (Costa, 1993) and that the period of maternal care lasts only for 16 — 18 days of lactation (Kovacs and Lavinge, 1986). White coated pups are then left on land until they moult and go to sea to feed for themselves. Since it is unlikely that milk can remain in the stomach undigested, the results suggest that the pups continue to suckle from the mothers after moulting (Philpott, 1999).

Results from parasitological examination show that grey seals harbour a number of different helminth parasites. Of these, the nematode *Otostrongylus circumlitus*, which was recorded in the lungs, bronchii, and heart, may have a negative effect on the overall health of the animal.

O. circumlitus are long nematodes (150cm) which, when attached to the lung parenchyma, cause considerable damage to the surrounding tissue. The overall prevalence was 56%, and the majority of infected seals were juveniles. While the sample size was not large enough to determine if there is a seasonal peak in infection, it may be that juvenile seals, starting to feed on fish or cephalopod species may be more susceptible to infection, either because they eat proportionally more infected intermediate hosts (which may be the more slowly swimming fish, as a result of being infected by the parasite) or that older seals, if they survive the original infection, can shed the parasite (Clayton, 1999).

This worm is considered to affect the health and diving performance of young seals, limiting their growth, feeding and ultimately their survival. Onderka (1989) and Gosselin (1995) working on lungworms in a number of seal species in Canada suggested that the amounts of mucous produced (in response to the worms) may reduce the volume of air penetrating the lungs, reducing the efficiency of gaseous exchange. Stroud and Dailey (1978) states that the presence of *O. circumlitus* with subsequent bacterial infection can lead to seal mortality and severe lungworm infection has been implicated in the deaths of juvenile seals in Donegal (Gassner and Rogan, unpublished data).

Unlike harbour porpoises, grey seals host a number of nematode species in their stomachs, including *Anisakis simplex*, *Contracaecum osculatum* and *Pseudoterranova decipiens*. Of these, the latter two are often referred to as cod worm and seal worm, respectively. Both of these worms have fish as their intermediate host and in high levels, devalue the quality and price of commercial fish. Twelve of the sixteen seals harboured stomach parasites giving an overall nematode prevalence of 75%. Individual total burdens ranged from 45 to 3,775 parasites. Ulceration associated with all three species of parasite was recorded, but neither the ulcers nor the parasite burden was thought to have a detrimental effect on the host.

Twelve of the sixteen seals harboured *Corynosoma strumosum* giving an overall Acanthocephala prevalence of 75%. *C. strumosum* is a small acanthocephalan (spiny headed) worm. There is clear evidence of habitat preference along the length of the intestine, with most worms recorded in the 15th segment, approximately 2/3rd along the intestinal tract (Musgrave, unpublished data). While there is very little differentiation along the length of the intestine, it may be that in this region, digestion of the intermediate host is complete and that the encysted stage of the worm can develop and attach. A clumped distribution along the intestine may also facilitate mating.

Very little parasitological work has been carried out on pinnipeds, especially in the north east Atlantic and this type of in-depth analysis provides interesting insights into life-cycles of parasites about which very little is known. In addition, they provide information about the health of the hosts and may be a useful tool in determining movements of animals and/or stock structure.

The problems in assessing causes of death means that the more animals examined, the more reliable the results become, and annual variations imply that long term studies must be conducted in order to achieve results that can be used as a meaningful baseline. Continued monitoring will help to determine whether changes are due to human impact or natural pathogens and furthermore will assist in the evaluation of threats for marine mammals.

5. Conclusions and Recommendations

- The Irish and Celtic Seas are very important areas for marine mammals. Twelve species of Cetacea and two species of pinniped have been recorded in this region through the collaborative strandings programme. Harbour porpoises were the most commonly recorded cetacean species and grey seals the most commonly reported pinniped. Leatherback turtles were also frequently recorded. The strandings scheme provided information on distribution, calving and in some cases seasonal occurrence of most of the species concerned. Post-mortem examination of the stranded animals gave a good insight into the cause of death in some incidences, and disease and parasite levels.

Over the duration of the project, there has been an increase in awareness of marine mammals in the region and an increase in the number of volunteers reporting strandings. There has also been an increase in the number of animals reported annually, probably a reflection of the increased volunteer effort. This is particularly true for seal records in Ireland, where heretofore, no formal stranding scheme was in operation.

Stranding schemes are the most effective and efficient method of long-term monitoring of cetaceans and pinnipeds and post-mortem examination provides very valuable biological information. The collaborative approach, focusing on the Irish Sea INTERREG area provided a much larger and integrated dataset, giving useful data on habitat use by a number of different species, including the rarer whale species. The joint stranding database is probably inadequate to determine the status of most species of cetaceans but is sufficient to identify unusual single or mass stranding events including high mortalities due to fisheries interactions, epizootics and even inter specific interactions such as bottlenose dolphin/harbour porpoise interactions. It is **recommended** that this strandings scheme be continued and that a long-term monitoring programme be maintained.

- Harbour porpoises were recorded from the Irish Sea throughout the year and there is evidence of some site fidelity. The proportionally high calf and juvenile mortality indicates that this area is also an important breeding, calving and possibly nursing area. Calving appears to occur between June and August. Genetic and contaminant data shows evidence of stock structure and it is **recommended** that harbour porpoises in the Irish Sea be considered a separate ecological stock for management purposes. Further genetic analysis, in conjunction with contaminant analysis, would better elucidate stock structure of this and other species in this region.

- From the strandings programme, it is evident that harbour porpoises, other cetacean species and grey seals are incidentally caught in fishing gear. A better understanding of the levels of incidental capture in different fisheries is necessary and in that regard, it is **recommended** that independent observer programmes be established.

- Some information is available on contaminant levels in marine mammals in the Irish Sea. For example, ^{137}Cs is found at higher levels in Irish Sea porpoises than in samples measured from other areas around the UK and Irish coasts. More data on contaminant levels in cetaceans and pinnipeds in the *INTERREG* are needed and it is **recommended** that analyses be carried out, on existing stored material and on an on-going basis, to investigate the possible link with disease and contaminants, in particular for the resident and coastal bottlenose dolphins and harbour porpoises.

- For better management of the area, in particular for the proper evaluation of threats to cetaceans, it is **recommended** that boat-based surveys be conducted to obtain abundance estimates for harbour porpoises and other cetaceans inhabiting the Irish Sea area. A joint survey to cover these waters and the adjacent areas to the north and west of Scotland and the Celtic Sea would provide information on the abundance, distribution and movements of species in these regions. Similarly, it is **recommended** that population census of grey and common seals should be carried out, especially in Ireland, to provide better population estimates for both species.

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Go raibh mile maith agaibh go l ir.
Diolch yn fawr i pawb.

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Appendix 1

IRISH WHALE AND DOLPHIN GROUP

STRANDINGS RECORDING FORM

(Please fill in as much as possible)

Name of recorder:
Address: Telephone no.:

Date of visit to stranding: Date of stranding (if known):
Location:
County: Grid Reference:

___

Description

Species:

Body colouration/pattern-.

Shape/Position of dorsal fin:

Tail notch present:

Condition:	Fresh	Poor	Very poor

Sex:

Toothed whale:

No.of teeth/ sockets

Upperjaw:	Left	Lower jaw:	Left
	Right		Right

Width of tooth socket (if no teeth present):
Shape of tooth:

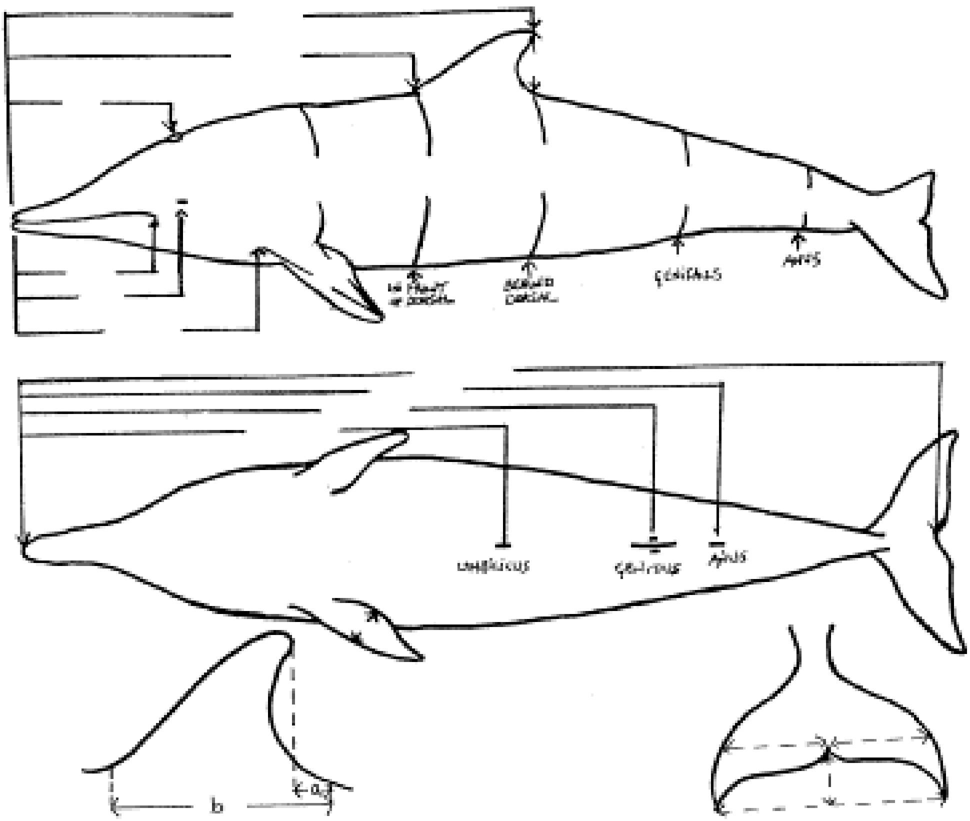
Baleen whale:

Length of longest baleen:	6-9feet(2-3m)	3feet(lm)	lfoot(0.3m)
Colour of baleen:	black	yellow	slate grey

Any obvious markings (damage to specimen prior to death)?

Diagram/Photograph of specimen

Measurement
(please enter measurements in cm)



Canting Index (a/b):

Blubber Thickness (mm):

Dorsal:
Mid:
Ventral:

Parasites:
Heart:
Stomach:
Head:
Lungs:
Others:

Intestine:
Total length:

Heart weight (g):

Testes: Weight (g) Length (mm)
Left:
Right:

Stomach:
Total weight:

1st stomach weight:
Parasite weight:
Food weight:
Ulcers/cysts:

If Female:
Pregnant:
Lactating:

Check list of samples taken

Stornach and contents: PLASTIC Teeth: JAR Skin: JAR
Reproductive organs: FORMALIN
Liver, Kidney, Muscle, Blubber (3 sections): FOIL and PLASTIC Heart & Lungs; Scapula & 5th rib: PLASTIC

Appendix 2

Seal Postmortem Report

Name of recorder:
Address:

Telephone no.:

Location of stranding:
Date of stranding:
Grid Reference:
Date of visit/pm

Description

Species:

Body colourationlyatterns:

Sex:

Condition: Fresh Poor Very poor

Any obvious markings/damage?

Bycatch or Stranding?

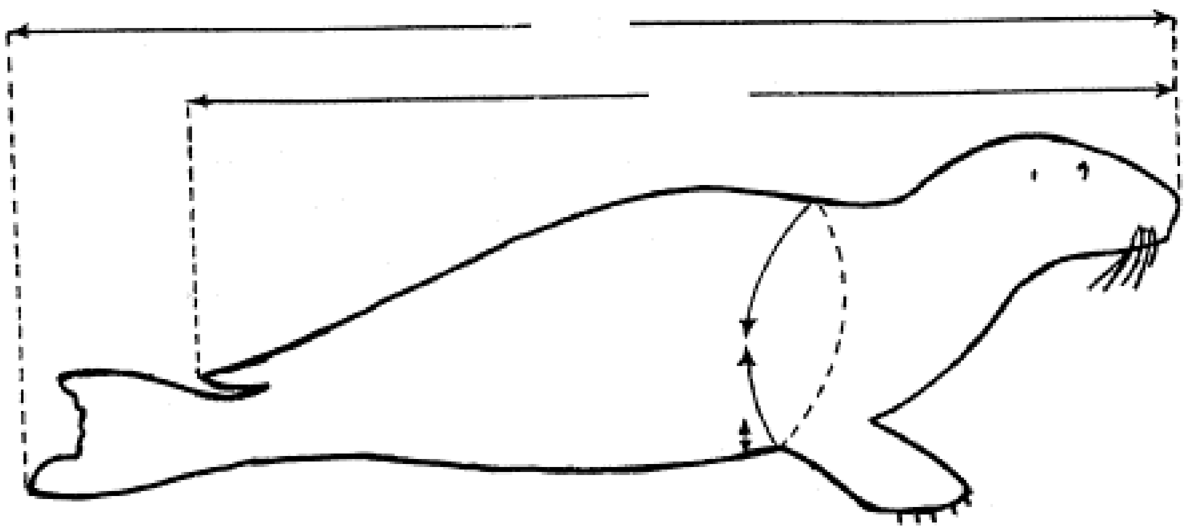
If bycatch

- type of fishing?
- type of net?

Diagram/Photograph of specimen

Measurements

(please enter measurements in cm)



Total body weight:

Blubber Thickness:

Dorsal:
Sternal:

Heart weight:

Parasites:

Heart:
Lungs:
Stomach:
Intestine:
Others:

Sculp mass:

Stomach:

Total weight:
Food weight:
Parasite weight:

Intestine:

Total length:

Testes:

Weight (g)	Length (cm)
Left:	
Right:	

Check list of samples taken

Stomach and contents: PLASTIC

Reproductive organs: FORMALIN

Heart & Lungs; Scapula & 5th rib: PLASTIC

Liver, Kidney, Muscle, Blubber: FOIL & PLASTIC

Teeth: PLASTIC

Skin: JAR

Appendix 3

Participation in other national and international projects and theses associated with this project

Genetic analysis

Species	*Laboratory*
Harbour porpoise	University College, Dublin
Common dolphin	University of Madrid, Spain
	Duke University, North Carolina, USA
Northern Bottlenose whale	University of Otago, New Zealand
Cuviers beaked whale	University of Otago, New Zealand

Contaminant analysis

Harbour porpoise (PCBs)	University of Plymouth
Harbour porpoise (TBTs)	CEFAS, Burnham on Crouch, England
Harbour porpoise137 Cs/40 K	Radiological Protection Institute of Ireland, Dublin.

Morphometric studies

All species	National Museum, Edinburgh

Student theses

Browne, E. 1999. The diet of the harbour porpoise, *Phocoena phocoena*, in Irish waters. Unpublished MSc Applied Science - University College, Cork. 56pp.

Clayton, P. 1999. The lungworm, *Otostrongylus circumlitis*, of grey seals, *Halichoerus grypus*, in Ireland. Unpublished MSc Applied Science - University College, Cork. 38pp.

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Wynne, A. 1999. Nematode parasites of the cranial sinuses of the harbour porpoise (*Phocoena phocoena*). Unpublished BSc thesis, University College, Cork.

Appendix 4

MARITIME INTERREG PROJECTS

The following co-operative projects and networks are supported under Measure 1.3 Protection of the Marine and Coastal Environment and Marine Emergency Planning , of the Maritime (Ireland/Wales) INTERREG Programme (1994 — 1999):

Co-operative Projects

1. **Roseate Terns - The Natural Connection - A Conservation and Research Project linking Wales and Ireland**
   Irish Wildbird Conservancy / North Wales Wildlife Trust.
2. **Marine Mammal Strandings - A Collaborative Study for the Irish Sea**.
   National University of Ireland, Cork / Countryside Council for Wales.
3. **South West Irish Sea Survey (SWISS).**
   Trinity College Dublin / National Museum of Wales, Cardiff.
4. **The Fate of Nutrients in Estuarine Plumes.**
   National University of Ireland, Galway / University of Wales, Bangor.
5. **Water Quality and Circulation in the Southern Irish Sea**
   National University of Ireland, Galway / University of Wales, Bangor.
6. **Grey Seals: Status and Monitoring in the Irish and Celtic Seas.**
   National University of Ireland, Cork / Dyfed Wildlife Trust.
7. **Sensitivity and Mapping of inshore marine biotopes in the Southern Irish Sea (SensMap).**
   Ecological Consultancy Services (Dublin), D chas / Countryside Council for Wales.
8. **Marine Information System: Scoping Study (Phase I).**
   Marine Institute, National Marine Data Centre/ Countryside Council for Wales.
9. **Achieving EU Standards in Recreational Waters**.
   National University of Ireland, Dublin / University of Wales, Aberystwyth.
10. **Irish Sea Southern Boundary Study**
    Marine Informatics Ltd (Dublin) / University of Wales, Bangor.
11. **Marine Information System: Demonstration (Phase II).**
    Marine Institute, National Marine Data Centre / Countryside Council for Wales.
12. **Emergency Response Information System (ERIS)**
    Enterprise Ireland, Compass Informatics, IMES / University of Wales, Bangor.
13. **Risk Assessment and Collaborative Emergency Response in the Irish Sea (RACER)**
    Nautical Enterprise Centre (Cork), National University of Ireland, Cork, University of Wales, Cardiff.
14. **Critical assessment of human activity for the sustainable management of the coastal zone.**
    National University of Ireland, Cork / University of Wales, Aberystwyth.
15. **SeaScapes — Developing a method of seascape evaluation**
    Brady Shipman Martin, National University of Ireland, Dublin / University of Wales, Aberystwyth.
16. **Ardfodir Glan — Clean Coasts/Clean Seas**
    CoastWatch Ireland / Keep Wales Tidy Campaign.

Co-operative Networks

17. **Irish Sea Hydrodynamic Modelling Network**
    Trinity College Dublin / University of Wales, Bangor.
18. **CoAST - Co-operative Action - Sustainability Network**
    Dublin Regional Authority / Isle of Anglesey County Council.
19. **ECONET - Erosion Control Network**
    Enterprise Ireland / Conwyn County Council.
20. **Navigate with Nature**
    Irish Sailing Association / Centre for Economic and Environmental Development (UK).
21. **Land Dividing - Sea Uniting Irish Seas Exhibition**
    Irish Seal Sanctuary, ENFO / National Assembly for Wales.
22. **From Seawaves to Airwaves**
    West Dublin Community Radio / Radio Ceredigion CYF.
23. **BENSIS — Benthic Ecology Network**
    Trinity College Dublin / National Museum of Wales, Cardiff.
24. **Remote Sensing of Suspended Sediment Load in the Coastal Zone**
    National University of Ireland, Galway / University of Wales, Bangor.
25. **Paving the Information Highway**
    Ecological Consultancy Services (Dublin) / Irish Sea Forum, University of Wales, Bangor.
26. **Inland, Coastal and Estuarine (ICE) Journal**
    National University of Ireland, Dublin / Centre for Economic and Environmental Development (UK).

Maritime Ireland/Wales *INTERREG* Report Series (ISSN: 1393 — 9025):

1. Raine, R. and LeB Williams, P.J. (2000) —*The fate of Nutrients in Estuarine Plumes*. 31pp.
2. Newton, S.F. and O. Crowe (2000) *Roseate Terns — The Natural Connection*. 66pp.
3. Kiely, O, Ligard, D., McKibben, M., Connolly, N., & M. Barnes (2000) *Grey Seals: status and monitoring in the Irish and Celtic Seas*. 76pp.
4. White, M., Gaffney, S., Bowers, D., and P. Bowyer (2000) *Water Quality in the Southern Irish Sea*. 28pp.
5. Hill, M., Briggs, J., Minto, P., Bagnall, D., Foley, K. & A. Williams. (2001). *Guide to Best Practice in Seascape Assessment*. 58pp.
6. Bruen, M.P., Crowther, J., Kay, D., Masterson, B.F., O Connor, P.E., Thorp, M.B & M.D. Wyer (2001). Achieving EU Standards in Recreational Waters (In Press).
7. Feighery, L., White, M., Bowers, D., Kelly, S., O Riain, G & P.Bowyer (2001*). Feasibility study of the use of digital cameras for water quality monitoring in the coastal zone*. (IN Press).

Other *INTERREG-II* Publications

Wilson, J.G., Mackie, A.S.Y., O Connor, B.D.S., Rees, E.I.S. & T. Darbyshire (2001). Benthic Biodiversity in the Southern Irish Sea 2: The South-West Irish Sea Survey - - *Studies in Marine Biodiversity and Systematics from the National Museum of Wales*. BIOM R Reports 2 (1): 1-143**.**

For further information on the Maritime Ireland/Wales INTERREG-II Programme see

http://www.marine.ie/intcoop/interreg/

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