Sub No. 10

ONMENTAL PROTECTION AGENCY
09 FEB 2005

Dúlra Nature Tours
Elly,
Clogher,
Belmullet,
Co. Mayo.
28 Jan 2005

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The Secretary,
Environmental Protection Agency,
PO Box 3000,
Johnstown Castle Estate,
Co.Wexford.

Ref. 738 – Corrib gas development application for waste licence

Dear Sir/Madam,

I am a wildlife tour operator based on the Mullet Peninsula, Co. Mayo and I wish to make the following observations on the EIS (Offshore Field to Terminal) submitted by Shell E&P Ireland Ltd. on their application for a waste/emissions licence applicable to the waters surrounding and including Broadhaven Bay, Co. Mayo.

I believe the EPA should take the following points into consideration when processing the application by Shell E&P Ireland Ltd (formerly Enterprise Energy Ireland Ltd.):

1. The **highly questionable scientific integrity** of the EIS currently under review by the EPA.

2. **Protected species** and the **EU Habitats Directive**.

3. **Protected species** and the **EU Birds Directive**.

4. The **inappropriate positioning** of the Corrib refinery's discharge/outfall pipe.

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I will now deal with these matters in succession.

**1. EIS under review by the EPA**

The EIS covering aspects of the development from Offshore Field to Terminal was published in October 2001 and has not been updated since. This is a grievous matter of considerable environmental concern because Shell E&P Ireland Ltd. since commissioned a **marine biological study by University College Cork** and have **failed to take its findings into account or deliver new information to accompany the EIS** currently under review.

My enquiries with members of EPA staff also highlight the fact that Shell E&P Ltd. **have failed to furnish the EPA with the relevant final scientific report** published in March 2003. It is my opinion that this information is highly relevant (i) to the EIS; (ii) to the marine area proposed for development under the Corrib project, and (iii) to the protection of several marine species under Irish and European law. For this reason I myself have enclosed a copy of University College Cork's final report commissioned by Enterprise Energy Ireland Ltd.

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## 2. Protected species and the EU Habitats Directive

In its EIS, the developer stated that an appropriate assessment of Annex II species, as required by the EU Habitats Directive was "thought not to be necessary" (*see p.7-29 of EIS: Offshore Field to Terminal*). While the EIS acknowledged loosely that marine mammal species (whales, dolphins, porpoises, seals, otters) are known to occur in the coastal waters of Mayo, the more recent University College Cork (UCC) study which commenced in August 2001 and is entitled

**"Marine mammal monitoring in the waters of Broadhaven Bay & northwest Mayo: 2001-2002."**
Authors: O. Ó Cadhla, A. Englund, E. Philpott, M. Mackey, S. Ingram
Report to Enterprise Energy Ireland, Ltd. by the Coastal and Marine Resources Centre, University College Cork.

demonstrated conclusively that the specific waters into which the developers wish to discharge harmful elements such as Arsenic, Cadmium, Lead, Mercury and Zinc constitute

> ***"an important area for marine mammals and other species. There are few, if any, comparable examples of a relatively small, discrete bay in Ireland containing all five Annex II marine mammal species with such frequency. It was also clear in 2001-02 that the area contained important foraging habitats for numerous marine mammal species, plankton-feeding basking sharks and seabirds."***

In fact, the UCC study found a total of seven cetacean (i.e. whale and dolphin) species occurring in the waters immediately surrounding the developer's proposed discharge/outfall, all of which are afforded strict protection under Irish (Irish Wildlife Act 1976, 2000) and European law (Habitats Directive) (*see p.5 of the UCC report*).

All conclusions in the EIS therefore, regarding the **environmental risks and potential effects of discharge** on marine mammals in the area are not only **outdated** but also **potentially in breach of Irish and European conservation laws**. The UCC study further concluded

> ***"that the biological significance of the area, both described and potential, should not be overlooked at this stage"***

Considering the study's findings and the very recent publication of a new 3-volume body of work by UCC entitled "Cetaceans and Seabirds of Ireland's Atlantic Margin", there is no doubt that

(i) the EIS (October 2001) is now grossly deficient in its scientific content, and

(ii) a serious review of all current marine data pertaining to the development and its discharges and incorporating the findings of research since August 2001 should be undertaken by the relevant authorities and perhaps by an independent panel of experts.

For the EPA to grant a licence for discharge/outfall of up to 3 tonnes of carbon and methanol waste into Broadhaven Bay under the current circumstances would surely be illegal.

## 3. Protected species and the EU Birds Directive

Under the same UCC study commissioned by Enterprise Energy Ireland Ltd. over 2,500 seabird records (*see p. 13 of UCC report*) were obtained from the Broadhaven Bay study area. None of the seabird data has been made available by Shell E&P Ireland Ltd., however, either to the scientific community or the public. Nor has the information been provided to any relevant government agency charged with the study or protection of marine animals. **This constitutes the deprivation of critical information from all interested parties, including the EPA.**

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Many of the seabird species recorded in the waters of Broadhaven Bay (e.g. guillemot, puffin) are strictly protected under the EU Birds Directive. Yet the EIS (October 2001) has made no scientific assessment of the numerical abundance or species occurrence in the waters directly affected by proposed waste discharge/outfall from the Corrib refinery. The current EIS therefore is **negligent of the true facts** pertaining to seabird life in Broadhaven Bay and **no measures to protect these highly vulnerable species** are offered therein. This situation is of very serious concern and, again, warrants **a full expert review of all current marine data** pertaining to the waters of Broadhaven Bay, thereby providing an independent detailed scientific assessment, before an EPA licence should be considered.

**4. The position of the Corrib refinery's discharge/outfall pipe**

The general location of the Corrib refinery's discharge/outfall pipe is a highly critical matter. This was determined by the Department of Communication, Marine and Natural Resources' Marine Licence Vetting Committee **without any prior knowledge** of the UCC study and **before its findings became available** in 2003. UCC's final report to Enterprise Energy Ireland Ltd. now yields irrefutable independent scientific evidence attesting to the significance of these marine habitats. It indicates that **a review of the DCMNR marine licence is urgently required** to place all new applications, including the location of the discharge/outfall pipe, in the correct and up to date context. Observational information alone (*see Fig. 3 and others in enclosed UCC report*) clearly indicates the presence of protected marine species throughout Broadhaven Bay and in the immediate vicinity of the proposed discharge/outfall pipe. Yet **no reference** has been made to this new information and it has been **given no consideration in the application before the EPA**.

As a resident of northwest Mayo and a tour operator in the area, whose livelihood and that of my family depends on the sustainability and health of the region's wildlife populations, I am very seriously concerned about the basis upon which the EPA might be making its judgement on this application. The granting of an EPA licence to Shell E&P Ireland Ltd. must surely be in breach of Irish and European law if all current information is not adequately considered or based on an up to date Environmental Impact Assessment.

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It is my opinion that the following are immediately necessary:

1. **A new independent assessment of environmental impact on protected marine mammal species now known to occur in Broadhaven Bay and surrounding waters;**
2. **The release and assessment of seabird information gathered in the UCC study in order to determine potential impacts of the development and provide advice on measures to protect the species concerned;**
3. **Following the precautionary approach, the relocation of the discharge/outfall pipe to its source, as is common and responsible practice in the gas extraction and refinement process at sea.**

A copy of this letter and enclosed report will be sent to the relevant European Union environmental bodies and to the National Park and Wildlife Service of the Department of the Environment, Heritage and Local Government. I trust that the material herein is of use to the EPA in reaching a decision.

Yours sincerely

Anthony Irwin
Manager, Dúlra Nature Tours

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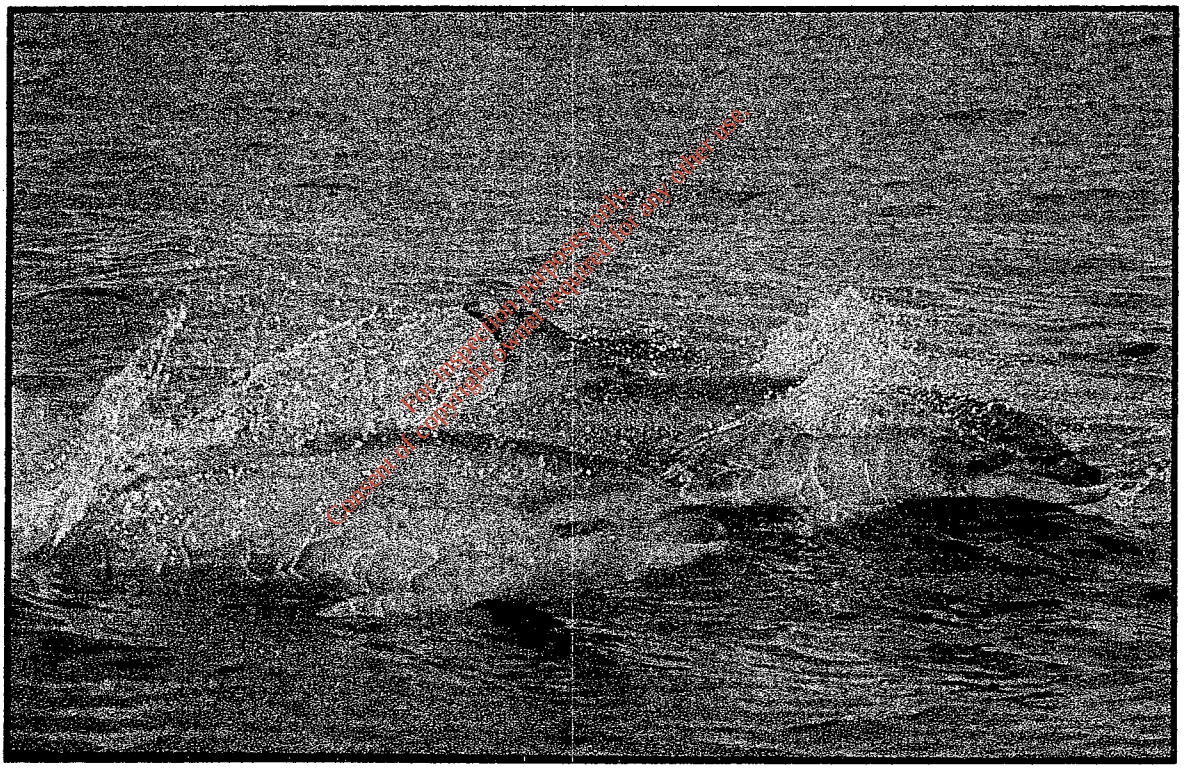
# Marine mammal monitoring in the waters of Broadhaven Bay & northwest Mayo:

# 2001-2002



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## Final project report to Enterprise Energy Ireland Ltd.

## March 2003

COASTAL & MARINE RESOURCES CENTRE
ENVIRONMENTAL RESEARCH INSTITUTE
UNIVERSITY COLLEGE
CORK

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# Marine mammal monitoring in the waters of Broadhaven Bay & northwest Mayo:

# 2001-2002

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# SUMMARY

Under a development plan for the CORRIB gas field off western Ireland, Enterprise Energy Ireland Ltd. commissioned the Coastal & Marine Resources Centre (CMRC), University College Cork to conduct an independent cetacean (i.e. whale & dolphin) monitoring programme in northwest Ireland in 2001-02. Due to the findings of preliminary field surveys in 2001 the study's remit was expanded to include other marine mammal species recorded in the study area. Research was undertaken in Broadhaven Bay (Special Area of Conservation - SAC), County Mayo and its adjoining coastal waters and the results of marine mammal monitoring conducted between October 2001 and October 2002 are presented in this report.

The primary objectives of the research project were:

1. To independently investigate the occurrence and habitat use of marine mammals in Broadhaven Bay and adjoining coastal waters of northwest Mayo;
2. To conduct a marine mammal monitoring programme before, during and after pipeline development in the study area;
3. Through consultation between EEI, CMRC and DÚCHAS – The Heritage Service, to develop an optimal method for minimising disturbance to the animals in the event of significant potential anthropogenic disturbance (e.g. underwater blasting).

Due to changes in marine construction work schedules in the area, the pipeline was not laid in 2002 and research undertaken became an effective baseline study for the area. Key results obtained by the CMRC research team are presented under the headings described below:

**1 – *Visual monitoring for marine mammals***

- Marine mammal sighting data obtained from cliff- and boat-based surveys within Broadhaven Bay SAC and its neighbouring waters between Aug. 2001 and Oct. 2002;
- A total of 223 distinct sightings of marine mammals were recorded over a 12-month field-survey period;
- Seven cetacean species, two seal species and otters were observed in the study area;
- Additional sighting information of interest included Basking sharks (21 sightings), Sunfish (five sightings), and a single sighting of a sea turtle.

**2 – *Acoustic monitoring for small cetaceans***

- Methods and results from dedicated acoustic monitoring for harbour porpoises and other toothed cetaceans;
- A total of 45 distinct detections of harbour porpoises and 14 dolphin detections were obtained within a focal study area (Rossport Bay) during the summer of 2002;
- Acoustic detections occurred during day and night-time and in all tidal states;
- The data were critical to the investigation of cetacean occurrence and habitat use in 2001-02.

**3 – *Photo-identification of bottlenose dolphins***

- Methods and results from boat-based photo-identification of bottlenose dolphins in the study area;
- A minimum of 25 recognisable dolphins (max. = 39) were encountered during the summer of 2002 and the data suggested a level of residency by individual dolphins in these months.

4 - ***Scientific conclusions*** are presented on the basis of the data collected in 2001-02.

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# INTRODUCTION

## BACKGROUND TO THE STUDY

Under proposed exploitation of the CORRIB gas field, which lies approximately 65 kilometres off the west coast of Ireland, a plan of development was devised by Enterprise Energy Ireland Ltd. (EEI) and its partners on the CORRIB project. It was concluded that the gas should be brought ashore in its natural state via a subsea pipeline to the County Mayo coast, making landfall at Dooncarton in Broadhaven Bay. It was further planned that the gas would be conditioned ashore at a nearby terminal facility while treated water associated with the refining process would be returned to the sea via a seabed outfall pipe (*see* CORRIB Environmental Impact Statement [E.I.S.], 2001). While a final planning decision on the terminal facility is currently awaited, the Minister for Communications, Marine & Natural Resources granted a series of licences in 2002 for all aspects of the development's marine phase (i.e. gas field to landfall) under a number of conditions. Such conditions included the repositioning of the proposed outfall to waters outside the Broadhaven Bay Special Area of Conservation (SAC), the submission of a detailed Environmental Management Plan for the development and the establishment of an Environmental Monitoring Group for the duration of the CORRIB project.

Broadhaven Bay, Co. Mayo was designated by DÚCHAS – The Heritage Service (Dept. of the Environment) as a candidate Special Area of Conservation (SAC) in 2000. It was put forward for such designation due (i) to the presence of four key marine/coastal habitat types listed on Annex I of the EU Council Directive on the Conservation of Natural Habitats and of Fauna and Flora (Habitats Directive: 92/43/EEC, 1992), namely Atlantic salt marsh, tidal mud flats, reefs and large shallow bay; (ii) to the presence of a number of unusual marine communities and species, and (iii) to the seasonal presence of wintering waterfowl and breeding terns (*Sterna* spp.) within the bay area.

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It was acknowledged in the CORRIB E.I.S. (2001) that the offshore waters of northwest Ireland are likely to be important for cetaceans (*a.k.a.* whales & dolphins). This is reflected by (i) historical information from whaling operations based in northwest Co. Mayo (Fairley, 1981); (ii) recent research findings (Gordon *et al.*, 1999; Ó Cadhla *et al.*, *in press;*); (iii) voluntary records collated and submitted for the CORRIB E.I.S. (2001) by the Irish Whale & Dolphin Group (IWDG), and (iv) reliable reports of groups of dolphins in Broadhaven Bay and Blacksod Bay. This background information underlined the need to safeguard these animals from significant impacts during the marine construction phase of the CORRIB development.

Prior to the present study there were few data on marine mammal populations specifically available for the waters of northwest Mayo and the immediate areas surrounding either the proposed pipeline landfall or outfall. In the context of Broadhaven Bay SAC, little background information was available on the use of its waters or neighbouring intertidal habitats by cetaceans, seals or otters. In view of marine mammal research being conducted in Ireland's offshore and coastal waters by the Coastal & Marine Resources Centre (CMRC), University College Cork, EEI invited the CMRC to undertake the present study. The project was initiated in August 2001 and undertaken in full between October 2001 and December 2002.

## RATIONALE

The broad rationale behind the project was to investigate the relative importance of Broadhaven Bay and its neighbouring coastal waters for marine mammals, while considering the necessary measures that should be put in place to safeguard these animals from significant impacts under



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the CORRIB development's coastal construction phase. This was applicable, in particular, where construction operations planned for 2002 would see potential underwater drilling & blasting cycles aimed at clearing limited sections of bedrock along the pipeline route ashore (Plate 1).

Plate 1. Excavation operations under way in Broadhaven Bay during the summer 2002. The angle of view is approximately northwards from the Glengad site.

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Under the 1976 Wildlife Act and a 1982 amendment to the Whale Fisheries Act, cetaceans are afforded legislative protection within the 200-mile Exclusive Fishery Zone (EFZ) limit of the State. In 1991, Ireland's territorial waters were officially declared a whale and dolphin sanctuary by the then government (Rogan & Berrow, 1995). While the operational status of this sanctuary is somewhat unclear today, all cetacean species occurring in Irish waters, in addition to European otters, are now also afforded strict protection as Annex IV species (i.e. *species of Community interest in need of strict protection*) under the Habitats Directive. Within this European Directive to which Ireland is bound, five marine mammal species known to occur in Irish waters, i.e:

1. Bottlenose dolphin (*Tursiops truncatus*)
2. Harbour porpoise (*Phocoena phocoena*)
3. Grey seal (*Halichoerus grypus*)
4. Harbour/Common seal (*Phoca vitulina vitulina*)
5. European otter (*Lutra lutra*)

are further listed as Annex II species, i.e. *species of Community interest, whose conservation requires the designation of Special Areas of Conservation.*

As marine mammals whose predominant sense is that associated with hearing, cetaceans are particularly vulnerable to underwater noise and water-borne pressure waves from a wide range of sources (Richardson *et al.*, 1995). While the effects of exposure to noise are the subject of ongoing research, there is sufficient evidence to indicate that marine mammals can suffer direct physical trauma from pressure waves such as those caused by underwater explosions (Ketten, 1995; Richardson *et al.*, 1995). In some cases this has led to disorientation, increased stranding rates and mortalities. Chronic effects of such exposure include damage to ear structures, depressed auditory capabilities (Richardson *et al.*, 1995) and a reduced ability to navigate, communicate and find prey. These animals may also be affected by marine industrial or construction activity through indirect means: e.g. through changes in habitat quality or in prey availability and distribution, perhaps the most important factors governing their natural distribution and abundance at sea (Evans, 1990) or on land.



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Since the EEI plan of development within Broadhaven Bay indicated the potential explosive removal of sections of submerged bedrock and excavation of sediment from the Bay, a number of issues concerning the protection of marine mammals required consideration. The very limited background data for the inner bay area (known locally as "Rossport Bay") in which drilling & blasting might occur, were not sufficient to indicate what marine mammal species might be affected nor to what degree. Previous studies of acoustic trauma to marine mammals (e.g. Ketten, 1995) reported that the level of impact from explosive sources depends on the location and the sensitivity of particular species, neither of which were understood prior to this project. In the present study, therefore, which was to take place simultaneous to various elements of the CORRIB development within Broadhaven Bay, EEI engaged the CMRC research team to take such factors into account and to place all marine mammal data collected into an immediate framework for the mitigation of all significant impacts to the animals in question.

## PROJECT FRAMEWORK

Against this background and the objectives outlined below, the project was structured according to the schematic in Fig. 1:

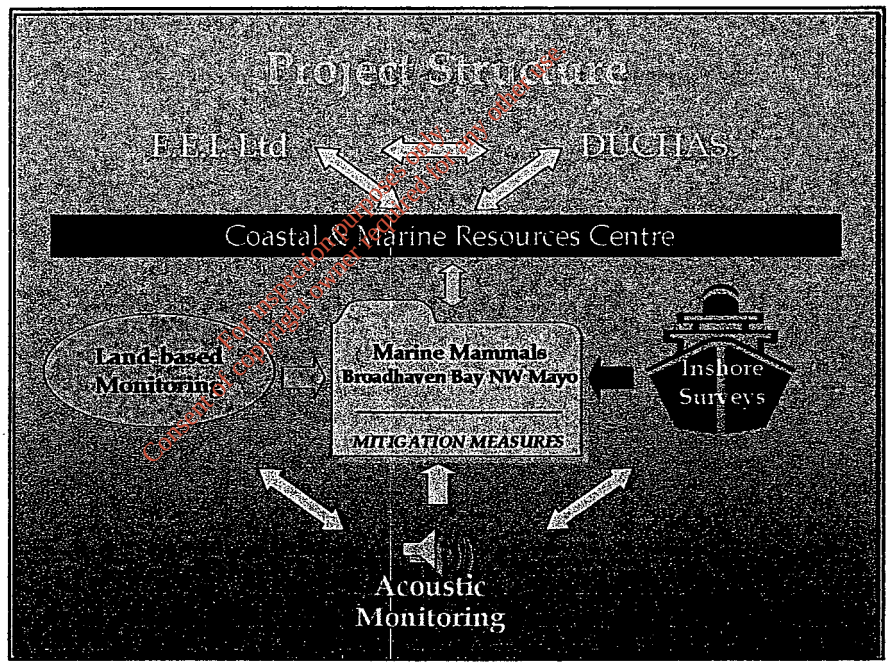


Figure 1. Flow diagram of the project structure implemented during the study.

## RESEARCH OBJECTIVES

The objectives of the study in 2001-02 were as follows:

1. To independently investigate the occurrence and habitat use of marine mammals in Broadhaven Bay and adjoining coastal waters of north-west Mayo;

2. To conduct a marine mammal monitoring programme before, during and after pipeline development in the study area;

3. Through consultation between EEI, CMRC and DÚCHAS, to develop an optimal method for minimising disturbance to the animals in the event of significant



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potential anthropogenic disturbance (e.g. underwater blasting).

NOTE: Research covering the latter objective (3) was undertaken. However, in view of a change in construction work schedules within the study area, many of the measures developed were not necessitated during 2001-02 and are ongoing in nature. These are not incorporated in the present report, which seeks to document the findings of baseline research to date while remaining relatively concise.

## STUDY AREA

Broadhaven Bay, also known as Broad Haven, is situated on the northwestern coast of Co. Mayo (Fig. 2). It opens northward between Erris Head to the west and Kid Island to the east, which lie approximately 8.6km apart. Broadhaven Bay contains a number of narrower tidal inlets that feed into its main area from the east (via Rossport Bay) and south (via a southern channel linking it to Blacksod Bay).

The main study area for the project (Fig. 2) consisted of the waters of Broadhaven Bay Special Area of Conservation (SAC) and neighbouring waters from Erris Head to the Stags of Broadhaven and within ca. 10km of the coastline. Supplementary data were also sought from the nearby coastal waters off northwest Mayo but survey effort and personnel were chiefly dedicated to the study area shown in Fig. 2.

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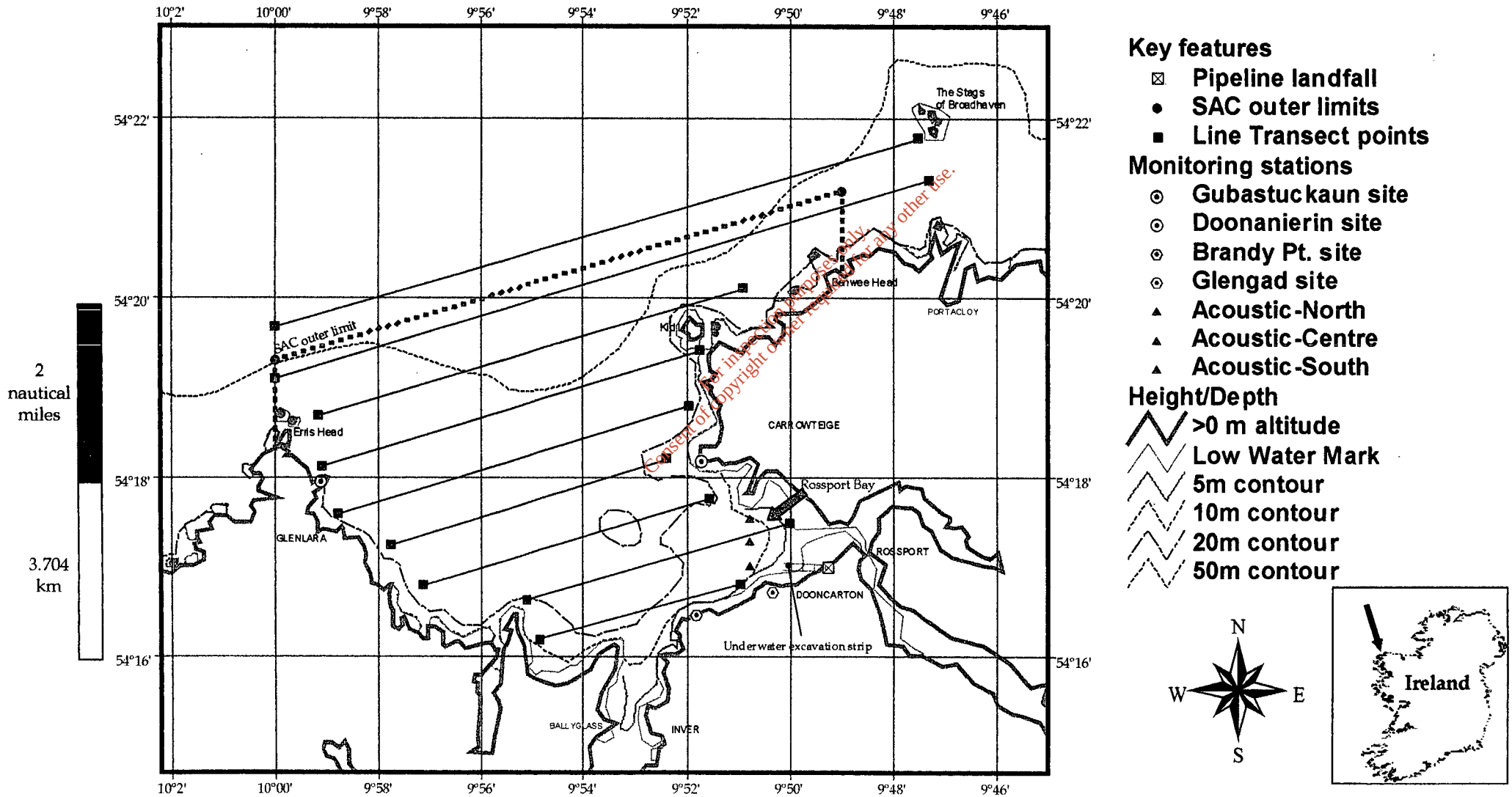


Figure 2. Map of the project's main study area incorporating much of Broadhaven Bay SAC and showing relevant features including depth contours and sites used for land-based, boat-based, and acoustic monitoring. Eastern and western outer limits of Broadhaven Bay SAC are approximately 12.4 km apart.

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# 1
# VISUAL MONITORING FOR MARINE MAMMALS

## 1.1 INTRODUCTION

Visual observation, from the shore or from the sea, can be an ideal method for studying marine mammals in coastal areas. Since these animals are naturally reliant on spending periods of time at the surface (e.g. to breathe and rest) they allow a range of visual cues to be detected from a suitable vantage point. Among the primary cues which may commonly be observed from shore and which assist in the detection of marine mammals are (a) the head or dorsal surface of the animal, including the prominent dorsal fin of cetaceans; (b) the exhalation 'blow' of larger whales; (c) distinctive splashes often associated with rapid movement; (d) breaches (i.e. where an animal jumps clear of the surface), and (e) seabird activity associated with foraging marine mammals.

The detectability of marine mammals varies greatly with species and factors such as behaviour, body size and group size may be important in determining whether or not members of a particular species are seen in the field. For example, optimal conditions for observing Ireland's smallest cetacean species, the harbour porpoise (generally <2m long; Rogan & Berrow, 1996; Rogan *et al.*, 2001), occur only in sea states ≤ Beaufort 1 (i.e. near-calm conditions) and it has been demonstrated experimentally that the detectability of harbour porpoises declines very rapidly once conditions deteriorate to higher sea states (e.g. Hammond *et al.*, 1995). This contrasts markedly with conditions allowed for surveys of blow-producing larger whales (e.g. humpback whales *Megaptera novaeangliae*), which may be allowed in conditions up to Beaufort 6 (i.e. fresh-strong winds and choppy seas).

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Shore-based techniques for detecting marine mammals show a number of advantages over boat-based methods. Firstly, they are non-invasive and do not alter the natural behaviour of the subject animals. This is particularly critical where studies of abundance or habitat use are being conducted, as intended in the present project. If suitable elevation is available near the coast, the immediate view over which a shore-based observer may preside is much greater than can be offered by any ship-based vantage point. Shore-based methods are also logistically undemanding and relatively inexpensive by comparison with the difficulties of accessing suitable vessel-based platforms.

Where marine mammals are detected from shore using the naked eye, binoculars or telescopes, accurate grid or latitude/longitude positions for the animals in question can be determined using a surveyor's theodolite positioned at a fixed monitoring station (Plate 2). The theodolite is a very precise surveying instrument and eliminates the need for reticle-binoculars, which are often used in distance determination at sea but whose precision varies greatly with environmental conditions (Lerczak & Hobbs, 1998). A theodolite fix for an individual marine mammal essentially gives measures of horizontal angle and distance to that animal from a known reference point. In general, the further the animal is from land, the higher the required observer-elevation for accurate readings (Würsig *et al.*, 1991). Theodolites have been used to study marine mammals in coastal areas for over 20 years and numerous research examples include extensive studies of habitat use by bottlenose dolphins in the Cromarty Firth, Scotland (Hastie, 2000) and dusky dolphins (*Lagenorhynchus obscurus*) in Argentina and New Zealand (Würsig *et al.*, 1991). Theodolites have also been used with video footage to investigate spatial relationships and associations between individual cetaceans (DeNardo *et al.*, 2001).

Shore-based monitoring is somewhat limited, however, in its ability to investigate marine mammal occurrence at distances nearing the limits of optical instruments or in addressing



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questions on group/individual behaviour or group structure (Hastie, 2000). The use of binoculars or higher-magnification telescopic equipment at exposed locations becomes very difficult in winds greater than Beaufort 3 and, unless significant shelter is available, the observer is thus reliant on the naked eye or lower magnification binoculars for observation purposes. Precipitation and glare from the sun may also significantly hamper an observer's ability to detect or track marine mammals.

Boat-based surveys may allow individuals or groups of animals to be monitored more closely. Such observation may be extremely helpful in species or group identification where the subjects are relatively far from land or inconspicuous in behaviour. Boat-based surveys can also be used to estimate marine mammal abundance in defined surface areas, using a variety of approaches (Hiby & Hammond, 1989; Buckland & Turnock, 1992; Buckland *et al.*, 1993). Hydrophones and other detection devices can also be used aboard vessels to carry out acoustic surveys alongside visual techniques, facilitating the detection of cetaceans during poorer weather or outside daylight hours (e.g. Aguilar de Soto *et al.*, *in press*).

While boat-based surveys may influence natural behaviour of the study animals (e.g. via vessel-attraction or -avoidance) and may often be more dependent on weather conditions than shore-watches, a number of dedicated surveys investigating marine mammal abundance and distribution at sea have been carried out successfully in Irish waters since the early 1990s (e.g. Hammond *et al.*, 1995; Pollock *et al.*, 1997; Gordon *et al.*, 1999; Ó Cadhla *et al.* 2001; Ó Cadhla *et al. in press*). These have tended to focus exclusively on cetaceans and to operate on large regional scales, often concentrating on offshore habitats from which few data are available. Closer to shore, the use of combined shore- and boat-based techniques have also proved successful in identifying important marine mammal habitats, the best example of which may be studies on the Shannon Estuary (e.g. Berrow *et al.*, 1996; Ingram, 2000).

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In view of the potential within the study area for conducting both shore- and boat-based visual surveys, the project began by investigating the technique(s) most suited to the region. The component of the study that incorporated all forms of visual monitoring aimed:

- To conduct an appropriate baseline visual monitoring programme in the study area;
- To clearly identify the species occurring within that area in 2001-02 and, where possible, to assess their relative abundance;
- To accurately describe/map the locations in which marine mammals were sighted;
- To assess the degree and variety of use of the study area by marine mammals;
- To examine marine mammal occurrence in the study area relative to a number of environmental variables (e.g. time of day, tidal state).

## 1.2 METHODS

All visual monitoring was conducted by CMRC personnel experienced in marine mammal monitoring techniques and in the identification of species, behaviours, etc. In order to maximise the use of shore- and sea-time, the research team collected marine mammal sighting data via a range of methods and in all suitable weather conditions. On any given field survey, individual researchers, whether shore- or boat-based, were able to communicate with one another via marine VHF or walkie-talkie while conducting visual monitoring. This allowed observers to collate information and optimise the field data collected in real time.

### 1.2.1 CLIFF-BASED SURVEYS

Preliminary field surveys highlighted a number of appropriate shore-based monitoring sites around Broadhaven Bay. Two primary and two secondary sites were chosen (Fig. 2). Sites at



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Gubastuckaun and Doonanierin on the western and eastern sides of the bay allowed a large area to be monitored visually from cliffs greater than 50 metres above mean sea level. The chosen site at Gubastuckaun afforded an excellent view northwards beyond Erris Head, stretching eastwards towards the Stags of Broadhaven and Kid Island, while covering a significant part of the bay itself. The view from the Doonanierin site (Plate 2) was concentrated somewhat towards the central and inner bay area, stretching from Rossport Bay and the landfall location in a westward arc across the entrance to Ballyglass Harbour and outwards to the central and outer reaches of Broadhaven Bay.

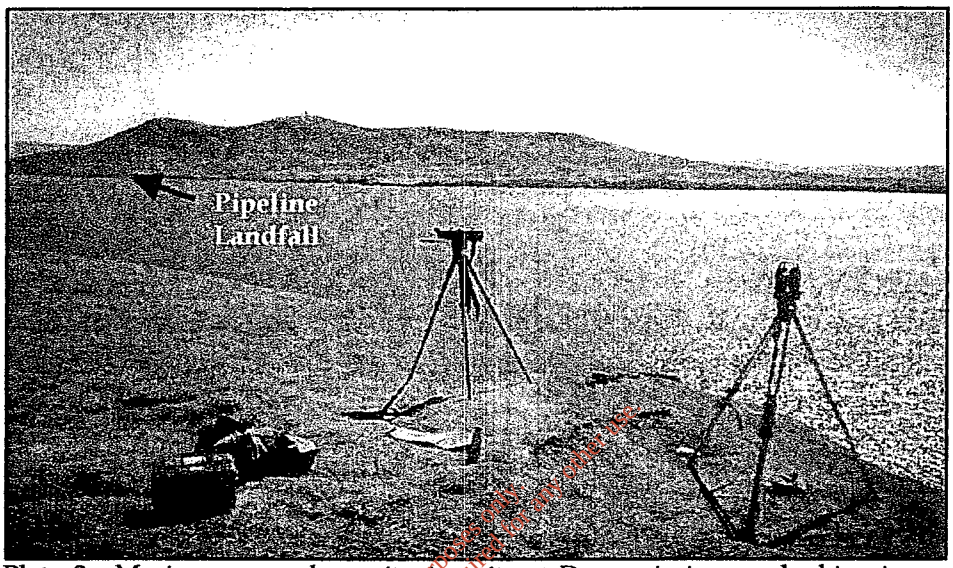


Plate 2. Marine mammal monitoring site at Doonanierin, overlooking inner (i.e. Rossport Bay, shown left) and outer portions of Broadhaven Bay. Telescopic and theodolite equipment are shown. The angle of view is approximately southwards.

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In selecting the two primary visual monitoring sites, it was expected that a large portion of the bay could be covered visually on any given survey day. A level of overlap between observers on opposing sides of the bay was also anticipated. Since these observers could communicate with one another, it allowed for the discrimination between duplicate and non-duplicate sightings of marine mammals where necessary. Secondary lower-altitude sites at Brandy Point and Glengad (Fig. 2) were also used on occasion. These were more restrictive in view but facilitated the focal monitoring of Rossport Bay (Plate 1) in which sediment removal and associated operations were conducted during the summer of 2002.

The standard optical equipment used at cliff-based monitoring sites consisted of a tripod-mounted *Kowa* telescope (32x magnification, wide-angle) and a monopod-mounted pair of *Silva* binoculars (7x50). A tripod-mounted *Sokkia* digital theodolite was also employed in the study for position-determination and this was placed at a fixed location within the Doonanierin site (Plate 2).

Cliff-based visual monitoring consisted of repeated scan samples of the visible study area from a monitoring site using both telescope and binocular equipment in succession. Each scan was of a minimum 60 minutes in duration and varied in total-duration depending on whether or not marine mammals were seen. Each full scan of the visible study area was followed by a period of 30 minutes during which the observer was encouraged to rest his/her eyes. Visual monitoring conducted on each survey day continued as long as daylight and weather conditions allowed. In general, dedicated scan sampling was abandoned once the wind strength increased above Beaufort 3-4, conditions in which the detectability of marine mammals is severely



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compromised. On such occasions, observers might opportunistically continue to use binoculars where wind direction (e.g. offshore) or sea conditions made such monitoring yet worthwhile.

Standard marine mammal sighting data collected by shore-based observers included species identification and position, estimated group size and composition (number of adults, immatures, etc), behaviour (e.g. surfacing intervals, foraging/social/travel, etc), sighting cues, and any associations with birds or other species. Survey effort, environmental conditions (e.g. glare, wind strength, swell height) were also recorded.

### 1.2.2 BOAT-BASED SURVEYS

Boat-based surveys were carried out aboard a 7.5m long rigid-hulled inflatable boat (Atlantic RIB Charter, Elly Bay) which allowed an observers' height-of-eye of approximately 2m above sea level.

**Line-transect surveys** (Buckland *et al.*, 1993) were conducted in sea states ≤ Beaufort 3. All were carried out when observers were working simultaneously from cliff-based monitoring sites on east and west sides of the bay. Communication between boat- and cliff-based observers thus allowed the research team to co-ordinate survey efforts, to obtain accurate positional information for sighted animals and to further investigate sightings of particular interest (e.g. foraging events, groups containing calves). A standard survey route was developed in 2002 when sea conditions became more favourable for boat-based trials. The design consisted of a series of nine parallel transect-lines within the study area (Fig. 2), spaced approximately 1 km apart. Eight of these lines were situated within the confines of the SAC while one was placed approximately 500m outside the SAC limits. The design was of sufficient length to allow completion of all transect lines within 5-6 hours with the additional provision to approach particular cetacean groups and other species of interest for identification purposes.

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Survey methods used in 2001-02 were an adaptation of those used offshore by Ó Cadhla *et al.*/Mackey *et al.* (*in press*) and Pollock *et al.* (1997) and allowed the simultaneous collection of marine mammal data alongside ancillary data of scientific interest (e.g. shark sightings, seabird distribution). A dual-observer approach was implemented, whereby one CMRC observer conducted a visual survey on one side of the moving vessel, from 0° (ahead) to 90° abeam. He/she used both the naked eye and *Leica* 10x42 binoculars for species detection/identification and recorded (i) all marine mammal sightings and ancillary data within viewing range, in addition to (ii) seabird data within a 200m-wide strip-transect (*after* Tasker *et al.*, 1984). The second observer operated on the opposite side of the vessel and recorded all marine mammal sightings and ancillary data within viewing range, from 0° (ahead) to 90° abeam. He/she was equipped with 7x50 binoculars to assist in species identification. All data parameters collected on cliff-based surveys (i.e. survey effort, environmental conditions, species, location, group size, etc) were also recorded during boat-based surveys.

**Casual surveys** were also conducted in 2002. These occurred opportunistically when the vessel was deployed for equipment trials and acoustic monitoring or when sea conditions did not allow dedicated surveys to be implemented.

### 1.2.3 DATA COLLECTION & ANALYSIS

Site investigations using a *Sokkia* electronic total station and *Trimble* differential global positioning system (GPS) allowed the determination of the exact positions and altitudes of cliff-based observers and calibration of sighting positions in relation to distance from the fixed theodolite station and to tidal state. Marine mammal and ancillary sighting information collected during visual monitoring and all associated effort, environmental and positional data, whether from the shore or vessel, were recorded in the field on paper or dictaphone. These data were subsequently transcribed in full and coded for entry into standard PC-based spreadsheets.



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Ancillary seabird data collected during boat-based surveys were not included in the present report due to the large size of the dataset (i.e. >2,500 sighting records) and time constraints under the present project.

All cliff- and boat-based sighting data were collated. Due to field communication between observers, the chance of recurrent sightings by cliff-/boat-based observers was investigated in real time. Further examination of the data saw sightings classified either as *non-duplicate* (i.e. different individual/group) or *potential duplicate* sightings (i.e. 'Possible', 'Likely' or 'Definite'; Ó Cadhla *et al., in press*) on the basis of date, location, time and associated information. All potential duplicate sightings were excluded from the analysed dataset. Thus, the data used in further analysis constituted only distinct (i.e. non-duplicate) sightings of individual animals or groups. All such marine mammal and ancillary sightings were examined in relation to survey effort and basic environmental factors (i.e. tidal state and time-of-day). Distributions for each species were plotted in Irish grid using *ArcVIEW GIS* 3.1 (© ESRI Inc.) with positions representing the initial sighting location of species concerned. No tracking information are presented.

## 1.3 RESULTS & DISCUSSION

### 1.3.1 CLIFF- & BOAT-BASED SURVEY EFFORT

Preliminary shore-based monitoring was carried out opportunistically over two days in August 2001 from Glengad. Full monitoring commenced in October 2001 and, although weather conditions in north Mayo restricted the number of suitable days for effective visual observation, particularly between the months of December 2001 and March 2002, the research team conducted cliff-based monitoring on 57 days between 1st October 2001 and 1st October 2002.

This resulted in a total of 317.32 hours (19,039 minutes) of full monitoring from cliff-top observation sites. The two primary observation sites of Doonanierin and Gubastuckaun saw 93.6% of cliff-based monitoring effort. Due to logistic considerations and weather constraints at both sites, effective simultaneous watching from both primary sites was possible for 21.6% of the total cliff-based monitoring time.

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Boat-based surveys were severely restricted by weather conditions but a total of 9 dedicated line-transect surveys of the study area were achieved when weather conditions were most favourable between May and October 2002. In addition, four extensive casual surveys were undertaken in the study area during this period, while six smaller-scale circuits of Broadhaven Bay were conducted on an opportunistic basis in poorer weather.

### 1.3.2 MARINE MAMMAL SIGHTING DATA

A total of 223 distinct sightings of marine mammals were recorded during the 2001-02 study. Visual observations of marine mammals within the study area consisted primarily of various cetacean species and both native species of seal. The overall marine mammal dataset contained four potential duplicate sightings that were excluded from further analysis. These were all sightings of cetaceans: 2 were sightings of bottlenose dolphin groups, one a white-beaked dolphin, and one an harbour porpoise sighting.

Marine mammals were observed throughout the study area in all months of the year when monitoring was feasible. Sightings occurred during all tidal states and times-of-day surveyed, as near inshore as the entrances to Ballyglass Harbour and Rossport strand, and as far as 10km outside the limits of Broadhaven Bay SAC (Fig. 3). In general, concentrations in marine mammal sightings during the entire study appeared to occur off the Gubastuckaun-Erris Head area and within the northern part of Rossport Bay/inner Broadhaven Bay, in the vicinity of Rinroe Point.



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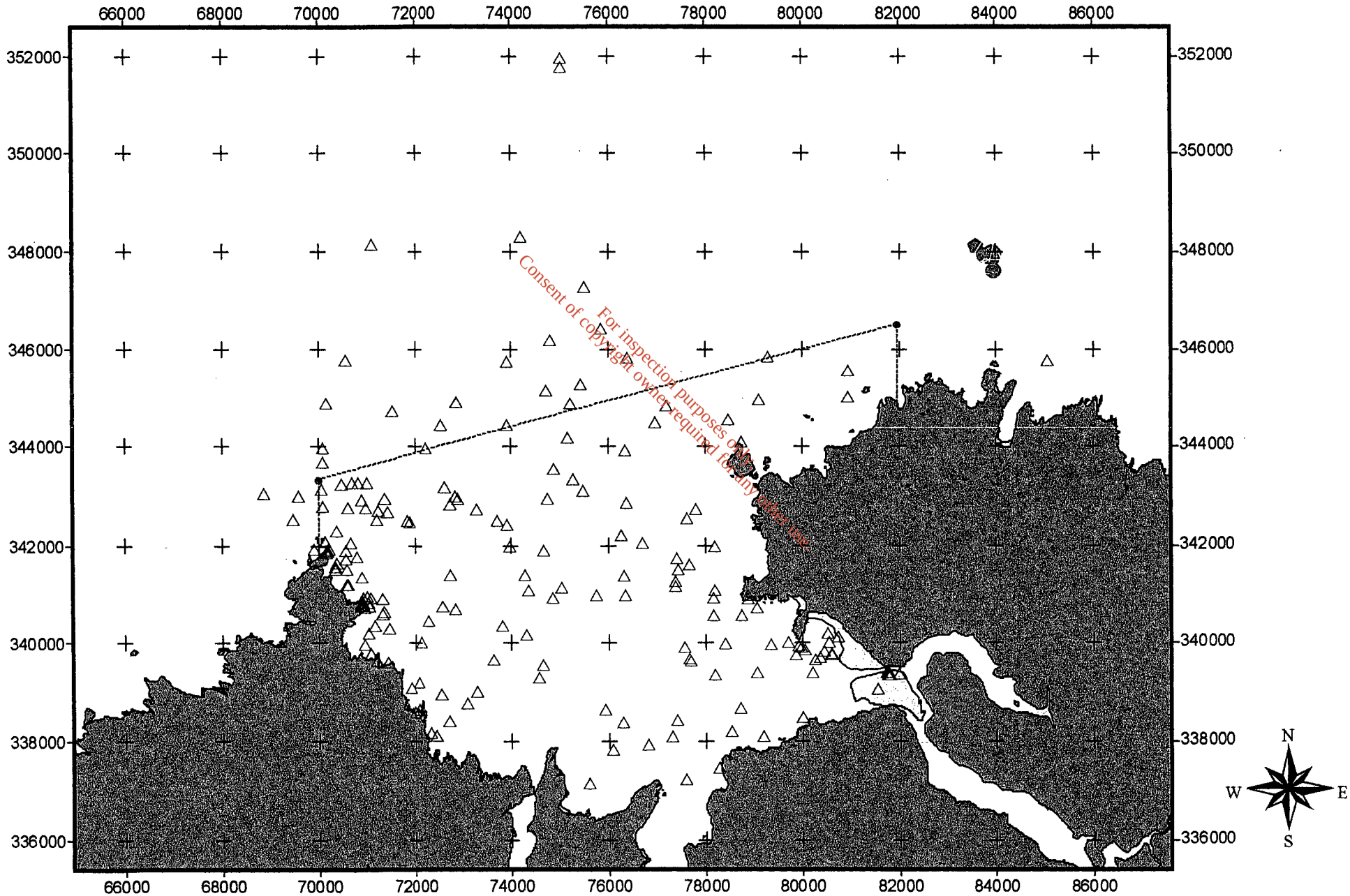


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Figure 3. Distribution map (Irish grid) for all marine mammal sightings (triangles) recorded by CMRC observers between August 2001 and October 2002.

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## A. *Cetaceans* (Whales & dolphins)

Cetaceans groups and individual animals were observed on 59.6% of days during which visual monitoring could be conducted, either by cliff-based or boat-based means. Ninety-two distinct cetacean sightings were recorded by CMRC observers during the study, the majority of which were sighted from cliff-based monitoring sites (Table 1). A total of 20 cetacean sightings were obtained during boat-based surveys conducted between the months of May and October 2002. Seven species (one whale and six dolphin/porpoise species) were identified in the study area and all were recorded within the waters of Broadhaven Bay SAC (*see* Figs. 7,8 & 10-12). Nine sightings of dolphins occurred which could not be identified to species level. This was due to the animals' inconspicuous behaviour or distance from the observer(s), which made positive identification difficult. All cetacean species except one (i.e. minke whale) were observed in social groups of two or more animals and two species were recorded in groups containing newborn calves (Table 1).

TABLE 1. Summary of cetacean sighting records within the study area, obtained by CMRC observers between August 2001 and October 2002. Triangles denote the recorded composition of groups seen.

| Species | *No. of Records* Cliff-based | Boat-based | No. of distinct sightings | Total no. of animals *N* | *Adults* | *Juv.* | *Calves* | Group Size *Range* |
|---|---|---|---|---|---|---|---|---|
| *BALEEN WHALES* | | | | | | | | |
| Minke Whale | 10 | 1 | 11 | 11 | ▲ | - | - | 1 |
| *TOOTHED CETACEANS* | | | | | | | | |
| Risso's Dolphin | 8 | 2 | 10 | 19 | ▲ | - | - | 1-3 |
| Bottlenose Dolphin | 20 | 3 | 21 | 239 | ▲ | ▲ | - | 1-18 |
| White-sided Dolphin | 2 | 6 | 8 | 93 | ▲ | ▲ | ▲ | 4-25 |
| White-beaked Dolphin | 2 | 1 | 2 | 10 | ▲ | - | - | 3-4 |
| Common Dolphin | 5 | 2 | 7 | 111 | ▲ | ▲ | ▲ | 1-49 |
| Harbour Porpoise | 20 | 5 | 24 | 47 | ▲ | ▲ | - | 1-4 |
| *UNIDENTIFIED SPECIES* | | | | | | | | |
| Unidentified dolphins | 9 | 0 | 9 | 37 | ▲ | - | - | 1-10 |
| TOTALS | 76 | 20 | 92 | 567 | | | | |

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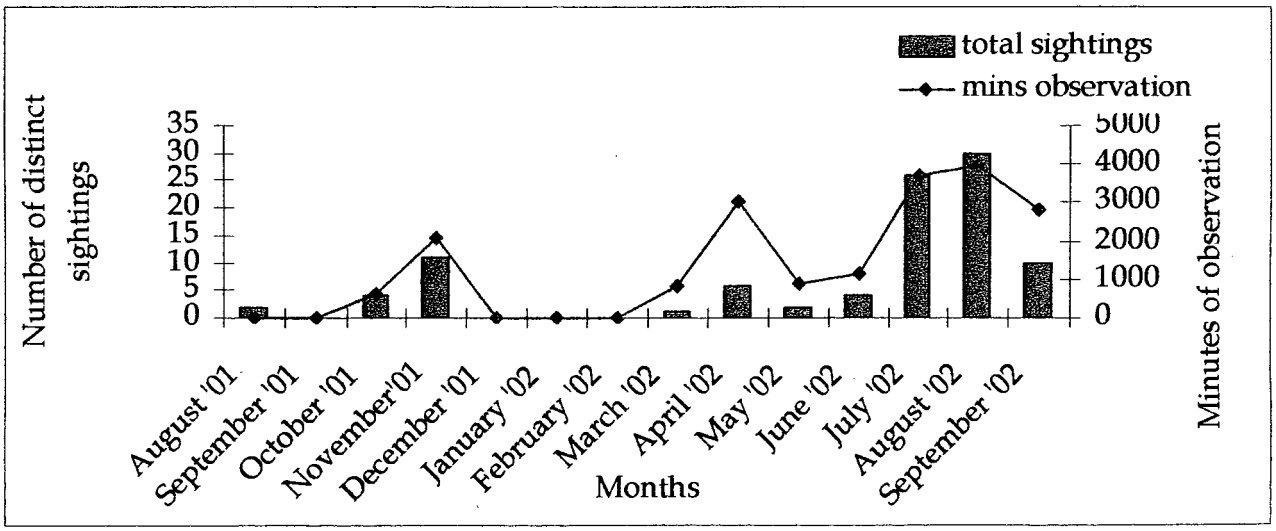


Figure 4. The total number of distinct cetacean sightings recorded per month of the study, plotted against total effective monitoring effort (in minutes).



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Sightings of cetaceans occurred in all months during which visual monitoring was possible (Fig. 4) and peak sighting rates (i.e. number of sightings per unit observation time) occurred in July and August 2002. While this coincided with the greatest cliff-based monitoring effort, similar parallels were not observed during secondary peaks in monitoring effort during the months of April and September 2002. Relatively high numbers of sightings per unit effort were also found in the month of November 2001. Significantly lower survey effort in the month of October 2001, from December 2001 to March 2002, and in May/June 2002 was due to consistent deterioration in weather conditions beyond those acceptable for visual monitoring. Site visits were made during such periods but they often proved less than worthwhile and resulted in little effective visual survey effort. Consequently, the relatively low number of cetacean sightings recorded during these periods must be interpreted with caution at this stage.

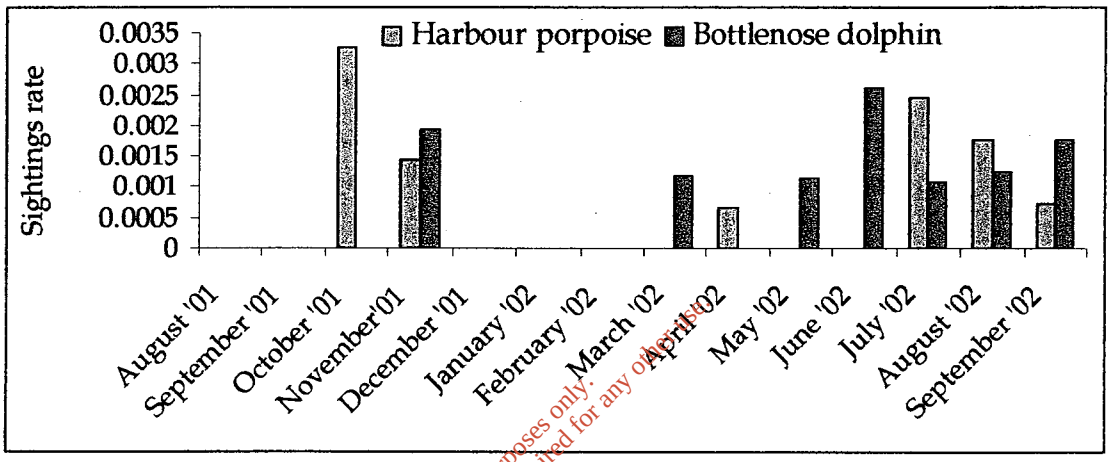


Figure 5. Monthly sighting rates for the most commonly recorded cetacean species observed during the 2001-02 study - harbour porpoise and bottlenose dolphin.

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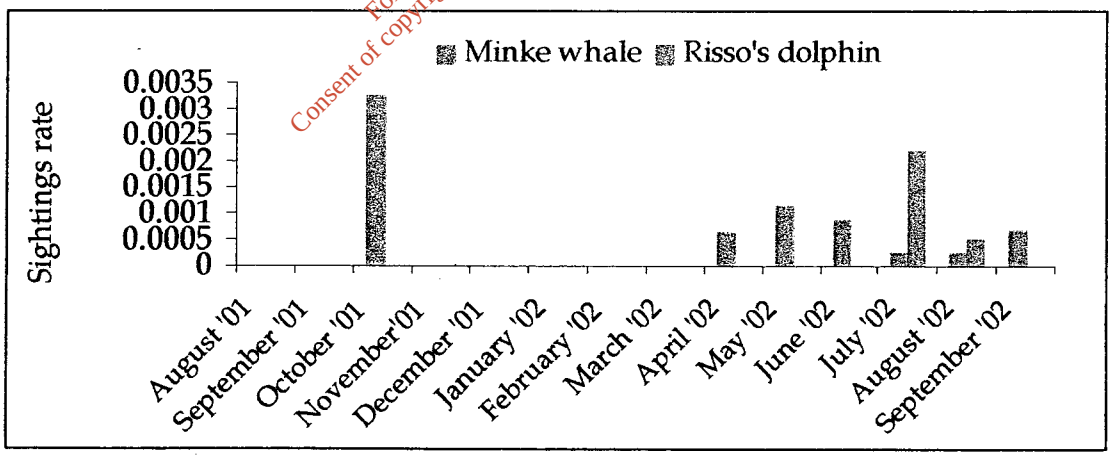


Figure 6. Monthly sighting rates for two additional species recorded relatively frequently during the 2001-02 study - minke whale and Risso's dolphin.

Most commonly recorded by far were groups of bottlenose dolphins and harbour porpoises, which together accounted for 48.9% of all cetacean sightings in the study area. Either one or the other Annex II species was recorded in each month of the year when visual monitoring was possible (Fig. 5) and co-occurrence within the study area was recorded by the research team in the months of November (2001) and July-September (2002). Comparatively high overall sighting rates were also recorded for minke whales and Risso's dolphins (Fig. 6) both species of which were observed singly or in small groups on all occasions (Table 1).



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**BALEEN WHALES (*Mysticeti*)**

One species of baleen whale was recorded by CMRC observers during cliff-based and boat-based monitoring conducted between August 2001 and October 2002:

**Minke whale** *Balaenoptera acutorostrata*

Eleven distinct sightings of minke whales (Plate 3) were recorded during the study. No more than one individual was recorded on any occasion and all were of adult size (Table 1). The species was recorded during a preliminary visual survey by the research team in early August 2001, and subsequently in October 2001 and all months between April and September 2002 (Fig. 6). Sighting rates for minke whales were highest in the months of October 2001 and May 2002, although both months saw comparatively lower monthly visual monitoring effort.

Sightings of minke whales (Fig. 7) were recorded on nine occasions (81 % occurrence) within the waters of Broadhaven Bay SAC and these tended to occur in the central bay and outer parts of the study area. The species was observed more frequently on a rising tide and around high water (60% of sightings). Re-sightings of individual minke whales commonly recurred off Erris Head, in the central bay and between Erris Head and Kid Island. Their behaviour type was determined as foraging on just one occasion and no obvious surface foraging behaviour (e.g. feeding lunges) was recorded in the present study.

Plate 3. An adult minke whale performing a shallow dive. Note the relatively slender body, curved dorsal fin and distinctive white-colouration on the pectoral fin (submerged), all of which assist in field identification of the species.

Minke whales appear to be widely distributed, predominantly in waters less than 800-1,000m deep, throughout the Irish Atlantic Margin from the offshore Rockall Bank to continental slope and shelf waters (Ó Cadhla *et al., in press*). Several studies (Hammond *et al.*, 1995; Northridge *et al.*, 1995; Pollock *et al.*, 1997) indicate that inshore waters of southwestern Ireland and western Scotland may be favoured by the species in late spring and summer with a decline in sightings in late autumn (Northridge *et al.*, 1995). The data obtained in the present study and in a 1993 survey off the Mayo coast (Gordon *et al.*, 1999) support this broad view, although reduced visual survey effort between the months of December 2001 and March 2002 do not allow the evaluation of seasonal trends in occurrence within the study area at this stage.



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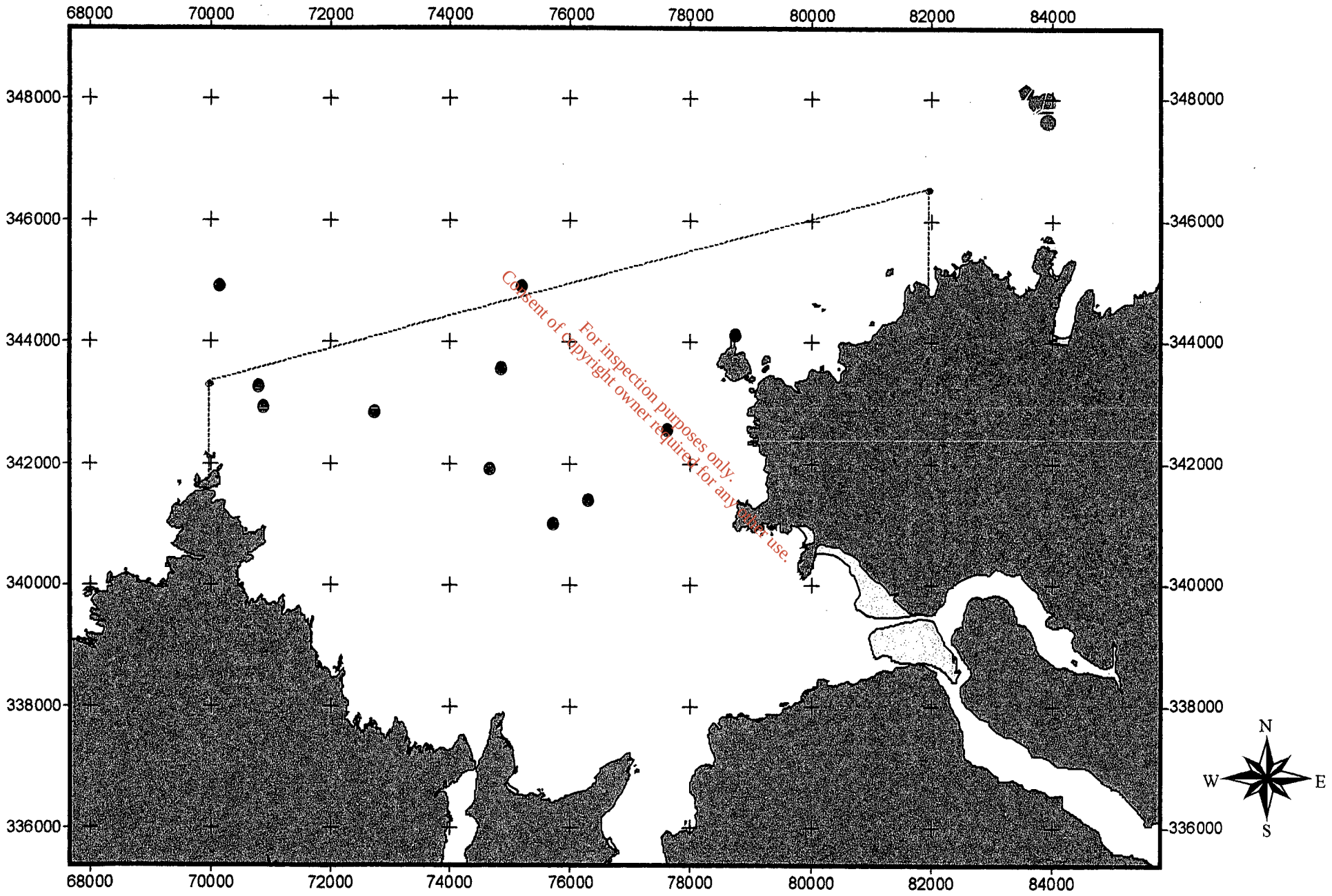


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Figure 7. Distribution map for all distinct sightings of minke whales in the study area between August 2001 and October 2002.

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**TOOTHED WHALES & DOLPHINS (*Odontoceti*)**

Six species of toothed whale/dolphin were positively identified in the study area by CMRC researchers between August 2001 and October 2002:

**Risso's dolphin** *Grampus griseus*

Ten distinct sightings of Risso's dolphins (Plate 4) were recorded during the study. All were records of between one and three adult dolphins (Table 1). Sightings occurred solely in the months of July and August 2002 with a distinct peak in sightings per unit effort recorded in July (Fig. 6). All sightings in July consisted of two animals and average (i.e. mean) group size recorded during the entire study was 1.9 animals (± standard deviation [*s*] = 0.57). Attempts at conducting photo-identification were not successful in 2002 due to difficulties in approaching animals to within photographic range.

Sightings of Risso's dolphins were mostly distributed in the western half of the study area (Fig. 8) with a significant proportion (60%) occurring within a 2km radius of Erris Head. Although foraging behaviour was clearly identified on just one occasion, several cliff-based and boat-based records noted the apparent association between Risso's dolphins and distinctive strong tidal eddies along southern and northern margins of the east ← → west tidal stream. Sixty percent of sightings occurred on ebbing tides.

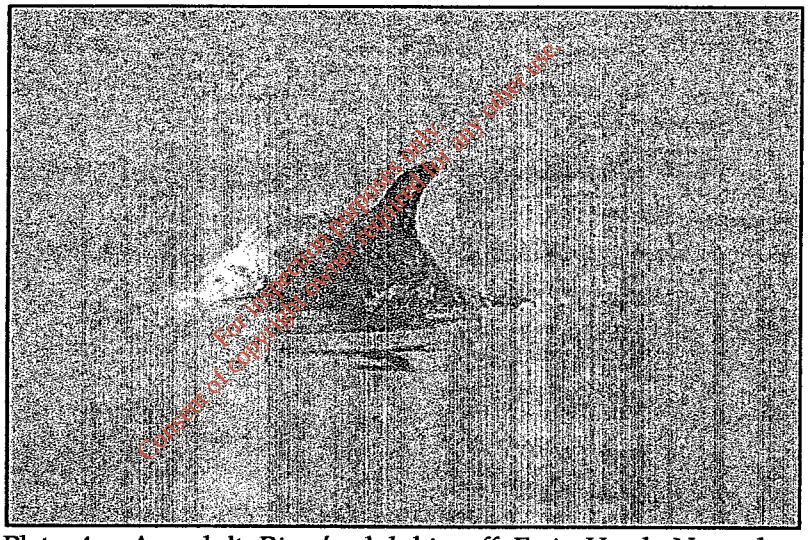

Plate 4. An adult Risso's dolphin off Erris Head. Note the extensive white scarring, which is characteristic of this species and can be used to recognise individual animals.

Risso's dolphins are relatively inconspicuous, vessel-shy species thought to prey exclusively on squid (Leatherwood & Reeves, 1983). They tend to be observed in coastal Atlantic waters and may be comparatively uncommon throughout Irish waters as a whole (Ó Cadhla *et al.*, *in press*). However, sites of concentration for the species are well-documented in the UK (e.g. Outer Hebrides; Pollock *et al.*, 2000) and 'local' groups may show a level of residency within such areas (Atkinson *et al.*, 1997). In Ireland, sightings of groups of Risso's dolphins have previously been documented in Broadhaven Bay (e.g. Lang, 1972; Nairn & Curry, 1979; Berrow *et al.*, 2002) and it may be that records in the present study represent the recurrence of specific groups within the study area. Although Pollock *et al.* (1997) recorded a higher proportion of sightings in waters overlying the continental shelf edge between May and July, the present study and other sightings (e.g. Nairn & Curry, 1979; Hammond *et al.*, 1995; Berrow *et al.*, 2002) indicate the coastal occurrence of Risso's dolphins in summer with clusters of sightings also recorded off eastern, southeastern and southwestern coasts (Hammond *et al.*, 1995; Berrow *et al.*, 2002).



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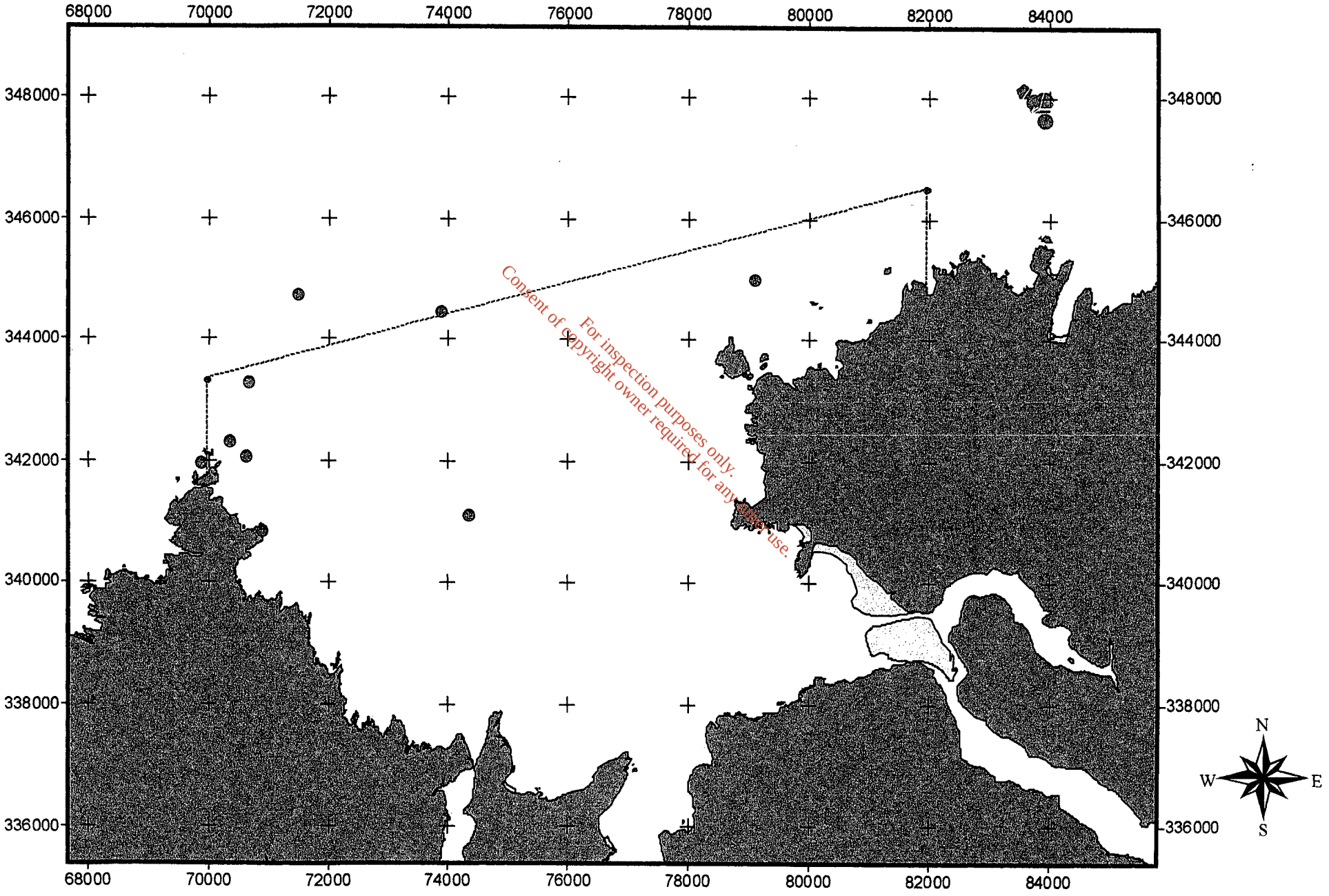


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Figure 8. Distribution map for all distinct sightings of Risso's dolphins in the study area between October 2001 and October 2002.

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**Bottlenose dolphin** *Tursiops truncatus*

Twenty-one distinct sightings of bottlenose dolphins (cover photo) were recorded during cliff-based and boat-based visual monitoring in the study area. This Annex II species thereby contributed approximately 22.8% of all cetacean sightings between August 2001 and October 2002. Two additional records were regarded as potential duplicate sightings and were thus eliminated from further analysis. Sightings of bottlenose dolphins occurred in all seasons and during most months of full visual monitoring but were not recorded in October 2001 or April 2002 (Fig. 5). The rate at which sightings occurred within the study area was relatively stable throughout the summer months with notable peaks occurring in June and September 2002. No relationship between sightings of bottlenose dolphin groups and tidal state was observed during the study.

Due to the relatively high number of sightings of this species within the study area, recorded behaviours are plotted below (Fig. 9) to give a preliminary indication of habitat use. Foraging behaviour (which included surface rushes and frequent changes of direction) was the most frequently observed behaviour during the study. "Milling" behaviour (whereby individuals encircle prey and dive repeatedly around the prey patch) was also recorded on a number of occasions. On one occasion during which foraging behaviour was being recorded, four salmon (*Salmo salar*) were successively tossed into the air by individual dolphins over a 45-minute period. All such events were immediately preceded by surface rushes of one or more dolphins. Such behaviour was only recorded in 2002 within the eastern part of the study area, between Kid Island and the Stags of Broadhaven. Mackerel (*Scomber scombrus*) were also observed being tossed into the air or "breaking" (i.e. attempting to avoid capture) on two occasions in the Gubastuckaun-Erris Head area. Similar fish-tossing events, associated with foraging bottlenose dolphin groups, have often been recorded on the Shannon Estuary (Ingram, 2000).

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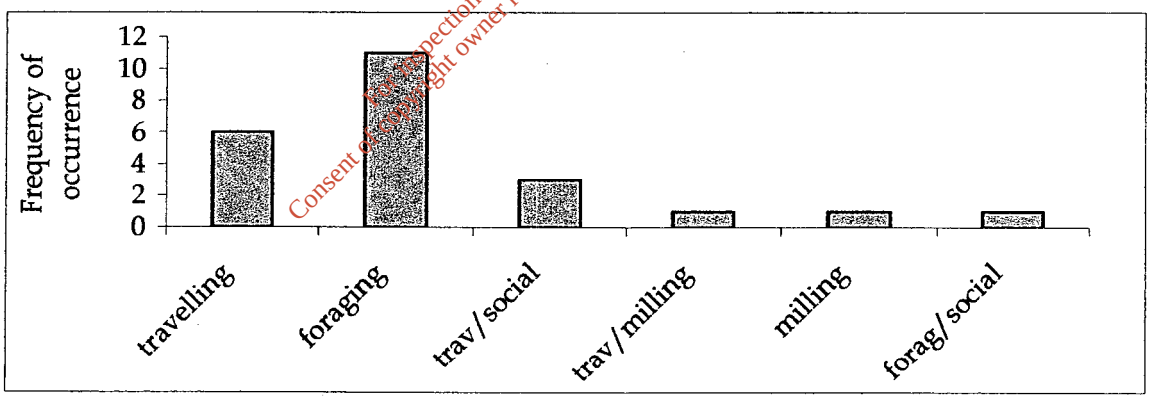


Figure 9. Frequency of occurrence of various behaviours demonstrated by bottlenose dolphin groups in the study area between 2001 and 2002. [trav/ = travelling in combination with other behaviours, e.g. social; forag/ = foraging in combination with other behaviours]

Bottlenose dolphin groups recorded in the present study were composed of adults and juvenile animals (Table 1) and no newborn calves were observed in the study area. Single animals were recorded on two occasions (ca. 9.5% of all sightings) but estimated group size was commonly between 9 and 18 individuals (mean = 10.04 ± *[s]* 5.02). The majority of sightings (85.7%) were distributed throughout the waters of Broadhaven Bay SAC (Fig. 10) and the remaining three sightings occurred within 2km of the SAC's outer limits. Tracked groups occasionally passed outside the study area beyond Erris Head and the Stags of Broadhaven while several reliable reports to the research team during the study period indicated that bottlenose dolphin groups occasionally occurred as close inshore as Ballyglass Harbour and inner Rossport Bay/Glengad in the summer of 2002.



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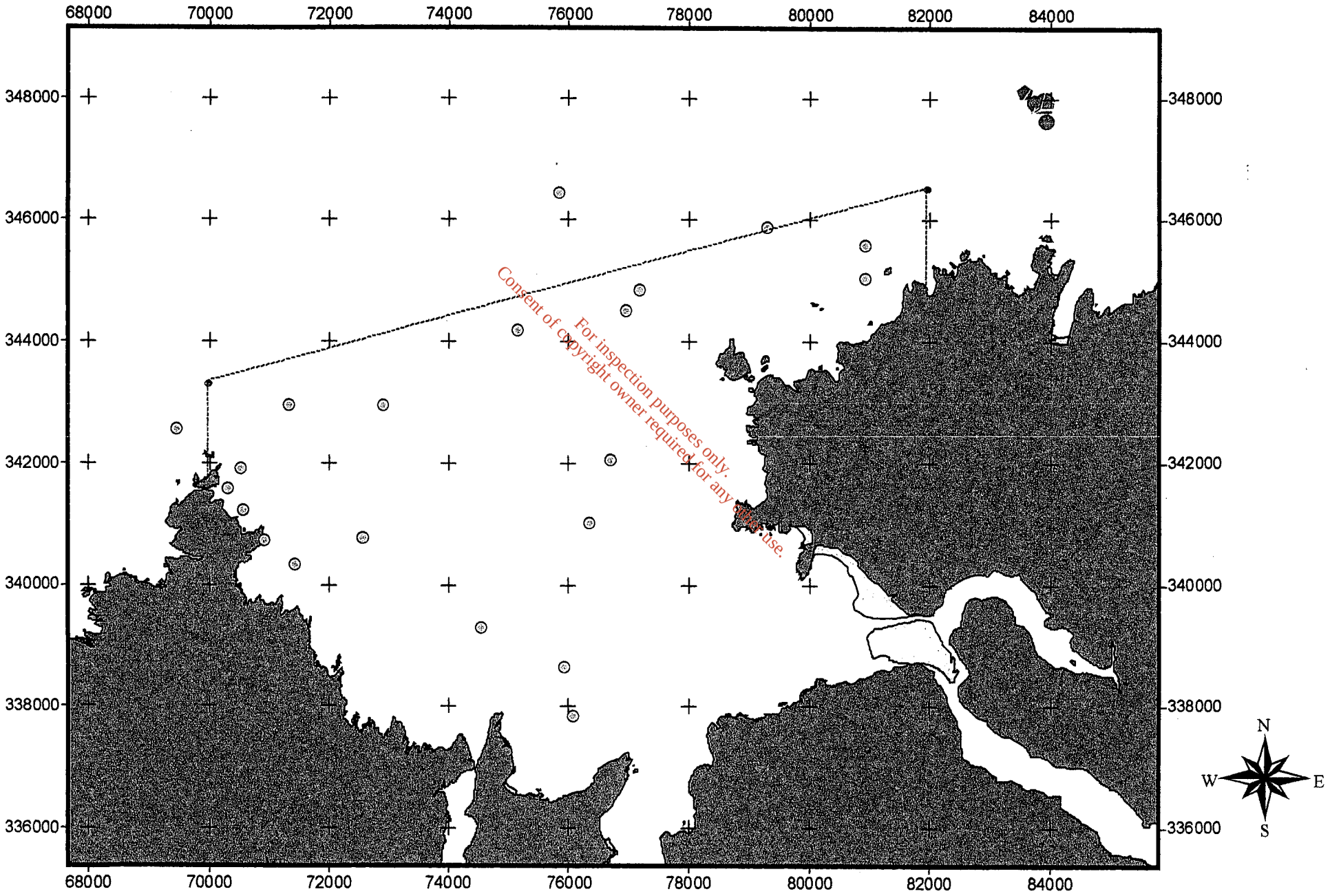


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Figure 10. Distribution map for all distinct sightings of bottlenose dolphins in the study area between October 2001 and October 2002.

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**Atlantic white-sided dolphin** *Lagenorhynchus acutus*

Eight sightings of white-sided dolphins occurred during the study and all were recorded on either 20th or 26th August 2002. Sightings were of distinct groups or 'sub-groups', commonly in tight formation and consisting of between 4 and 25 animals (mean = 11.88 ± 9.66). Animals of all age classes were observed (Table 1). Individual newborn calves were recorded from the survey vessel among three distinct groups and these were notable by their very small size and the presence of distinctive neonatal folds along the sides of their bodies.

Sightings of white-sided dolphins occurred predominantly (i.e. 87.5%) within 2km of the outer limits of Broadhaven Bay SAC (Fig. 11) and all sightings occurred around low water and within the first three hours of the rising tide. One group of five white-sided dolphins was recorded on 20th August in close association with small groups of white-beaked and common dolphins while another group of four animals was recorded within Broadhaven Bay alongside a group of four common dolphins.

Although behaviour of white-sided dolphin groups was commonly described as 'travelling' (i.e. in transit) or 'travel/foraging' (i.e. possible pursuit of prey), one group of ca. 20 white-sided dolphins was observed displaying distinctive foraging behaviour in association with large flocks of diving gannets (*Morus bassanus*), approximately 5km outside the SAC's limits (Fig. 11). It is not known what target species were being hunted but very large numbers of juvenile mackerel (8-12cm long) were present throughout the study area in late August to mid-September 2002 and schools of mackerel could readily be observed at the surface by boat- and cliff-based observers during this time.

The data gathered in the present study are in general agreement with previous (e.g. Pollock *et al.*, 1997; Northridge *et al.*, 1997) and recent data collected along Ireland's Atlantic Margin (Ó Cadhla *et al.*, *in press*), which together suggest that numerous white-sided dolphin groups may occur off western and northwestern Ireland in mid-late summer.

A number of authors (Evans, 1981; Pollock *et al.*, 1997; Gordon *et al.*, 1999; Berrow *et al.*, 2002) suggested that sightings tended to occur in waters overlying the margins of the continental slope. However, the sightings of white-sided dolphins in the present study are not considered unusual in the context of recent research. Offshore surveys conducted since 1999 (Ó Cadhla *et al.*, 2001; Ó Cadhla *et al.*, *in press*) indicated the species' widespread distribution throughout Ireland's western continental shelf in summer and produced an estimated summer population of 5,490 animals of all ages (Coefficient of Variation = 0.43) in an area approximately 120,000km$^2$ in size off western Ireland. This research recorded white-sided dolphin groups through the Porcupine Bank and coastal waters off northwestern Ireland into the deep Rockall Trough. And, in contrast with indications from previous work, comparatively higher sighting rates of this species were associated with continental shelf habitats than with waters overlying the continental slope or deeper basins (Ó Cadhla *et al.*, *in press*).

White-sided dolphins may commonly occur in group sizes in excess of 100 individuals (Leopold & Couperus, 1995; Pollock *et al.*, 2000; Ó Cadhla *et al.*, *in press*), that are often seen in the summer months during what is believed to be the species' calving and breeding season (Berrow & Rogan, 1997; Rogan *et al.*, 1998; Reeves *et al.*, 1999a). It may be that such groups enter inshore waters, particularly where concentrations of prey exist or where the continental shelf edge lies relatively close to the coast, as is the case in northwest Mayo.

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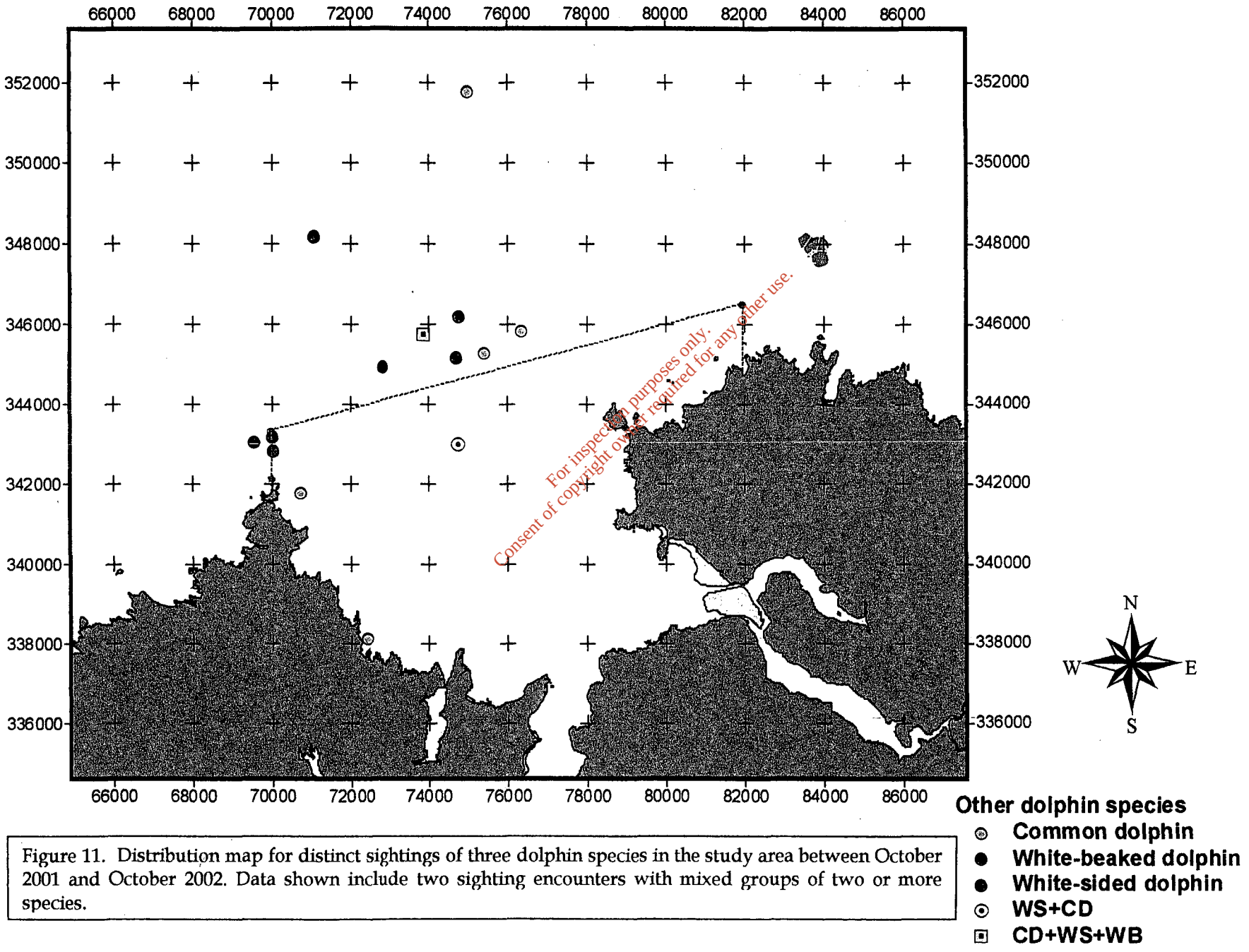


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Figure 11. Distribution map for distinct sightings of three dolphin species in the study area between October 2001 and October 2002. Data shown include two sighting encounters with mixed groups of two or more species.

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**White-beaked dolphin** *Lagenorhynchus albirostris*

Two distinct sightings of white-beaked dolphin groups were recorded in the study area in 2002 (Fig. 11). These occurred on the 18th July and 20th August. One potential duplicate sighting of three individuals was eliminated from further analysis. White-beaked dolphin groups recorded during the study were composed of three or four adult animals that readily approached the survey vessel (Plate 5) in order to travel in its bow-wave (a practice known as bow-riding). One group of four animals was recorded on 20th August <2km outside the SAC's outer limits, travelling westwards in association with small groups of white-sided and common dolphins. The remaining sighting occurred off Erris Head within Broadhaven Bay SAC (Fig. 11).

Plate 5. An adult white-beaked dolphin approaching to bow-ride.

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According to the literature, white-beaked dolphins appear to be comparatively less common in Irish waters than several other dolphin species and Northridge *et al.* (1995, 1997) determined that the species is more commonly found in the continental shelf waters of northwestern, northern and eastern Britain. Recent research throughout Ireland's Atlantic Margin (Ó Cadhla *et al., in press*), previous indications from vessel- or land-based sightings (Pollock *et al.*, 1997; Berrow *et al.*, 2002) and stranding records (Berrow & Rogan, 1997) off the west of Ireland indicate that the species is predominantly distributed in offshore waters overlying the continental shelf and slope. Nevertheless groups of this species may also be observed in coastal areas during the summer months (Berrow *et al.*, 2002), as in the present study. White-beaked dolphins are thought to feed predominantly on fish, such as members of the cod family *Gadidae* and herring family *Clupeidae* (Reeves *et al.*, 1999b) but little is known of their diet in Irish waters.

**Short-beaked common dolphin** *Delphinus delphis*

Seven distinct sightings of common dolphins were recorded during the study, beginning on 13th November 2001 (approx. 15 dolphins), 7th April 2002 (3 adults) with the remaining five records occurring on 20th August (3 sightings) and 26th August 2002 (2 sightings). Group composition recorded during 2001-02 was similar to that observed among white-sided dolphin groups with large groups or smaller 'sub-groups' seen in tight formation (Plate 6). Common dolphin group size was more variable, however, consisting of between two and 49 animals (mean = 16.42 ± 19.56). Smaller common dolphin groups of three and four animals were recorded in association with both white-sided and white-beaked dolphins (Fig. 11) on 20th August 2002. Animals of all age classes were observed during the study period (Table 1). At least two newborn calves, notable by their very small size and remnant neonatal folds along the sides of their bodies, were recorded during a sighting of approximately 39 common dolphins on 26th August 2002. This



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sighting occurred ca. 8km outside the waters of Broadhaven Bay SAC, while the remaining sightings were either recorded within the SAC or within 1.5km from its outer limits (Fig. 11). Individual records were distributed across many tidal states and thus no suggested pattern was displayed by the data gathered in 2001-02.

Behaviours indicative of foraging activity were recorded within the study area on four out of seven (approx. 57%) sighting occasions in 2001-02. On one particular occasion on 26th August 2002, an estimated 49 adult and juvenile common dolphins raced into the central reaches of Broadhaven Bay and began milling intensively in tight circles within a small inlet close to the western side of the bay (Fig. 11). The dolphins occasionally broke into fast surface-rush activity (Plate 6), forming two sub-groups after a period of 25-35 minutes' foraging. These subsequently appeared to forage in separate areas (approx. 100-150m apart) for a further period of 10-12 minutes, before sub-groups split further apart, one returning seaward at high speed, the other moving slowly towards the inner bay off Ballyglass lighthouse. Similar foraging activity was also noted during the sighting of an estimated 39 animals (including newborn calves) on the same day further offshore. On this occasion, several hundred gannets and several other seabird species including Great skua (*Stercorarius maximus*), Manx shearwater (*Puffinus puffinus*), Sooty shearwater (*Puffinus griseus*) and European storm-petrel (*Hydrobates pelagicus*) were present overhead or diving/dipping in the immediate area in which dolphins were foraging.

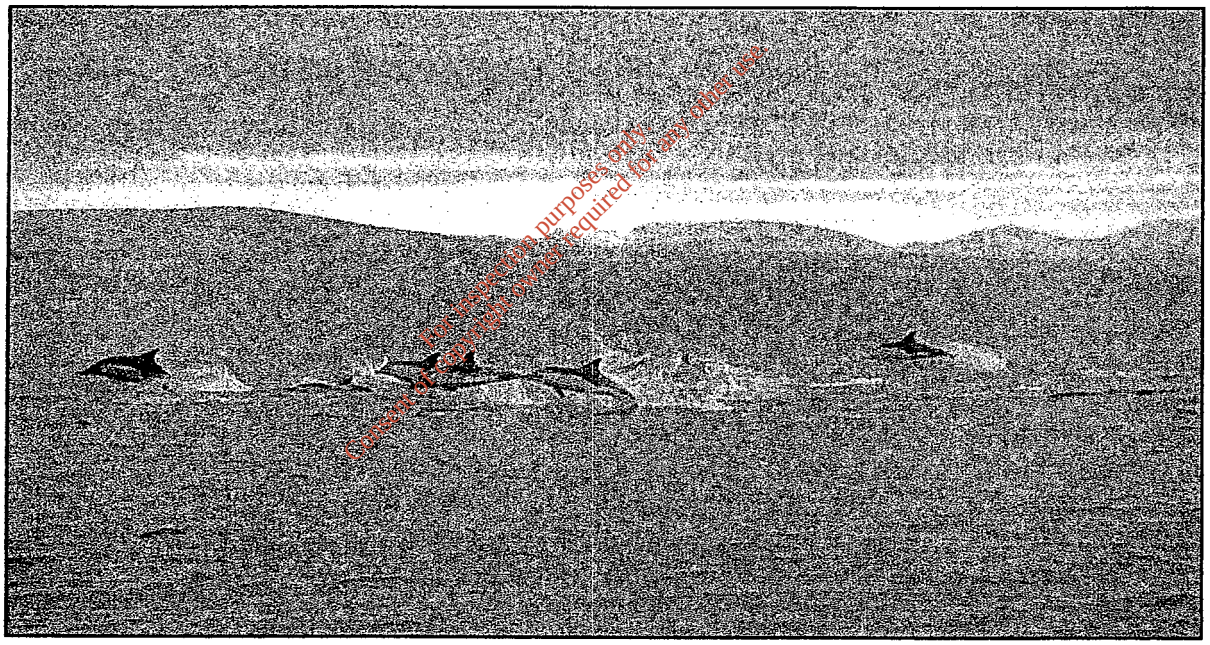

Plate 6. Part of a large group of 49 adult and juvenile common dolphins that was observed foraging intensively within the inner part of Broadhaven Bay on the evening of 26th August 2002.

Common dolphins are frequently recorded in Irish waters via land- or boat-based sightings (e.g. Berrow *et al.*, 2002; Ó Cadhla *et al.*, *in press*) and strandings (Berrow & Rogan, 1997). Dedicated cetacean surveys have recorded this species with relatively high frequency (e.g. Evans, 1981; Evans, 1990; Pollock *et al.*, 1997; Gordon *et al.*, 1999; Ó Cadhla *et al.*, 2001), suggesting that it may be Ireland's most numerous species year-round. Summer abundance estimates have been derived (a) for the Celtic Sea from 1994 SCANS survey data (75,450 animals, Coefficient of Variation [CV] = 0.67; Hammond *et al.*, 2002), and (b) for an area approx. 120,000 km$^2$ in size off western Ireland, from data collected during the 2000 SIAR survey (4,496 animals, CV = 0.39; Ó Cadhla *et al.*, 2001).



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Although the data obtained in the present study suggest that groups of common dolphins may occur in the study area year-round, the cluster of sightings in the month of August, co-incident with a similar cluster in white-sided dolphin sightings, is notable. Numerous groups of both species were recorded off the northwest Mayo coast during the SIAR survey (Ó Cadhla *et al.*, 2001) while common dolphin groups in excess of 50 animals, containing newborn calves, were recorded between the months of July and September off western Ireland in studies conducted between 1999 and 2001 (Ó Cadhla *et al.*, *in press*). Thus there are indications that the numbers of both species off western Ireland may increase through the summer months, co-incident with the breeding/calving period and, set against this background, the records of common dolphins in the present study are not unusual.

**Harbour porpoise** *Phocoena phocoena*

Ireland's smallest cetacean species, the harbour porpoise, was the most common cetacean observed during the study (26.1% of total) and 24 distinct sightings were recorded between August 2001 and October 2002. One further sighting consisting of a potential duplicate record was eliminated from further analysis. This inconspicuous Annex II species was recorded predominantly through cliff-based monitoring although five records were obtained through boat-based visual surveys (Table 1).

Harbour porpoise sightings occurred in all seasons although no records were obtained in the study area in the months of March, May or June 2002 (Fig. 5). All three months also saw relatively lower visual survey effort due to weather constraints. The rate at which harbour porpoise sightings occurred within the study area displayed noteworthy peaks in October-November 2001 and July-August 2002. All but one sighting of the species was obtained during the period of high tide or in ebbing tidal states up to and including the period of low water.

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Group sizes of up to four animals were recorded but estimated group size was more commonly between one and three individuals (mean = 1.92 ± 0.93). The vast majority of harbour porpoises recorded in the present study were adults, although juvenile animals were also recorded within groups of three or four individuals during the summer of 2002 (Table 1). No newborn calves were observed in the study area in late 2001 or 2002 but, due to the relatively small size and inconspicuous behaviour of this species, the occurrence of calves in the study area during the study period cannot be discounted at this stage.

All but one sighting of harbour porpoises (95.8%) were distributed throughout the waters of Broadhaven Bay SAC (Fig. 12) in spite of considerable visual monitoring effort beyond the SAC's outer limits. A single sighting of this species was also recorded in the north-eastern margin of the study area off the entrance to Portacloy Harbour. Areas of concentration for harbour porpoises, based on visual sighting data, appeared to occur (a) along the outer margins of Rossport Bay/inner Broadhaven Bay between Doonanierin and Brandy Point, and (b) in outer SAC waters within 3-4km east of Erris Head (Fig. 12). Distinctive milling behaviour of harbour porpoises was noted within the waters of Broadhaven Bay during sightings in the months of October 2001, April and August 2002.

In spite of numerous sighting records in the present study, the relative abundance of this inconspicuous Annex II species may have been underestimated. This was due to continued use of cliff-based and boat-based visual survey methods in the present study in sea states up to and including Beaufort 3-4, in spite of the known difficulty with which harbour porpoises may be detected in conditions greater than Beaufort 2 (Hammond *et al.*, 1995). Yet the importance of the waters of Broadhaven Bay SAC for this species was highlighted through visual monitoring of the area and underlined the necessity for implementing acoustic survey methods (*see* 2.2).



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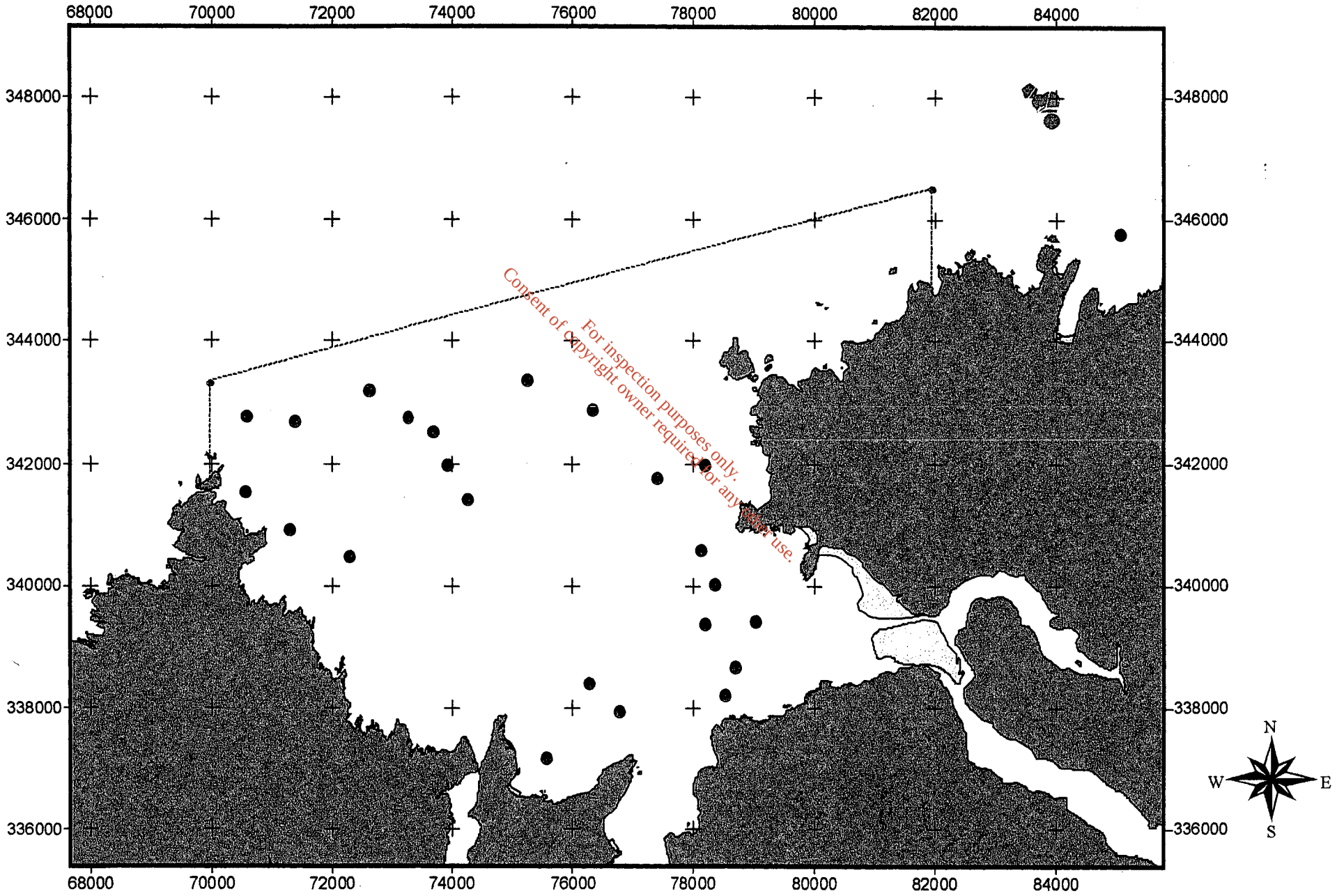


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Figure 12. Distribution map for all distinct sightings of harbour porpoises in the study area between August 2001 and October 2002.

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## B. *Seals & Otters*

Both grey and harbour seals were recorded with relatively high frequency in the study area. Seals were sighted on 56.1% of all days during which visual monitoring could be conducted using either cliff-based or boat-based methods.

Total numbers of sightings were interpreted with care, due to reduced abilities in tracking individual seals at sea (as a result of seal diving behaviour) compared with tracking cetaceans. This may lead to (i) under-recording of potential duplicate sightings as they occur in the field and (ii) analytical difficulties in discriminating between non-duplicate and potential duplicate sightings. However, every effort was made to eliminate all potential duplicates and rely only on distinct records. The analysis resulted in a total of 129 seal sightings recorded by CMRC observers during the study, the majority of which (86.8%) were sighted from cliff-based monitoring sites (Table 2). Seventeen seal sightings were also obtained during boat-based surveys conducted between the months of May and October 2002.

TABLE 2. Records of seals and otters sighted during visual monitoring, both cliff- and boat-based, within the study area between August 2001 and October 2002.

| Species | No. of records | | Total number of animals | Group size |
|---|---|---|---|---|
| | Cliff-based | Boat-based | | |
| Grey seal | 75 | 14 | 99 | 1-7 |
| Harbour seal | 35 | 3 | 85 | 1-11 |
| *Unidentified seal* | 2 | 0 | 2 | 1 |
| European Otter | 2 | 0 | 2 | 1 |

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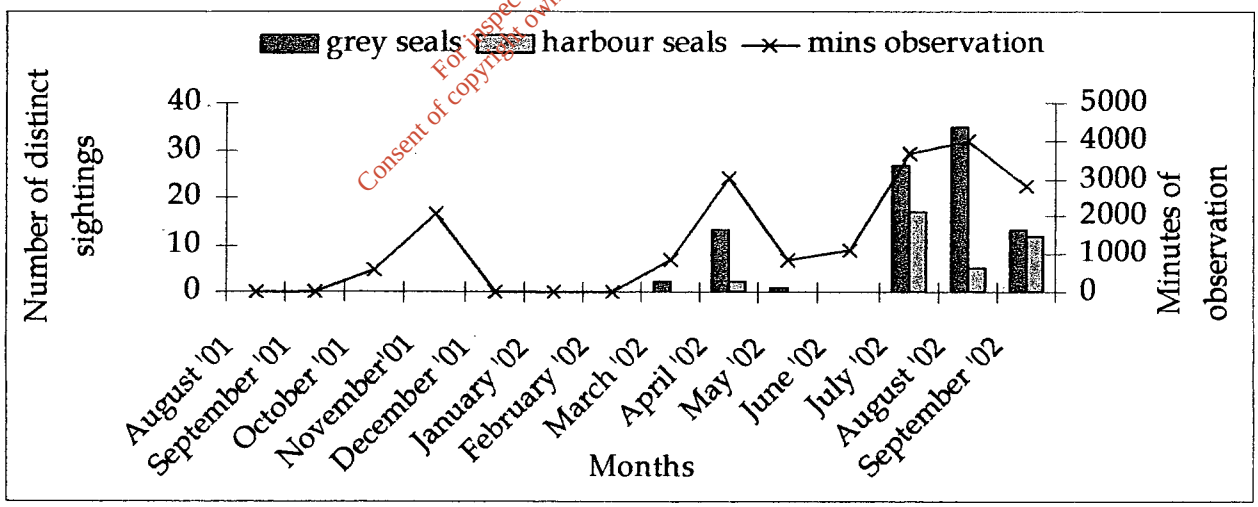


Figure 13. Sightings of either species of seal per month of the study, plotted against visual survey effort (minutes).

Seal sightings occurred predominantly within Broadhaven Bay, both in the water and at terrestrial haul-out sites (*see* Figs. 14,15). Two sightings could not be identified to species level due to distance, glare or angle-of-view relative to the observer(s). All seals recorded in the water were single individuals though aggregations of up to 11 animals were seen together at haul-out sites within the SAC (Table 2). No seals were recorded in late 2001 or in June 2002 in spite of visual monitoring. The number of sighting records for both species was highest during the months of July-August 2002 (Fig. 13) with a secondary peak in grey seal sightings recorded in



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April 2002. While peak sighting numbers tended to coincide with higher monitoring effort, they may be partially explained by the annual cycles of both species, which see increases in time hauled out ashore associated with annual pupping, mating and moulting phases.

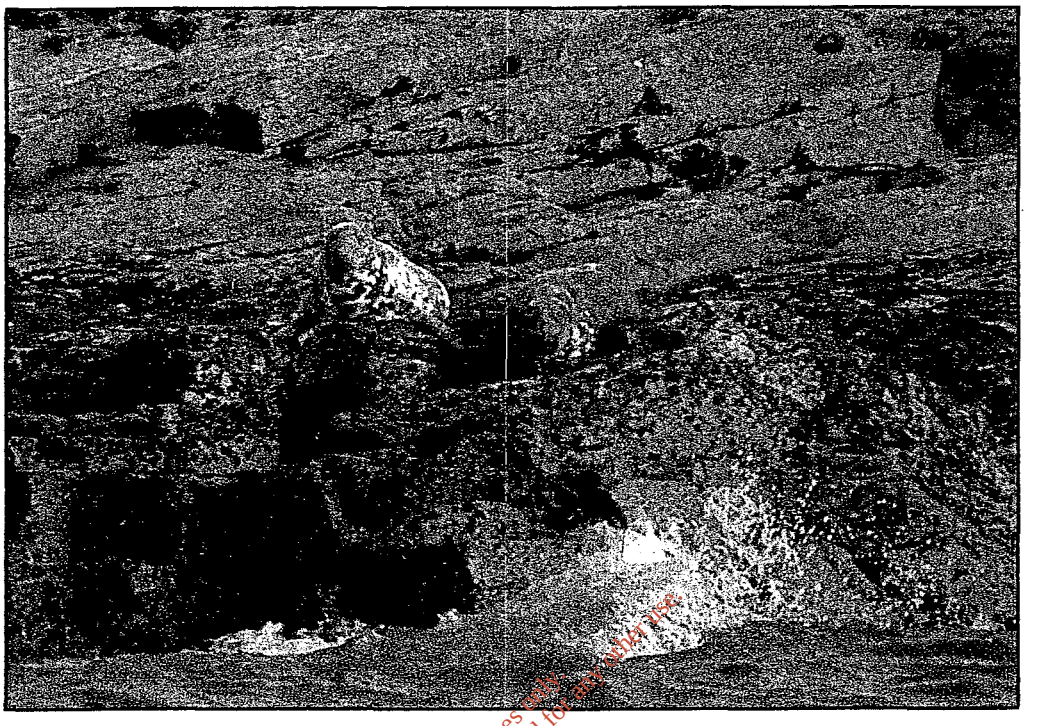

Plate 7. Adult female (left) and male (right) grey seal ashore at an inter-tidal summer haul-out site in northwest Mayo.

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**Grey seal** *Halichoerus grypus*

A total of 89 distinct sightings of grey seals were recorded during the study, 84.3% (i.e. 75) of which were detected via cliff-based monitoring (Table 2). All but four sightings were of single adult or sub-adult individuals (mean group size = 1.11 ± 0.68), although haul-out groups of between one and seven animals were recorded on six occasions in August-September 2002 on small, prominent skerries in the vicinity of Erris Head and Glenlara on the western side of Broadhaven Bay (Fig. 14). Sightings of grey seals in the water occurred during all tidal states and were predominantly distributed (i.e. 95.5% or 85 sightings) within the waters of Broadhaven Bay SAC in spite of considerable cliff-based and boat-based coverage through the entire study area.

In spite of visual monitoring effort in other months of the year, sightings of grey seals were largely recorded (approx. 96.6%) during the months of April and July-September 2002 (Fig. 13). While this pattern in grey seal sightings within the study area occurred simultaneous to increases in achieved visual effort, it was also broadly coincident with the main annual foraging period, that is believed to take place once animals have undergone the winter-spring moult (Bonner, 1990) and which phase appears to be complete in Co. Mayo by late March or early April (Kiely, 1998). No sightings were obtained in the months of October or November 2001, which coincide with the known peak breeding season in Co. Mayo (Kiely & Myers, 1998). Thus, although research was conducted over just one year, the data indicate that use of habitats within the study area by grey seals may be linked to discrete phases in the species' annual cycle and individual foraging requirements.

Some level of grey seal preference may have been detected during the study for waters within the western half of the SAC, which saw higher numbers of sightings as a whole (Fig. 14). Though grey seal sightings were also recorded in eastern and inner parts of Broadhaven Bay with small clusters occurring off Doonamierin and Rinroe, most grey seal sightings were recorded during the months of April and July-September 2002 (Fig. 13), during which periods both sides of the bay normally saw simultaneous observer coverage. Therefore the observed sighting distribution cannot be explained by variation in observer effort and the potential preference for habitats on the western side of the bay is certainly noteworthy at this stage.

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Dietary studies indicate that grey seals forage predominantly in the "demersal" zone (i.e. on or close to the seabed – e.g. Hammond *et al.*, 1994; Kiely *et al.*, 2000) and it is difficult to determine habitat use without conducting detailed telemetry studies. Consequently, most recorded behaviours could only be described by the research team as 'resting' or 'diving'. However, a few feeding events were observed (n = 3), where individual grey seals were observed eating fish prey at the surface. All such sightings occurred in the vicinity of the Gubastuckaun site.

Data on grey seal populations around the west coast of Ireland are relatively sparse, though recent research efforts have sought to establish the current status at several regional colonies (Ó Cadhla & Mackey, 2002). Detailed studies conducted at the Inishkea island group off northwest Mayo (Kiely, 1998), which is situated approximately 15-20km from the present study area, indicate that these islands may represent the most important breeding and haul-out area for grey seals in the west of Ireland with a population size of at least 539-693 animals (Kiely & Myers, 1998) and peak moult haul-out sizes in excess of 1,500-2,000 seals (Kiely, 1998). Due to their importance, terrestrial habitats on the Inishkea islands now constitute a candidate SAC for this species. However, very little is known of the aquatic habitats which are important to this species and, in this context, the frequent sightings of grey seals in Broadhaven Bay during the present study are interesting.



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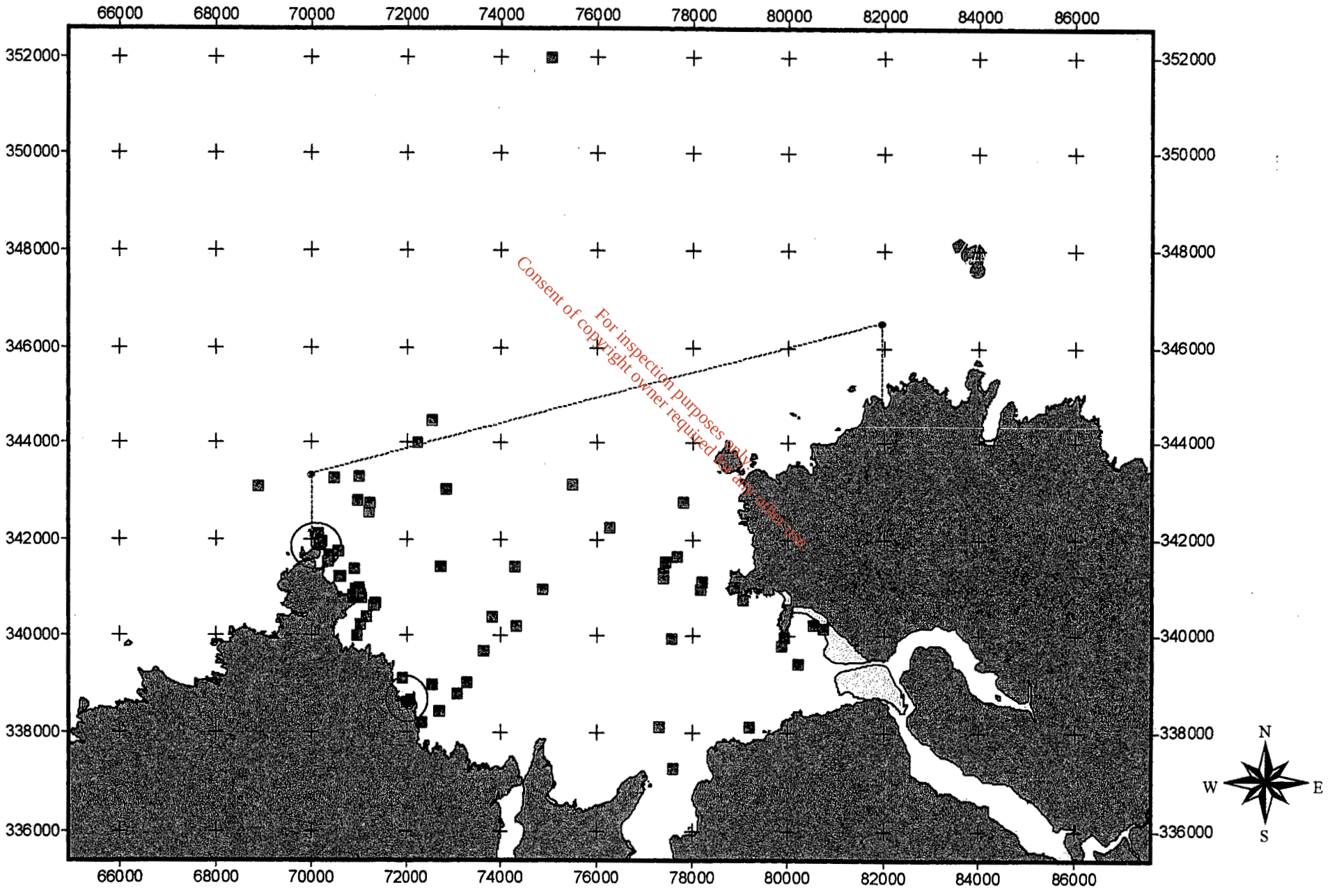


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Figure 14. Distribution map for all distinct sightings of grey seals in the study area between October 2001 and October 2002. Haul-out sites are circled in blue.

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**Harbour seal** *Phoca vitulina vitulina (a.k.a.* Common seal*)*
A total of 38 distinct harbour seal sightings were recorded during the study (Table 2), nine of which (approx. 23.7%) were records of animals hauled out within the eastern part of Rossport Bay (Fig. 15), and two of which were records of one and four individuals hauled out in the vicinity of Glenlara. All haul-outs of harbour seals within the study area were recorded between mid-July and the end of September 2002. Haul-out sizes recorded in Rossport Bay ranged between two and 11 animals (mean group size = 5.89 ± 3.10).

Haul-out groups were also observed by the research team on the small island of Inishderry that lies within SAC waters in the southern channel between Ballyglass Harbour and Belmullet. Although this island lay outside the principal study area, low-tide counts of harbour seal haul-outs on this island were conducted opportunistically from the mainland between May and October 2002. These generally consisted of 12-18 seals and newborn pups were observed at this site in the month of June 2002, which is during the peak breeding period for this species (Bonner, 1972, 1990). Due to the relatively short time-scale of the present study, the possibility that mother-pup pairs also utilise known sandbank areas of inner Rossport Bay during the breeding season cannot be ruled out at this stage.

The majority of sightings of harbour seals in the water (approx. 96.2%) were distributed throughout Broadhaven Bay SAC with just one sighting of this species occurring outside the SAC limits (Fig. 15). Similar to the observed distribution of grey seal sightings, records of harbour seals were non-existent in northern and north-eastern parts of the study area, in spite of considerable visual monitoring effort. In contrast, a distinct cluster of harbour seal sightings was recorded during the study off Rinroe Point within the northern part of Rossport Bay.

In spite of visual monitoring effort in other months of the study, sightings of harbour seals in the study area were largely recorded (approx. 92.1%) during the months of July-September 2002 (Fig. 13). While this pattern in sightings within the study area occurred simultaneous to a seasonal increase in visual effort, it also coincided with the annual moult period (Bonner, 1990). It is interesting that, in spite of considerable visual monitoring effort, few if any harbour seal sightings were recorded in the months of October or November 2001, March-April 2002, or coincident with the known breeding season in May-June 2002. Thus, similar to the grey seal data obtained during the study, there are indications that harbour seal use of habitats within Broadhaven Bay SAC may be linked to discrete phases in the species' annual cycle (e.g. breeding/moult) and individual or collective habitat requirements during these phases.

Information on harbour seals in Ireland is sparse and the most recent population assessments date back to 1978-1984 (Summers *et al.*, 1980; Warner, 1983, 1984). No recent published data are available for harbour seal populations in northwest Mayo and the nearest other known areas of importance for the species occur in Killala Bay and Clew Bay (DÚCHAS, *unpublished data*). Local haul-outs have also been observed, however, in Blacksod Bay and individuals are also occasionally recorded among grey seal haul-out aggregations among islands in the Inishkea group. In the context of haul-out groups observed within the study area and breeding haul-outs observed on Inishderry, the numerous sightings of harbour seals in the waters of Broadhaven Bay during the present study are of particular interest since harbour seals are thought to forage relatively close to local haul-out sites (i.e. within 50km; Thompson, 1993; Thompson *et al.*, 1991).

In spite of an European outbreak of Phocine Distemper Virus (PDV) during mid-2002, confirmed pathology and significant local increases in harbour seal deaths along Ireland's west coast, no signs of the disease or mortalities were recorded among harbour seals in the study area up to 1st October 2002, nor among the few harbour seals encountered among the Inishkea island group in October-December 2002.

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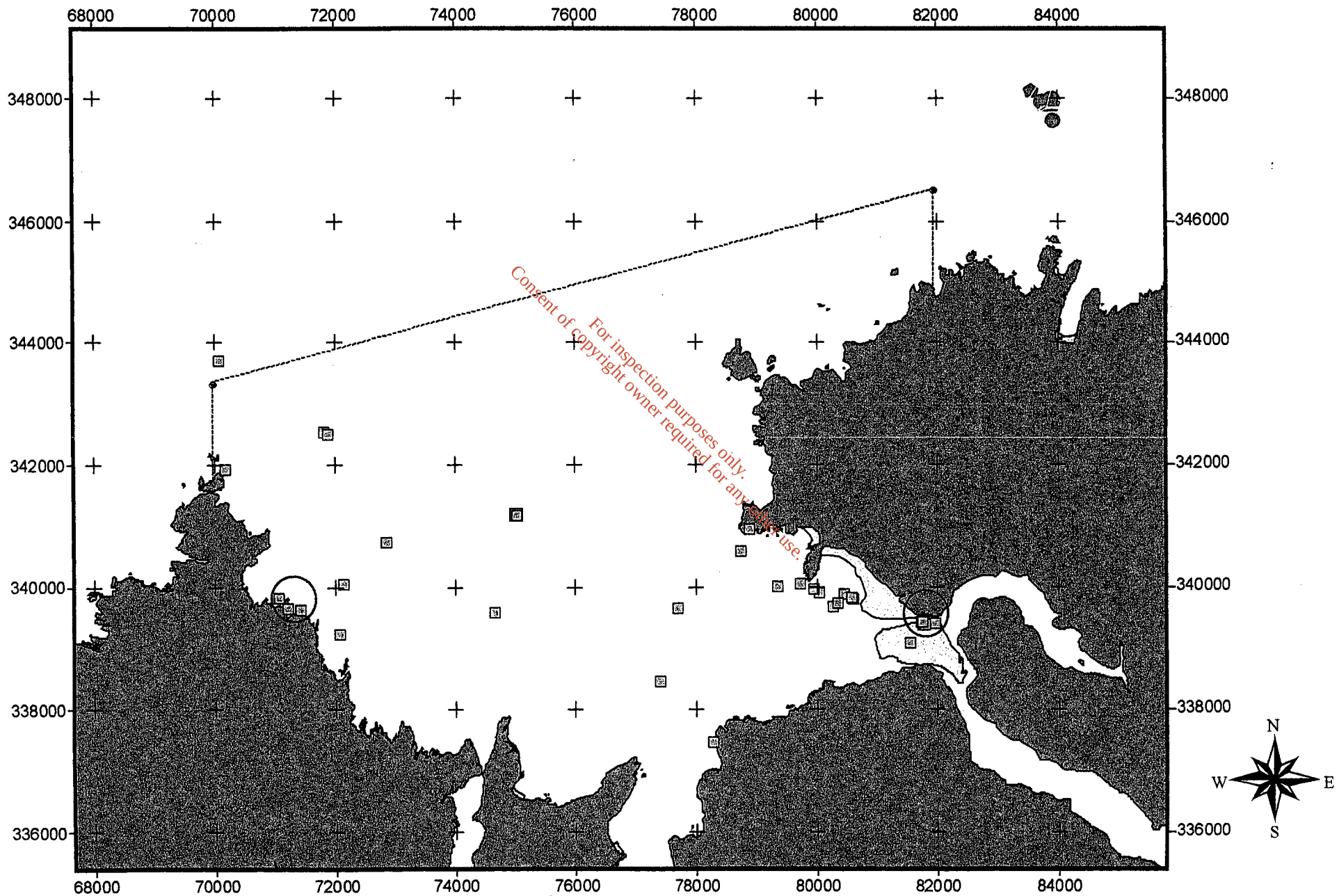


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Figure 15. Distribution map for all distinct sightings of harbour seals between October 2001 and October 2002. Haul-out (i.e. shore) sites are circled in red.

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**European otter** *Lutra lutra*

Two individual adult European otters were recorded on separate occasions within the waters of Broadhaven Bay SAC. One was recorded foraging close to the coastline below the Gubastuckaun site (Fig. 16) on 16th November 2001, while a second otter was observed in the intertidal zone below Glengad in Rossport Bay/inner Broadhaven Bay on 15th July 2002.

While the CORRIB EIS (2001) acknowledged the likely presence of otters in the vicinity of Sruwaddacon estuary, which lies inland from Broadhaven Bay to the south/southeast of Rossport village (Fig. 2), the data collected in the present study confirm information from local residents that the species also occurs within Broadhaven Bay.

The island of Ireland is believed to represent an internationally important area for otter populations. It appears that northwestern counties may constitute a stronghold for coastal and freshwater otters and a national survey in 1980-81 found a very high incidence of otter signs throughout the Mayo region (Chapman & Chapman, 1982), although survey effort was predominantly focused on riverine habitats. In spite of the designation of candidate SACs for otters within Blacksod Bay and along the north Mayo coast (Dwyer, 2000), the current population status of otters in coastal Co. Mayo is poorly understood. Otters are believed to be sensitive to human disturbance and changes in territorial 'sprainting' behaviour associated with increasing human disturbance in summer months have been described in previous studies (e.g. MacDonald *et al.*, 1978; Chapman & Chapman, 1982). Consequently, it has been suggested that otters may represent an important indicator of environmental quality (Lunnon & Reynolds, 1991).

Studies by Kingston *et al.* (1999) on Inishmore, Aran Islands, indicated that otters preferred to feed on slow-moving prey and more frequently in areas where the substrate was hard. Considering the data gathered in the present study and the variety and relatively undisturbed nature of coastal habitats around Broadhaven Bay, it is considered likely that otters occur throughout the study area in locations offering ready access for the animals to undisturbed shorelines and freshwaters inputs. The relatively few sightings of the species in the present study may be explained (i) by the research team's primary focus on inshore waters within the study area and not on the shoreline or intertidal zone (ii) by reduced sprainting in summer time (Chapman & Chapman, 1982; Fairley, J.S., *pers. comm.*) and (iii) by the small size and diurnal/seasonal behaviour of otters which may focus activity at night or during periods of least human disturbance (Fairley, J.S., *pers. comm.*).

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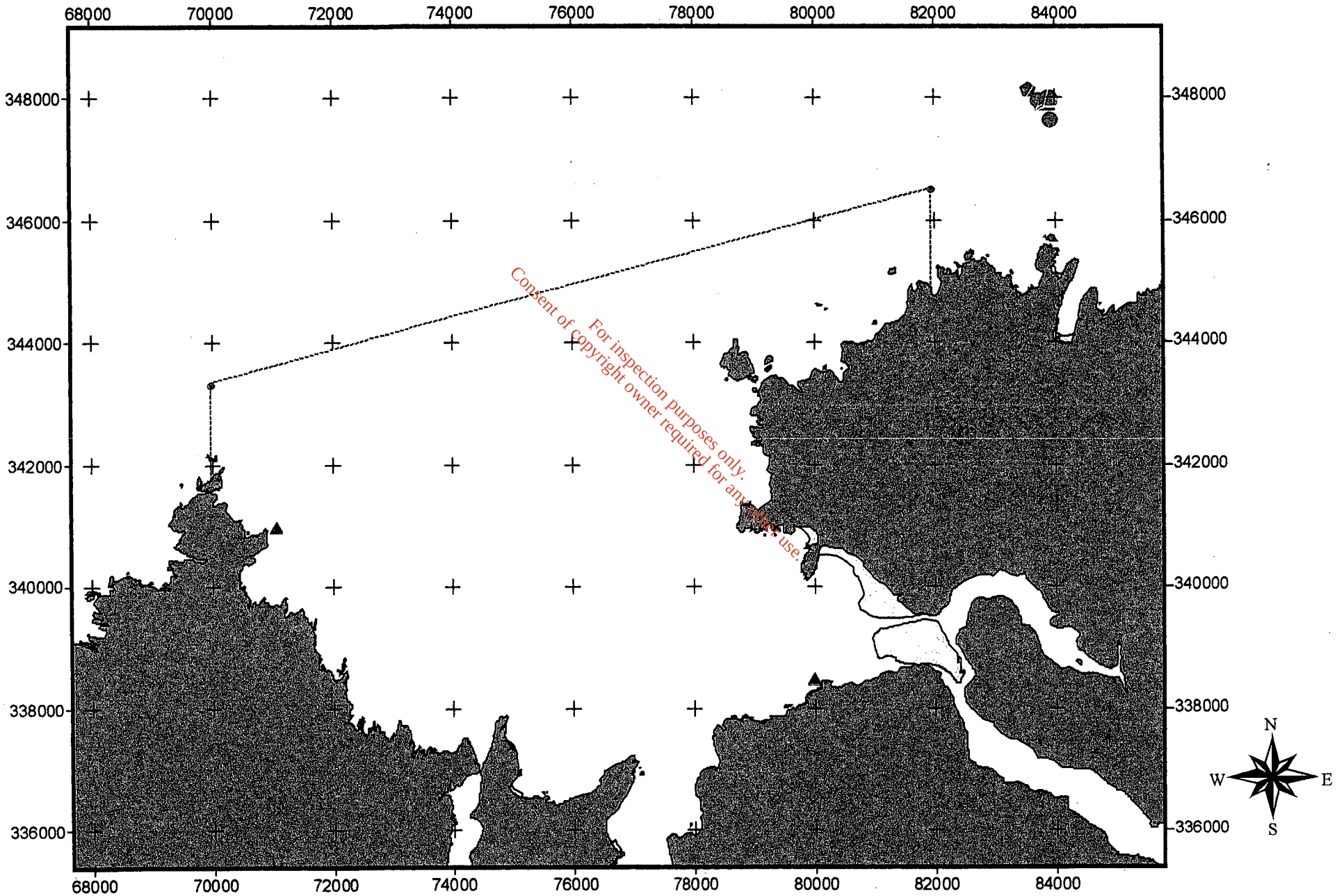


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Figure 16. Distribution map for two sightings of individual otters in the study area on 16 November 2001 and 15 July 2002.

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## C. ***Unidentified marine mammals***

A total of 11 distinct visual observations of marine mammals (4.93% of all sightings) during the study could not be identified to species level due to a variety of factors (e.g. weather conditions, distance from the observer, indistinct cues, glare, etc). With the exception of two sighting records of unidentifiable seals (Table 2), most of these records were of small toothed cetaceans given the category of "Unidentified dolphin" (Table 1). This grouping includes possible sightings of harbour porpoises that were insufficiently clear to allow for positive identification.

### Unidentified dolphins

Nine sightings of unidentifiable small cetaceans were obtained during the course of the study. The majority of these were of groups of animals seen in unsuitable weather conditions or at large distances from the cliff-based observers. The average (i.e. mean) recorded group size for this category was 4.11 animals (± 2.71) and ranged from one to ten cetaceans. Sightings were distributed through the study area, both within and outside the waters of Broadhaven Bay SAC (Fig. 17).

### Unidentified seals

Two unidentified seals were recorded during the course of the study. Both sightings were of individual animals that were observed very briefly, ruling out any chance of discriminating between either species. A position was not obtained for one of these animals. The remaining seal was observed in the relatively shallow waters of inner Rossport Bay in the vicinity of Rinroe Pt. (Fig. 17).

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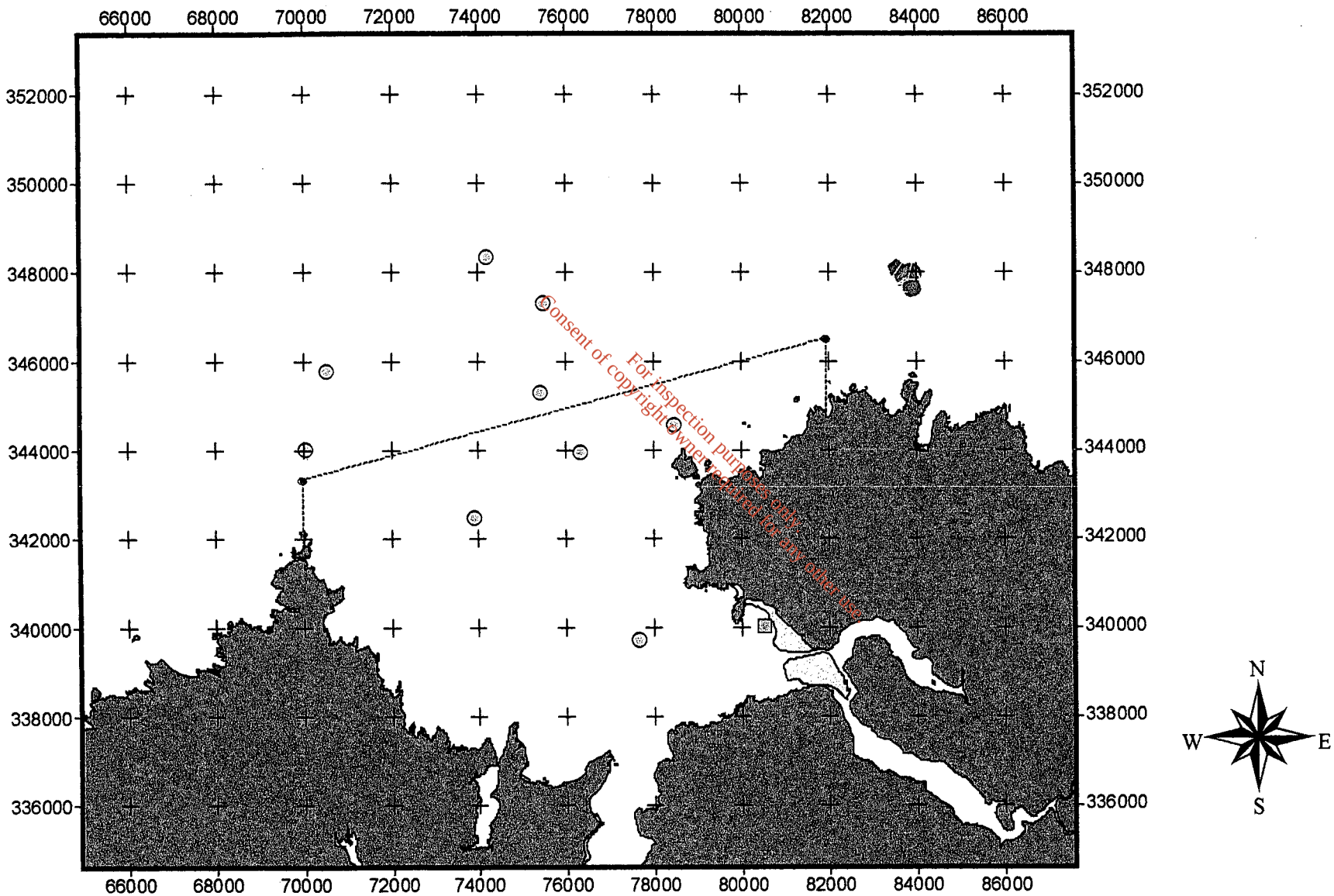


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Figure 17. Distribution map for distinct sightings of unidentifiable marine mammals in the study area between October 2001 and October 2002.

**Unidentified marine mammals**

- **Unidentified dolphin or porpoise**
- **Unidentified seal**

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## D. *Other species of interest*

During the course of the project, several other marine species of interest were recorded within the study area. These included all seabird species in addition to opportunistic sightings of basking sharks, sunfish, etc. These ancillary records were obtained via cliff- and boat-based monitoring in the study area (Table 3). Seabird data, however, could not be included in the present report due to the large dataset generated on boat-based surveys (>2,500 sighting records) and insufficient time available for analysis. Data for other species are presented below:

TABLE 3. Summary of ancillary records of marine species of interest recorded during the study in 2001-02.

| Species | Number of Records Cliff-based | Boat-based | Total |
|---|---|---|---|
| Basking sharks | 12 | 9 | 21 |
| Sunfish | 1 | 4 | 5 |
| Sea turtle | 0 | 1 | 1 |

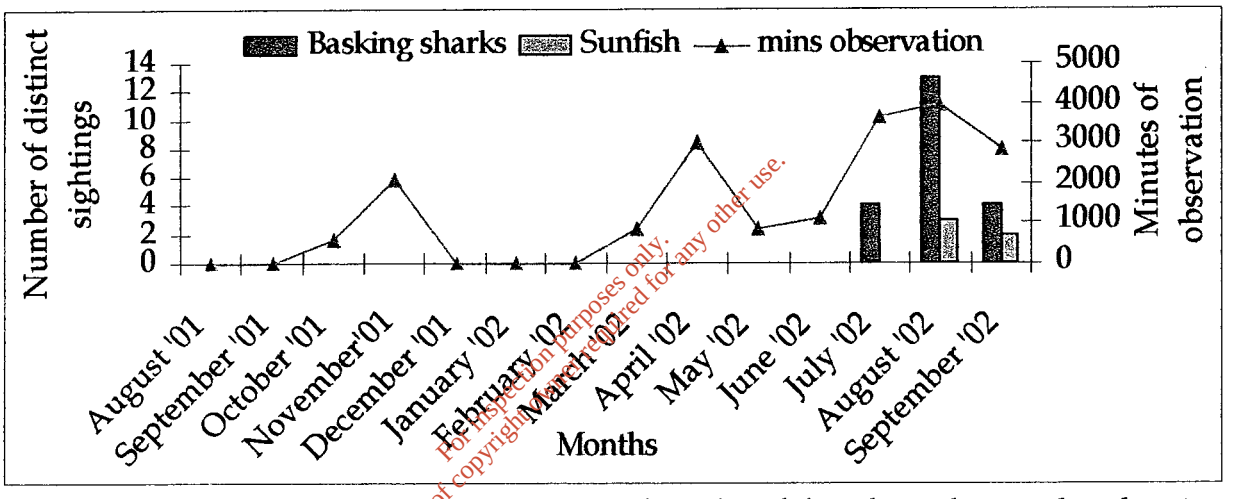


Figure 18. Monthly sighting records of basking sharks and sunfish in the study area plotted against cliff-based monitoring effort (in minutes) between August 2001 and October 2002.

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**Basking shark** *Cetorhinus maximus*

A total of 21 distinct sightings of basking sharks (Plate 8) were recorded within the study area (Table 3). In spite of visual survey effort through all seasons, all sightings occurred between the months of July and September 2002 with records of basking sharks reaching a clear peak in the month of August 2002 (Fig. 18) and a total of six distinct sightings recorded on 26th August. All basking shark sightings except one (an individual approx. 6.5m long) were of relatively small sharks estimated between 2.5m and 4.5m in body length. Basking sharks were mostly recorded singly in the study area, except for one sighting of two individuals. Feeding behaviour was noted on all occasions, since the animals were swimming at the surface with mouths open to strain planktonic prey. Sightings were obtained throughout the waters of Broadhaven Bay SAC (81.0% of records) as close inshore as the entrance to Ballyglass Harbour while the species was also occasionally recorded in waters outside the bay (Fig. 19).

Basking sharks were once fished heavily in the waters off western Ireland and one such fishery occurred off Achill island, Co. Mayo. The data gathered in the present study are relatively consistent with the findings of Berrow & Heardman (1994) suggesting that basking shark occurrence in Irish waters reaches an annual peak during the summer months.



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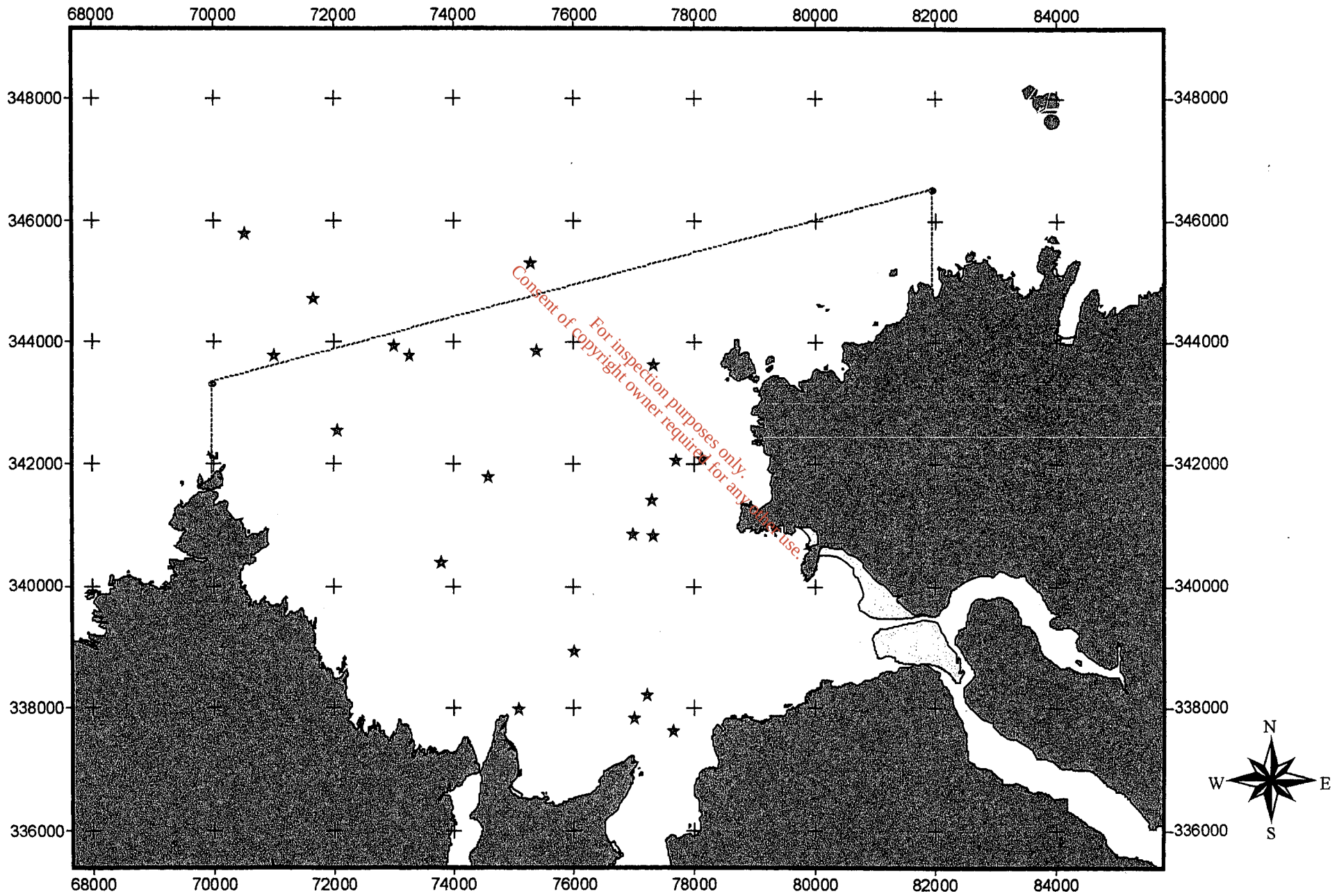


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Figure 19. Distribution map of all distinct sightings of basking sharks in the study area between October 2001 and October 2002.

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However, the predominant size of animals recorded in the present study was somewhat smaller than that (4-6m in length) described by these authors. It is believed that basking shark distribution on a local scale may be related to topography and oceanographic features that promote seasonal primary productivity and, as a result, basking sharks may be important 'bio-indicators' of such marine phenomena. This is of interest in the context of Broadhaven Bay SAC.

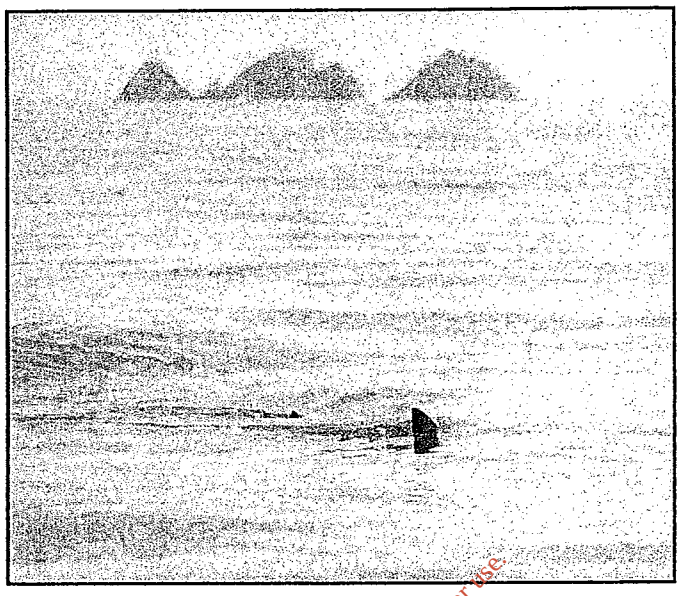

Plate 8. Characteristic dorsal fin and trailing tail-fin (tip showing) of a basking shark (approx. 3m long) recorded in the study area in 2002.

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**Sunfish** *Mola mola*

A total of five sightings of individual sunfish (Plate 9) were recorded during the study. Four were sighted by boat-based observers. These unusual plankton-feeding fish were solely recorded in late August or early September and all but one sighting occurred within the waters of Broadhaven Bay SAC (Fig. 20). The sunfish is an oceanic species that is believed to be carried seasonally into offshore and coastal Irish waters by surface currents.

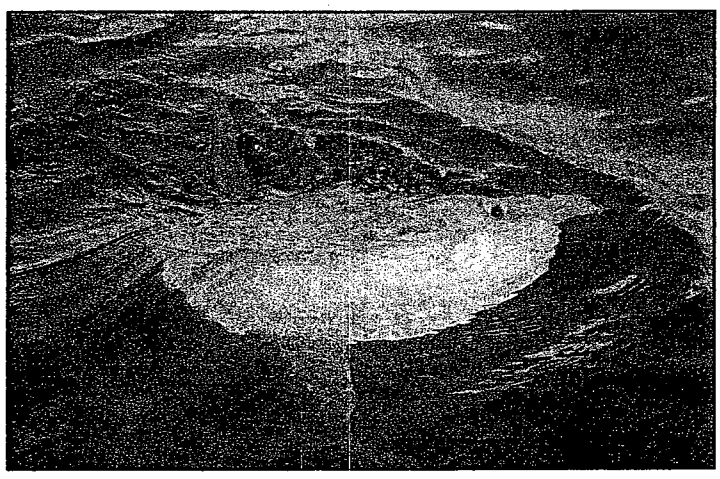

Plate 9. A sunfish measuring approx. 1m in length, recorded in the waters of Broadhaven Bay in August 2002.

A single unidentifiable **Sea turtle** was also recorded in the study area on 20th August 2002 (Fig. 20). The animal, measuring approximately 1.0-1.5 m in length, was observed at the surface with its head and dorsal surface visible for a short time.



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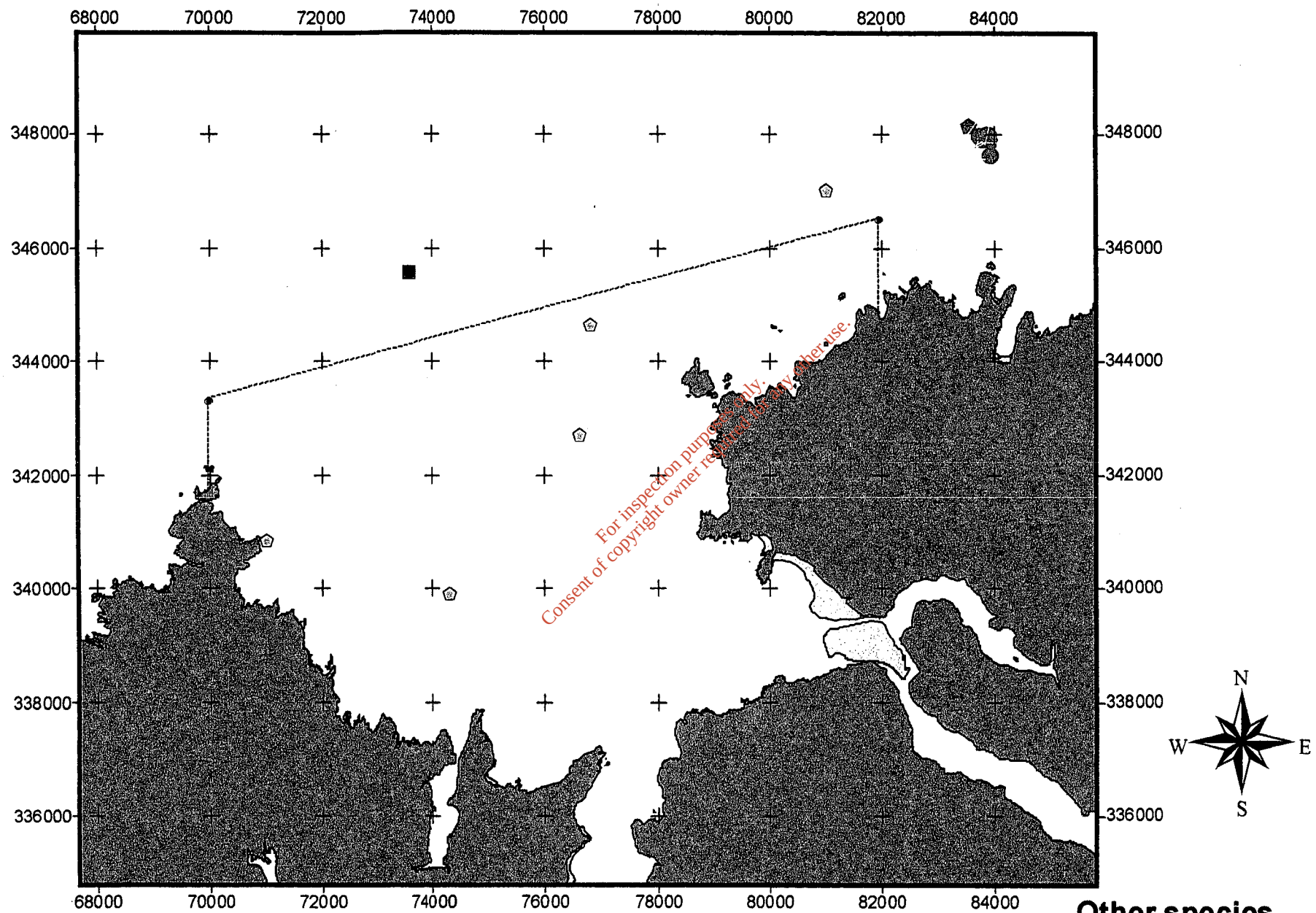


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**Other species**

- Sunfish
- Sea turtle

Figure 20. Distribution map of all distinct sightings of individual sunfish and a single sea turtle recorded in the study area during the summer 2002.

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### 1.3.3 FURTHER DISCUSSION

Total cliff-based survey effort achieved by CMRC researchers within the study area compares favourably with other baseline studies of its kind in Ireland (e.g. Shannon Estuary 1993-94: 212 hours - Berrow *et al.*, 1996; IWDG 'constant-effort' scheme 1991-2001: <314 hours at select headlands - Berrow *et al.*, 2002). However, simultaneous monitoring on both sides of Broadhaven Bay (~ 'full' visual coverage) could only be conducted effectively 21.6% of the time and therefore the sighting data obtained represent the minimum occurrence of marine mammal species within the study area in 2001-02. This was supported in part by reliable reports from several sources during periods when visual monitoring was not possible; members of the RNLI, Atlantic RIB Charter, local fishermen and residents kindly provided sighting records of bottlenose dolphins within the study area in 2001-02, occasionally as close inshore as Ballyglass Harbour and Rossport Bay. Such dolphin sightings in the vicinity of Rossport Bay during the summer of 2002 could be further validated by echolocation clicks detected on acoustic devices deployed in the area at the time (*see* 2.3.5).

Fishermen and other sources occasionally provided useful records from outside the study area. Two such records consisted of 1-2 killer whales (*Orcinus orca*) seen off Achill Head to the southwest of the study area on the 20th and 27th August 2002 (Mr P. Walker, MFV "*Favourite*", *pers. comm.*), while a further two reliable records of Risso's dolphins in the vicinity of Erris Head and the Inishkea islands (<20km from Broadhaven Bay) were also kindly provided to the research team. The latter sightings were of particular interest in the context of additional sightings of this species within the project's study area.

Total numbers of distinct marine mammal sightings within the study area indicate that these waters contain important habitats for ecologically-diverse species with a number of cetacean species showing strong seasonal patterns in occurrence (e.g. Risso's dolphin, white-sided dolphin). All Annex II (EU Habitats Directive) marine mammal species were recorded within the study area, four of which were the most frequently recorded species during the monitoring programme. Few, if any, examples of such species richness within a relatively small-sized bay are described in Irish waters. Although this may be due in part to lower levels of monitoring effort elsewhere along the Irish coast, extensive cliff- and boat-based coverage in outer Bantry Bay (2000-01; D. Roycroft, UCC, *pers. comm.)* and the Shannon Estuary (1996-2001; S. Ingram, CMRC, *pers. comm.*), which probably represent the best-studied habitats known as areas of importance for cetaceans, fail to match the number and frequency of occurrence of marine mammal species observed in the present study area.

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Since the 2001-02 research was relatively baseline in nature it was not possible to determine the factors that may explain or influence marine mammal occurrence in the study area throughout all seasons. However, distinctive foraging behaviours within the study area were described for several marine mammal species during the study. Numerous sightings of basking sharks and several sunfish indicated further the potential biological significance of these waters, reliant as these species are on areas of high primary productivity for foraging. And, although no newborn calves of either Annex II cetacean species were observed in the study area in 2001-02, groups of common and white-sided dolphins containing newborn calves were recorded in the summer of 2002, underlining the area's potential as a breeding/rearing habitat for several cetacean species and one species of seal (i.e. harbour seal).

Sightings of marine mammals in the study area indicated particular areas of concentration in the vicinity (<3km radius) of Gubastuckaun-Erris Head and Doonanierin-Rossport Bay, although distributional data varied significantly between species. This general pattern in marine mammal distribution within the study area may have been influenced somewhat by the nature and location of cliff-top monitoring sites and distance-limits at which marine mammals and



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other species could be observed from land using optical equipment. Broadhaven Bay and its neighbouring waters do not represent a homogeneous inshore area and variation in tidal currents and wind direction introduce associated variation in monitoring ability depending on the location of the observer. While every effort was made to confine visual monitoring effort to appropriate weather conditions, general marine mammal distribution within the study area should be interpreted with caution at this stage.

With the exception of the Shannon Estuary population, little is known of the ecology of bottlenose dolphins in Irish coastal or offshore waters (Ó Cadhla *et al., in press*). Recent surveys by Ingram *et al.* (2001) confirmed that identifiable groups of bottlenose dolphins frequent a number of different bays along the west coast of Ireland including Donegal Bay, Clew Bay and Brandon Bay. Cliff- and boat-based sighting and photo-identification data (*see* 3.3) collected in the present study certainly support the necessity for further investigation of the ecology, population size and degree of residency described by bottlenose dolphin groups in the waters of northwest Mayo.

While bottlenose dolphins are an Annex II cetacean species observed relatively easily in the field due to their body size, approachability and, often, conspicuous behaviour, the presence of harbour porpoises may often be overlooked due to the difficulty with which this small, inconspicuous species can be detected in sea states greater than Beaufort Force 2. Considering the continuation of monitoring effort in the present study in sea states up to Beaufort 3-4, it is considered likely that harbour porpoises were occasionally missed by CMRC observers during the 2001-02 study. Although this was unavoidable, it underlined the need for using alternative detection methods within the study area (*see* 2.2, 2.3), and particular care should be taken in interpreting the distribution of the sighting records presented.

Research on harbour porpoise distribution and abundance in Irish waters (i.e. Leopold *et al.*, 1992; Hammond *et al.*, 1995; Northridge *et al.*, 1995; Pollock *et al.*, 1997) indicates that the inshore waters of southwestern Ireland, in particular, contain high densities of this species in summer. However, comparatively low survey effort and poorer weather conditions off western Ireland may have masked other areas of importance for the species (Ó Cadhla *et al., in press*). It is considered that, on the basis of visual monitoring in the present study, previous research and current studies elsewhere in Ireland (e.g. Bantry Bay & Shannon Estuary - D. Roycroft, UCC, *unpublished data*; Dublin Bay - R. Leeney, UCD, *pers. comm.*), the waters of Broadhaven Bay may constitute at least part of one such area of importance. Future research may indicate reasons for the relative significance of the study area to this and other protected marine mammal species.

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## 1.4 CONCLUSIONS FROM VISUAL MONITORING

1. Data obtained during dedicated visual monitoring represent a minimum measure of the occurrence and habitat use of marine mammals within the study area in 2001-02;
2. Results of cliff- and boat-based sighting surveys indicated that Broadhaven Bay SAC and its neighbouring waters represent important habitats for several marine mammal species, three of which were recorded with offspring in 2002;
3. All five Annex II (EU Habitats Directive) marine mammal species were observed within the study area while a further five Annex IV cetacean species were also recorded during the study within the waters of Broadhaven Bay SAC;
4. The apparent biological significance of the study area was supported by sightings of basking sharks, sunfish and over 2,500 seabird records obtained during the project;
5. The data underlined the need for complementary monitoring methods in 2001-02 and for impact mitigation to safeguard all species from potential environmental degradation.



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# 2
# ACOUSTIC MONITORING FOR SMALL CETACEANS

## 2.1 INTRODUCTION

As previously outlined, marine mammals may be difficult to observe and identify in their natural environment. Research effort has therefore looked into non-visual methods to detect their presence and investigate various aspects of their ecology.

Cetaceans rely on sound for navigation, communication and foraging (Evans, 1987) and since individual species produce an unique repertoire, this can be used in scientific monitoring. One type of sound emitted by odontocetes (toothed whales & dolphins) is known as echolocation (sometimes called "sonar"). This sound-type is produced in the form of distinct "click sequences" that are directional, pulsed sounds of high acoustic intensity (dB) and high frequency (kHz). Pulses are emitted in very short time-units (i.e. microseconds or milliseconds) and the reflected sound (i.e. echo), from the physical environment or other target, is received by the animal through its complex auditory system. Dolphins typically emit clicks that are very short in duration using a wide range of frequencies while clicks from porpoises are generally longer and with higher peak frequencies (Evans, 1987).

Acoustic monitoring techniques offer a number of advantages over visual survey methods in Irish waters (Aguilar de Soto *et al., in press*). Cetaceans may be more vocal than visible, since they use sound as their primary sense and spend much of their lives beneath the water surface (Evans, 1987). Acoustic equipment can be used to monitor marine mammal activity at night, when visual monitoring is impossible. Furthermore, acoustic detection of marine mammals is not prone to rough weather conditions in the way that visual detection can be and may be considerably less demanding from a logistical point of view than intensive visual techniques. The process may even be automated to a large degree with detection information, positional data and other detection components stored in real time on computer (Gillespie & Chapell, 1998; Aguilar de Soto *et al., in press*).

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Acoustic methods for detecting and monitoring cetaceans have been successfully used in Irish waters before now. Gordon *et al.* (1999) carried out an acoustic and visual survey off the Mayo coast in 1993 and, more recently a large-scale study of Ireland's offshore waters, incorporating acoustic methods, was completed in 2002 (Aguilar de Soto *et al., in press*). Gordon *et al.* (1999) reported detections of cetacean vocalizations over an estimated 29% of total visual/acoustic monitoring time. The study underlined the usefulness of acoustic techniques in the region since many cetaceans were detected acoustically but never seen by observers. Other cetaceans were first detected acoustically before they were observed from the vessel. Studies by Aguilar de Soto *et al.* (*in press*) showed how acoustic methods could, when combined with effective visual monitoring, provide support for the identification of important habitats and the key species that occur therein. In the present study, it was felt at the outset that acoustic methods could provide a useful tool in determining such factors, particularly since the study area is relatively exposed to the Atlantic weather, making visual methods more difficult. Secondly, preliminary surveys had identified the presence of harbour porpoises in Broadhaven Bay, making the reliance on visual methods alone somewhat limiting.

A number of devices may be used in acoustic monitoring, depending on what species is being studied. Harbour porpoises, for example, cannot be detected in the same frequency range as any of the larger toothed whales or dolphins (Evans, 1987). As a result, specialised hydrophones



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have been developed, for example, to detect porpoises over fishing grounds in an effort to prevent accidental capture in fishing gear (Berggren *et al.*, 2002; Bystedt, 2002) and to monitor the effect of construction activities on porpoises (Teilmann *et al.* 2002).

The characteristic properties of porpoise echolocation clicks make them relatively simple to distinguish from other underwater sounds and from the echolocation clicks produced by other cetaceans. Due to its very high frequency band, the sonic realm in which porpoises echolocate is the quietest part of the marine sound spectrum. Consequently, acoustic detection of porpoises is less prone, for example, to interference from vessel noise, which poses problems for acoustic monitoring of other cetacean species (Leaper & Scheidat, 1998; Aguilar de Soto *et al., in press*).

In order to effectively monitor the occurrence and habitat use of harbour porpoises and dolphins in Broadhaven Bay the use of a number of acoustic devices were examined to reinforce and complement visual data collected by the CMRC research team. It was felt that efforts should especially consider the inner bay (i.e. Rossport Bay) in which drilling and blasting activities were proposed to take place in 2002. The aims of this element of the project were:

- To examine the suitability of various acoustic techniques to the study area and species therein;
- To develop optimal methods for detection of key species, particularly in Rossport Bay;
- To conduct continuous acoustic monitoring for cetaceans within the study area, collecting data at night and during bad weather when visual methods could not be implemented;
- To cross-correlate acoustic data with the results of the visual monitoring programme;
- To provide the added means for effective mitigation of potential impacts of the development on all marine mammal species occurring within the study area.

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## 2.2 METHODS

### 2.2.1 ACOUSTIC EQUIPMENT

A range of acoustic monitoring methods were considered for the present project. On the basis of preliminary sighting information gathered in 2001, it was decided to concentrate acoustic survey effort on more inconspicuous cetacean species that could not easily be detected by visual means. The equipment chosen by the research team could be preset, deployed and allowed to record cetacean detections independently of cliff- or boat-based observers. Thus the potential for reduced detection of animals due to poor weather or research vessel activity could be avoided.

The acoustic data gathered in 2002 were collected using passive underwater monitoring devices called PODs (Baines *et al.* 1999; Tregenza & Northridge, 1999). The POD device was developed in the mid-1990s for the detection of harbour porpoise echolocation clicks. Newer versions in the form of 1st and 2nd generation T-PODs are now also available. These latter PODs are able to detect dolphin species as well as porpoises and can also be left unattended for comparatively longer periods of time due to increased memory and battery capacity.

A POD is a self-contained submersible electronic device with an analogue signal processing system to select tonal ultrasonic signals (such as the echolocation clicks of cetaceans), and a digital recording system. In contrast to a conventional hydrophone often used in cetacean acoustic monitoring, these devices do not record the actual sound but instead log, to 10-microsecond (μs) resolution, the start- and end-time of all selected sounds. Subsequent analysis



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of these data identifies trains of sounds that have the characteristics of cetacean "click trains" (*see* 2.2.3).

Three POD types were used in this study: PODs, 1st generation T-PODs (T-POD 1) and 2nd generation T-PODs (T-POD 2). The PODs and T-PODs are powered by either six or twelve 1.5V D-cell alkaline batteries and contain 8 or 32MB RAM memory. This allows the devices to be deployed for a period of up to three months, depending on the device. The POD and T-POD electronics are encased in a tubular PVC housing approximately 50-70cm long (*see also* 2.2.2). Each device contains an internal or external hydrophone, an amplifier and electronic filters which combine with a data-logger to process underwater signals. The device can be set to log signals (i.e. clicks) that have acoustic properties similar to those produced by echolocating cetaceans. Upon recovery of the remotely-deployed device, the stored data from POD units may be downloaded onto a laptop computer via a serial cable for later analysis.

**The original POD**

The original POD was developed for the detection of porpoise echolocation clicks and is not considered to be reliable in monitoring echolocation of dolphins which produce less tonal sounds. The actual number of clicks detected is not logged. Instead, individual clicks or groups of clicks are detected and counts of clicks in a defined period are placed into "click categories". This is essentially a means of compressing the volume of data to be stored. Underwater sound that meets preset frequency/intensity and duration criteria initially triggers one of three click detectors operating at three frequency bands (Hi, Mid or Low frequency). The categorised sounds are then tested against different sets of duration criteria on the basis of known characteristics of porpoise clicks. These combined frequency and duration bands are termed "channels" and original PODs were designed to allow the simultaneous operation of eight such channels.

On occasions when a detected signal falls outside the duration criteria for any of the channels in operation, the device rejects the signal as of cetacean origin. Some of these rejected events may in fact be true porpoise clicks that are excluded due to features that do not meet the preset frequency or duration criteria. However, these rejected detections may be logged in 'reject' channels for later manual inspection and analysis. High levels of boat activity in an area may give rise to "false positive" detections, especially at lower frequency settings in which much vessel noise may also be concentrated. False positive detections can be minimised through the manual selection of more restrictive settings but only at the cost of reduced sensitivity to true porpoise clicks. False positive detections in the high frequency channels are much less likely to occur since they do not overlap with many other sources of underwater sound. Where detections do occur in this frequency band, background noise can be discriminated from porpoise clicks relatively easily, since the latter tend to describe a recognisable, highly clustered pattern.

**The T-POD**

The T-POD is a newer version of the original POD which records the time of each click and allows post-collection processing to detect the trains of clicks from porpoises, dolphins and other odontocetes. This device identifies cetacean echolocation clicks by the comparison of only two electronic filter outputs. Filter pairs can be changed and each pair constitutes a "scan" (Fig. 21). Each pair of filters allows for acoustic monitoring on a target "centre frequency"(A kHz, Fig. 21) and a predetermined blocking frequency (B kHz, Fig. 21). T-PODs allow a total of six channels to operate in succession, with each step or 'scan' lasting 9.3 seconds. The "Q" or relative bandwidth characteristic of each filter can also be set.

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During operation, detections are then either included or rejected on the basis of three criteria: (i) the ratio of energy received by the A filter compared with the B filter; (ii) the duration and (iii) the minimum threshold intensity detected by the A filter. Hardware settings for T-POD scans can be defined by choice, in a similar manner to those for PODs. However, the T-POD provides train detections through the dedicated T-POD.exe software (www.chelonia.demon.co.uk).

**POD and T-POD settings**

The original PODs were programmed to monitor acoustic signals on a total of three of the available eight channels. Two of these were Hi-channels set for porpoise detections at a centre frequency of 132kHz and one was set as a Low 'reject' channel at 50kHz. The click duration criteria for the two Hi channels were set at minimum/maximum intervals of 25-500 microseconds (µs) and 500-2000µs. The Low channel setting range was 0-2000µs in duration.

| v1 | | 2 | | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Scan | 1 | 2 | 3 | 4 | 5 | 6 |
| A kHz | 130 | 50 | 130 | 50 | 130 | 130 |
| B kHz | 90 | 80 | 90 | 80 | 90 | 90 |
| Ratio | 3 | 2 | 3 | 2 | 3 | 3 |
| A Q | 8 | 8 | 8 | 8 | 8 | 8 |
| B Q | 18 | 18 | 18 | 18 | 18 | 18 |
| Threshc | 0 | 0 | 0 | 0 | 0 | 0 |
| limit | none | 240 | none | 240 | none | none |

| v2 | | 2 | | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Scan | 1 | 2 | 3 | 4 | 5 | 6 |
| A kHz | 130 | 50 | 130 | 50 | 130 | 130 |
| B kHz | 90 | 90 | 90 | 90 | 90 | 90 |
| Ratio | 6 | 4 | 6 | 4 | 6 | 6 |
| A Q | 10 | 10 | 10 | 10 | 10 | 10 |
| B Q | 18 | 18 | 18 | 18 | 18 | 18 |
| Threshc | 6 | 6 | 6 | 6 | 6 | 6 |
| limit | none | 160 | none | 160 | none | none |

Figure 21. Settings used for 1st (v1) and 2nd (v2) generation T-PODs during the course of the study.

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Appropriate settings for T-PODs were chosen after the initial testing period within the study area. Four out of the six scans in each minute were set to scan for porpoises using a filter with a centre frequency of 130kHz and the remaining two scans were centred on 50kHz. The minimum duration allowed to trigger the T-POD detection system was set at 10µs. In order to minimise overlapping signals from porpoises and dolphins, the blocking filters (B-filters) were set at 90kHz for porpoise scans and 80kHz for dolphin scans (T-POD 1) or simply at 90kHz (T-POD 2). The received energy-ratio between the paired filters within each scan was set lower for dolphin scans than for porpoise scans as their clicks are less tonal. This does allow detection of some non-cetacean clicks but not as many as to prevent the detection of click-trains. It does mean that background noise is more likely to interfere with the detection of dolphin vocalisations than those of porpoises. In addition, a limit was set on the total number of clicks detected per scan within the low frequency channels in order to avoid memory being filled by unwanted boat or other low frequency noise.

**Calibration and testing**

In order to calibrate individual POD devices and investigate differences in sensitivity between devices, PODs were initially tested in pairs on one of two vertical test moorings. Further testing of POD sensitivity and detection capabilities was performed in the Shannon Estuary, Co Clare from 19th October to 30th October 2002. This allowed the research team to conduct additional investigations in an area frequently used by bottlenose dolphins (Ingram, 2000). Part of this experiment sought to estimate the range of acoustic detection by individual PODs, determined by visual theodolite-based tracking.



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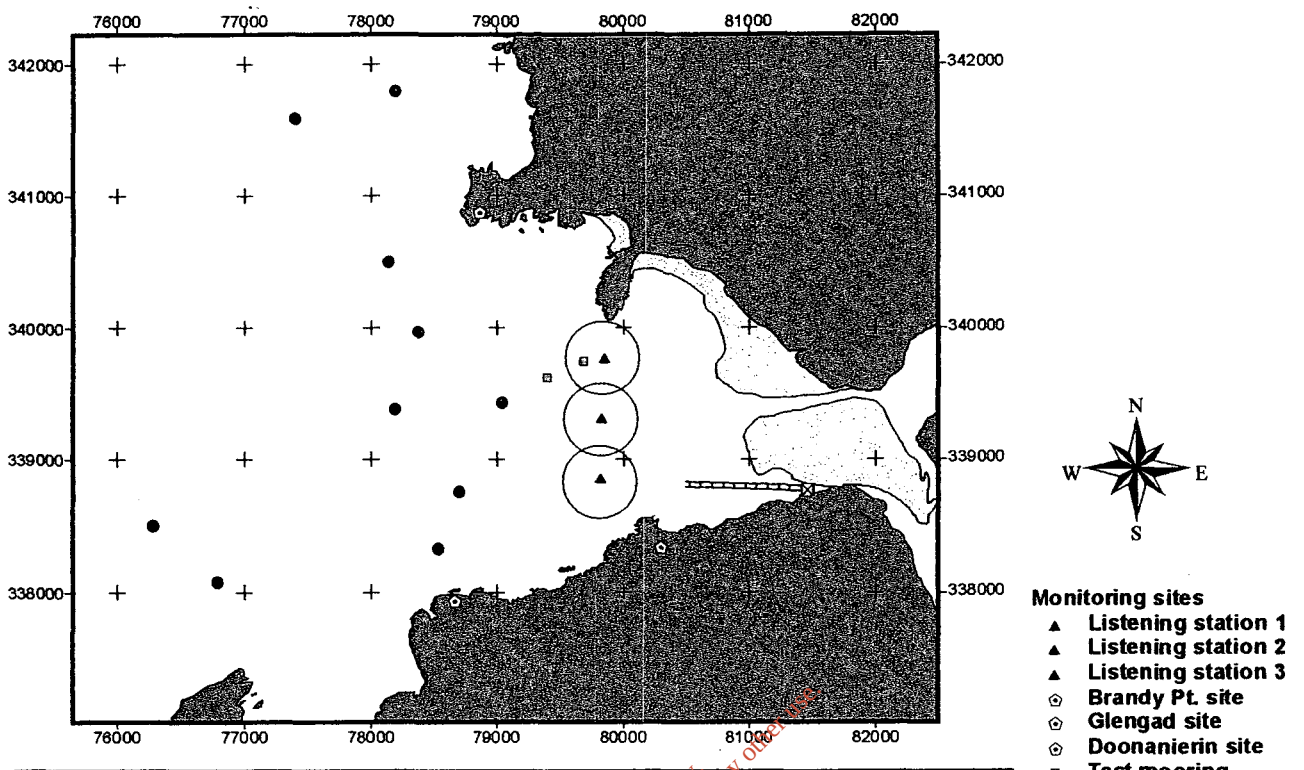


Figure 22. Map of inner Broadhaven Bay including Rossport Bay, showing the positions of acoustic and visual monitoring sites, harbour porpoise sightings and the inshore construction site.

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### 2.2.2 DEPLOYMENT METHODS

Since construction activity planned for 2002 involved the excavation of rock and sediment material inside Broadhaven Bay and the potential drilling and blasting of bedrock along the inshore pipeline route, it was felt that focal acoustic studies should be conducted within Rossport Bay, the area in which noise and other environmental impacts were expected to be most critical. Consequently, after a period of testing and calibration, three fixed listening stations were set up across the mouth of Rossport Bay creating an acoustic detection 'gateway' (Fig. 22) to detect any echolocating small cetacean entering or leaving the area. The listening stations were placed 500m apart and PODs were deployed at each listening station via a vertical "running mooring" (Fig. 23). The developed system of pulleys made it possible to recover and re-deploy individual PODs without having to move the entire mooring. Average depth of deployment was 17 metres.

### 2.2.3 DATA ANALYSIS

After download of stored detection data from the PODs, recorded signals were analysed using the relevant software. For data collected by the original POD, categories containing less than eight potential clicks were filtered out before any further analysis was conducted (N. Tregenza, Chelonia, *pers. comm.*). This may result in rejection of true porpoise clicks but the risk of accepting false positive detections is greatly reduced. A comparison between detections made on Hi and Low filters was carried out manually in order to examine acoustic events assigned to the Low 'reject' channel by the detection process. When rejected detections showed strong correlation in time with clusters of accepted signals they were likely to contain many true cetacean clicks. If on the other hand, received signals were predominantly logged in the 'reject'



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channel and showed weak temporal correlation with few simultaneous accepted signals they were less likely to be true cetacean clicks and the detections in question were rejected.

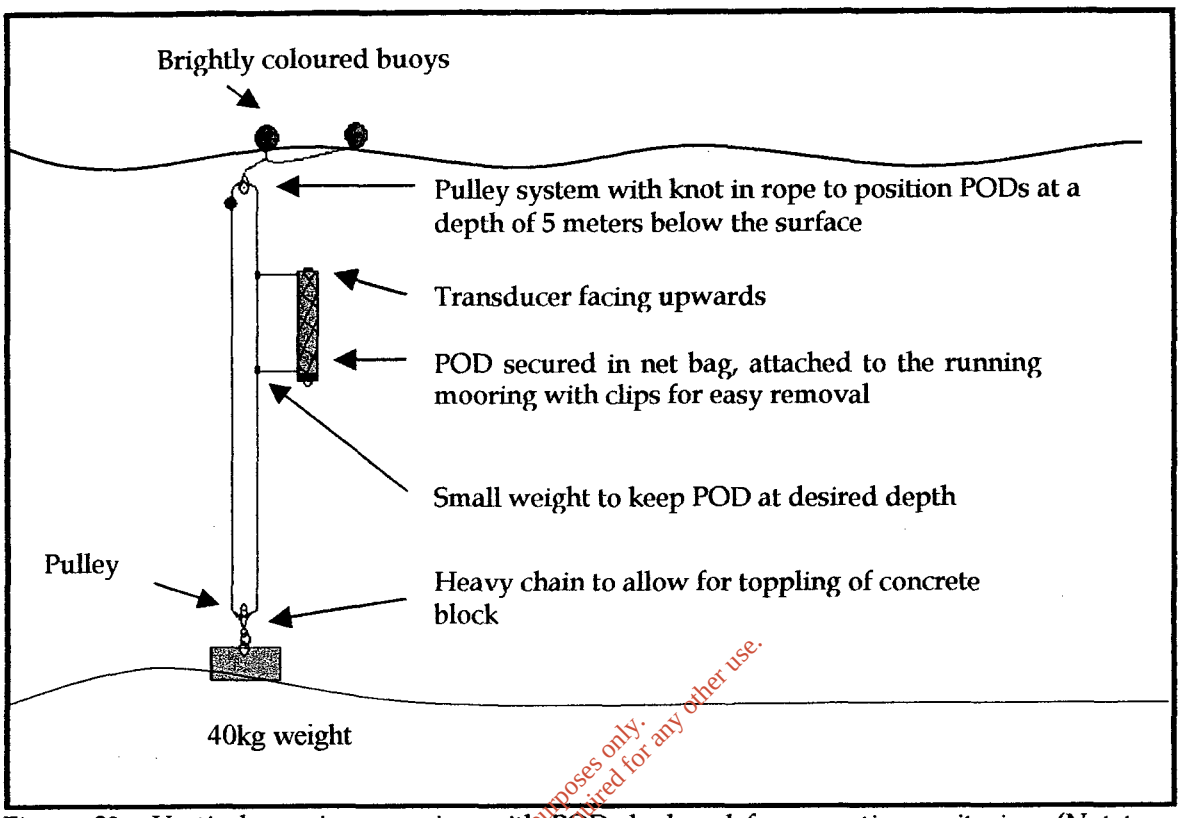


Figure 23. Vertical running mooring with POD deployed for acoustic monitoring. (Not to scale).

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The T-POD data were analysed similarly, but the newer T-POD software allowed the added feature of extraction of click-trains from the stored information. Research has shown that characteristic signals are produced in regular clusters of three or more distinct click emissions. In addition the T-POD hardware settings can distinguish between click-trains of harbour porpoises and dolphin species.

Click-train detection allows the T-POD to achieve a much higher specificity in the detection of cetaceans than is possible from any method based purely on click characteristics. Click-train detection uses the probability of a click-train arising by chance, from a background rate of non-cetacean clicks, to reject any trains that are not sufficiently far above that level of probability, as 'doubtful'. This has the effect that short trains will all be rejected even though they come from dolphins because they are not sufficiently unlikely to have arisen by chance. The software displays click-duration and timing graphically. The data were further inspected to verify that positive detections had the characteristic profile of cetacean click-trains. Since short click-sequences have a higher chance of occurring from non-cetacean sources, caution was taken in analysing short-trains classified as cetacean detections by the program.

Detections satisfying the criteria set up for high-probability click trains, denoted as 'Cet Hi' and 'Cet Low' in the T-POD software, were extracted from the T-POD data files. In the present study, only these two probability classes were used. This could result in true cetacean clicks being overlooked but would further minimise false positive detections. True acoustic "encounters" were defined as periods of click-train activity separated by a silent-time of at least



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ten minutes. Detections were finally arranged into listening station encounter rates (i.e. the no. of encounters per unit time per POD). The use of a 10-minute silent period as a separator for "encounters" was determined to be appropriate in studies elsewhere (Berggren *et al.* 2002; Teilmann *et al.*, 2002).

Since boat sonar is acoustically similar to cetacean echolocation it is important to be able to reliably distinguish between these sound sources to avoid false positive detections. The T-POD software allows the recognition of boat sonar to a certain extent, by detection of the regularity of occurrence of the clicks. Some cetacean click-trains may also be classified as boat sonar where they are relatively regular and slow in repetition-rate. However, detected boat sonar predominantly consists of large clusters of "echoes" from which a number of trains are falsely detected by the software. Therefore, manual analysis was necessary in the present study in order to verify the classification into cetacean and boat sonar detections.

## 2.3 RESULTS & DISCUSSION

### 2.3.1 ACOUSTIC COVERAGE OF ROSSPORT BAY

PODs and T-PODs were in place from 22nd May 2002 and all three listening stations were tested and fully operational from 26th June. Except for short periods when data were downloaded and batteries changed (every 2-3 weeks), monitoring was continued until 10th October 2002. Acoustic monitoring by all PODs combined totalled 7,911.8 hours (or 329.7 days) of listening time using five separate POD units (Fig 24). Total acoustic gateway coverage (i.e. at least one POD operating at each listening station) was obtained for 1,325 hours (or 55.2 days) and partial coverage (i.e. ≥ 1 listening station) was obtained for a total of 3,170 hours (or 132.1 days). Partial coverage led to slight differences in the proportion of time that listening stations were active (Fig. 25). The deployment set-up proved to be very successful and relatively easy to operate from the survey vessel. In spite of the fact that the most exposed of the three listening stations (Listening station 3, Fig. 22) occasionally contended with a swell of 2-3m in height, none of the moorings moved position by more than 1-2 metres between deployments and it was concluded that, for Rossport Bay at this time of year, the system of deployment worked very well.

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### 2.3.2 EQUIPMENT PERFORMANCE

It is important to note that PODs and T-PODs are undergoing continual development and that the performance of individual PODs was monitored closely to determine their effective use in the study. Some of the original PODs initially obtained by the research team presented difficulties during testing and these were excluded from the study. POD 32 experienced electrical problems in mid-June before which it had been working properly. These problems were probably caused by a build-up of dampness within the housing and since, by this stage, full coverage of the bay could be achieved using the newer T-PODs, the device was not further used after mid-June. Table 4 lists the PODs available for the study, some of which were not available from the manufacturer until July or August.

Eight days of experimental POD deployment in the Shannon Estuary resulted in a total of 41,558 click-train detections (30,740 for harbour porpoises and 10,818 for dolphins). In dealing with detections of harbour porpoises, T-POD 25 and T-POD 74 displayed similarly high abilities to one another, while T-POD 77 turned out to be the best of these T-POD 1 devices. The newer version T-POD 141 showed a reduced ability to accurately identify true cetacean click-trains, making it the least effective T-POD. This was due to its acute sensitivity and a lack of adequate testing time, which led to the over-recording of background noise, that in turn masked true cetacean detections. The acoustic data for dolphins indicated that T-POD 25, 74 and 141



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possessed similar abilities in detecting dolphin echolocation clicks whereas T-POD 77 was less effective. Similar to T-POD 141 this was due to its sensitivity to background noise.

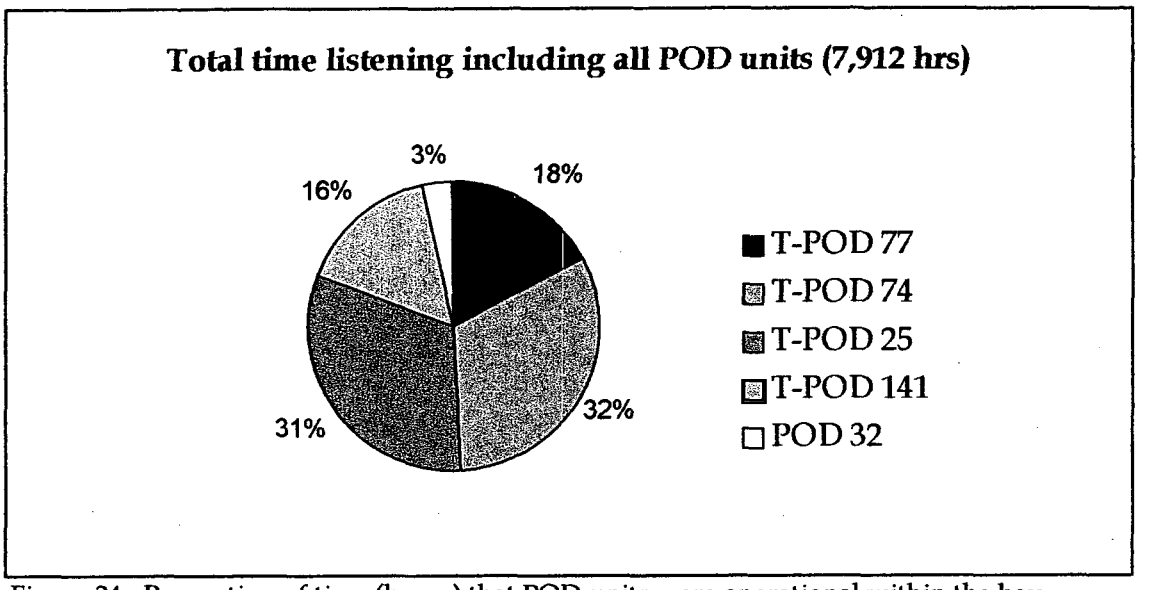


Figure 24. Proportion of time (hours) that POD units were operational within the bay.

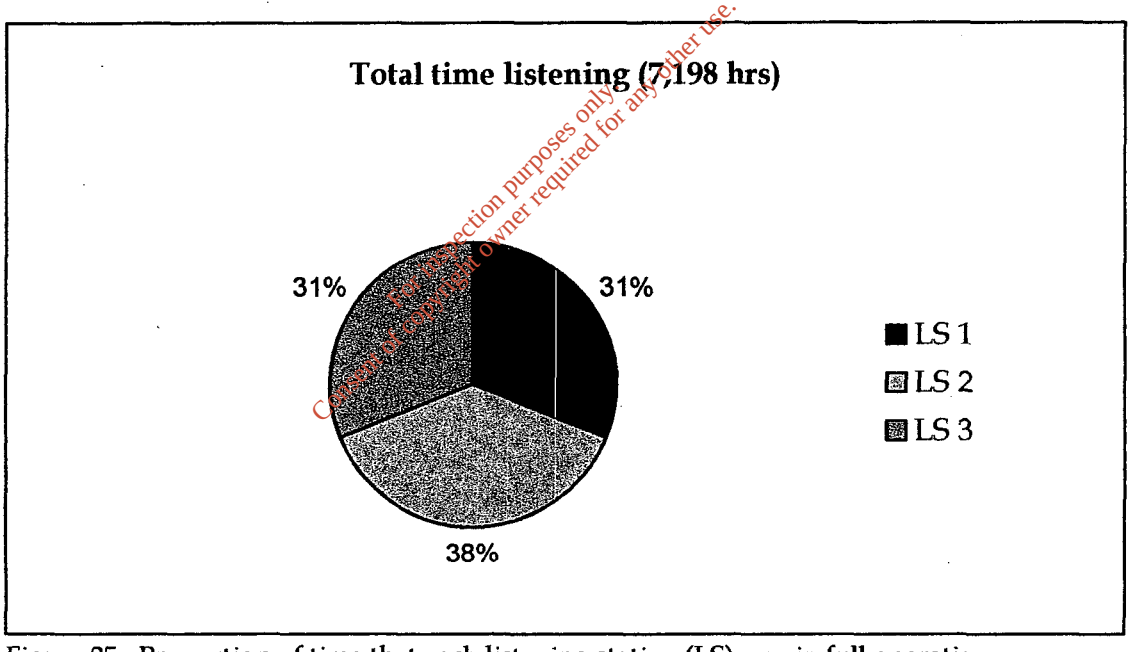


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Figure 25. Proportion of time that each listening station (LS) was in full operation.

TABLE 4. Summary of general POD specifications and operation periods in 2002.

| ID | Type | Hydrophone | Detections | Memory (MB) | Period of operation |
|---|---|---|---|---|---|
| 28 | POD | Internal | Porpoises only | 8 | Test |
| 29 | POD | Internal | Porpoises only | 8 | Test |
| 32 | POD | Internal | Porpoises only | 8 | May to June |
| 25 | T-POD 1 | Internal | Porpoises & dolphins | 8 | May to October |
| 74 | T-POD 1 | External | Porpoises & dolphins | 8 | May to October |
| 77 | T-POD 1 | External | Porpoises & dolphins | 8 | July to October |
| 141 | T-POD 2 | External | Porpoises & dolphins | 32 | August to October |



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### 2.3.3 PRELIMINARY ANALYSIS OF POD DATA

In manual examination of the original POD data, four false positive boat detections that were logged in cetacean categories were removed. An example of a true porpoise detection logged by the POD software is shown in Fig. 26; one of the boat detections is shown in Fig. 27. An example of detections of boat sonar is shown in Fig. 28. Just one encounter logged by the T-POD program as harbour porpoise in origin was removed since it was manually determined to be a false positive detection of boat sonar.

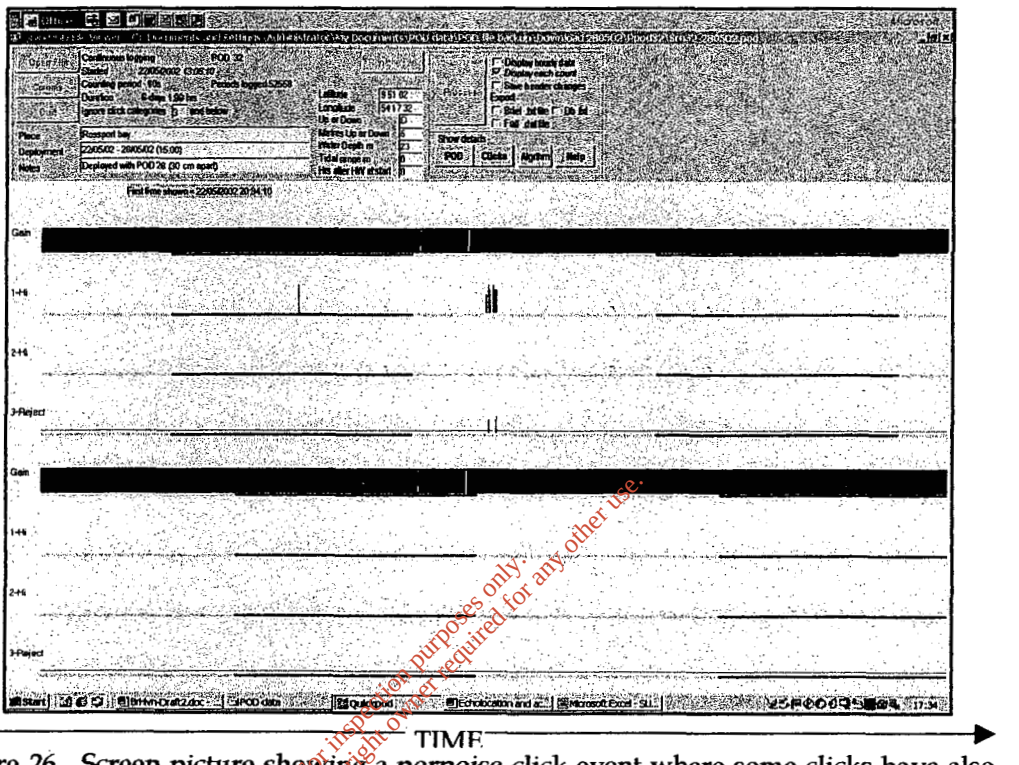


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Figure 26. Screen picture showing a porpoise click-event where some clicks have also been placed in the 'reject' channel. The strong temporal correlation between results in different channels shows that all clicks logged are likely to be of porpoise origin.

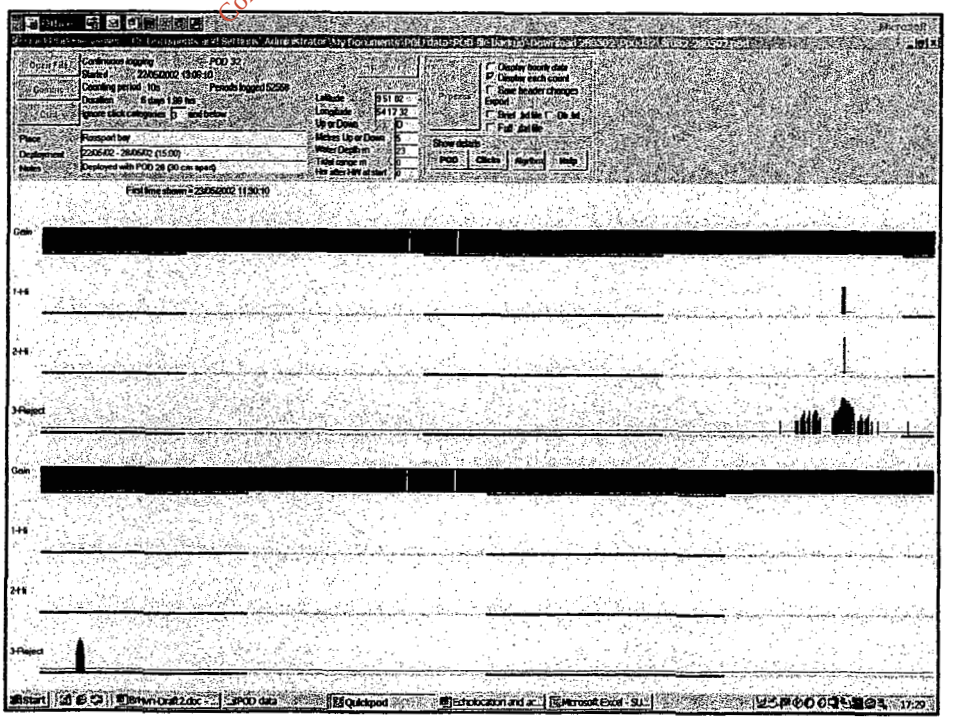


Figure 27. Screen picture from analysis of POD data showing predominant detections placed in the 'reject' channel. This represents a highly likely detection of boat sonar.



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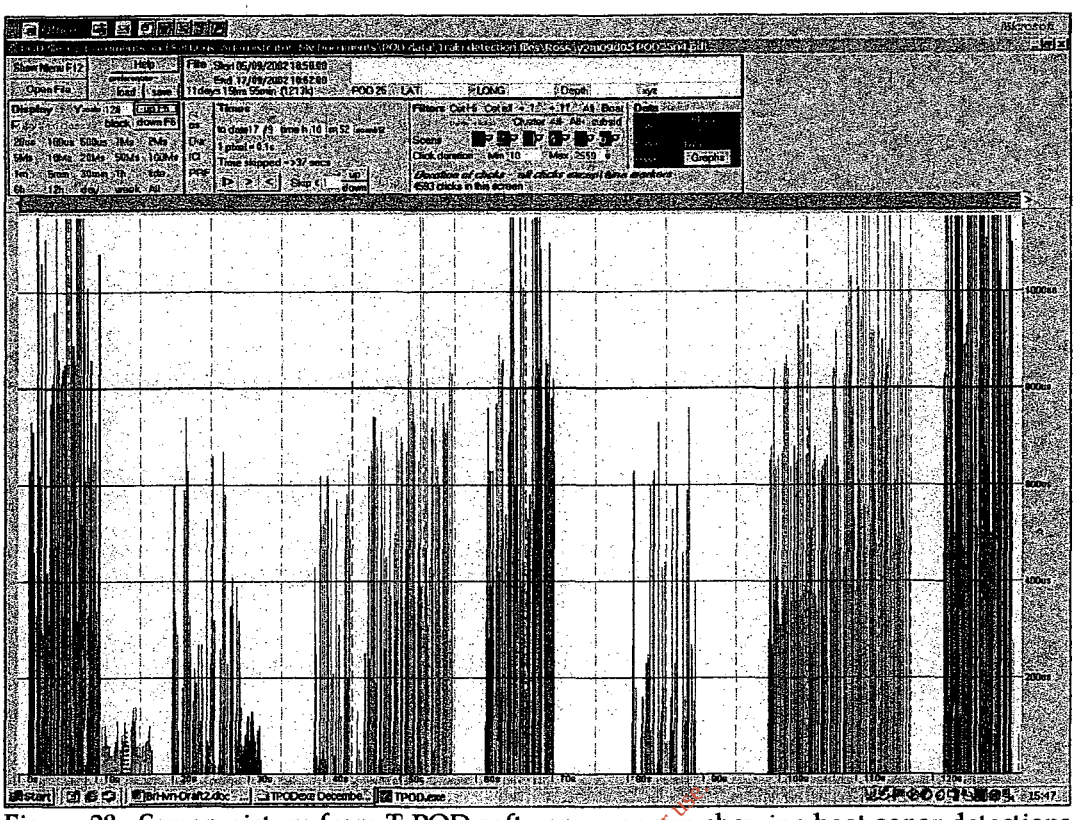

Figure 28. Screen picture from T-POD software program showing boat sonar detections mainly in the four channels scanning for porpoises (shown in pink, blue, magenta and black). These detections were rejected as click trains by the software.

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Due to the more difficult situation regarding accurate detection of dolphin echolocation clicks against background noise, a total of eight potential false positive encounters (three in July, five in August) were manually removed since these were not certain to be of dolphin origin. The removed potential click-trains were all extremely short in duration (i.e. <7 clicks long) and all were classified only as "Cet Low". In such cases no higher-classified click-trains were detected at the time of any of the rejected signals and they were all detected by just one listening station on each occasion.

### 2.3.4 ACOUSTIC DETECTIONS OF HARBOUR PORPOISES

An example of an harbour porpoise detection, composed of six recorded click-trains, is shown in Fig. 29. A total of 45 distinct harbour porpoise encounters were logged acoustically on 25 separate days during the study. The proportion of detections was higher on falling tides including the period of low tide (64%) than on rising tides (46%) but this was not statistically significant at the 95% level. A total of 53.3% (n = 24; Table 5) of all porpoise encounters recorded by the acoustic equipment occurred at night; A remaining 44.5% (n = 20) occurred on days when weather conditions did not allow for effective visual monitoring while a single acoustic encounter was recorded during simultaneous visual monitoring (2.2% of total).

Harbour porpoises were encountered in all months of the study with peak numbers in the late spring and early autumn. An apparent slight decrease in the number of encounters was observed in the month of August (Table 5).

Porpoise encounter rate was generally higher at the southernmost (i.e. Glengad) listening station (Fig. 22) than at other stations (Fig. 30) and notable increase in encounter rate at this site was recorded during the months of September and October 2002.



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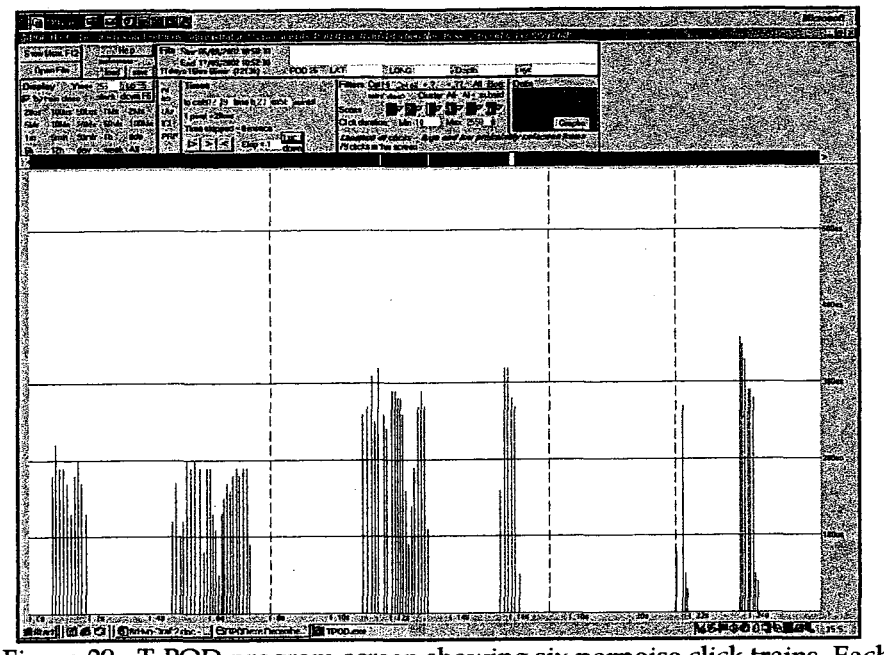

Figure 29. T-POD program screen showing six porpoise click trains. Each train consists of several clicks with their individual duration (between 100 and 300µs) showing on the y-axis and the time in seconds on the x-axis.

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TABLE 5. Harbour porpoise encounters and duration of monitoring (hrs) per listening station (LS).

| | No. of encounters | | | Hours of monitoring | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Month*** | ***Total*** | ***day*** | ***night*** | ***Total*** | ***LS 1*** | ***LS 2*** | ***LS 3*** | ***Test*** |
| May | 11 | 9 | 2 | 299.1 | 0 | 0 | 0 | 299.1 |
| June | 3 | 0 | 3 | 1132.4 | 0 | 358.3 | 359.1 | 415.0 |
| July | 7 | 2 | 5 | 1925.0 | 449.9 | 737.3 | 737.8 | 0 |
| August | 3 | 3 | 0 | 1852.5 | 769.1 | 753.5 | 329.9 | 0 |
| September | 16 | 7 | 9 | 1962.5 | 715.4 | 644.7 | 602.4 | 0 |
| October | 5 | 0 | 5 | 740.5 | 304.6 | 217.6 | 218.3 | 0 |
| Total | 45 | 21 | 24 | 7912.0 | 2239.0 | 2711.4 | 2247.5 | 714.1 |

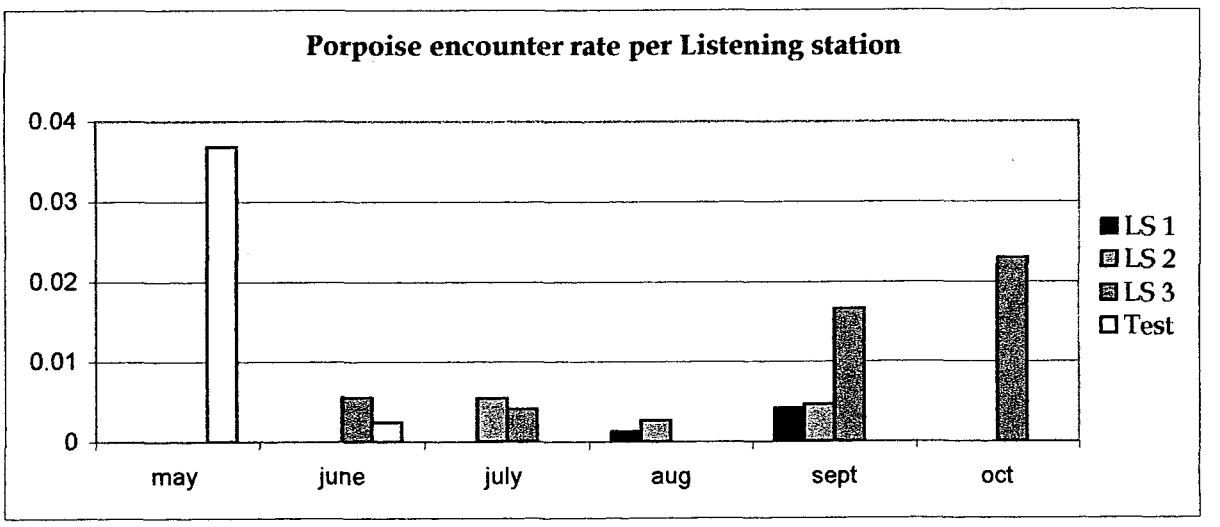


Figure 30. Diagram showing the monthly rate of acoustic encounters with harbour porpoises in Broadhaven Bay. Encounter rate was calculated as number of encounters per hour of listening time at each station.



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### 2.3.5 ACOUSTIC DETECTIONS OF DOLPHINS

PODs were operational and set to detect dolphin echolocations during a total of 7,659 hours (or 319.1 days). This was slightly less than the total acoustic monitoring time since POD 32 could only be set to detect harbour porpoises. An example of an acoustic detection of dolphins within the study area is shown in Fig. 31.

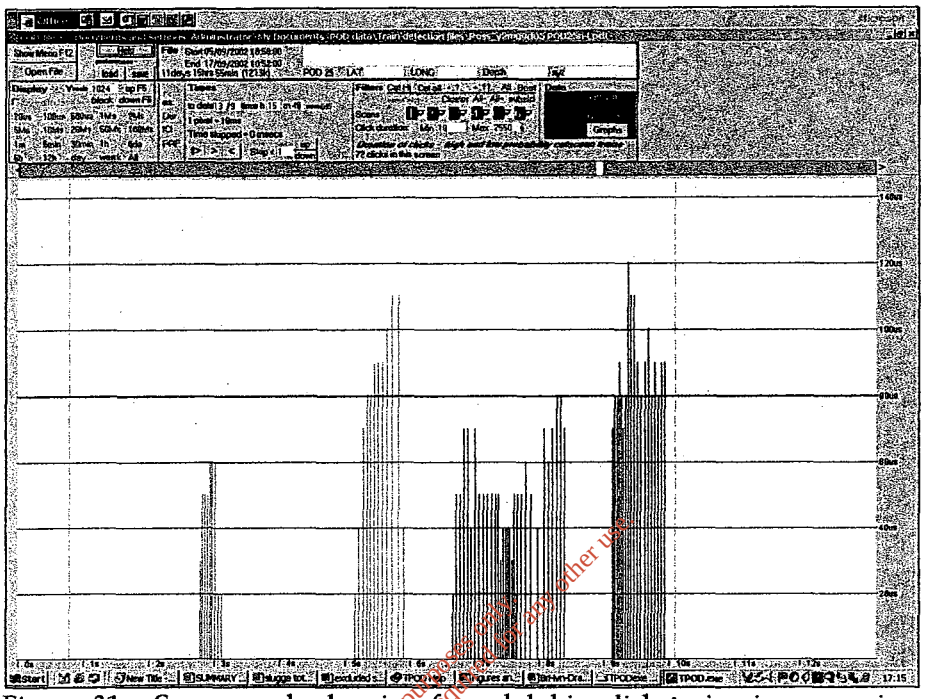

Figure 31. Screen grab showing four dolphin click trains in succession. Individual click duration is shown to range between 40 and 120µs.

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A total of 14 acoustic encounters with dolphins were recorded by the T-POD devices on four separate days in June, July and September 2002 (Table 6). Nine (64%) occurred at night and the remaining five (36%) during daylight, all on days when weather conditions in the study area were unsuitable for visual monitoring. A further total of 46 encounters were recorded over a five-day period in October. These were distributed equally between day and night.

There appeared to be a noticeable peak in detection rate in the months of September and October (Fig. 32). Unusually, all detections recorded in October occurred on a single T-POD (77) deployed at Listening station 1, while other T-PODs did not detect the same sources.

TABLE 6. Dolphin encounters and duration of monitoring (hrs) per listening station.

| | No. of encounters | | | Hours of monitoring | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Month*** | ***Total*** | ***Day*** | ***Night*** | ***Total*** | ***LS 1*** | ***LS 2*** | ***LS 3*** | ***Test*** |
| May | 0 | 0 | 0 | 153.2 | 0 | 0 | 0 | 153.2 |
| June | 1 | 1 | 0 | 1025.1 | 0 | 358.3 | 359.1 | 307.7 |
| July | 1 | 0 | 1 | 1925.0 | 449.9 | 737.3 | 737.8 | 0 |
| August | 0 | 0 | 0 | 1852.5 | 769.1 | 753.5 | 329.9 | 0 |
| September | 12 | 4 | 8 | 1962.5 | 715.4 | 644.7 | 602.4 | 0 |
| October | 46 | 23 | 23 | 740.5 | 304.6 | 217.6 | 218.3 | 0 |
| Total | 60 | 28 | 32 | 7658.8 | 2239.0 | 2711.4 | 2247.5 | 460.9 |



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During this period T-POD 77 logged numerous encounters (n = 46) of very fast click trains in both dolphin channels. These click-trains were classified by the software as "Cet Hi" and "Cet Low" and they included clusters of over 2000 clicks per second. Graphic examples of one of these very fast click-trains are displayed in Figs. 33 and 34.

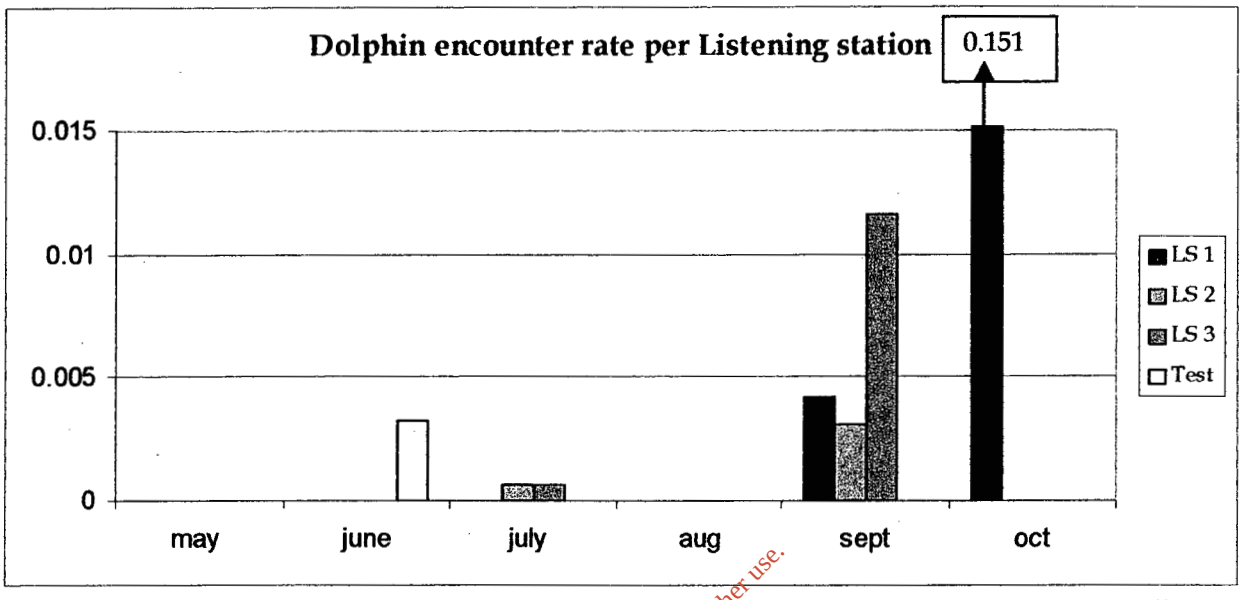


Figure 32. Diagram showing the monthly rate of acoustic encounters with dolphins in Broadhaven Bay. Rates are calculated as number of encounters per hour of listening time at each station.

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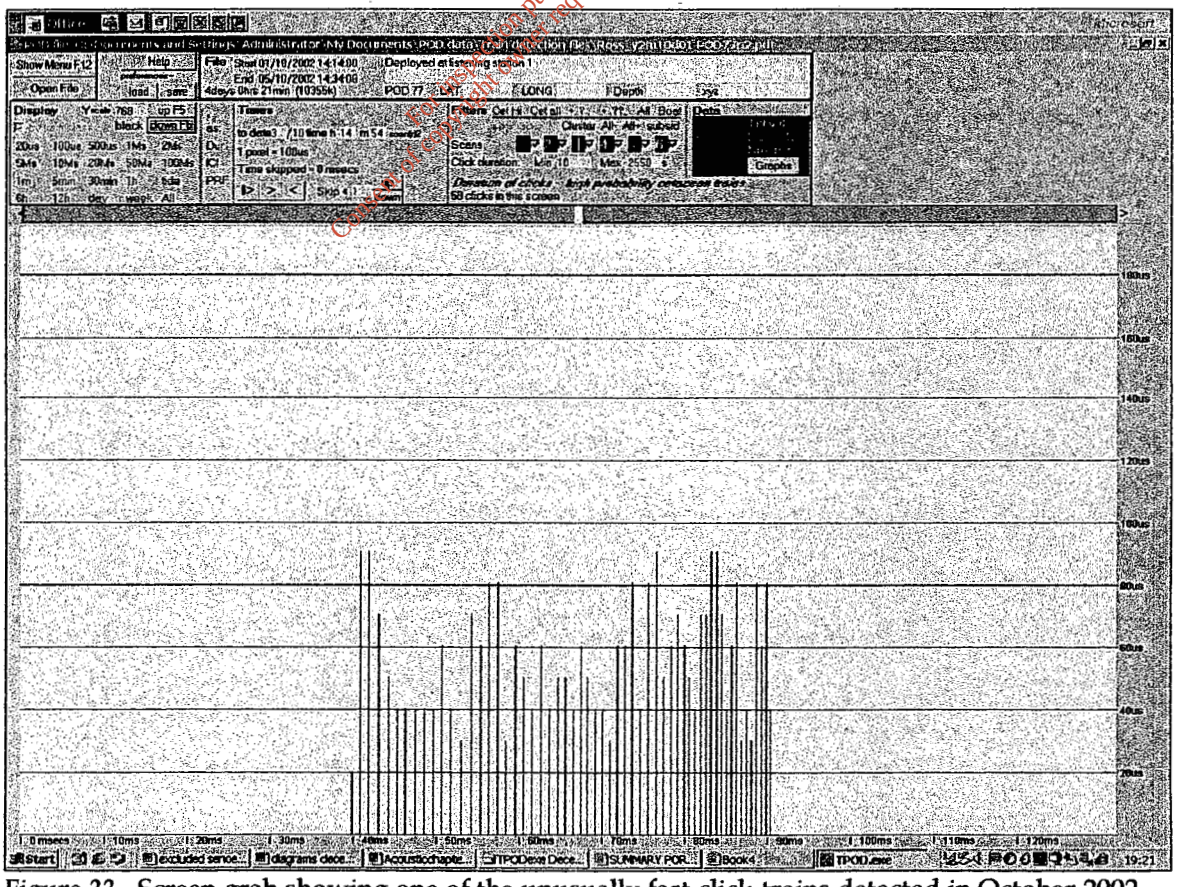

Figure 33. Screen grab showing one of the unusually fast click-trains detected in October 2002.



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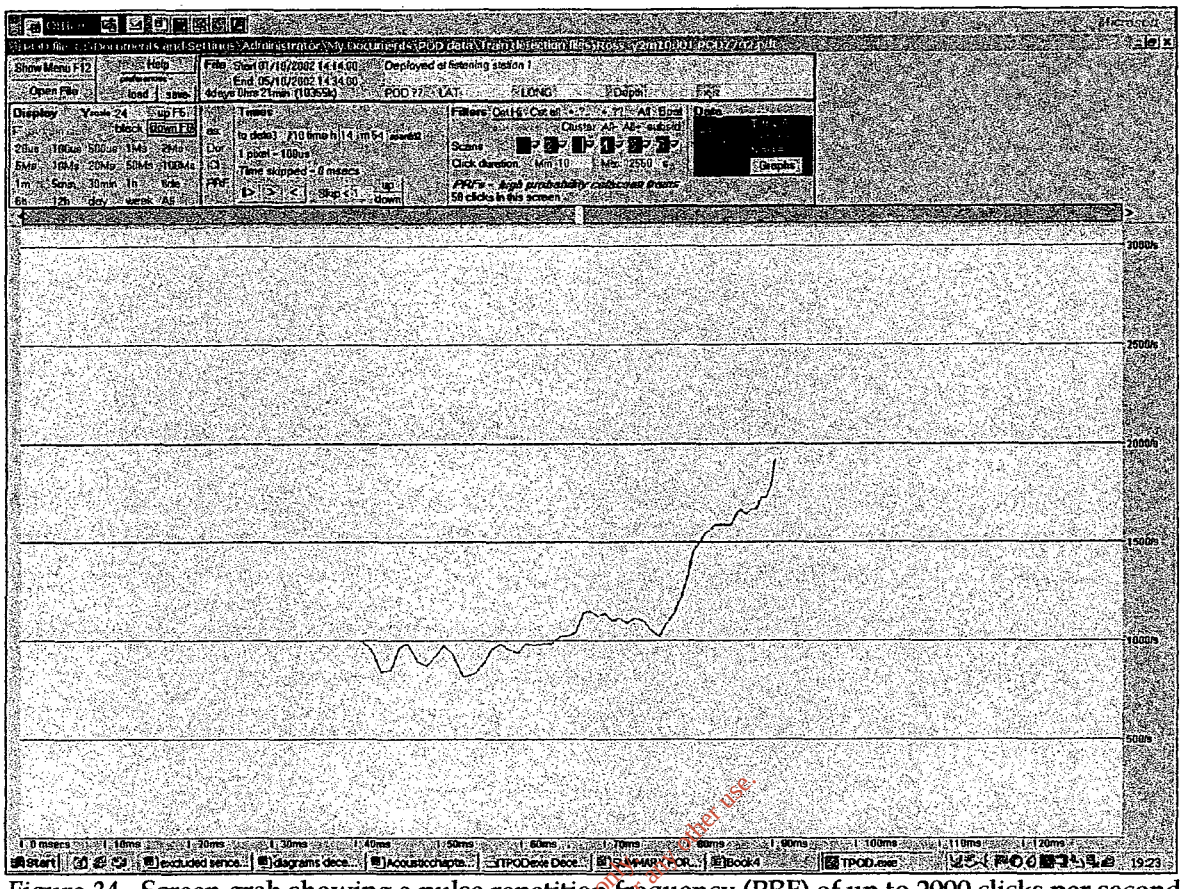

Figure 34. Screen grab showing a pulse repetition frequency (PRF) of up to 2000 clicks per second for the same click-train shown in Fig. 33. Number of clicks per second is shown on the y-axis and time on the x-axis.

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## 2.3.6 DISCUSSION

The acoustic data gathered in this study strengthened the results from visual observations in Broadhaven Bay, which indicated that the area supports considerable harbour porpoise activity and also sees the use of inner Broadhaven Bay by dolphins. This element of the project also provided new information on cetacean activity in the area outside daylight hours and when weather conditions did not allow for visual monitoring. Furthermore, the study's focus in Rossport Bay proved critical in assessing the potential impacts of construction activity on small cetaceans, providing a more effective means of determining appropriate management measures for the study area as a whole.

The method does, however, have its limitations PODs of all kinds showed some differences in sensitivity and consequently detection range. Furthermore, only animals that are (a) actively vocalising and (b) doing so within the detection range of devices, are recorded. The difficulty to detect dolphins acoustically due to the overlap between their echolocation and other marine sounds may have resulted in fewer dolphin detections than actually occurred in the study environment. Similarly, the stringent application of software analysis parameters in the present study may also have eliminated "true", albeit less distinctive, encounters with harbour porpoises. Neither of these factors could be avoided since the risk of false positive detections must always be minimised. Therefore, the number of acoustic encounters of harbour porpoises and dolphins respectively, should be taken as a minimum in the context of the present study.

The acoustic programme did not cover the entire study area for the total period of marine mammal monitoring. This was largely due to difficulties in obtaining sufficient equipment from



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the manufacturers. Nevertheless, the visual monitoring achieved before PODs were available allowed for the better planning and use of acoustic equipment in the study and the prioritisation of research aims. For example, it became clear during 2001 and early 2002 that harbour porpoises were potentially present year-round throughout Broadhaven Bay SAC. Thus the implementation of measures to safeguard these animals became immediately relevant. The establishment of an acoustic detection gateway in Rossport Bay was thus critical to the detection of these inconspicuous, vessel-shy animals within a potential "danger zone" and, should they occur therein, to their effective protection.

Without the information obtained from the POD units it would not have been clear whether harbour porpoises frequented the immediate vicinity of inshore construction. Only one sighting of the species was recorded in Rossport Bay during the entire study and all but one acoustic detection within Rossport Bay occurred when visual monitoring was not underway. The low number of simultaneous visual/acoustic encounters (n = 1) is likely to be due to a combination of frequent sub-optimal weather conditions (which ruled out the use of visual methods, though acoustic effort was maintained) and porpoise behaviour in the area.

The acoustic data obtained in 2002 showed that harbour porpoise activity in Rossport Bay occurred both day and night and during all months of monitoring. These results also supported monthly patterns obtained by visual means, which tentatively indicate an increase in harbour porpoise activity in the study area, as a whole, in late summer-autumn. It could not be determined if the observed peak in harbour porpoise encounters in May, as shown by acoustic methods, would also have been detected by visual methods. This was due to weather conditions which only allowed for comparatively low visual effort during this month.

The acoustic programme must be considered as a baseline study and diurnal, inter-seasonal and inter-annual variation in porpoise occurrence and habitat use cannot be discounted at this stage. In this respect, the higher acoustic encounter rate recorded by the southernmost listening station in the months of September and October 2002, while providing valuable background data on porpoise occurrence in the near-construction zone, requires additional monitoring to determine its validity over successive years.

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The detection of 46 dolphin encounters (via rapid click trains) over a successive five-day period in October 2002 cannot be fully explained at this stage. The detections in question were unusual and require further research. However, they are highly unlikely to be of non-cetacean origin due to their characteristics and there is no alternative source of sufficient interclick duration and frequency documented in the literature. Since the T-POD in question was working perfectly on deployments before and after these specific detections were made, it is unlikely that they were a result of malfunction.

The occurrence of dolphins in the inner reaches of Broadhaven Bay, indicated by acoustic means, were supported by visual data obtained by the research team in 2002. Both sources showed that groups of dolphins can occur well within Broadhaven Bay, while visual monitoring showed that more than one dolphin species may do so. Considering the nature of acoustic detections obtained, results from combined visual-/POD-based monitoring in the Shannon Estuary, click train characteristics known from other studies, and reliable reports of groups of bottlenose dolphins in the study area during the period of T-POD-deployment, it is considered that this species was probably responsible for many, if not all, dolphin detections recorded by the T-POD devices. However, since 64% of all dolphin detections occurred at night, the presence of other species (e.g. common dolphins) within acoustic range of the T-POD devices cannot yet be disregarded.



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In summary, the acoustic programme implemented in 2002 provided a vital component to the study as a whole and contributed towards the meeting of overall research objectives. The success of acoustic monitoring in combination with visual methods has been demonstrated in studies elsewhere in Ireland (i.e. Gordon *et al.*, 1999; Aguilar de Soto *et al.*, *in press*) and it is felt that ongoing studies of this nature should, by default, include an appropriate acoustic dimension whenever possible.

## 2.4 CONCLUSIONS FROM ACOUSTIC MONITORING

1. Acoustic monitoring provided key information that could not be obtained by other means (e.g. outside daylight hours) and contributed towards the meeting of research objectives;
2. Detection data obtained by acoustic means indicated that visual monitoring in the study area was relatively effective when weather conditions were appropriate;
3. POD/T-POD acoustic devices were deployed and recovered in the focal area with relative ease, allowing automated 24-hour monitoring for up to three weeks' duration per unit;
4. Total numbers of acoustic encounters for harbour porpoises (n = 45) and dolphins (n = 14) are considered to be minimum counts for the focal area, due to the analysis applied and the need to minimise false positive detections;
5. Acoustic data obtained in the summer of 2002 indicated that porpoises and dolphins occurred within the inner reaches of Broadhaven Bay during both night- and day-time;
6. While the acoustic research implemented in 2001-02 was somewhat limited in spatial and temporal coverage, this was necessary to the present study and the methods used would enhance and support future research in the study area as a whole;
7. The choice of a focal acoustic study area in Rossport Bay delivered a significant improvement in knowledge of porpoise/dolphin occurrence within this area. This confirmed assumptions made in the development of appropriate protection measures for marine mammals in the area.

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# 3
# PHOTO-IDENTIFICATION OF BOTTLENOSE DOLPHINS

## 3.1 INTRODUCTION

Bottlenose dolphins (*Tursiops truncatus*) are widely distributed across a range of marine and estuarine habitats in temperate and tropical waters (Wells & Scott, 1999). The species has been well documented in Irish waters from historical records (Fairley, 1981), sighting schemes (Berrow *et al.*, 2002) and cetacean research (e.g. Berrow *et al.*, 1996; Pollock *et al.*, 1997; Gordon *et al.*, 1999; Ingram, 2000; Ingram *et al.*, 2001). Recent research on cetaceans along Ireland's Atlantic Margin reported groups of bottlenose dolphins distributed predominantly off western Ireland, from shallow inshore waters to oceanic waters in excess of 2000m depth (Ó Cadhla *et al.*, *in press*). The study suggested that areas of importance for this species include not only coastal waters but also parts of the offshore Porcupine Seabight, the "Porcupine Shelf" and the adjacent continental slope areas. The western margin of the Celtic Sea has also been identified as an area of potential importance for bottlenose dolphins (Hammond *et al.*, 1995).

Studies have been undertaken on resident groups of bottlenose dolphins at various locations worldwide including, Shark Bay in Australia (Connor *et al.*, 1992), Sarasota Bay in Florida (Irvine *et al.*, 1981;Wells & Scott, 1990), Doubtful Sound in southern New Zealand (Williams *et al.*, 1993), and the Moray Firth in Scotland (Wilson, 1995). In addition a resident community of bottlenose dolphins has been identified in the Shannon Estuary on the west coast of Ireland. Using mark-recapture estimates the abundance of bottlenose dolphins using the Shannon has been estimated at 113 (± 16) (Ingram, 2000) and these dolphins have been the focus of research effort since the early 1990s (e.g. Berrow *et al.*, 1996, Ingram, 2000). Due to its status as an Annex II species under the Habitats Directive, the Shannon Estuary has been designated as a candidate Special Area of Conservation (SAC) for bottlenose dolphins in Ireland.

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Prior to the present work, published information (e.g. Gordon *et al.*, 1999), sightings collated by the IWDG (Berrow *et al.*, 2002) and local sources suggested that bottlenose dolphins might occur in the study area on an annual basis. Ingram *et al.* (2001) conducted a preliminary survey in the Broadhaven Bay area in August 2001 as part of an extensive west coast photo identification survey. Although no bottlenose dolphins were located in Broadhaven Bay by these authors, local anecdotal sighting information and the knowledge on bottlenose dolphins at other areas along the Irish west coast suggested that preliminary photo-identification of bottlenose dolphins in the study area might be appropriate to the present project.

Photo-identification is a useful and cost-effective technique whereby permanent nicks and marks on a cetacean's dorsal fin or tail-flukes are used to identify different individuals over time (Hammond, 1986). For bottlenose dolphins, nicks and tooth rakes on the dorsal fins acquired through interactions with members of the same species are usually used as identifying features (Würsig & Würsig, 1977; Würsig, 1978). Photo-identification has been used in studies of numerous bottlenose dolphin populations worldwide (e.g. Williams *et al.*, 1993; Wilson, 1995; Berrow *et al.*, 1996; Wilson *et al.*, 1997; Ingram, 2000). The method can be used to derive estimates of abundance based on mark-recapture analysis or to indicate patterns in habitat use (Wilson *et al.*, 1997; Ingram & Rogan, 2002) and social structure (Würsig & Jefferson, 1990; Ingram, 2000).

Since photo-identification is a non-invasive monitoring method and does not require physical capturing and handling of the animals, if boat disturbance is kept to a minimum it should not



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significantly affect the behaviour of the animals (Hammond, 1986) or introduce potentially impacts on the species in question.

Photo-identification as a means of individual recognition has its limitations. For example not all animals have identifying markings, and the degree of marking or the persistence of marks will differ between individuals. For example, Tolley *et al.* (1995) found male dorsal fins to be more scarred and marked than those of females. Some marks, such as superficial and deeper scratches to the skin, may often heal completely within 5-20 months whereas extensive fin nicks are permanent (Lockyer & Morris, 1990).

Such factors introduce bias into resighting probabilities for different animals, favouring the identification of well-marked individuals and excluding poorly-marked animals, and thus must be considered in subsequent analysis. Although the present study spanned just one year, it was felt that photo-identification might be a useful and cost-effective method for monitoring cetaceans in the study area. The aims of the photo-identification element within the present project were:

- To determine whether bottlenose dolphins encountered in the study area were suitably marked and approachable for photo-identification purposes;
- To determine whether the method was feasible in northwest Mayo, as a means of estimating the population size associated with the region, and of monitoring the species, its habitat use and ecology in the area;
- To investigate whether individually identified bottlenose dolphins encountered during the study displayed a level of "residency" to the study area.

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Such investigations could enhance the data gathered in the overall project, qualifying land-based and anecdotal sighting information and allowing the determination of the importance of these waters for this Annex II species. It would also allow a more effective determination of appropriate management measures for the protection of the species in the area (a) during the CORRIB marine construction phase, and (b) on an ongoing basis.

## 3.2 METHODS

### 3.2.1 BOAT-BASED METHODS

Surveys for bottlenose dolphins were conducted using the survey vessel both *systematically* via line-transect surveys *(see* 1.2.2*)* and *opportunistically* (i.e. when land-based or anecdotal sightings indicated the presence of animals in the area or whenever the survey vessel was mobilised for acoustic work). Encounters with groups of bottlenose dolphins began with an assessment of group size and composition, location and behaviour. When the research team determined that an approach by the vessel was appropriate and would not cause significant disturbance to the group, photographs were taken of the dorsal fins of as many individuals as possible, while keeping the time spent with the group to a minimum. Photo-identification was conducted using a standard SLR camera fitted with a databack and 300mm zoom lens. Colour transparency (i.e. slide) film (Kodachrome, 200 A.S.A.) was used in all photo-ID encounters and positional data were recorded either aboard the vessel using a GPS or derived from land using a theodolite.

### 3.2.2 ANALYSIS OF IMAGES

For each photo-identification session carried out in the field, slides for that encounter were examined using an 8x loupe magnifier and a light box. Standard procedures were used in the photo-identification process following Wilson (1995). Each slide was labelled as either the left or



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right side of the dorsal fin and photographs were also graded on the basis of their quality, taking into account focus, light, the orientation of the fin to the camera and distance from the camera. A datasheet was then filled out for each film, noting which side of the fin was photographed in each frame and also the image quality for each frame. Identifiable fins from each session were recorded using the film- and frame-numbers for each image and the highest quality photograph of each distinct identifiable fin was selected for subsequent analysis.

Some fins were readily identifiable from both left and right-hand sides due to their degree of marking and a slide projector was used to examine such slides closely. However some individuals could only be positively identified from either the left or right side. Each identifiable fin was then given a catalogue number and the best picture of that fin was traced carefully using a slide projector. The fins themselves were also graded, based on their degree of marking (1= permanent nicks and notches [e.g. Plate 10]; 2= less permanent tooth rakes; 3= subtle marks and patches). Details of each survey, encounters with dolphins and catalogue information were entered into a standard database used for photo-identification studies of bottlenose dolphins in the Shannon Estuary and along the west coast of Ireland (Ingram, 2000; Ingram *et al.*, 2001).

### 3.2.3 DATA ANALYSIS

The proportion of well-marked dolphins in the groups encountered was analysed (i) to determine the degree to which these dolphins were identifiable, and (ii) to assess the feasibility of carrying out ongoing photo–identification studies on these animals. The data were also examined to see if the rate of discovery of marked animals increased or decreased as the summer season and survey effort progressed (*see* Williams *et al.*, 1993; Wilson *et al.*, 1999; Ingram, 2000). This would give an indication of the abundance of dolphins in the area and how demographically closed the sampled population was, i.e. if other animals were moving into or leaving the group or study area during the season.

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The number of animals identified during each photo-identification session was compared with estimated group sizes from simultaneous boat and cliff-based counts. Cliff-based sighting records of bottlenose dolphin groups were also analysed, where possible, to assess whether recognisable individuals were present in the group, thereby supplementing photo-derived information on the degree of residency shown.

Mark-recapture analyses were not carried out on the dataset since photo-identification was confined to the summer season when weather constraints were significantly reduced. A comparison with the existing catalogue of photo-identified individuals along Ireland's western seaboard could not be made in 2001-02 due to time constraints.

## 3.3 RESULTS & DISCUSSION

### 3.3.1 PHOTO-IDENTIFICATION SURVEY RESULTS

A total of 13 boat-based surveys of the study area were carried out between June and October 2002. Seven photo-identification sessions were attempted during encounters with groups of bottlenose dolphins on these surveys. Three of these sessions occurred during systematic line-transect surveys (n = 9) of the study area, while additional photo-identification sessions were conducted opportunistically on casual surveys (n = 4). Two sessions were unsuccessful in that they did not yield any recognisable individuals. On both occasions this was due to poor weather and low light conditions, which made photography very difficult.



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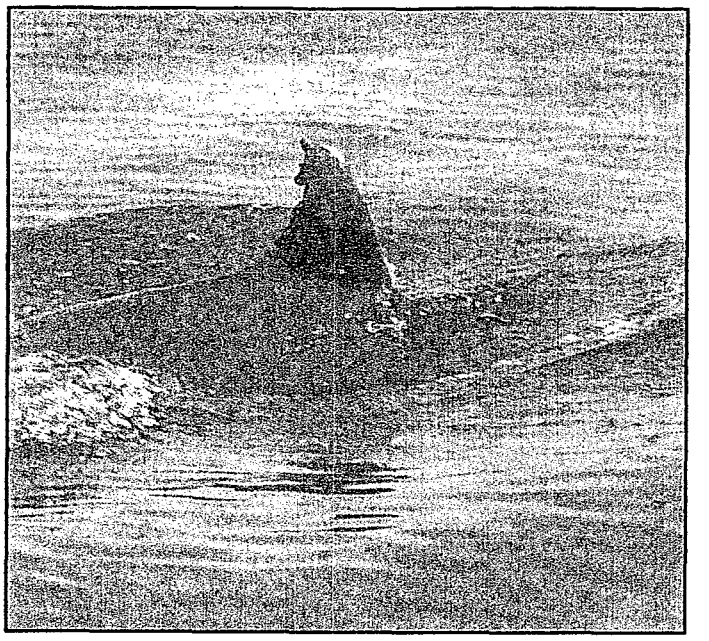

Plate 10. A side-profile image of the most easily recognised bottlenose dolphin encountered in the study area in 2002 - Animal number 1506.

A relatively high percentage (28.2% or 11 individuals) of dolphins had dorsal fins bearing permanent, distinct marks such as notches and nicks (Table 7). Two such individuals were recognisable by eye (Plate 10), which occasionally allowed them to be identified by eye when they were close to cliff-top monitoring sites. A further 35.9% (n = 14) of the dorsal fins examined in the photo-identification study contained less permanent but distinctive markings (e.g. deep tooth rakes) and 35.9% (14 individuals) of the remainder contained significant scratches or other lesions (Plate 11). Thus, within the 2002 study season, all animals photographed possessed recognizable markings, demonstrating that the photo-identification method was feasible in assessing the residency and numbers of bottlenose dolphins occurring in the area within 2002.

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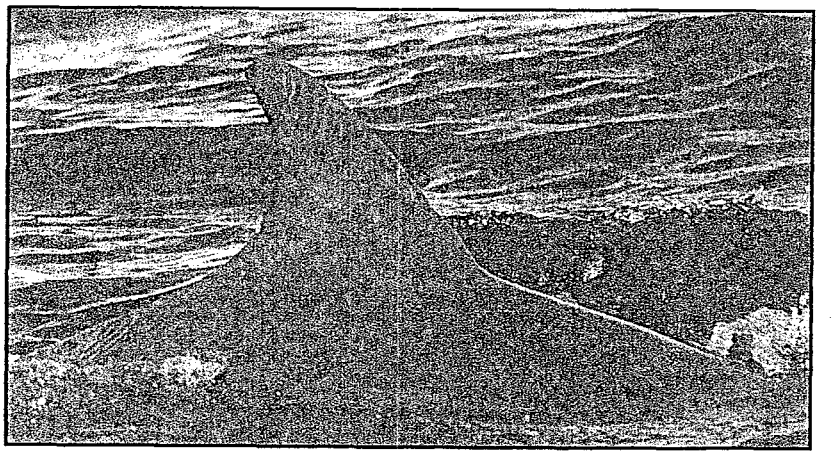

Plate 11. A bottlenose dolphin dorsal fin photographed in 2002, showing tooth rakes and other lesions.



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TABLE 7. Summary of recognition criteria for all bottlenose dolphin images from photo-identification surveys between June and October 2002. (*= Dolphins recognisable by both sides of the dorsal fin).

| Animal No. | Left side | Right side | *Nicks, Notches* | *Deep tooth rakes* | *Scratches, Other lesions* |
|---|---|---|---|---|---|
| 1501 | - | ✔ | – | O | - |
| 1502 | ✔ | - | – | - | Δ |
| 1503 | ✔ | - | – | O | - |
| 1504* | ✔ | ✔ | □ | - | - |
| 1505 | ✔ | - | □ | - | - |
| 1506* | ✔ | ✔ | □ | - | - |
| 1508 | - | ✔ | – | - | Δ |
| 1509 | ✔ | - | – | - | Δ |
| 1510 | - | ✔ | □ | - | - |
| 1512 | ✔ | - | – | - | Δ |
| 1513 | ✔ | - | – | O | - |
| 1514 | ✔ | - | – | - | Δ |
| 1515* | ✔ | ✔ | □ | - | - |
| 1516 | - | ✔ | – | - | Δ |
| 1517 | ✔ | - | – | - | Δ |
| 1518 | - | ✔ | | O | - |
| 1519 | - | ✔ | – | O | - |
| 1520* | ✔ | ✔ | □ | - | - |
| 1521 | - | ✔ | – | O | - |
| 1522 | - | ✔ | – | - | Δ |
| 1523 | - | ✔ | – | - | Δ |
| 1524 | - | ✔ | – | O | - |
| 1526 | - | ✔ | – | O | - |
| 1527 | - | ✔ | – | O | - |
| 1528* | ✔ | ✔ | □ | - | - |
| 1529 | - | ✔ | – | O | - |
| 1530* | ✔ | ✔ | □ | - | - |
| 1531 | - | ✔ | – | O | - |
| 1532 | ✔ | - | – | O | - |
| 1535 | ✔ | - | – | - | Δ |
| 1536 | ✔ | - | – | - | Δ |
| 1537* | ✔ | ✔ | □ | - | - |
| 1539 | ✔ | - | – | - | Δ |
| 1540 | ✔ | - | □ | - | - |
| 1541 | ✔ | - | – | O | - |
| 1542 | - | ✔ | – | - | Δ |
| 1543 | - | ✔ | – | O | - |
| 1544 | - | ✔ | – | - | Δ |
| 1545 | ✔ | - | □ | - | - |

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**TABLE 8. Records of all photo-identified bottlenose dolphins encountered during surveys in the study area in 2002. (* = Dolphins recognisable by both sides of the dorsal fin).**

| Animal No. | 28th June | 13th July | 19th July | 3rd Sept | 4th Sept |
|---|---|---|---|---|---|
| 1501 | ✔ | - | ✔ | ✔ | - |
| 1502 | ✔ | - | ✔ | - | - |
| 1503 | ✔ | - | ✔ | - | - |
| 1504* | ✔ | - | ✔ | ✔ | ✔ |
| 1505 | ✔ | - | - | - | - |
| 1506* | ✔ | ✔ | ✔ | ✔ | ✔ |
| 1508 | ✔ | ✔ | - | - | - |
| 1509 | ✔ | - | - | - | ✔ |
| 1510 | ✔ | ✔ | - | - | - |
| 1512 | ✔ | - | - | - | - |
| 1513 | ✔ | - | - | - | - |
| 1514 | ✔ | - | - | - | - |
| 1515* | ✔ | ✔ | ✔ | ✔ | ✔ |
| 1516 | ✔ | - | - | - | - |
| 1517 | ✔ | - | - | - | - |
| 1518 | ✔ | ✔ | ✔ | ✔ | ✔ |
| 1519 | - | ✔ | ✔ | ✔ | ✔ |
| 1520* | - | ✔ | ✔ | ✔ | ✔ |
| 1521 | - | ✔ | ✔ | - | ✔ |
| 1522 | - | ✔ | - | - | - |
| 1523 | - | ✔ | - | - | - |
| 1524 | - | ✔ | ✔ | ✔ | ✔ |
| 1526 | - | - | ✔ | - | - |
| 1527 | - | - | ✔ | ✔ | ✔ |
| 1528* | - | - | ✔ | ✔ | - |
| 1529 | - | - | ✔ | ✔ | - |
| 1530* | - | - | ✔ | - | - |
| 1531 | - | - | ✔ | ✔ | ✔ |
| 1532 | - | - | ✔ | - | ✔ |
| 1535 | - | - | ✔ | - | - |
| 1536 | - | - | - | ✔ | ✔ |
| 1537* | - | - | ✔ | ✔ | ✔ |
| 1539 | - | - | - | ✔ | - |
| 1540 | - | - | - | ✔ | - |
| 1541 | - | - | - | ✔ | ✔ |
| 1542 | - | - | - | ✔ | - |
| 1543 | - | - | - | ✔ | - |
| 1544 | - | - | - | ✔ | - |
| 1545 | - | - | ✔ | - | ✔ |

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A maximum of 39 individual dolphins were identified among the five successful photography sessions in 2002 (Table 7). Seven were identifiable from both the left and right sides of their dorsal fins. A further 17 animal numbers were assigned to dolphins whose dorsal fins were recognisable by the right side only; 15 to those recognisable only by the left side of the dorsal fin. A comparison of group sizes determined by photo-identification and visual means (Table 9) showed that group sizes determined photographically were commonly higher those recorded either from the vessel or cliff-top monitoring sites. This suggests that, on each encounter, there were animals photographed from both the left and right sides, whose corresponding images cannot yet be matched to the same individual. This is due to the type of markings carried, dolphin behaviour and the relatively short time-scale of the present study. Nevertheless, through a process of elimination, taking account of known and potential duplicate left and right matches, the minimum number of distinct dolphins photo-identified in 2002 was 25 individuals.

TABLE 9. Estimated sizes of bottlenose dolphin groups encountered on boat-based photo-identification surveys in the study area in 2002, determined from data collected during boat surveys and simultaneous shore watches.

| Date | Group size - estimate 1 *(observers-boat)* | Group size - estimate 2 *(observers-cliff)* | No. of dolphins *(photo-identification)* |
|---|---|---|---|
| 28 June '02 | 10 | >10 | 16 |
| 13 July '02 | 14-15 | - | 11 |
| 19 Aug '02 | 18 | 15-17 | 21 |
| 3 Sept '02 | 15 | 15 | 20 |
| 4 Sept '02 | 11 | 14 | 16 |

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The results of photo-identification in 2002 determined that at least one relatively large group of bottlenose dolphins occurred in the study area on a regular basis during the summer months, supporting the results of cliff-top surveys. Members of this group identifiable by their markings were encountered in all five photo-identification sessions within the waters of Broadhaven Bay SAC. Three highly recognisable individual dolphins were recorded in all successful photo-identification sessions. A further four distinct individuals were observed photographically on four out of the five sessions. Five others were identified on three occasions, 11 on two encounters and 16 were recorded in one photo-identification session only (Table 8).

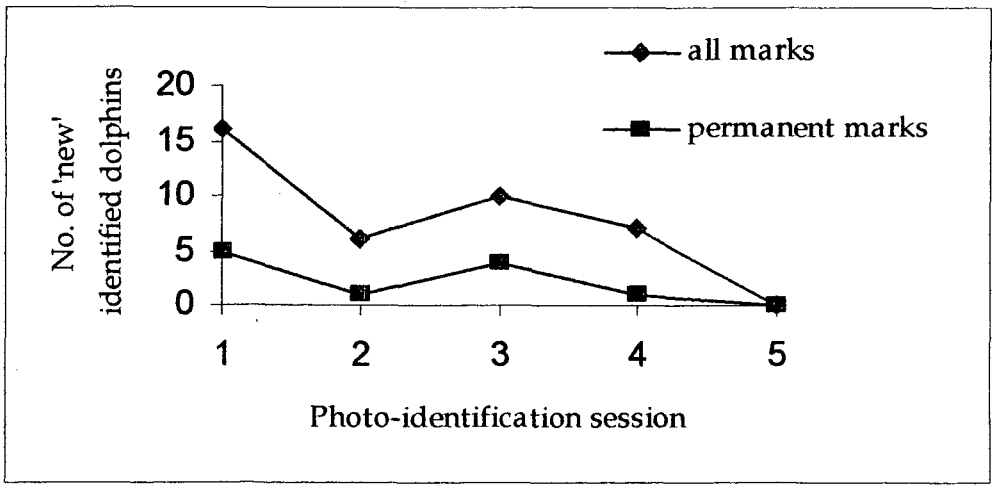


Figure 35. The rate of discovery of marked dolphins on successive photo-identification sessions in the study area in 2002.



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To determine the possible residency of bottlenose dolphins within the study area during the summer 2002, the rate of discovery of marked animals (Wilson *et al.*, 1999; Ingram, 2000) was assessed. In examining this feature (Fig. 35), it can be seen that the majority of dolphins could be identified from photographs taken during initial surveys and, by the fifth photo-identification survey, no additional identifiable animals were encountered. Since all identified dolphins had been photographed on at least one occasion and the rate of 'discovery' decayed with time, this implied a relative stability in occurrence of individually recognisable dolphins within the study area.

### 3.3.2 DISCUSSION

Although photo-identification formed a relatively short-term pilot study, it allowed a number of important research questions to be explored in the context of the CORRIB development within Broadhaven Bay SAC. These centred on the use of Broadhaven Bay and its neighbouring waters by groups of bottlenose dolphins, which are a protected species under Irish and European law.

There were few problems encountered with the method or the analysis of images obtained in the field. However, as with visual monitoring, local sea conditions during boat-based surveys occasionally made photography difficult in parts of the study area. Since there was a need to gather other data on the relatively few days when survey conditions were optimal, photo-identification was also attempted on sub-optimal days with varying success. In an ideal situation, it would be better to concentrate photo-identification on dedicated days when conditions are optimal but this is not often the case in the waters of north Mayo, particularly in the outer reaches of Broadhaven Bay.

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The photo-identification study was facilitated through simultaneous cliff-based monitoring and communication between observers, which allowed for the best use of time at sea and gave boat-based researchers the opportunity to temporarily avoid bottlenose dolphin groups when they were engaged in foraging behaviour. The study was also assisted by the presence of a relatively high proportion of well-marked animals that may be identified within and between years. Some individuals could be readily recognised from the survey vessel and even occasionally by cliff-top observers. Owing to its distinctive dorsal fin, one dolphin (animal no. 1506 - Plate 10) was identified a number of times during the summer in dolphin groups recorded by members of Atlantic RIB Charter, with whom the research team was working. Such information may prove useful in the further determination of residency and specific areas used by bottlenose dolphin groups along the northwest Mayo coastline.

While it is difficult to identify all individual dolphins by both sides of the dorsal fin within a single season, due to several factors (e.g. the number of fins without permanent nicks or notches), at least 25 individual dolphins were identified within the study area, many of which were encountered on two or more occasions. Photo-identification determined that at least one relatively large group of bottlenose dolphins occurred in the Broadhaven Bay area on a regular basis during the summer of 2002. In conjunction with sightings from cliff-based research (*see* 1.3.2) those from reliable local sources and the example from studies on the Shannon Estuary (Ingram, 2000) and elsewhere in western Ireland including Killary, Co. Mayo (Ingram *et al.*, 2001), it is considered that the species may be resident in the study area, at least in the summer months.

The degree of residency (or site fidelity) within and between years and a precise estimate of abundance cannot be determined at this stage. Data collected from cliff-based monitoring between 1 October 2001 and 30 September 2002 indicate the occurrence of bottlenose dolphins in the study area in all seasons. Combined cliff- and boat-based sightings in 2001-02 recorded bottlenose dolphins within Broadhaven Bay SAC on more than one third of days when the



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weather was suitable for surveying. However it cannot be assumed that these were always the same animals since photo-identification was carried out on less than 10% of survey days. On one noteworthy occasion, a group of approximately 17 animals, encountered on the evening of 26 August 2002, did not contain any distinctive individuals commonly seen or photographed in other sessions. Unfortunately, due to poor lighting conditions, the animals could not be photographed for identification purposes.

Since bottlenose dolphins are recorded along the entire western seaboard of Ireland (Ingram *et al.*, 2001) and the species' distribution also extends into deeper offshore Atlantic waters (Ó Cadhla *et al. in press*), it is very likely that the animals observed within the present study area are part of a larger population. Using the results of photo-identification data, the minimum number of bottlenose dolphins encountered within the study area in 2002 was 25. This figure was higher than the estimated size of any bottlenose dolphin group encountered during the 2002 season, either by boat-based or cliff-based means.

Estimates of group size derived by photo-identification may be higher than the true number of animals seen, particularly in pilot studies of this nature. This may be due to the number of unmatched left-side and right-side dorsal fins and field underestimation of group size. In the context of Broadhaven Bay SAC, this issue may be resolved by a more comprehensive photo-identification study in future years, which would provide data for a mark-recapture analysis of population size within the study area. In the case of the Shannon Estuary, mark-recapture population estimates based on photo-identification (Ingram, 2000) indicate a population size larger than that ever recorded simultaneously within the area, underlining the transient movements of bottlenose dolphin groups within a larger 'home range'. The photo-identification study conducted in 2001-02 throughout Broadhaven Bay and its neighbouring waters certainly suggested a level of residency by individual dolphins during the summer months but also indicated that some individual dolphins (e.g. those which were photo-identified on only one occasion) may join and leave a 'core group'.

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The use of photo-identification as a monitoring tool certainly proved feasible within the study area and will allow future comparison with bottlenose dolphin catalogues from elsewhere in western Ireland (e.g. Ingram *et al.*, 2001). Such integrated studies of bottlenose dolphins occurring along Ireland's coastline would be likely to yield important information on population size, structure, ecology, habitat use, and the relationship between inshore and offshore populations of this Annex II species as a whole.

## 3.4 CONCLUSIONS FROM PHOTO-IDENTIFICATION

1. The boat-based photo-identification technique allowed the successful identification of individual bottlenose dolphins occurring within the study area in the summer of 2002;
2. The method was facilitated in the study by simultaneous cliff-based monitoring;
3. A relatively high proportion of animals carried natural markings that allowed the identification of individual dolphins with relative ease;
4. The estimated minimum number of individually-recognisable bottlenose dolphins encountered in 2001-02 was 25, while the maximum number was 39;
5. Photo-identification data showed that a distinct group of dolphins occurred consistently in the study area in the summer of 2002. This group may be resident within the region;
6. The bottlenose dolphins encountered during the study are likely to be part of a larger population inhabiting the waters of western Ireland;
7. Future studies would be likely to allow the determination of local population size and the relationship between the study animals and other known groups of this species.



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# SCIENTIFIC CONCLUSIONS

## 1. Implementation of the research programme

Research was conducted quite successfully, although weather conditions in the region made field surveys difficult in some months. Schedule changes related to the development allowed for greater pre-construction monitoring than expected in 2002 and construction activities in Broadhaven Bay were comparatively limited within the summer season. Thus the present research project may constitute an effective minimum baseline study for the area.

## 2. The importance of Broadhaven Bay for marine mammals and other biota

Broadhaven Bay SAC and its neighbouring coastal waters undoubtedly represent an important area for marine mammals and other species. There are few, if any, comparable examples of a relatively small, discrete bay in Ireland containing all five Annex II marine mammal species with such frequency. It was also clear in 2001-02 that the area contained important foraging habitats for numerous marine mammal species, plankton-feeding basking sharks and seabirds. Recurrent encounters with photo-identifiable bottlenose dolphins during 2002 and sightings of newborn common and white-sided dolphin calves also underlined the area's potential as a breeding/rearing habitat for several cetacean species. Thus it is considered that the biological significance of the area, both described and potential, should not be overlooked at this stage.

## 3. Mitigation measures to protect marine mammals from significant impacts

During the course of the project, it became clear that several protected marine mammal species occurring in the study area could be affected by construction noise and other impacts associated with CORRIB's marine development phase. Since one of the research objectives of the study was to devise effective measures to mitigate all significant construction impacts on marine mammals, considerable effort was spent by EEI, CMRC and DÚCHAS devising measures that could allow the works to proceed under a customised protocol of agreed operational conditions. Such measures were eventually unnecessary for drilling & blasting construction phases in the study area, since these marine works were suspended in August-September 2002.

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## 4. Proposed drilling & blasting works within the waters of Broadhaven Bay SAC

In the context of construction-related drilling & blasting cycles, planned to occur in selected nearshore and foreshore bedrock areas, and for which impact mitigation measures were developed during 2002 through consultation between by CMRC, EEI and DÚCHAS, it is considered that such measures would be difficult to implement effectively due to strict weather constraints necessary for effective visual monitoring and the frequency with which protected marine mammal species were recorded in the inner part of Broadhaven Bay in 2002.

## 5. Continued monitoring in the waters of Broadhaven Bay SAC & northwest Mayo

It is considered on the basis of data gathered in 2001-02 that these specific waters represent a significant habitat for marine mammals and other biota. Therefore, all precautionary steps should be put in place to safeguard these animals and habitats from potential environmental degradation both in the short and long-term. It is further recommended that a marine mammal monitoring programme is continued in the study area prior to, in parallel with and following construction and pipe-laying activity in the region. The use of marine mammals as bio-indicators may itself provide an appropriate means of monitoring longer-term impacts on environmental quality of the CORRIB development.



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***Go raibh míle maith agaibh go léir.***

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