# Harbour Porpoise *Phocoena phocoena* Occurrence
# Carmarthen Bay - Gower Penninsula - Swansea Bay

## December 2002 - February 2004

## Report

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**Gower Marine Mammals Project**
**August 2004**

This paper reports the findings of an investigation into Harbour porpoise activity and occurrence off the South Wales coast. The study was a joint project by-

- Bridgend Biodiversity Partnership
- Carmarthenshire Local Biodiversity Action Plan Partnership
- Countryside Council for Wales Species Challenge Fund
- Gower Marine Mammals Project
- Neath Port Talbot Biodiversity Forum
- Swansea Biodiversity Steering Group.

The project was funded by CCW Species Challenge Fund grant SC7506, with "match funding" (cash and staff time) from Bridgend, Carmarthen and Neath Port Talbot County Borough Councils, the City and County of Swansea Council and GMMP.

The project was coordinated by Gower Marine Mammals Project (GMMP), on behalf of the partners.

# Acknowledgements

The initial project proposal, by GMMP, was developed and progressed by the enthusiasm and support of the project-partners' key officers: Steve Moon (Bridgend), Rosie Carmichael (Carmarthenshire), Aethne Cooke and Emily Dicks (CCW), Suzanne Waldron (Neath Port Talbot), and Deb Hill (Swansea). Early encouragement from Joan Edwards, Marine Policy Officer (the Wildlife Trusts) and Elizabeth May (Swansea Institute) was much appreciated.

Mick Baines (Nekton) provided early support and expertise. Nick Tregenza (Chelonia Marine Conservation Research) and Roy Wyatt (Seiche Instruments) gave continuous technical advice and support, and much practical help.

Keith Naylor (Swansea University) skippered the work-boat with unfailing good humour, endless patience in the face of eccentric requests, and an invaluable disregard for the temporal constraints of a normal working day. In addition to endless mugs of tea, he invariably delivered a full crew of volunteers back to port.

Mike and David Tonge (Gower Coast Adventures) and Mike O'Kane and Don Fletcher (Swansea Yacht & Sub-Aqua Club) each plumbed the depths to retrieve "lost" equipment. Chris Williams of Coastal Rib Tours provided boat time to help search for equipment. Dr Graham Savage (Strangford Loch Marine Laboratory, University College Belfast) kindly returned a missing POD to us.

Ted Solomons (Bryn Moel), Emyr Morris (Gwe Preseli) and Chris Williams/Eleri Owen (United Utilities) made generous donations of time and equipment to the project.



Numerous volunteers manned the boat, collected data, sourced and prepared equipment, and helped with data processing. Special thanks are due to the ever-present core-crew: John Galvin, Len Moran & Neil Price. Thanks also to Erica Colkett, Tom Colley, Rhian Jenkins, Sian McDonald, Emyr Morris, Sian Moran, Catrin Roberts, Steve Rosser, Robin Snape, Rob Taylor, Dave Thomas, Barbara Watkins & Hannah Webb

This research was conducted in part using software (Logger 2000 & Porpoise Detector) developed by the International Fund for Animal Welfare (IFAW) to promote benign and non-invasive research Some of this research was conducted using (hydrophone) equipment developed by the International Fund for Animal Welfare; the use of analytical software was licensed by IFAW.

# Summary

A joint project by Bridgend Biodiversity Partnership, Carmarthenshire Local Biodiversity Action Plan Partnership, Countryside Council for Wales Species Challenge Fund, Gower Marine Mammals Project, Neath Port Talbot Biodiversity Forum and Swansea Biodiversity Steering Group investigated Harbour porpoise occurrence in the northern-central Bristol Channel. The project was funded by CCW Species Challenge Fund grant SC7506, with "match funding" from the other partners.

The project ran from December 2002 until January 2004. Static hydrophones linked to data recorders were placed in Carmarthen Bay, off south Gower, in Swansea Bay and off the Porthcawl-Kenfig coasts: these devices monitored for passing porpoise, and recorded the ultrasound echolocation noise made by the animals. Boat-based survey transects were made throughout the area, from inshore to 10 miles offshore, using experienced observers and an array of towed hydrophones. Constant-effort shore-watches were made from suitable coastal vantage points, such as Worm's Head and Burry Holms; six years' shore-watch field notes were also entered into the project data-base.

Data were analysed to investigate porpoise distribution and the effects of tide, lunar cycle and daytime on porpoise movements, to identify porpoise "hot spots", to identify any simultaneous use of different areas, and to gather data which might eventually allow estimates of numbers in the area. Evidence of breeding (presence of calves) in the area was sought.

# Contents

# Introduction

The Harbour porpoise is the smallest and most numerous cetacean recorded in the north east Atlantic: the 1994 SCANS survey (Hammond et al, 1995) suggests a population of 36,000 over the Celtic Shelf between Ireland and Brittany.

Harbour porpoise typically occur in small groups of one to three animals. Their behaviour and presence is rarely obvious: unlike larger dolphins, they seldom show exuberant surface behaviours and, it is suggested, actively avoid boats. What little is known of their ecology comes largely from North American tagging/tracking-studies, and from post-mortem examination of stranded animals (various studies).

Porpoise are reported to feed on a wide range of fish species, particularly small schooling gadoids (eg. Read, 1999); squid (*Loligo, Illex*) are also taken, and might be locally and/or seasonally important (R. Penrose, pers. com).

High and unsustainable rates of mortality, associated with commercial fisheries bycatch, are reported from the Celtic Sea/Irish Sea (eg. Tregenza et al, 1997). Widespread concern about the species' status is reflected in its inclusion in the UK Biodiversity Action Plan "priority species" listing, and, in Wales, as a Species of Principal Importance under Section 74 of the Countryside and Rights of Way Act 2000.

Locally high densities of Harbour porpoise are known from coastal waters off south-west Wales (Reid et al, 2003), with large feeding aggregations frequently reported around the offshore islands and at Strumble Head in Pembrokeshire; several surveys have attempted to quantify porpoise use of these waters (eg. Pierpoint, 2001).

East of Pierpoint's study area (ie. east of Milford Haven) there has been no systematic attempt to evaluate porpoise occurrence or activity in the northern Bristol Channel. Prior to 1995, the Seawatch UK database held only four (casual) porpoise records from the area (M. Baines, pers.com.); a 1998 review of Welsh records (anon, 1998) was able to add only the early results of a single observer's constant-effort watches from the Gower peninsula.

From 1996 onwards, constant-effort seawatches centred around the Gower demonstrated a year-round porpoise presence off the west Glamorgan coast (pers. data). In 1999, a "Sustainable Swansea" funded project sought casual-sightings records from sea-users, resulting in a spread of porpoise records from Carmarthen and Swansea bays east to Port Talbot harbour approaches (GMMP, 1999). (Risso's dolphin *Grampus griseus*, Common dolphin *Delphinus delphis*, Basking shark *Cetorhinus maximus* were also recorded in the area.)

With the growing realisation of cetacean use of the northern Bristol Channel, and with Harbour porpoise listed in all of their Local Biodiversity Action Plans, the four coastal counties of Carmarthenshire, Swansea, Neath Port Talbot and Bridgend jointly initiated the study reported here, as a first step towards an understanding of Harbour porpoise use of the area.

# Objectives

The study sought to:

- gather quantitative porpoise-presence data at a range of sites throughout the study area (figure one), by the remote-collection of data via submarine hydrophones
- describe porpoise patterns of distribution across the study area, by observer- and towed hydrophone-transect survey across and through the study area.

Principal foci of interest, which data collection sought to address, included:

- patterns of seasonality of occurrence, across the area and at a range of sites with known regular porpoise activity
- diel, lunar (spring-neap variation) and tide-state (high-low : ebb-flo) patterns of activity at a range of sites
- simultaneous positive recordings at different sites, to indicate the presence of more than one "group" of animals
- comparison of simultaneous shore-watch and auto-collected data, to evaluate each
- to identify specific sites with elevated levels of porpoise activity
- to produce constant-effort survey data, to allow comparison with other, similarly treated, areas.

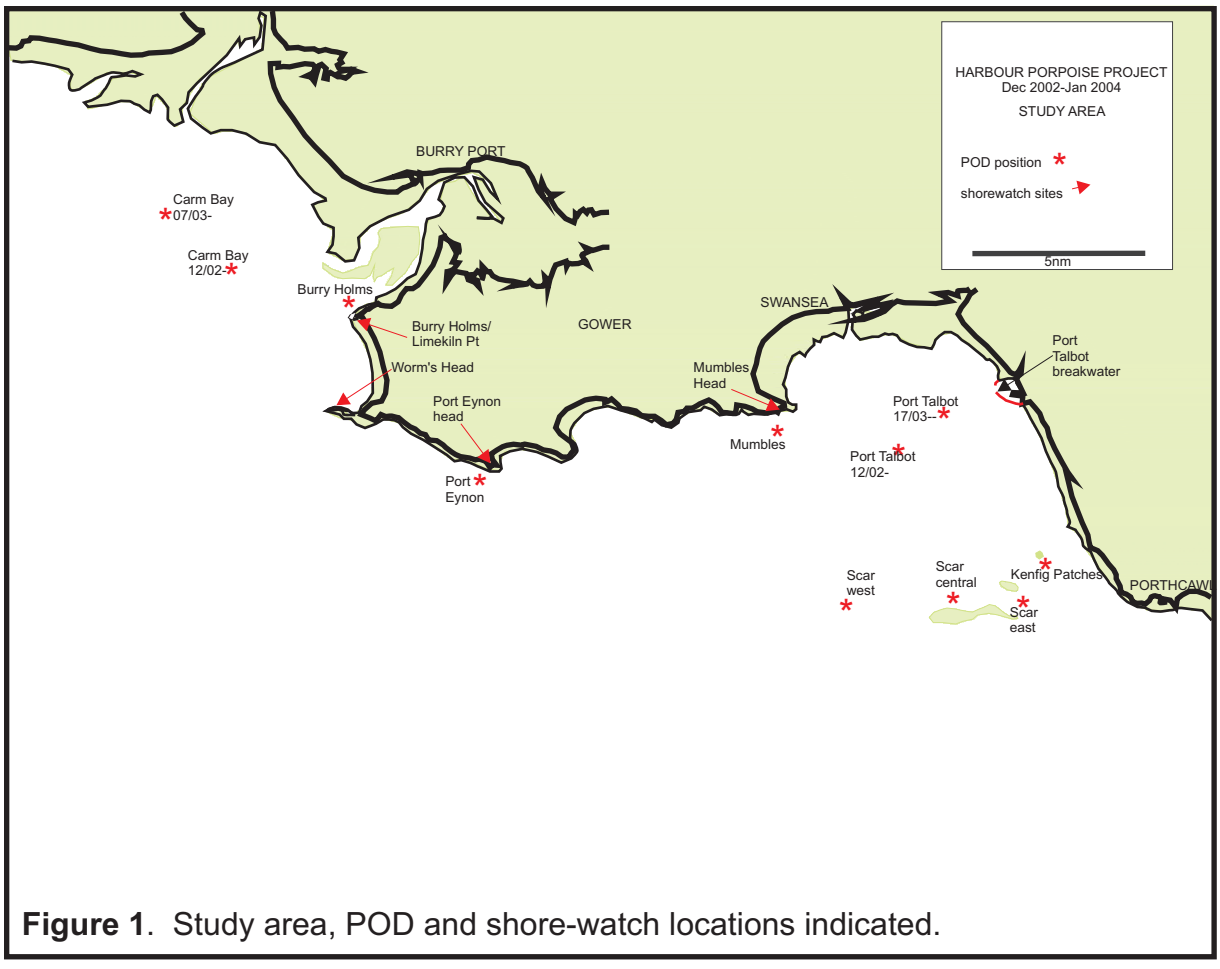



**Figure 1**. Study area, POD and shore-watch locations indicated.

# Methods

In this study, acoustic and visual surveying methods were utilised.

# Acoustic Surveying

Porpoise use ultrasound as a means of navigation and prey location. Their vocalisations can best be described as 'clicks'. They are narrow band vocalisations, with a principal frequency range of 115-145 KHz. Discussion of the acoustic dynamics of porpoise vocalisations is beyond the scope of this report, however, a number of researchers have measured harbour porpoise source levels (see Appendix 1).

Porpoise clicks are beyond the range of human hearing, which has an upper limit of 18-20 kHz. Surveying for porpoises using acoustic methods therefore requires the use of specialist electronic equipment. Two acoustic porpoise detection systems were utilised in this study: TPOD automatic data-loggers and IFAW hydrophones.

## T-POD – Porpoise Detectors

The POD (Figure 2) is a self-contained submersible hydrophone with computer that recognizes and logs echolocation clicks from porpoises and dolphins. The T-POD does not record sound, it simply logs the presence or absence of appropriate sound by selecting tonal clicks and recording their time of occurrence and duration. These data are subsequently processed on a PC to detect "click trains" (i.e. sequences of clicks), and classify the trains by their likely source. The POD cannot differentiate the individual-animal sources of click-trains, and does not count animals; the POD cannot record passing animals that are not emitting ultrasound, and it is likely that nearby animals whose ultrasound is directed in an opposite direction will not be recorded.

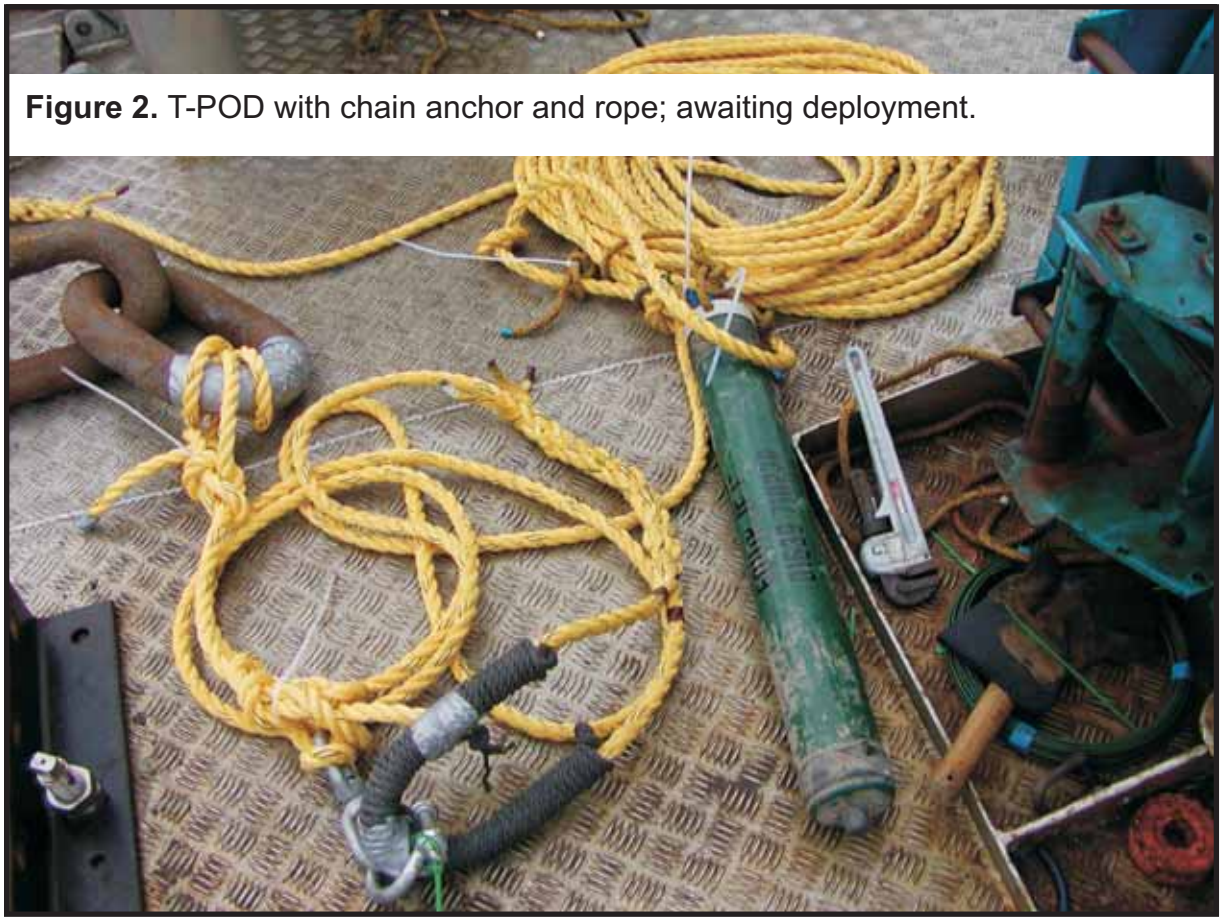


**Figure 2.** T-POD with chain anchor and rope; awaiting deployment.

The T-POD allows continuous data gathering, throughout the life of the internal battery pack (variable, but typically 40+ days with x6 D batteries). T-PODs continue to collect data during the hours of darkness and during heavy sea conditions and can be placed beyond the sight limits of shore-watchers. At a unit price of c£1500, POD data 'cost' is potentially far lower than the cost of boat time or shore-based observer time.

Bespoke software, TPOD.EXE, performs analyses of the recorded clicks. The software analyses the clicks and searches for click trains. This allows ambient and environmental noise e.g. shifting sand, dragging anchor chains etc. to be separated out. The effect of filtering out the non-train clicks is illustrated at figures 3a & b. The click trains are further analysed by the software to classify them by likely source, e.g. Cetacean detection or boat sonar/outboard motor (figures 3b & c). The probability that a given click train was produced by a cetacean is displayed and can be examined visually and exported for further analysis. TPOD.EXE classifies click trains as: "Cet-Hi" - high probability (red bar in the display), "Cet-Lo" - low probability (yellow bar in the display), "?" - unlikely (green bar in the display), "??" - very unlikely (white bar in the display) and "Boat" - high probability boat sonar (magenta bar in the display). When there is doubt about the origin of a click train, valuable when few clicks have been recorded, visual confirmation of the train's likely origin can be performed by an experienced user. This is possible because the narrow beam of the porpoise echo-location signal - a porpoise click about 1m ahead of a porpoise will occupy about 9 cm of water in its direction of travel and will extend sideways to about the width of a dinner plate (Nick Tregenza, TPOD Help files) - gives a characteristic pattern when displayed as clicks per second at high time resolutions by the software (figure 3d & 3e).

The electronics and software components of this system are 'new technology', subject to frequent revision and improvement: the experiences of this project have fed into this continuous refinement process.

Every minute, the T-POD executes six successive scans of 9.3 seconds each. Clicks are logged in units of 10microseconds and time is logged once per minute. The detection scans are programmable, and can be altered to suit environmental conditions (e.g. variation in ambient environmental sound) and target species. The T-POD selects clicks by passing the incoming hydrophone signal through two audio filters, 'A' and 'B', and measuring the ratio of the two resulting signals. The filters block all frequencies except those close to their target frequency.

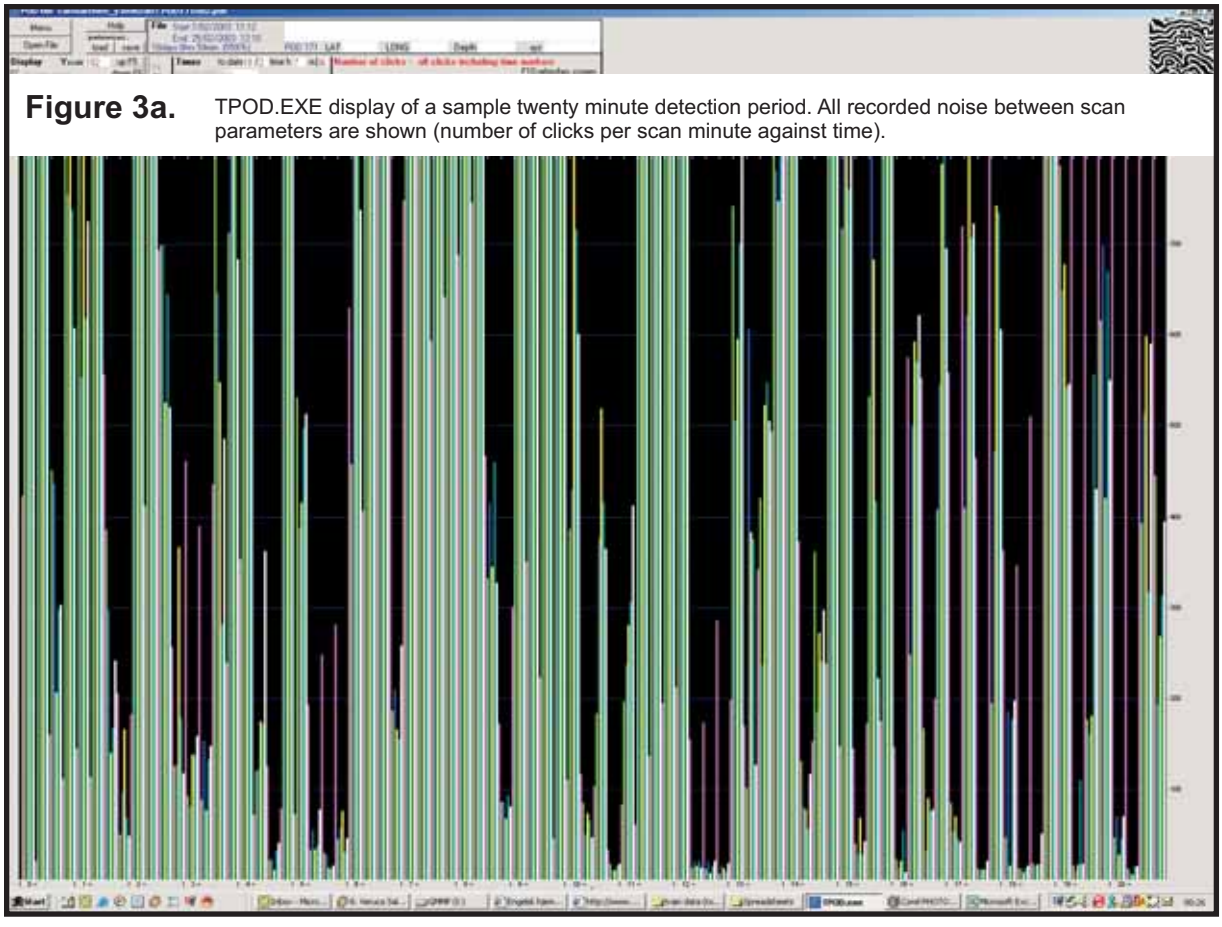


**Figure 3a.** TPOD.EXE display of a sample twenty minute detection period. All recorded noise between scan parameters are shown (number of clicks per scan minute against time).

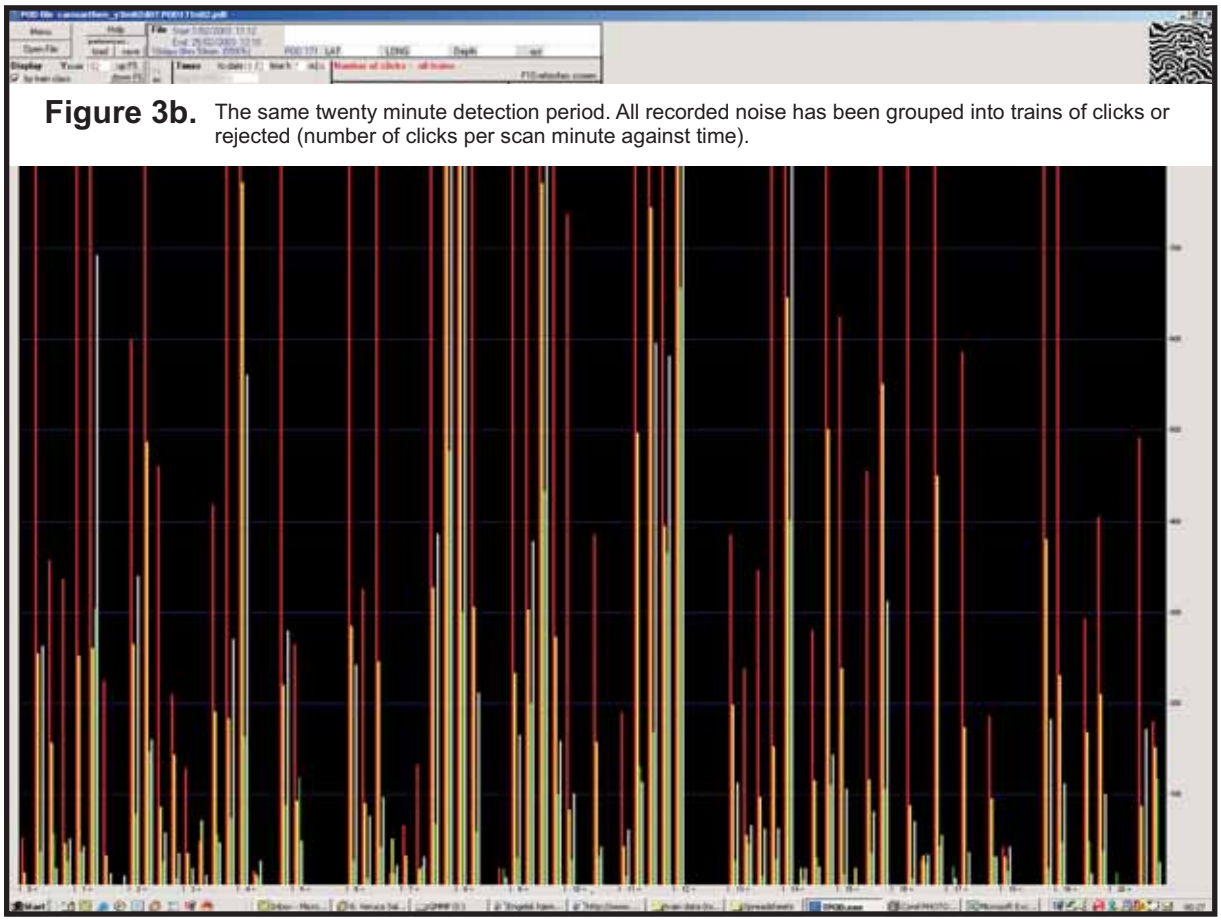


**Figure 3b.** The same twenty minute detection period. All recorded noise has been grouped into trains of clicks or rejected (number of clicks per scan minute against time).

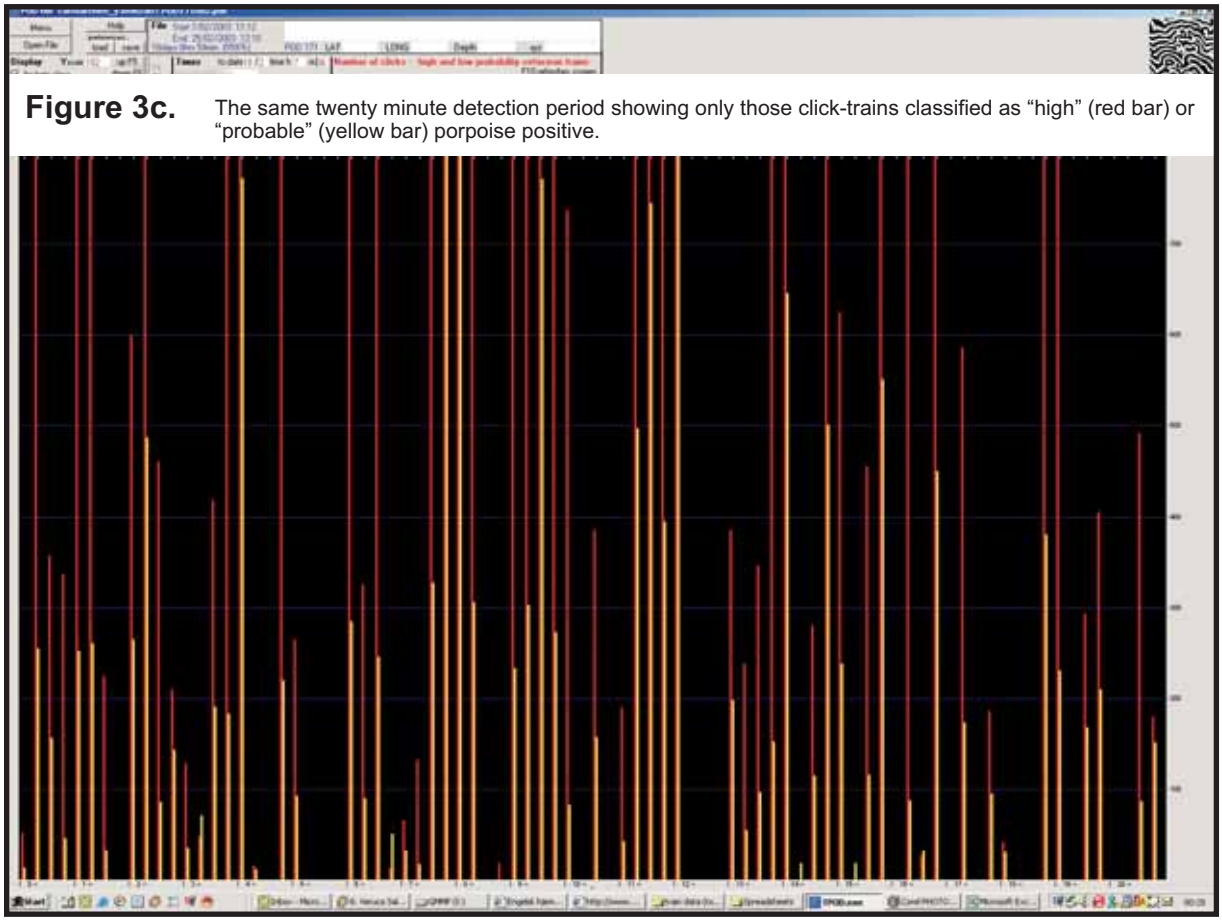


**Figure 3c.** The same twenty minute detection period showing only those click-trains classified as “high” (red bar) or “probable” (yellow bar) porpoise positive.

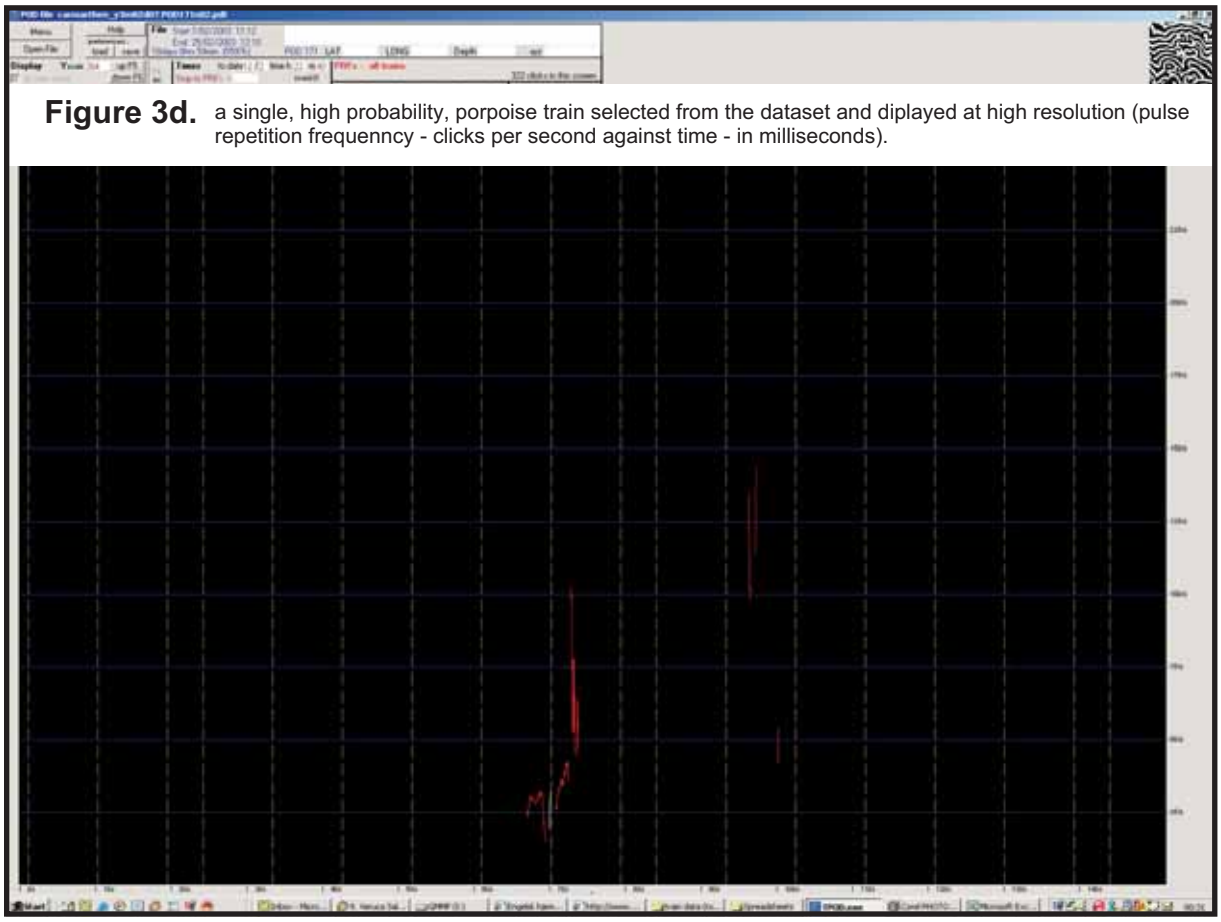


**Figure 3d.** a single, high probability, porpoise train selected from the dataset and diplayed at high resolution (pulse repetition frequenncy - clicks per second against time - in milliseconds).

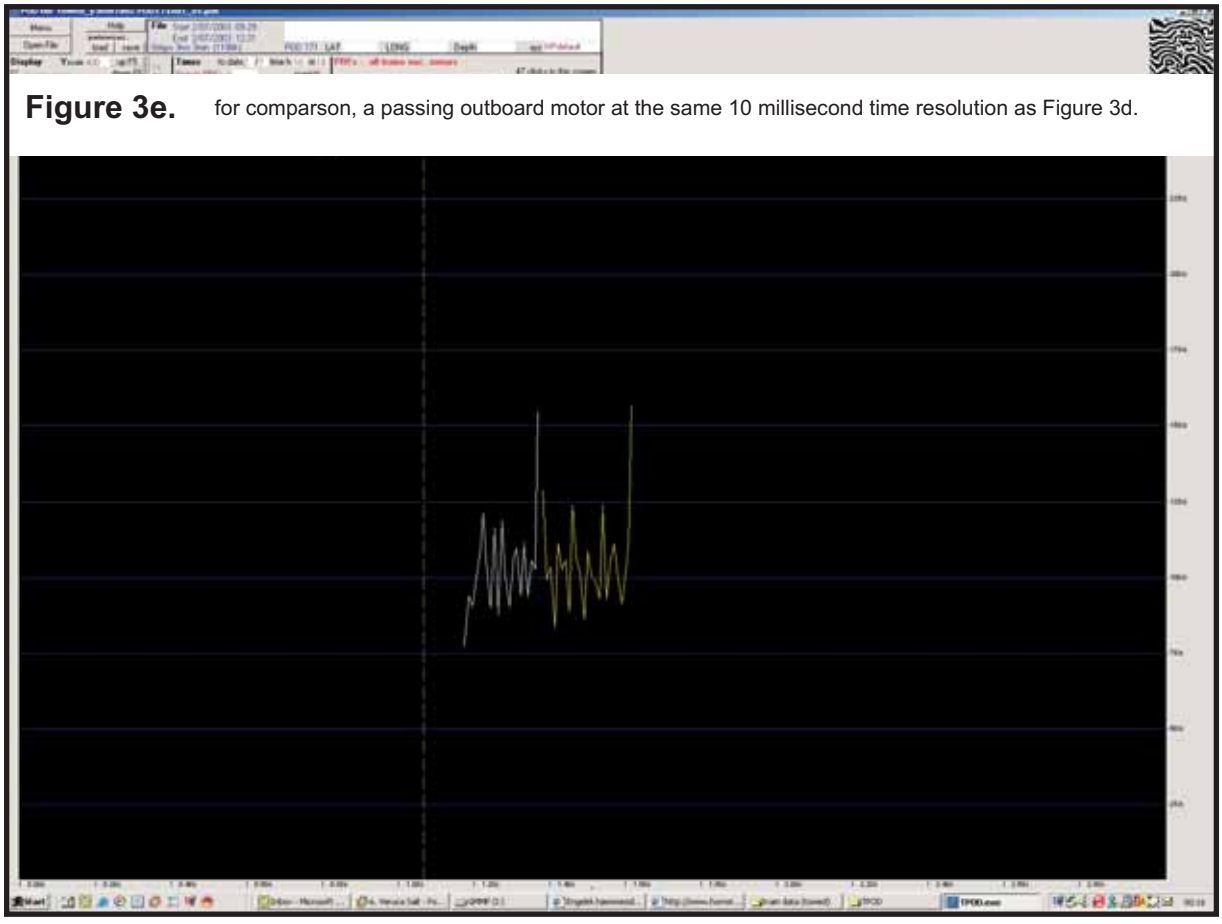


**Figure 3e.** for comparson, a passing outboard motor at the same 10 millisecond time resolution as Figure 3d.

Initially, the 'porpoise default' settings developed by the designer (table 1) were used in this study. With these settings, the T-POD listened for porpoises on all six of the available scans. However, after the first month of study, and discussion with the designer, these were amended to increase the specificity and decrease the sensitivity of the T-PODs. This reduced the amount of POD memory taken up by unwanted 'non-train' clicks. An additional change was made, to include a scan for bottlenose dolphins *Tursiops truncatus* at the same time (table 2), giving three advantages-

- scanning for Bottlenose dolphins
- allowing false positive porpoise detections caused by bottlenose dolphins to be detected
- allowing false positive porpoise detections caused by boat sonar to be detected.

Because the Bottlenose dolphin scan setting is more likely to be triggered by boat sonars than is the porpoise setting, it offers a useful cross-check. Porpoise will not trigger a positive result in the bottlenose scan but the opposite can occur (Nick Tregenza, pers. comm.).

**Table 1**

| | **Default Porpoise Detection Settings** | | | | | |
|---|---|---|---|---|---|---|
| | **Scan Number:** | | | | | |
| | **1** | **2** | **3** | **4** | **5** | **6** |
| **Target (A) filter frequency kHz** | 130 | 130 | 130 | 130 | 130 | 130 |
| **Target (BB) filter frequency kHz** | 90 | 90 | 90 | 90 | 90 | 90 |
| **Selective Ratio (A/B)** | 5 | 5 | 5 | 5 | 5 | 5 |
| **A' Integration Period** | short | short | short | short | short | short |
| **B' Integration Period** | long | long | long | long | long | long |
| **Minimum intensity** | 4 | 4 | 4 | 4 | 4 | 4 |
| **Scan limit on N of clicks logged** | 240 | 240 | 240 | 240 | 240 | 240 |

**Table 2**

| | **Revised Scan Settings** | | | | | |
|---|---|---|---|---|---|---|
| | **Scan Number:** | | | | | |
| | **1** | **2** | **3** | **4** | **5** | **6** |
| **Target (A) filter frequency kHz** | **50** | 130 | 130 | 130 | 130 | 130 |
| **Target (BB) filter frequency kHz** | **70** | 90 | 90 | 90 | 90 | 90 |
| **Selective Ratio (A/B)** | **4** | 5 | 5 | 5 | 5 | 5 |
| **A' Integration Period** | **long** | short | short | short | short | short |
| **B' Integration Period** | **long** | long | long | long | long | long |
| **Minimum intensity** | **8** | 4 | 4 | 4 | 4 | 4 |
| **Scan limit on N of clicks logged** | **120** | 240 | 240 | 240 | 240 | 240 |

## POD Deployment

Each POD was anchored to ground tackle, and positioned c.3m off the seabed on a rope to a surface buoy. Anchoring techniques are described in Appendix 2.

**December 2002-April 2003:**

On 6th December 2002, PODs were anchored at each of five sites:

| **Location** | **Latitiude** | **Longitude** | **Name of Nearest buoy/landmark** |
|---|---|---|---|
| Kenfig Patches | 51° 29'.144 N | 03° 46'. 349 W | Kenfig |
| Swansea/ Port Talbot | 51° 33'.588 N | 03° 52'. 395 W | Cabenda |
| Port Eynon | 51° 32'.049 N | 04° 13'. 313 W | East Helwick |
| Burry Holms | 51° 35'.724 N | 04° 19'. 955 W | Tip Burry Holms |
| Carmarthen Bay | 51° 38'.222 N | 04° 23'. 931 W | DZ6 |

- Kenfig Patches: an area of shallow sea and sandbanks, with deeper channels between, where tidal races were thought likely to give nutrient-stirring turbulence which would attract fish, and consequently porpoise.
- Swansea/Port Talbot: a shallow, sheltered bay with soft-sediment bottom; subject to heavy small-boat traffic from Swansea marina, and heavy-ship movements into the Port Talbot deep water harbour.
- Port Eynon: rocky headland, with known porpoise use; POD location within view of shore-watch site.
- Burry Holms: rocky headland tidal race where Loughour estuary meets Carmarthen Bay, with known porpoise use; POD location within view of shore-watch site.
- Carmarthen Bay: shallow, soft bottomed bay, with anecdotal reports of large aggregations of porpoise; POD siting restricted by military "no go" area.

These sites were chosen to-

- give a spread of locations from east to west
- sample areas of different coast/bottom topography
- sample areas beyond the reach of shore-watch effort
- coincide with areas of known activity (Port Eynon and Burry Holms), where simultaneous shore-watch data could be gathered and compared to electronically gathered data.

Notice of deployment (reproduced at Appendix 3) was i) posted at Porthcawl, Port Talbot, Swansea and Burry Port harbours, ii) posted to Swansea boats by the Noctiluca skipper, and iii) posted to South Wales Sea Fisheries Committee.

Between December '02 and April '03, PODs and/or mooring gear were lost at Kenfig Patches (unknown cause, POD subsequently recovered from Strangford Lough, Belfast), Burry Holms (buoys and ropes taken by fishing boat, POD and anchors jettisoned overboard- witnessed by shore-watchers), and Swansea/Port Talbot (dragged 1.5km off station, subsequently recovered). In the light of these failures, all PODs were taken ashore on April 17th.

**July 2003-January 2004:**

| Location | Latitiude | Longitude | Name of Nearest buoy/landmark |
|---|---|---|---|
| Scarweather | 51° 28'.554N | 03° 51'. 032 W | met. mast |
| Swansea/ Port Talbot | 51° 34'.680N | 03° 49'. 882 W | e. of deep water channel |
| Port Eynon | 51° 32'.049N | 04° 13'. 313W | East Helwick |
| Carmarthen Bay | 51° 39'.446N | 04° 27'. 112 W | within firing-range no-go area |

Trials of heavier mooring tackle and different buoyage were made (Appendix 2), off Port Eynon, during July '03. Using this revised mooring protocol, at sites considered less likely to be subject to interference, four PODs were deployed at:

Scarweather: the POD was sited close to the meteorological mast, north of Scarweather sandbank, in the hopes of minimising accidental trawling interference, and in the centre of the Shord Channel (the principal channel through the area)

Port Talbot: the POD was sited close to the deep water channel Solheim cardinal buoy, in the hopes of minimising accidental trawling interference

Carmarthen Bay: the POD was sited within the military firing range, by arrangement with the range commander, in the hopes of minimising accidental trawling interference. Boat access to this area is restricted during daylight hours

Port Eynon: original site.

**February 2004- July 2004:**

In connection with two follow-up projects within the study area, and using an extra POD supplied by United Utilities (a power supply company currently evaluating an offshore windfarm proposal within the area), five PODs were deployed in February '04 at Mixon Bank, Mumbles Head; at Port Talbot deep-water port approaches; at Hugo Buoy at the east of Shord Channel, Scarweather Sands ("Scar East"); at the meteorological mast, north of Scarweather Sands ("Scar Central"); at West Scar buoy, at the west of Shord Channel ("Scar West"). Data from these deployments, to the time of writing (August 2004), are incorporated into this report by agreement, because of their study-area relevance and to fill the April-June data gap in the 2003 dataset.

**POD Servicing:**

Each POD was visited at approximately monthly intervals, to download recorded data, replace the internal battery packs, and service the mooring gear. Initially, it had been planned that PODs would be site specific, however, concerns about equipment malfunction and the length of time required to upload POD data into the shipboard computer led to the adoption of a rotating deployment/pick-up protocol. With the purchase of additional PODs, this methodology became more efficient.

**POD Efficiency:**

Various factors resulted in data-collection failure, at different sites at different times-

- equipment loss: two PODs were permanently lost, one to direct interference (above) and one to unknown causes; loss of buoys/ropes delayed POD retrieval at two sites until divers could retrieve PODs
- equipment failure: two PODs were off-station for up to two months before being found and retrieved (below), when recovered, data had been lost- an artefact of the intermittent charging properties of failing batteries (Nick Tregenza pers. comm.); battery pack failure; tilt-switch mechanism malfunction; data rejected- eg dates scrambled; POD identification files corrupted; internal board noise; unknown causes
- other: excessive background noise filled internal memory.

## T-POD Data Analysis

First and second pass data analysis to identify and classify trains was performed by TPOD.EXE. Data were then exported and analysed using spreadsheet software (Microsoft Excel) and a statistical analysis package (SPSS). The following data tables were produced for analysis:

**Initial Analysis (TPOD.EXE)**

- Encounters Per Day
  The narrow beam of the Porpoise echolocation click can result in periods of non-detection even when porpoises remain in the vicinity of a POD. It has therefore become common practice to group porpoise-train-positive minutes as “encounters”, ignoring intervening periods of silence if they fall within a threshold value of 10 minutes. The number of encounters per day export function is a convenient tool for reviewing the gross details of porpoise activity at a given location and has been extensively used since it was incorporated into the software in March 2004 to produce summary updates. It is, however unsuitable for fine-scale analysis in this survey because TPOD.EXE cannot conditionally exclude scans 2-6 based on the state of scan 1 (the Bottlenose Dolphin error-check scan).
- Train Positive Minutes Per Day
  This export function, which sums the number of minutes per day that contain selected scans, has been used for reviewing the gross details of porpoise activity at a given location. It is unsuitable for fine-scale analysis in this survey.
- Encounter Details
  This export function lists the start time, finish time and number of recorded clicks in a porpoise encounter. It too has been used for reviewing gross details of porpoise activity but is unsuitable for fine-scale analysis in this survey.
- Train Details
  This export function lists full details of train classifications at a desired resolution. In this study, it is the principal export function used, as it provides information on which scan provided the

information that resulted in the final designation of a given minute (high", "probable", "doubtful", "very doubtful" or "boat"). This export function allows for detailed analysis of the data to be carried out post-export and is the chief export method used.

**Further Analysis (EXCEL, SPSS)**

Spreadsheet software was used to complete the analysis of the Train Details tables produced by TPOD.EXE. Specialist analysis software was written using the Visual Basic for Applications (VBA) programming language. Automatic data processing was necessary because of the volume of data and to allow for the continual addition of additional data without the need to reset any of the data worksheets. The analysis functions are robust enough to cope with the addition of new data until 2010 without significant changes to their code. The following analysis functions were developed and have been used to classify the data:

- Train Exclusion
  Train-details export data were selected and analysed to calculate the number of porpoise positive minutes (minutes containing trains classified as either "high" or porpoise "probable") in scans 2-6 that were to be excluded from the analysis because of a porpoise positive minute in scan 1, the error check scan.

- Hour of Survey
  Train-details export data were selected, and porpoise positive minutes were grouped by the hour of survey (GMT). This produced a table listing the number of train positive minutes per hour for use in calculating porpoise detection success and searching for simultaneous detections (Shorewatch Data were also included in this analysis).

- Simultaneous Detections
  Porpoise positive hours were selected, based on hour of survey (as above), and the number of porpoise positive hours that contained porpoise positive minutes in separate detection locations were calculated (Shorewatch data were also included in this analysis).

- Classify by Tide
  Train details export data were selected, and porpoise positive minutes (as above) were classified by state of tide. WTIDES, a tide prediction program (see Appendix 4), was used to produce tide tables for Mumbles based on the BODC dataset. Tide was defined as being made up of 12 zones of equal length where period 1 was the first hour of tide from low water and period 12 the last hour back down to the next low water. Shorewatch data were also included in this analysis.

- Classify by Lunar Day
  Train details export data were selected, and porpoise positive minutes (as above) were classified by day of lunar month using tables produced by WTIDES. A lunar month was classified as 28 periods of equal length beginning and ending with the rise of the New moon. Shorewatch data were also included in this analysis.

- Classify by Day State
  Train details export data were selected, and porpoise positive minutes (as above) were classified by day state using tables produced by WTIDES. Four zones were defined: Dawn (the period from start of nautical twilight to sunrise), Day (the period from sunrise to sunset), Dusk (the period from sunset until the end of nautical twilight) and Night (the period between the end of nautical twilight and the beginning of nautical twilight). Shorewatch data were not included in this analysis as no night-time porpoise watches were conducted.

- Encounters (corrected)
  Train details export data were selected and the encounter rule (less than ten minutes separation between porpoise positive minutes) was used to calculate encounters based on the accepted data. These data were then re-analysed to identify porpoise use that was spatially separated but temporally associated.

- Classify by 24 hours
  Train details export data were selected, and porpoise positive minutes (as above) were classified by 24 hour clock. This was performed to provide a variance reference dataset for use as a control in further statistical analysis.

- Classify by month
  Train details export data were selected and grouped by the month in which they occurred.

- Recording Summary
  Additional code was also written to calculate how many days in a given month a POD had been active and provide various statistics which have been used to calculate effort.

Many of the tables produced by these programs are too large to include in this report. However, the summary tables and associated graphs are included below (see results section).

Purchase of a license to use SPSS is beyond the means of the Gower Marine Mammals Project and did not form part of the original grant application because it was not, at the time, deemed necessary. Statistical analysis has been conducted with the assistance of the Biology Department, University College Swansea, on an ad-hoc basis.

## Towed Hydrophone

An initial intention to conduct hydrophone transect surveys by towing a low-cost, custom built hydrophone, linked to an amplifier and headphones (to allow aural identification) was abandoned when the supplier failed to deliver.

Following the reported success of other groups, efforts were made to tow a TPOD whilst in transit between anchored PODs. Numerous operational difficulties were encountered. Chief amongst these was the project's inabilty to successfully tow a POD, in spite of many hours experimentation: numerous professional and home-made devices (figure 4) failed to position the POD at a constant depth whilst under tow, and a range of tow-distances made no difference to the swamping of the POD recorder by unacceptable broadband noise (figure 5). Additionally, inter-POD travel times regularly had to be used to service and repair various equipment and the inter-POD distances precluded adding static "service time" to the daily schedule; it was also found that the time necessary to pay out a towing rig, and take it in on approach to an anchored POD, was unrealistic in the context of transit times. Methods of towing are detailed at appendix 5.

POD towing was abandoned when the IFAW system became available in September 2003.

## IFAW hydrophones and Logger

The IFAW system is named after its creators, the researchers of the International Fund for Animal Welfare. This equipment is now produced under licence by Seiche Electonics of Devon, UK. Equipment was provided by Seiche on a trial basis and has subsequently been leased. Use of the system and analysis software was governed by the terms and conditions of use laid down by IFAW (see Appendix 4).

The system (figure 6) comprises of a serial arrangement of two hydrophones with sufficient reinforced cable for them to be towed behind the survey vessel at a distance of 50m (figure 7). The array also contains a depth gauge so that behaviour in the water can be monitored. Signals from the hydrophones are received on-board by an analogue electronics module that uses high band-pass filters to split the hydrophone signals into three frequency bands, one covering the 115 to 145 kHz band where porpoises are known to vocalise (the “porpoise band”) and two lower (reference) frequencies at 50 and 71 kHz (figure 8). The combined response of the hydrophone element, cable, preamplifier and filters for each of the three bands are shown in the graph below (figure 9).

The signal from the front hydrophone, closest to the boat, provides the unit with 50Khz, 75Khz and 125Khz frequency signals; the rear hydrophone provides a single 125Khz signal.

Envelope tracing circuitry within the analogue unit converts the high frequency signals to lower frequencies, which are digitised by, and then analysed on, a computer. The signals from the three envelope tracing circuits are digitised at a sample rate of 25kHz using a 12 bit ADC board with a full scale of 5V.

The digitised signal is analysed by bespoke software developed by IFAW. The software decides whether clicks are likely to have been produced by porpoises or by another source based on the relative amplitudes of the signal in the three frequency bands and on the shape of each detected pulse (figures 10 & 11). It is also capable, with its dual hydrophone system, of estimating bearings to detected clicks based on the difference in arrival time of the signal at each hydrophone. Further information on the operation of the porpoise detector is available in the help files supplied with the software. The software is available, free of charge, from IFAW via their website (http://www.ifaw.org).

Click start times and the envelope waveforms are written to binary data files for permanent storage; these are analysed in real-time but can also be analysed off-line. Porpoise-like clicks are selected by requiring a minimum amplitude in the porpoise band and a minimum difference between the amplitude in the porpoise band and the mean background level.

Due to the small overlap between the distributions of porpoise click amplitudes and those of other click types it is impossible to unambiguously distinguish any but the louder porpoise clicks from background noise.

Porpoise detection events identified by the Porpoise detector software are automatically passed to

**Figure 4.** T-POD with towing rig, awaiting deployment (see appendix 5).

**Figure 5.** Sample T-POD display showing excessive noise from the tow.

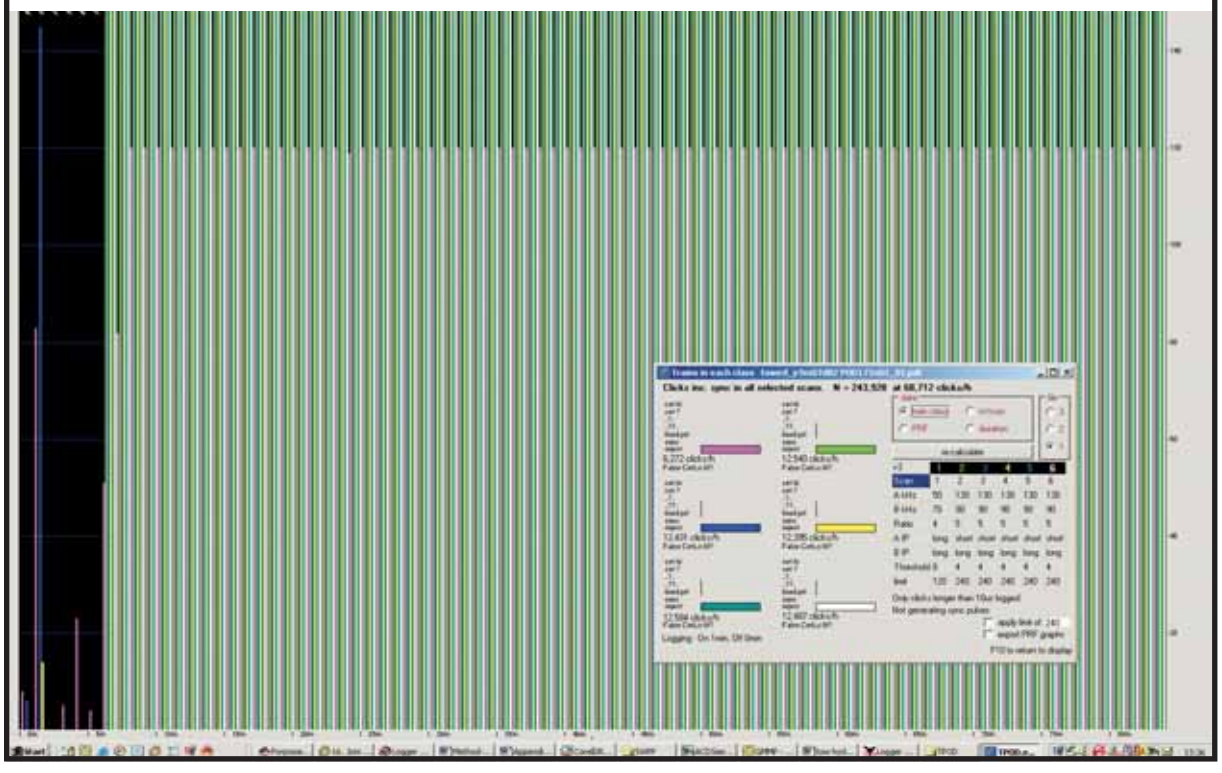


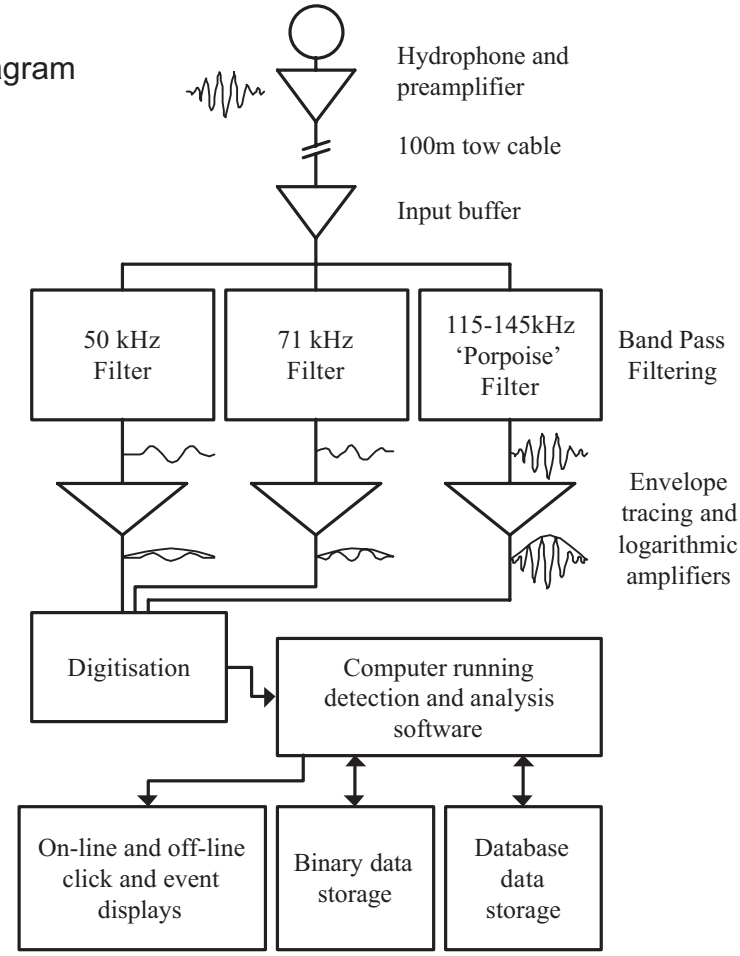
**Figure 6.** The IFAW monitoring hardware in use aboard Noctiluca.

**Figure 7.** Checking on the Hydrophone during a transect tow.

**Figure 8.**
IFAW Hydrophone Schematic Diagram

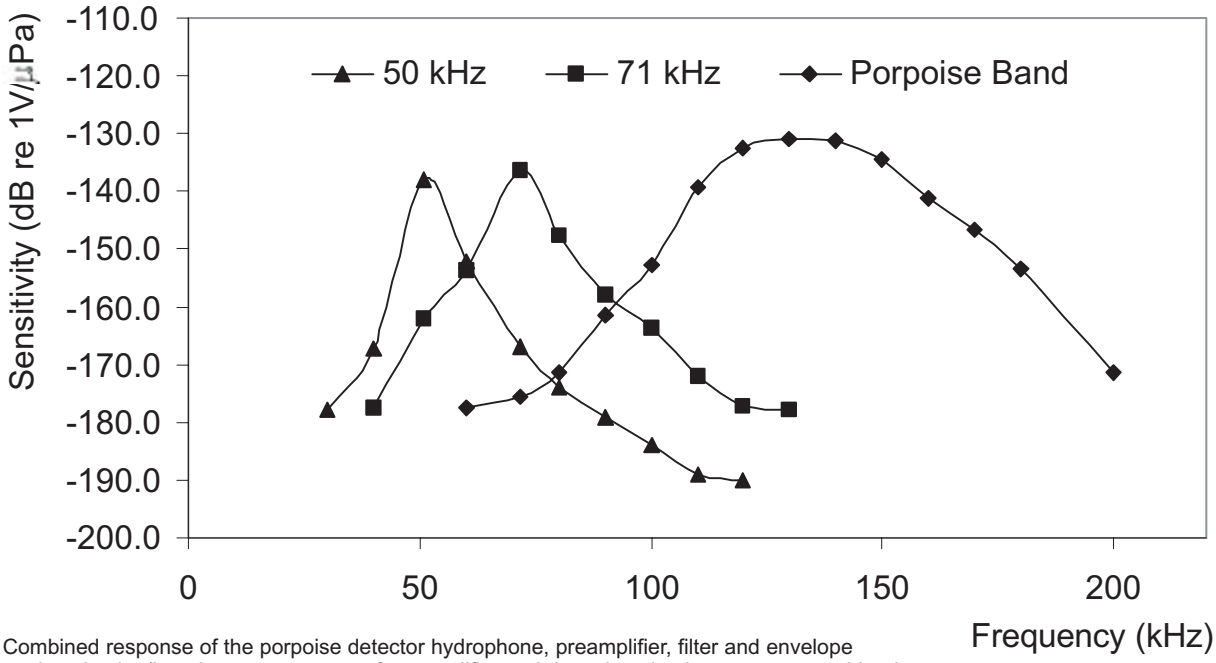
Schematic and graph reproduced from the help files supplied with the IFAW analysis software.

The software is available, free of charge, from IFAW via their website (http://www.ifaw.org). Further information and conditions of use are contained at appendix 5.




Schematic diagram of the porpoise detection equipment.

**Figure 9.** Frequency Response of Hydrophone and Analog Electronics




Combined response of the porpoise detector hydrophone, preamplifier, filter and envelope tracing circuits (bench measurements of preamplifier and detection circuit responses combined with the manufacturers hydrophone specification)

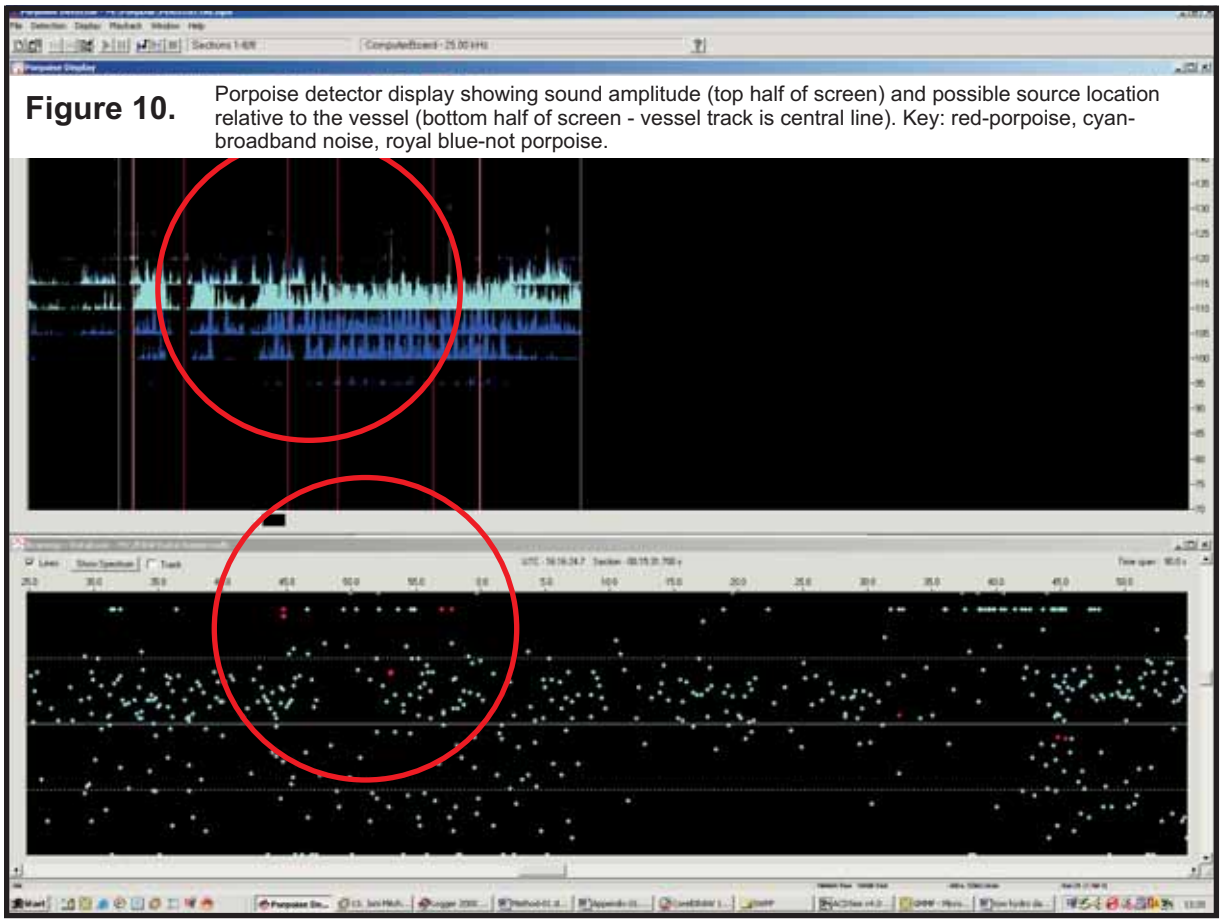


**Figure 10.** Porpoise detector display showing sound amplitude (top half of screen) and possible source location relative to the vessel (bottom half of screen - vessel track is central line). Key: red-porpoise, cyan-broadband noise, royal blue-not porpoise.

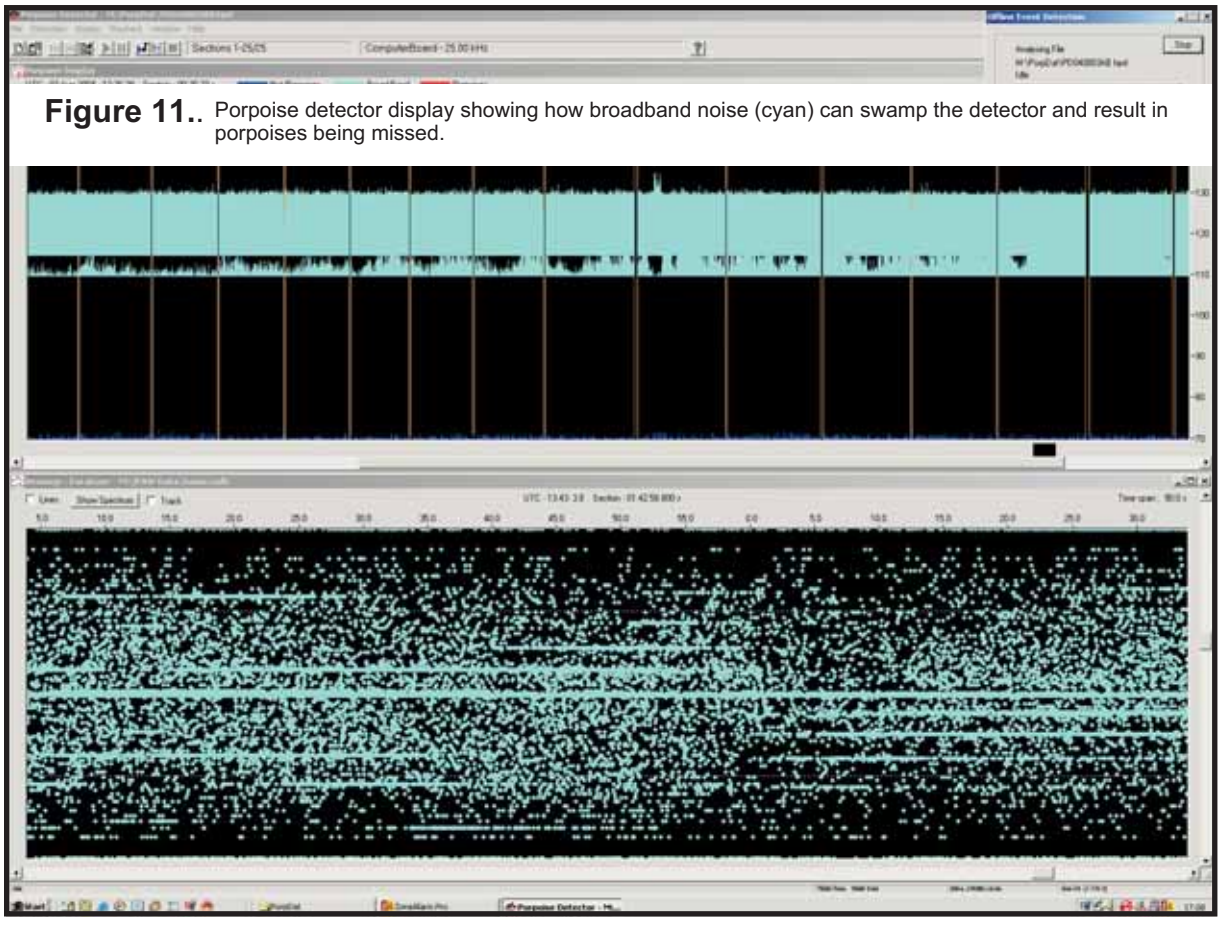


**Figure 11..** Porpoise detector display showing how broadband noise (cyan) can swamp the detector and result in porpoises being missed.

Logger, a companion utility that logs the event in a Microsoft Access database. The Logger software also checks the vessel's position using a GPS receiver and records this. Using Logger and Access it is possible to review all transects covered and record effort. Logger output, showing the transects covered by the hydrophone survey, can be seen at figure 12.

**September 2003-August 2004**

Offshore porpoise occurence was surveyed during five dedicated days during September 2003. Three offshore blocks, 10x5nm, were drawn between five to ten miles off the coasts of Carmarthen Bay/west Gower, south Gower and east Glamorgan: each block was drawn generally parallel to the nearest coast (figure 13). A 1nm-spaced grid was overlain on each block, to give a series of potential start points: start points at each block were selected randomly, and 30nm transects begun at these points on a zig-zag course to marked points on the opposite side of the grid, giving a route that crossed, rather than followed, sea-bed topography.

The hydrophone array was towed, at 8 knots, throughout these transects, and two observers at the bow surveyed using the methodology described below (see visual survey) (with the exception of 13.7nm of hydrophone-only survey, when sea conditions precluded observer survey).

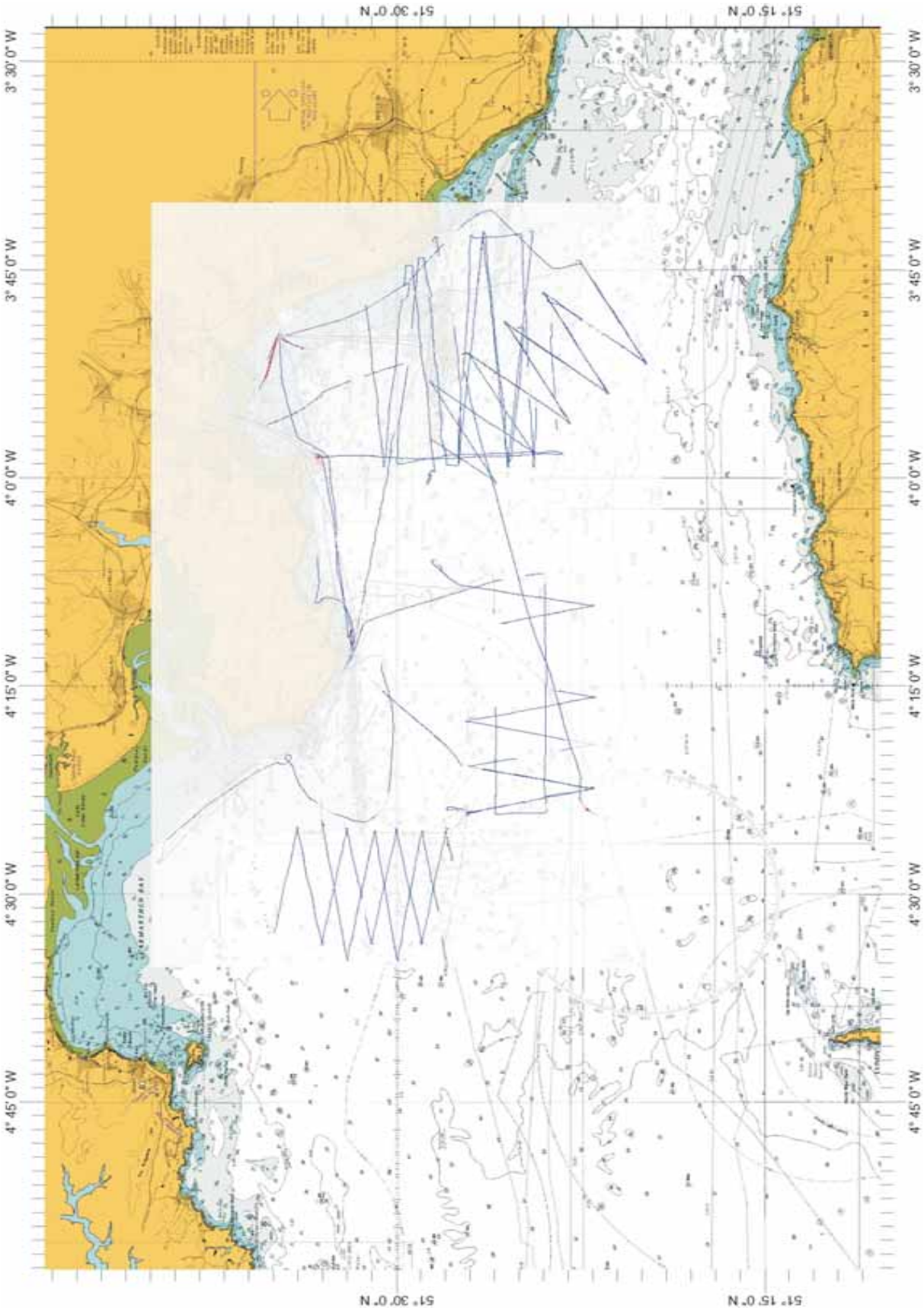
The intention to conduct two 30nm transects in each block was modified at the south Gower block by adverse sea conditions: four east-west-east transects were followed here.

Further transects, with observers at the bow and the IFAW towed array, were conducted opportunistically at post-September dates, including further survey at the south Gower transect grid. Additional towed hydropone plus observers transects have been conducted within the study area post January 2004: data from these efforts are included within this report. A total of 356nm (634km) towed-hydrophone + observers transect survey was completed.

The initial experimental deployment in September was hampered by problems of broadband noise in the "porpoise band". This was found to be the result of a failing laptop power supply. This was partially solved by the use of an electrically "cleaner" laboratory standard transformer unit to power the computer.

No recording occured between February and June 2004 whilst the T-PODs and the hydrophone array were serviced.

**Figure 12.** Chart of survey area with logger track-lines overlayed. Blue lines are porpoise detection effort. Red dots are porpoises.



# Visual Survey

## Shorewatch

Shore watches were conducted throughout the course of this study. Additional study-area data, collected from February 1996 to the start of this study, were incorporated into the data-set analysed below. Data were organised to give 15-minute summary periods: a total of 2026 shore-watch periods (506.5hrs) was accepted for analysis.

Each shore watch recorded a range of environmental factors (sea state, wind speed and direction, swell height, cloud cover, precipitation, visibility), the number (minimum and estimated) of cetaceans present, and the degree of confidence in species identification. These data are forwarded to the Seawatch UK-managed national database but environmental data are not treated in this report. Additionally, behavioural data, collected at the principal watch site (Burry Holms), are not treated here.

In an attempt to standardise effort quality, some (few) shore-watch data, from inexperienced/ unknown observers, have been omitted from the dataset. (An illustration of observer bias was inadvertently gained during a coordinated shore watch, when a single observer and a group of observers simultaneously and separately watched the Port Eynon headland: one party reported an estimated 11 porpoise, whilst the second party reported four porpoise and an unidentified dolphin species.)

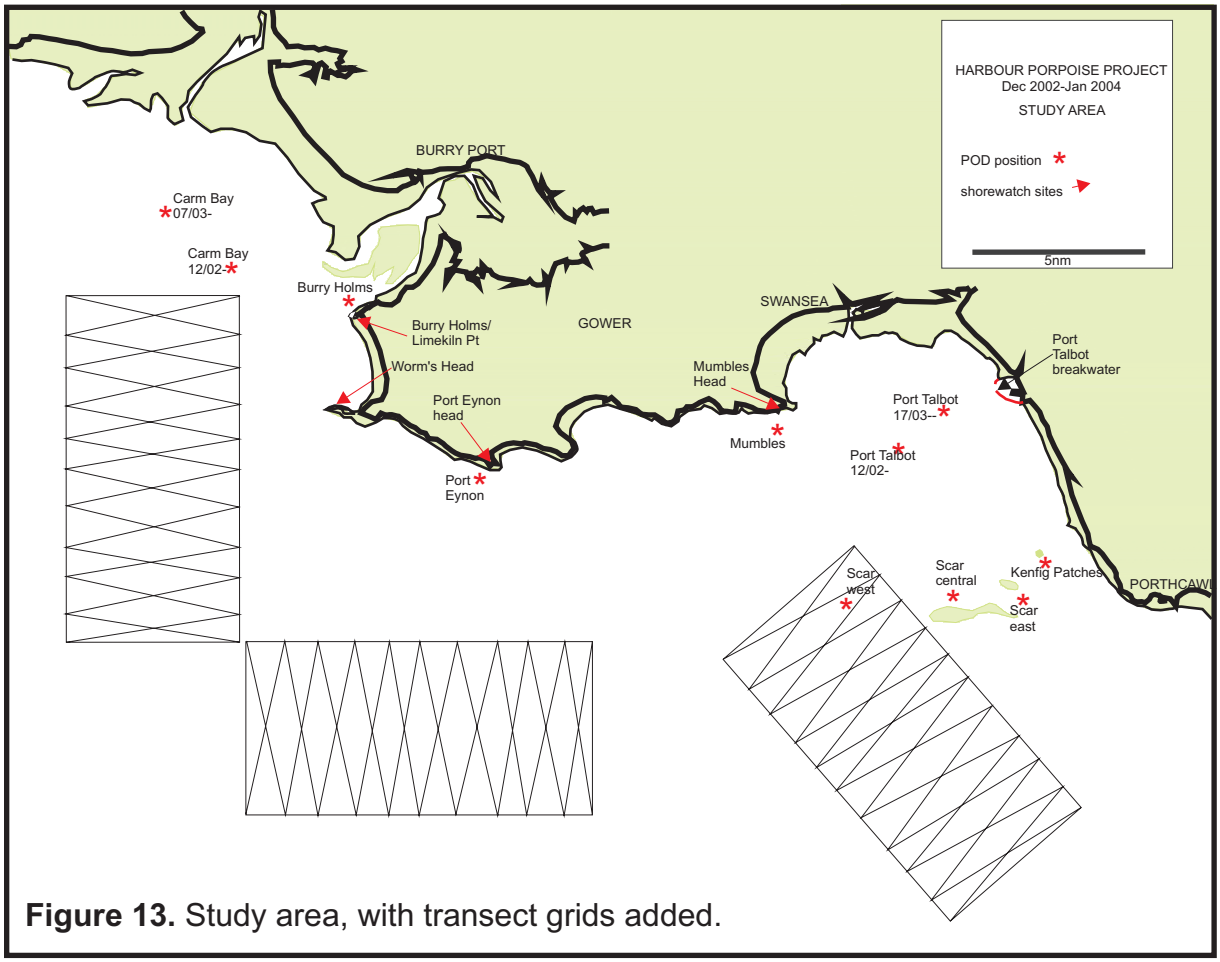



**Figure 13.** Study area, with transect grids added.

### Shore-watch locations:

Shore watch data were collected from a range of locations (Figure 13):

- Burry Holms/Limekiln Point: Burry Holms (SS398926) is a tidal islet at the north end of Rhossili beach, Gower; Limekiln Point (SS402927) is the closest mainland elevation. Observations from these points are of the same sea sector- the Carmarthen Bay tidal flow in/out of the Loughour estuary- and are treated together in analyses. The majority of the shore-watch data (78%) were collected here, and this site is treated seperately in "Results", below.
- Worm's Head (SS384877): a tidal island at the south of Rhossili Beach, Gower; rocky shore, with strong tidal flows.
- Port Eynon Point (SS467845): a south Gower headland; rocky shore, with strong tidal flows.
- Oxwich Point (SS508849): a south Gower headland; rocky shore, with strong tidal flows, sandy bay immediately east.
- Port Talbot (SS741877): parallel stone breakwaters extending c1km into Swansea Bay, enclosing a (dredged) deep water channel into Port Talbot/Corus dock.

### Data Analysis:

Shorewatch data were analysed using adapted versions of the VBA analysis programs created to analyse the T-POD data (sub-routines to classify observations by tide and day of lunar month were adapted). Where possible data were processed in a manner which allowed direct comparison and integration with data resulting from the other survey methods in use.

# Transect surveys

Constant-effort transects were undertaken opportunistically, largely within the inshore (0-2km) area whilst transiting between anchored PODs.

In all conditions of sea-state 3 or less, and when time and personnel availability permitted, two experienced observers were positioned at the bow of the boat to conduct visual survey for cetaceans. A minimum of three observers worked an hour-on/half-hour off rota; more usually, four observers allowed for an hour-on/hour-off rotation. Inexperienced observers were not included in the watch rota, but were frequently used as data recorders; their observations were treated as "casual" if not simultaneously recorded by a watch member. Each observer scanned a 90° arc to starboard and port, giving a survey arc of 180° off the bow. Boat sea-speed was limited to 8 knots.

Environmental conditions were noted at the beginning of each transect, and at times of environmental change: these data are forwarded to the Seawatch UK managed database but are not treated here. Each observer recorded the boat position (hand held GPS) and distance and angle from the boat of any cetacean sighting, to allow subsequent abundance calculations, and the minimum and estimated number of animals seen. Brief behavioural notes were also taken.

Between Dec, 2002 and the end of Jan. 2004, a total of 778.25nm (1441km) observer-based transect survey was completed (including transects with observers at the bow and a towed hydrophone array).

# Casual sightings

When personnel were preoccupied with deck-duties, when there was a requirement for >8 knot transit speeds, and when sea- state was greater than 3, constant-effort watches from the bow were suspended. Any cetacean sightings made in these situations, or whilst crew were involved in POD lifting/deployment, are recorded as "casual" sightings.

Additional casual sightings, made by the Noctliuca skipper during the course of other work in the study area during the project period, are included: these include several sightings of more than five porpoise feeding off Mumbles Head/Mixon bank.

# Project Management & Personnel

## Work platform:

Swansea University's R.V. Noctiluca was used for all POD placement and servicing, and for all transect survey. The vessel is a 12.5m, twin engined, aluminium catamaran, equipped with a 0.75ton North Sea double drum winch and a 1000kg hydraulic transom A-frame. A 12VDC main electrics system incorporates three 80Ah batteries, to power POD and hydrophone-array associated laptops/amplifiers/etc.

During the project, the Noctiluca logged c.1440nm (2669km), during c.172.5 hours at sea.

## Core crew:

GMMP provided project coordination and administration, key operational skills (electronics operation and repair, on-board and ashore) and a core of experienced porpoise "spotters". Data handling and analysis, initially the responsibility of a post-graduate collaborator, was undertaken by HW following the post-grad's withdrawal from the project.

## Volunteer time:

A total of 1870 volunteer hours was logged during the course of this project: this figure excludes most travel time, much equipment sourcing/collection and preparation, and all administration time. Boat time accounted for 1138 hrs. A further 414+ hours voluntary shore-watch time (1996-2002) was incorporated into the project.

# Results

## Acoustic Survey

### Static T-PODS

At the time of writing (August 2004), a total of 1 147 969 minutes of recording had been logged by the T-PODs since initial deployment in December 2002. Thirteen thousand, nine hundred and seventy three (13 973) of those minutes contained trains identified as having either “High” or “Probable” likelihood of being produced by a porpoise. These recording, or effort, minutes do not include periods when PODs were not in the water, or periods when they were in the water, but not recording as a result of mechanical failure.

POD recording calendar days (i.e. recording blocks of 24 hours starting at midnight where no recording gaps of over 60 minutes have occurred) are shown at figure 14. This schematic illustrates how POD recording data from all three calendar years of the project to date have been combined. POD recording periods, expressed as recording hours per month (including part calendar days) for each POD and calender month of the survey are detailed at table 3; the total combined monthly POD effort, expressed as hours and days are at table 4.

The contribution that each survey location has made to the entire dataset and the overall success of each site deployment is summarised at table 5 and figure 15. It can be seen that successful “in the water” time ranged from 14% to 100%, with different sites contributing between 3% and 27% of the total recording minutes.

Data from recording minutes, analysed by TPOD.EXE are summarised at table 6a-g and figures 16a-c. Tables 6a-c show the number of click trains detected, how they were classified and how many were rejected on the basis of a positive detection in scan 1 (the insurance scan); table 6d presents these data as percentages. Tables 6e&f summarise the total numbers of train positive minutes recorded, accepted and rejected. Table 6g shows the total number of minutes classified as “Porpoise Positive” as a result of accepted, Cet-Hi or Cet-Low porpoise trains. It should be noted that any given minute of survey could contain both Cet-Hi and Cet-Lo porpoise trains but would only be counted once as a Porpoise Positive minute. Porpoise positive minutes across the different sites range from 0.08% to 0.50% of the total recording minutes.

To identify possible seasonal patterns in porpoise detection, porpoise positive hours per project month and combined calender month of project are presented at tables 7 and 8; table 9 summarises the relative contribution each calendar year has made to the project (porpoise positive hours). Monthly porpoise occurrence is graphically illustrated at figure 17 (Number of hours) and figure 18 (percentage, positive / total recording hours). Positive hours range from 8% to 38% of total recording hours.

The classification of porpoise positive minutes by state of tide, achieved using the custom written analysis software, is presented at table 10 and illustrated at figure 19. Figure 20a illustrates the relative contribution of each location to the dataset. Figure 20b presents the same analysis, restricted to inshore PODs. Figures 21a-j present the tidal variation at individual locations. An apparent tidal correlation at the combined dataset is more obviously apparent at inshore sites.

The classification of porpoise positive minutes by day state, achieved using the custom written analysis software, is presented at table 11 and illustrated at figure 22. Figures 23a-j present the diel variation at individual locations. A considerable variation in activity across the survey area is reported, with nocturnal activity ranging from 7% (Scarweather Central) to 70% (Kenfig).

The classification of porpoise positive minutes by day of lunar cycle, achieved using the custom written analysis software, is presented at table 12 and illustrated at figure 24. Activity ranges 260-922 porpoise positive minutes across the lunar month.

The classification of porpoise positive minutes by hour of the clock (GMT), achieved using the custom written analysis software, is presented at table 13 and illustrated at figures 25. Figures 26a-j illustrate this varation at individual locations.

POD-POD and POD-shorewatch simultaneous porpoise positive hours are recorded at table 14a & b. A TPOD display, illustrating simultaneous detection at three locations is reproduced at figure 27.

Application of the Encounter Rule (see methodology) resulted in 3840 porpoise encounters being identified. Ranking encounters by start time, revealed that in 1055 cases (28%) the time to next encounter in that location was preceded by the encounter at a different location. These data are summarised in tables 15-22 and figures 28-33

- Table 15 shows the average same-location encounter separation for the entire dataset. Figure 28 shows the relative occurrence of “quick return” encounters (separated by less than 120 minutes). It can be seen that 20% of all encounters occurred within 30 minutes of the end of the previous encounter at that location.
- Table 16 shows the average separation time between encounters where the next consecutive encounter begins at a different location from the first. Secondary encounters identified in this way, as being temporally associated with the primary encounter (within 120 minutes) but spatially separated, are detailed in Figure 29. Near simultaneous encounters, with less than 30 minutes separation, make up 9% of the total (307 occurrences).
- Table 17 summarises the encounter separation data (number of close and near-simultaneous encounters.
- Table 18 & Figure 30 show the number of encounters per month at each location. Monthly totals range from 67 Encounters in April to 512 in November.
- Table 19 & Figure 31 show the average length of encounters logged per month. Encounter length ranges between 1.14 and 13.27 minutes.
- Table 20 & Figure 32 show the average wait time between encounters per month. Encounter separation ranges from 125 minutes (November) to 579 minutes (September). Shortest inter-encounter intervals were recorded in Carmarthen Bay (November) with Scarweather Central having the longest intervals (May).
- Table 21 & Figure 33 show the average number of encounters per hour of recording, and an effort corrected average for the summed sites per month.

## Towed T-POD

No data from the towed T-POD surveys were analysed, having been identified by TPOD.EXE as being of poor quality. The scan files contained virtually no identifiable trains and only one low probability porpoise encounter.

## Towed Hydrophone

The IFAW system created a larger and more complex dataset than was originally envisaged by the planned methodology (real-time aural observations) and GMMP personnel are currently working on further and finer analyses.

An initial review of the data suggests 272 porpoise-like acoustic events recorded over 438 nautical miles of survey. This gives a figure of 0.63 porpoises per nautical mile; however, if a confidence limit of 50% is applied, this value falls to 27 events, giving a porpoise per nautical mile value of 0.06. Summary data are presented at table 22 and figure 34.

# Visual Survey

## Transect Surveys

Detections by observer-based transects indicate 0.11 porpoise per nm (0.05 per km) across the entire study area. Eighty six porpoise were recorded during 778.25nm of transect survey. Figure 35 indicates routes travelled with two observer-constant effort from the bow (see methodology) and porpoise seen.

## Casual Observations

Figure 36 indicates porpoise sightings “casually” recorded (see methodology).

## Shorewatch Data

A total of 2027 shorewatch observation periods of fifteen minutes duration were logged between January 1996 and December 2003. Four hundred and one of these were porpoise positive. Porpoise positive observation periods are presented here, alongside porpoise negative periods. Detection events have been classed by tide state, day of lunar month, 24 hour clock, day state and month of survey. Porpoise positive days have also been used.

Shorewatch data were examined for group-size variance patterns at different sites and different tide states: only data points with positive porpoise sightings were used. Data are summarised at two scales: “observation periods” and “porpoise positive days”.

- observation periods, are the fifteen minute intervals summarised at each line of the shore-watch dataset; both "minimum" number (ie. the number of animals "confirmed" by observer) and "estimated" number (ie. the number of animals believed, by the observer, to be present) are treated here
- porpoise positive days, are those dates at which porpoise were recorded at a location; only “estimated" numbers (ie. the number of animals believed, by the observer, to be present) are treated here.

Data are presented for all sites (Burry Holms/Limekiln, Port Eynon, Worm's Head, Port Talbot, Paviland (south Gower)), summed as "all data"; data subsets, from the two most watched sites (Burry Holms/Limekiln and Port Eynon) are also presented.

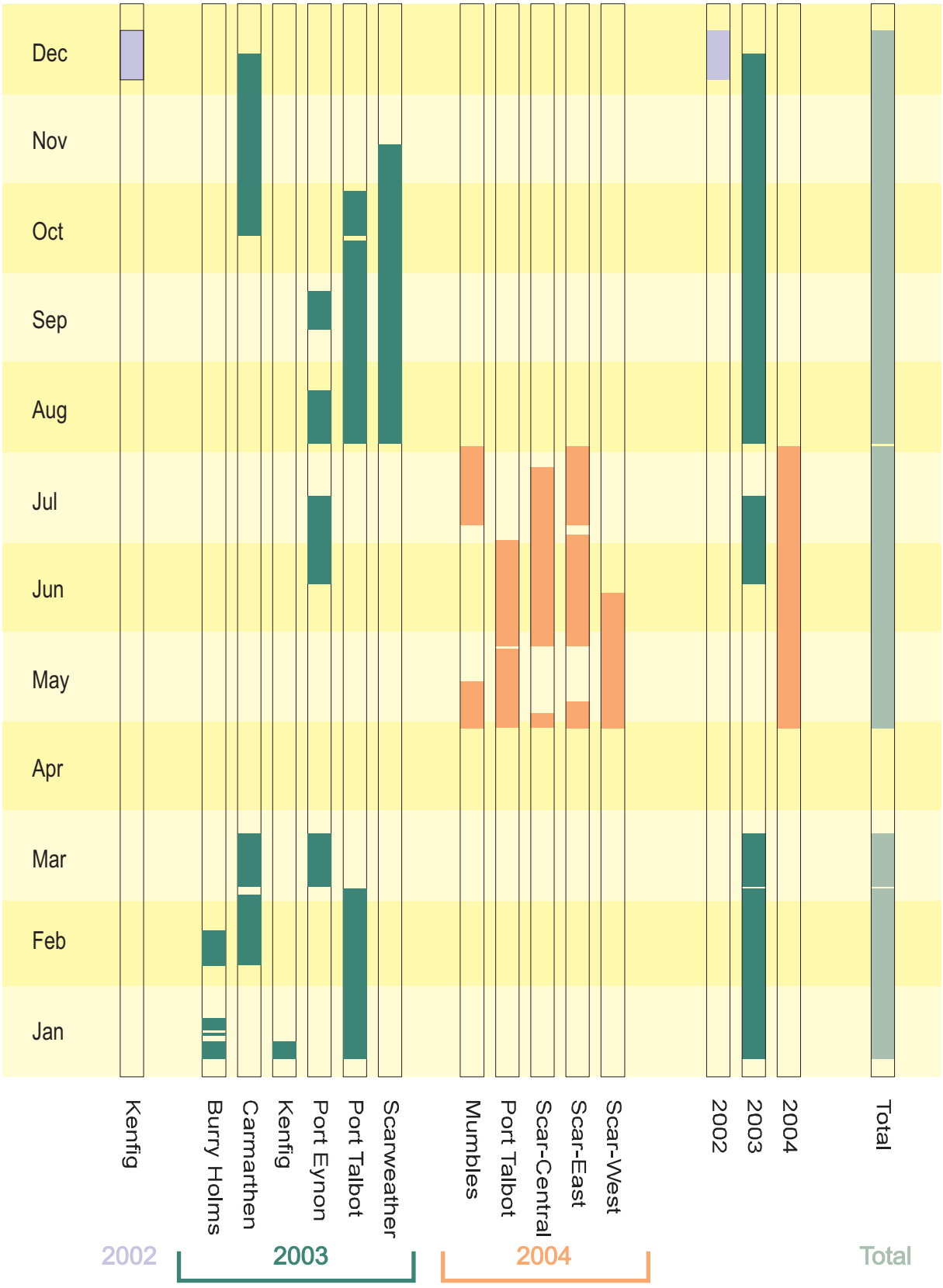
Summary data are tabulated and graphed:

- Table 23a-c shows shorewatch effort by year, month and location. This is summarised graphically in figure 37.
- Figure 38 shows the total number of porpoise positive observation periods.
- Figure 39 shows the number of porpoise positive observation periods as a percentage of the total observation periods (corrected for effort.).
- Table 24 observations classified by month of survey.
- Table 25 observations classified by time of day.
- Table 26 observations classified by state of tide.
- Table 27 observations classified by lunar day.
- Tables 28a & 28b show variance in group size by tidal state and month of year, using estimated numbers; 28c & 28d show the same summaries, using definite numbers.
- Tables 29a-c summarise group sizes against estimated number data.
- Tables 30a-e show group size against tide state at all locations, using definite numbers; 30f-j show the same summaries using estimated numbers.
- Tables 31a-c summarise group size data at Burry Holms / Limekiln.
- Tables 32a-c summarise group size data at Port Eynon.

# Table 3: Pod Deployment (hours per month and locations)

| Month | Burry Holms | Carmarthen | Kenfig | Mumbles | Port Eynon | Port Talbot | Scarweather | Scar-Central | Scar-East | Scar-West | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dec-02** | - | - | 435.05 | - | - | - | - | - | - | - | **435.05** |
| **Jan-03** | 348.63 | - | 161.15 | - | - | 629.83 | - | - | - | - | **1,139.62** |
| **Feb-03** | 349.65 | 516.82 | - | - | - | 671.35 | - | - | - | - | **1,537.82** |
| **Mar-03** | - | 550.67 | - | - | 457.13 | 135.38 | - | - | - | - | **1,143.18** |
| **Apr-03** | - | - | - | - | - | - | - | - | - | - | **-** |
| **May-03** | - | - | - | - | - | 4.82 | - | - | - | - | **4.82** |
| **Jun-03** | - | - | - | - | 341.58 | 68.05 | - | - | - | - | **409.63** |
| **Jul-03** | - | - | - | - | 408.75 | - | - | - | - | - | **408.75** |
| **Aug-03** | - | - | - | - | 446.05 | 661.80 | 661.35 | - | - | - | **1,769.20** |
| **Sep-03** | - | - | - | 19.45 | 326.43 | 720.22 | 719.70 | - | - | - | **1,785.80** |
| **Oct-03** | - | 422.67 | - | - | - | 677.97 | 744.00 | - | - | - | **1,844.63** |
| **Nov-03** | - | 720.00 | - | - | - | - | 358.52 | - | - | - | **1,078.52** |
| **Dec-03** | - | 372.08 | - | - | - | - | - | - | - | - | **372.08** |
| **Jan-04** | - | - | - | - | - | - | 0.57 | - | - | - | **0.57** |
| **Feb-04** | - | - | - | - | - | - | - | - | - | - | **-** |
| **Mar-04** | - | - | - | - | - | - | - | - | - | - | **-** |
| **Apr-04** | - | - | - | 60.85 | - | 63.07 | - | 60.90 | 61.83 | 60.17 | **306.82** |
| **May-04** | - | - | - | 336.28 | - | 736.92 | - | 208.83 | 314.57 | 743.98 | **2,340.58** |
| **Jun-04** | - | - | - | - | - | 720.00 | - | 720.00 | 720.00 | 320.80 | **2,480.80** |
| **Jul-04** | - | - | - | 609.63 | - | 23.98 | - | 624.87 | 704.50 | - | **1,962.98** |
| **Aug-04** | - | - | - | 55.55 | - | - | - | - | 56.42 | - | **111.97** |
| **Sep-04** | - | - | - | - | - | - | - | - | - | - | - |
| **Oct-04** | - | - | - | - | - | - | - | - | - | - | - |
| **Nov-04** | - | - | - | - | - | - | - | - | - | - | - |
| **Dec-04** | - | - | - | - | - | - | - | - | - | - | - |

**Figure 14.** Static POD recording periods (whole calendar days of recording).




Schematic showing the distribution of whole POD recording days throughout the project period. Whole recording days are defined as periods of 24 hours (starting at midnight) of continuous recording where a POD has been listening with a break in recording of no greater than sixty minutes. Days are excluded from calculations if a POD was not recording or has missed over one hour of the recording day (due to environmental conditions, POD error or deployment time).

# Table 4: Combined POD effort

Table shows summed recording hours from all three calender years of the project (December 2002-August2004).

| Month | Burry Holms | Carmarthen | Kenfig | Mumbles | Port Eynon | Port Talbot | Scarweather | Scar-Central | Scar-East | Scar-West | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Jan** | 348.63 | - | 161.15 | - | - | 629.83 | 0.57 | - | - | - | **1,140.18** |
| **Feb** | 349.65 | 516.82 | - | - | - | 671.35 | - | - | - | - | **1,537.82** |
| **Mar** | - | 550.67 | - | - | 457.13 | 135.38 | - | - | - | - | **1,143.18** |
| **Apr** | - | - | - | 60.85 | - | 63.07 | - | 60.90 | 61.83 | 60.17 | **306.82** |
| **May** | - | - | - | 336.28 | - | 741.73 | - | 208.83 | 314.57 | 743.98 | **2,345.40** |
| **Jun** | - | - | - | - | 341.58 | 788.05 | - | 720.00 | 720.00 | 320.80 | **2,890.43** |
| **Jul** | - | - | - | 609.63 | 408.75 | 23.98 | - | 624.87 | 704.50 | - | **2,371.73** |
| **Aug** | - | - | - | 55.55 | 446.05 | 661.80 | 661.35 | - | 56.42 | - | **1,881.17** |
| **Sep** | - | - | - | 19.45 | 326.43 | 720.22 | 719.70 | - | - | - | **1,785.80** |
| **Oct** | - | 422.67 | - | - | - | 677.97 | 744.00 | - | - | - | **1,844.63** |
| **Nov** | - | 720.00 | - | - | - | - | 358.52 | - | - | - | **1,078.52** |
| **Dec** | - | 372.08 | 435.05 | - | - | - | - | - | - | - | **807.13** |
| **Total** | **698.28** | **2,582.23** | **596.20** | **1,081.77** | **1,979.95** | **5,113.38** | **2,484.13** | **1,614.60** | **1,857.32** | **1,124.95** | **19,132.81** |

# Table 5: POD Contribution to Dataset

Total minutes: the total period during which a given location was part of the survey (measured from initial POD deployment to final removal).

Recording minutes: those minutes during which a POD was functioning in the water at a given location.

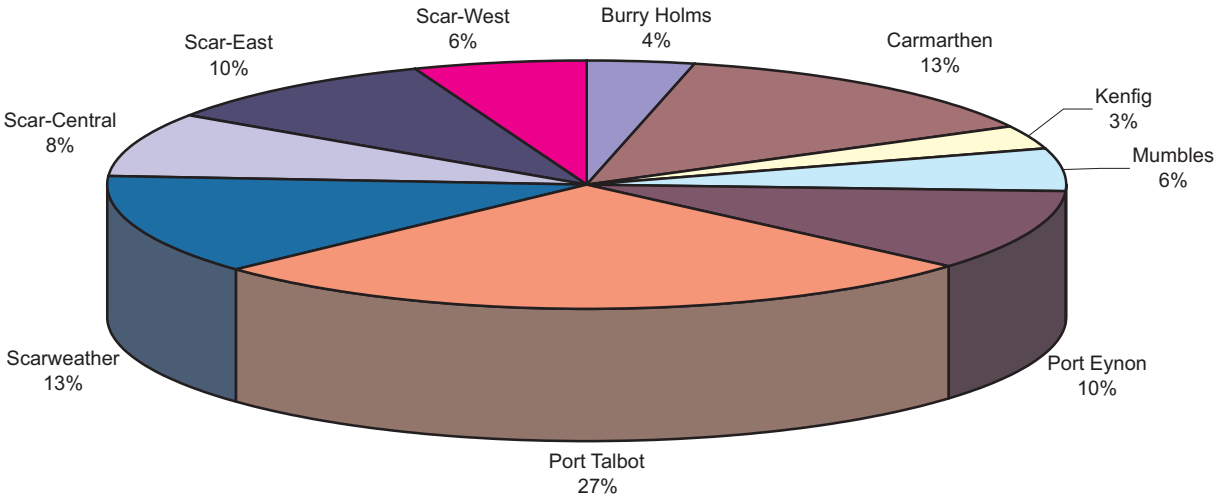
Not Recording minutes: the number of minutes when a POD was either malfunctioning or on-land being serviced.

% Recording: a measure of success at a given location (recording / non recording)

Overall Contribution to Dataset: the percentage of total recording minutes per location

| Survey Location | Recording (minutes) | Not Recording (minutes) | % Recording | Total Minutes | Overall Contibution to Dataset |
|---|---|---|---|---|---|
| **Burry Holms** | 41897 | 25008 | 63% | 66905 | **4%** |
| **Carmarthen** | 154934 | 294404 | 34% | 449338 | **13%** |
| **Kenfig** | 35772 | 21115 | 63% | 56887 | **3%** |
| **Mumbles** | 64906 | 388689 | 14% | 453595 | **6%** |
| **Port Eynon** | 118797 | 174589 | 40% | 293386 | **10%** |
| **Port Talbot** | 306803 | 474027 | 39% | 780830 | **27%** |
| **Scarweather** | 149048 | 107548 | 58% | 256596 | **13%** |
| **Scar-Central** | 96876 | 32110 | 75% | 128986 | **8%** |
| **Scar-East** | 111439 | 28152 | 80% | 139591 | **10%** |
| **Scar-West** | 67497 | 153 | 100% | 67650 | **6%** |
| **Total:** | **1147969** | **1545795** | | **2693764** | |

# Figure 15: POD Contribution to Dataset



# Tables 6a-d: POD Accepted and Rejected Trains

Table 6a

| Survey Location | Total Click Trains | | | | |
|---|---|---|---|---|---|
| | Cet Hi | Cet Lo | ? | ?? | Other |
| **Burry Holms** | 24053 | 16215 | 20328 | 76284 | 402 |
| **Carmarthen** | 305101 | 95188 | 22222 | 48377 | 0 |
| **Kenfig** | 3703 | 1401 | 424 | 892 | 0 |
| **Mumbles** | 39316 | 34260 | 28913 | 52300 | 3866 |
| **Port Eynon** | 61573 | 24931 | 11363 | 35650 | 2602 |
| **Port Talbot** | 33523 | 15272 | 7573 | 21759 | 2457 |
| **Scarweather** | 6025 | 2667 | 726 | 1399 | 0 |
| **Scar-Central** | 1249 | 938 | 1078 | 5849 | 270972 |
| **Scar-East** | 5267 | 3892 | 4154 | 17365 | 4523 |
| **Scar-West** | 18653 | 18527 | 16975 | 35701 | 1686 |
| **Total:** | **498463** | **213291** | **113756** | **295576** | **286508** |

Table 6b

| Survey Location | Rejected Click Trains | | | | |
|---|---|---|---|---|---|
| | Cet Hi | Cet Lo | ? | ?? | Other |
| **Burry Holms** | 5293 | 3735 | 6110 | 24285 | 54 |
| **Carmarthen** | 315 | 111 | 157 | 301 | 0 |
| **Kenfig** | 1705 | 649 | 193 | 477 | 0 |
| **Mumbles** | 129 | 30 | 22 | 544 | 571 |
| **Port Eynon** | 115 | 65 | 21 | 1811 | 1643 |
| **Port Talbot** | 3872 | 1085 | 496 | 1233 | 353 |
| **Scarweather** | 33 | 120 | 174 | 515 | 0 |
| **Scar-Central** | 0 | 21 | 153 | 804 | 331 |
| **Scar-East** | 0 | 25 | 147 | 789 | 1760 |
| **Scar-West** | 0 | 0 | 23 | 154 | 504 |
| **Total:** | **11462** | **5841** | **7496** | **30913** | **5216** |

Table 6c

| Survey Location | Accepted Click Trains | | | | |
|---|---|---|---|---|---|
| | Cet Hi | Cet Lo | ? | ?? | Other |
| **Burry Holms** | 18760 | 12480 | 14218 | 51999 | 348 |
| **Carmarthen** | 304786 | 95077 | 22065 | 48076 | 0 |
| **Kenfig** | 1998 | 752 | 231 | 415 | 0 |
| **Mumbles** | 39187 | 34230 | 28891 | 51756 | 3295 |
| **Port Eynon** | 61458 | 24866 | 11342 | 33839 | 959 |
| **Port Talbot** | 29651 | 14187 | 7077 | 20526 | 2104 |
| **Scarweather** | 5992 | 2547 | 552 | 884 | 0 |
| **Scar-Central** | 1249 | 917 | 925 | 5045 | 270641 |
| **Scar-East** | 5267 | 3867 | 4007 | 16576 | 2763 |
| **Scar-West** | 18653 | 18527 | 16952 | 35547 | 1182 |
| **Total:** | **487001** | **207450** | **106260** | **264663** | **281292** |

Table 6d

| Survey Location | % Rejected Click Trains | | | | |
|---|---|---|---|---|---|
| | Cet Hi | Cet Lo | ? | ?? | Other |
| **Burry Holms** | 22% | 23% | 30% | 32% | 13% |
| **Carmarthen** | 0% | 0% | 1% | 1% | |
| **Kenfig** | 46% | 46% | 46% | 53% | |
| **Mumbles** | 0% | 0% | 0% | 1% | 15% |
| **Port Eynon** | 0% | 0% | 0% | 5% | 63% |
| **Port Talbot** | 12% | 7% | 7% | 6% | 14% |
| **Scarweather** | 1% | 4% | 24% | 37% | |
| **Scar-Central** | 0% | 2% | 14% | 14% | 0% |
| **Scar-East** | 0% | 1% | 4% | 5% | 39% |
| **Scar-West** | 0% | 0% | 0% | 0% | 30% |

The high rejection rate of the Kenfig POD is a result two principal factors:

- there was a high level of ambient noise at the site, attributed to sand movement and dragging of the POD anchor
- The relative proportion of time this POD was set to "Porpoise Default" scan settings relative to the error-check settings used from February 2003 onwards has resulted in the rejection of a significant number of genuine positive porpoise trains during analysis.

# Tables 6e-g: POD Accepted and Rejected Trains

Tables summarising the ratio of accepted and rejected Porpoise positive click trains and the overall ratio of Porpoise train positive minutes to survey minutes.

Table 6e

| Survey Location | Accepted Train Positive Minutes | | | | |
|---|---|---|---|---|---|
| | Cet Hi | Cet Lo | ? | ?? | Other |
| **Burry Holms** | 338 | 730 | 759 | 1526 | 29 |
| **Carmarthen** | 4086 | 4331 | 1426 | 2503 | 0 |
| **Kenfig** | 48 | 53 | 19 | 34 | 0 |
| **Mumbles** | 760 | 1810 | 1475 | 1786 | 95 |
| **Port Eynon** | 1388 | 1696 | 835 | 1659 | 35 |
| **Port Talbot** | 582 | 836 | 433 | 909 | 48 |
| **Scarweather** | 105 | 143 | 64 | 89 | 0 |
| **Scar-Central** | 27 | 60 | 63 | 390 | 7407 |
| **Scar-East** | 103 | 204 | 213 | 733 | 81 |
| **Scar-West** | 408 | 939 | 832 | 943 | 68 |
| **Total:** | **7845** | **10802** | **6119** | **10572** | **7763** |

Table 6f

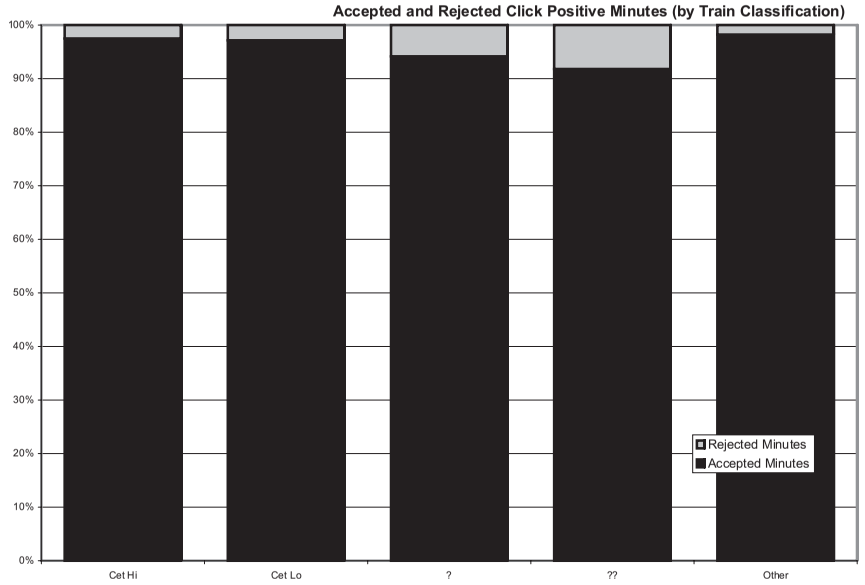
| Survey Location | Rejected Train Positive Minutes | | | | |
|---|---|---|---|---|---|
| | Cet Hi | Cet Lo | ? | ?? | Other |
| **Burry Holms** | 109 | 169 | 240 | 466 | 5 |
| **Carmarthen** | 3 | 10 | 20 | 35 | 0 |
| **Kenfig** | 25 | 33 | 16 | 26 | 0 |
| **Mumbles** | 3 | 2 | 2 | 26 | 20 |
| **Port Eynon** | 4 | 7 | 3 | 81 | 47 |
| **Port Talbot** | 57 | 75 | 43 | 96 | 9 |
| **Scarweather** | 2 | 13 | 22 | 59 | 0 |
| **Scar-Central** | 0 | 4 | 17 | 81 | 27 |
| **Scar-East** | 0 | 5 | 15 | 64 | 26 |
| **Scar-West** | 0 | 0 | 2 | 12 | 7 |
| **Total:** | **203** | **318** | **380** | **946** | **141** |

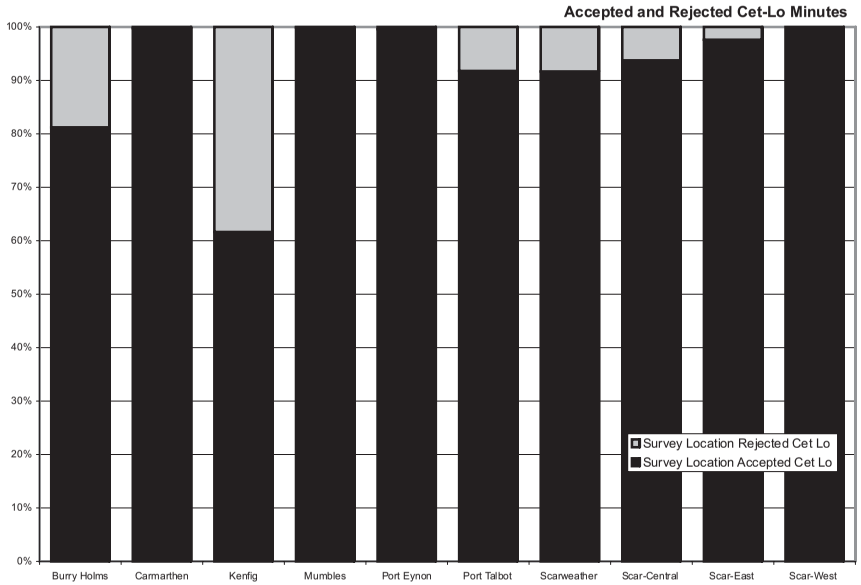
Table 6g.

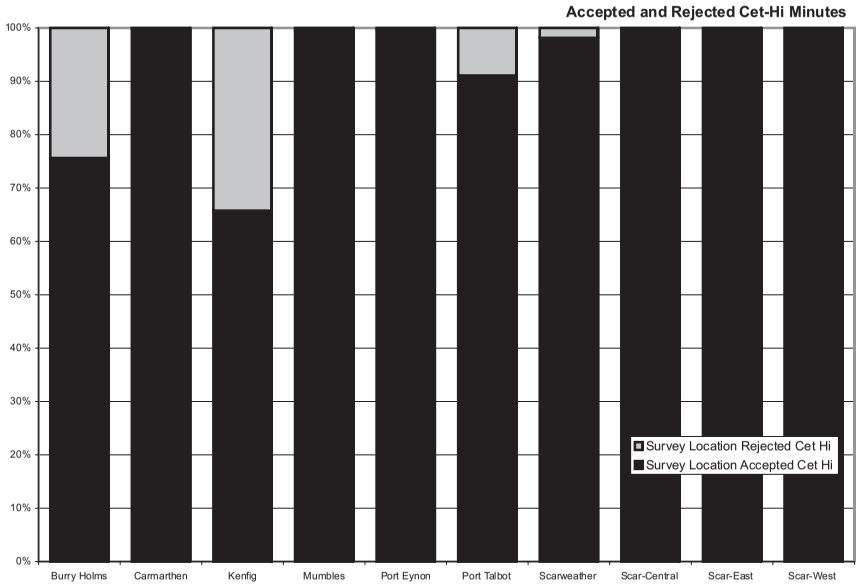
| Survey Location | Porpoise Detection | | | | |
|---|---|---|---|---|---|
| | Cet High Minutes | Cet Lo Minutes | Porpoise Positive (Cet Hi or Cet Lo) | Minutes of Detection | % Porpoise Positive |
| **Burry Holms** | 338 | 730 | 883 | 41897 | **0.08%** |
| **Carmarthen** | 4086 | 4331 | 5786 | 154934 | **0.50%** |
| **Kenfig** | 48 | 53 | 77 | 35772 | **0.01%** |
| **Mumbles** | 760 | 1810 | 2095 | 64906 | **0.18%** |
| **Port Eynon** | 1388 | 1696 | 2418 | 118797 | **0.21%** |
| **Port Talbot** | 582 | 836 | 1128 | 306803 | **0.10%** |
| **Scarweather** | 105 | 143 | 177 | 149048 | **0.02%** |
| **Scar-Central** | 27 | 60 | 75 | 96876 | **0.01%** |
| **Scar-East** | 103 | 204 | 235 | 111439 | **0.02%** |
| **Scar-West** | 408 | 939 | 1099 | 67497 | **0.10%** |
| **Total:** | **7845** | **10802** | **13973** | **1147969** | |

# Figure 16a-c

Accepted and Rejected Train Positive Minutes



# Table 7. POD - Porpoise Positive Hours Per Month of Survey

Table 7. Porpoise Positive Hours Per Month

| POD / MONTH | Burry Holms | Carmarthen | Kenfig | Mumbles | Port Eynon | Port Talbot | Scarweather | Scar-Central | Scar-East | Scar-West | Shorewatch | POD Total | POD Detection Hours | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| December-02 | - | - | 30.00 | - | - | - | - | - | - | - | 6.00 | 30.00 | 435.05 | 7% |
| January-03 | 113.00 | - | 9.00 | - | - | 69.00 | - | - | - | - | 4.00 | 191.00 | 1,139.62 | 17% |
| February-03 | 106.00 | 243.00 | - | - | - | 57.00 | - | - | - | - | 1.00 | 406.00 | 1,537.82 | 26% |
| March-03 | - | 169.00 | - | - | 88.00 | 23.00 | - | - | - | - | 3.00 | 280.00 | 1,143.18 | 24% |
| April-03 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| May-03 | - | - | - | - | - | - | - | - | - | - | - | - | 4.82 | 0% |
| June-03 | - | - | - | - | 146.00 | 8.00 | - | - | - | - | 6.00 | 154.00 | 409.63 | 38% |
| July-03 | - | - | - | - | 167.00 | - | - | - | - | - | 3.00 | 167.00 | 408.75 | 41% |
| August-03 | - | - | - | - | 141.00 | 50.00 | 29.00 | - | - | - | 11.00 | 220.00 | 1,769.20 | 12% |
| September-03 | - | - | - | 15.00 | 65.00 | 50.00 | 15.00 | - | - | - | 2.00 | 145.00 | 1,785.80 | 8% |
| October-03 | - | 76.00 | - | - | - | 53.00 | 21.00 | - | - | - | 1.00 | 150.00 | 1,844.63 | 8% |
| November-03 | - | 395.00 | - | - | - | - | 19.00 | - | - | - | 1.00 | 414.00 | 1,078.52 | 38% |
| December-03 | - | 115.00 | - | - | - | - | - | - | - | - | - | 115.00 | 372.08 | 31% |
| January-04 | - | - | - | - | - | - | - | - | - | - | - | - | 0.57 | 0% |
| February-04 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| March-04 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| April-04 | - | - | - | 34.00 | - | 6.00 | - | - | 3.00 | 21.00 | - | 64.00 | 306.82 | 21% |
| May-04 | - | - | - | 142.00 | - | 67.00 | - | 6.00 | 15.00 | 180.00 | - | 410.00 | 2,340.58 | 18% |
| June-04 | - | - | - | - | - | 66.00 | - | 26.00 | 51.00 | 70.00 | - | 213.00 | 2,480.80 | 9% |
| July-04 | - | - | - | 283.00 | - | 1.00 | - | 11.00 | 47.00 | - | - | 342.00 | 1,962.98 | 17% |
| August-04 | - | - | - | 23.00 | - | - | - | - | 5.00 | - | - | 28.00 | 111.97 | 25% |
| September-04 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| October-04 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| November-04 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| December-04 | - | - | - | - | - | - | - | - | - | - | - | | - | 0% |
| Total Porpoise Positive Hours | 219 | 998 | 39 | 497 | 607 | 450 | 84 | 43 | 121 | 271 | 38 | 3329 | 19,132.81 | 17% |
| Total Recording Hours at site | 698.28 | 2582.23 | 596.20 | 1081.77 | 1979.95 | 5113.38 | 2484.13 | 1614.60 | 1857.32 | 1124.95 | | | | |
| *% Porpoise Positive Hours* | 31% | 39% | 7% | 46% | 31% | 9% | 3% | 3% | 7% | 24% | | | | |

# Table 8. POD - Porpoise Positive Hours Per Month of Survey (Combined)

Table 8. Porpoise Positive Hours Per Month of survey (Combined)

| POD / MONTH | Burry Holms | Carmarthen | Kenfig | Mumbles | Port Eynon | Port Talbot | Scarweather | Scar-Central | Scar-East | Scar-West | Shorewatch | POD Total | POD Detection Hours | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | 113.00 | - | 9.00 | - | - | 69.00 | - | - | - | - | 4.00 | 191.00 | 1,140.18 | 17% |
| Feb | 106.00 | 243.00 | - | - | - | 57.00 | - | - | - | - | 1.00 | 406.00 | 1,537.82 | 26% |
| Mar | - | 169.00 | - | - | 88.00 | 23.00 | - | - | - | - | 3.00 | 280.00 | 1,143.18 | 24% |
| Apr | - | - | - | 34.00 | - | 6.00 | - | - | 3.00 | 21.00 | - | 64.00 | 306.82 | 21% |
| May | - | - | - | 142.00 | - | 67.00 | - | 6.00 | 15.00 | 180.00 | - | 410.00 | 2,345.40 | 17% |
| June | - | - | - | - | 146.00 | 74.00 | - | 26.00 | 51.00 | 70.00 | 6.00 | 367.00 | 2,890.43 | 13% |
| July | - | - | - | 283.00 | 167.00 | 1.00 | - | 11.00 | 47.00 | - | 3.00 | 509.00 | 2,371.73 | 21% |
| Aug | - | - | - | 23.00 | 141.00 | 50.00 | 29.00 | - | 5.00 | - | 11.00 | 248.00 | 1,881.17 | 13% |
| Sept | - | - | - | 15.00 | 65.00 | 50.00 | 15.00 | - | - | - | 2.00 | 145.00 | 1,785.80 | 8% |
| Oct | - | 76.00 | - | - | - | 53.00 | 21.00 | - | - | - | 1.00 | 150.00 | 1,844.63 | 8% |
| Nov | - | 395.00 | - | - | - | - | 19.00 | - | - | - | 1.00 | 414.00 | 1,078.52 | 38% |
| Dec | - | 115.00 | 30.00 | - | - | - | - | - | - | - | 6.00 | 145.00 | 807.13 | 18% |
| Total | 219.00 | 998.00 | 39.00 | 497.00 | 607.00 | 450.00 | 84.00 | 43.00 | 121.00 | 271.00 | 38.00 | 3,329.00 | 19,132.81 | 17% |

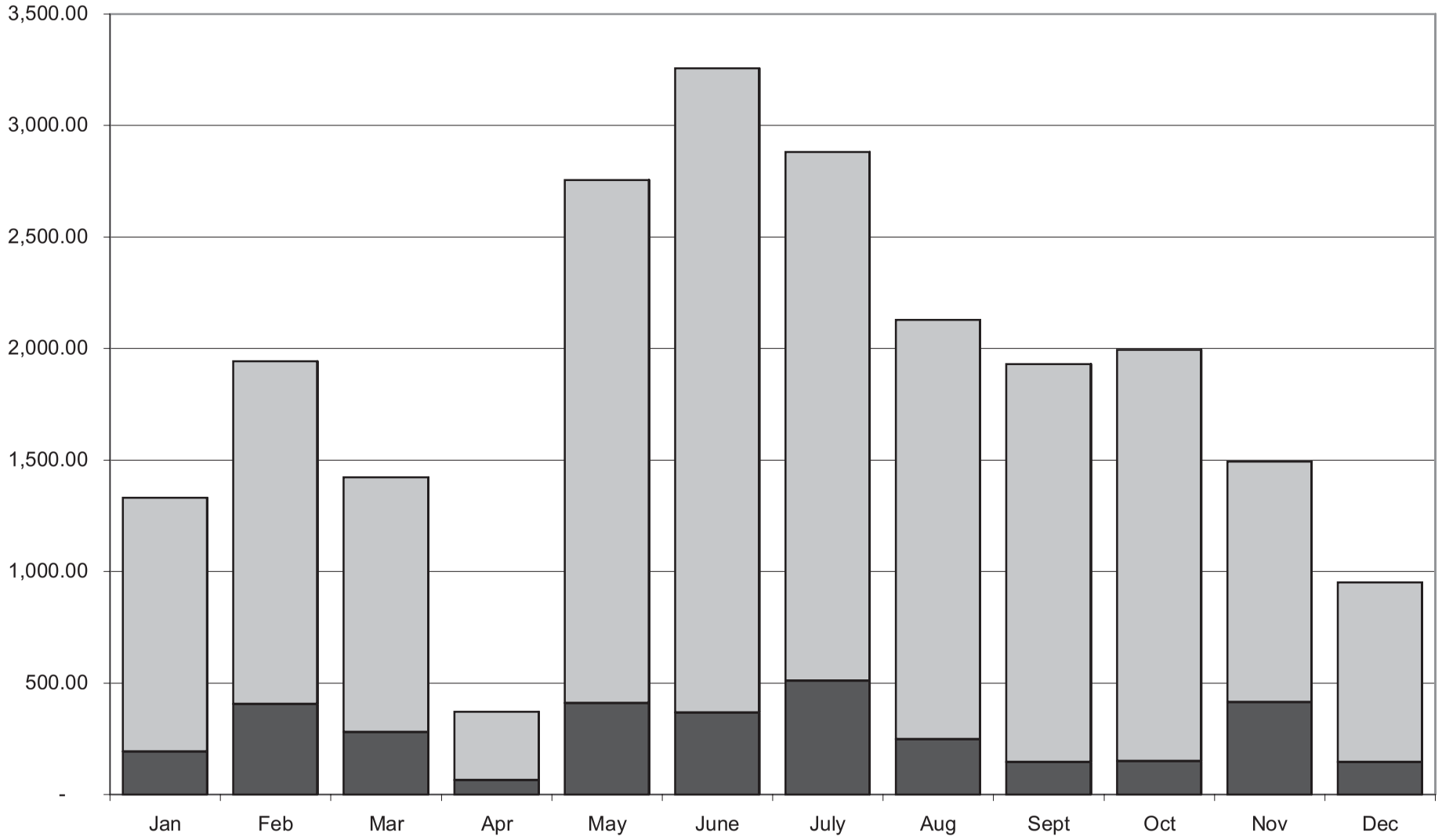


# Table 9. POD - Porpoise Positive Hours Per Year of Survey

| Year | Burry Holms | Carmarthen | Kenfig | Mumbles | Port Eynon | Port Talbot | Scarweather | Scar-Central | Scar-East | Scar-West | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2002 | - | - | 30.00 | - | - | - | - | - | - | - | 30.00 |
| 2003 | 219.00 | 998.00 | 9.00 | 15.00 | 607.00 | 310.00 | 84.00 | - | - | - | 2,242.00 |
| 2004 | - | - | - | 482.00 | - | 140.00 | - | 43.00 | 121.00 | | 1,057.00 |
| **Total** | **219.00** | **998.00** | **39.00** | **497.00** | **607.00** | **450.00** | **84.00** | **43.00** | **121.00** | **271.00** | **3,329.00** |

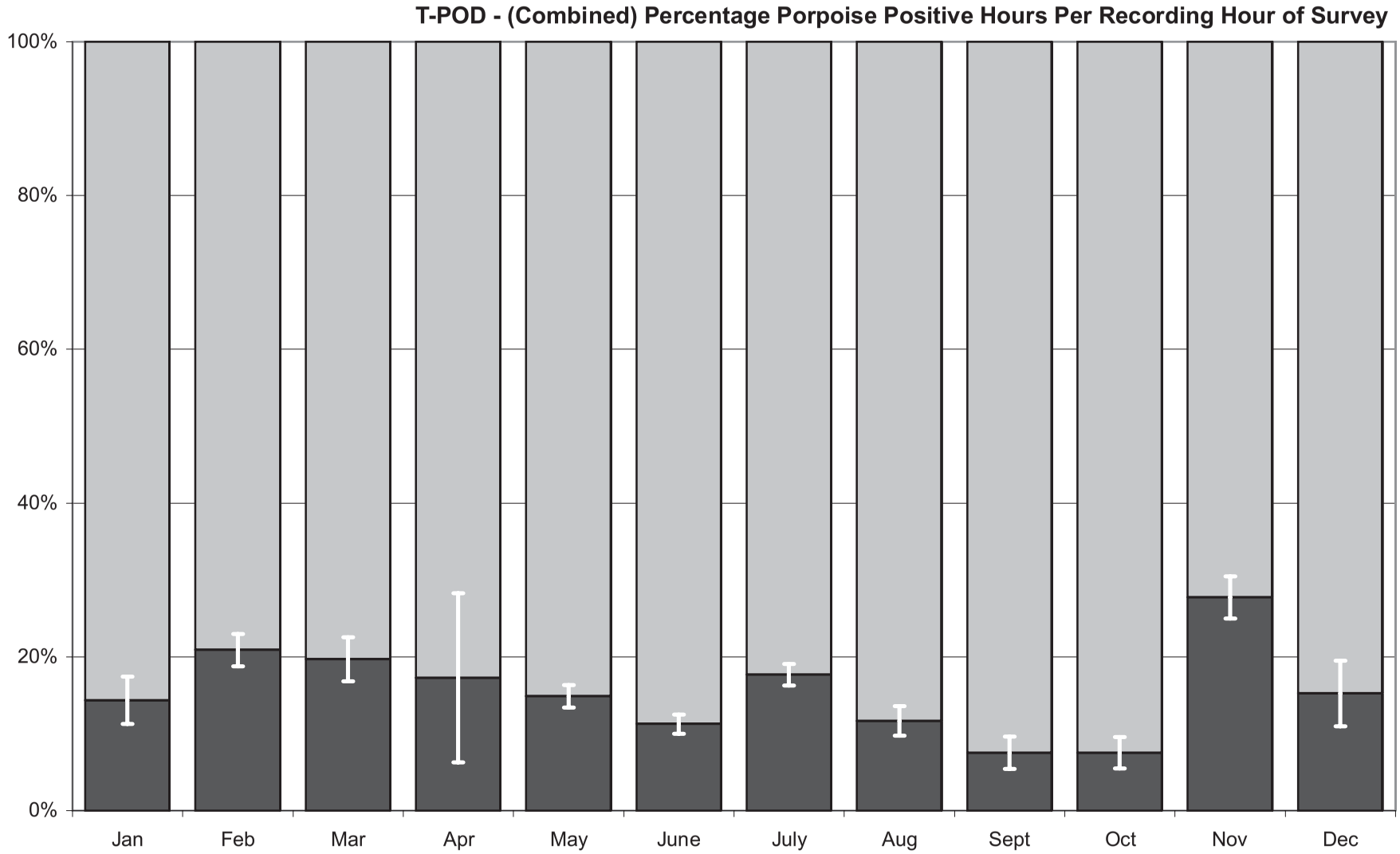
# Figure 17. TPOD - Porpoise Positive Hours Per Recording Hour of Survey

Combined Months / Absolute Number



# Figure 18. T-POD - Porpoise Positive Hours Per Recording Hour of Survey

Combined months / effort corrected. Error bars set at 1 Standard Error of Mean.



# Figure 19. POD - Porpoise Positive Minutes Classified by Tide State

Tide state 1 is the first period of approximately 1 hour after low water: period 12 is the last hour down the following low water.
Error bars set at 1 Standard Error of mean frequency

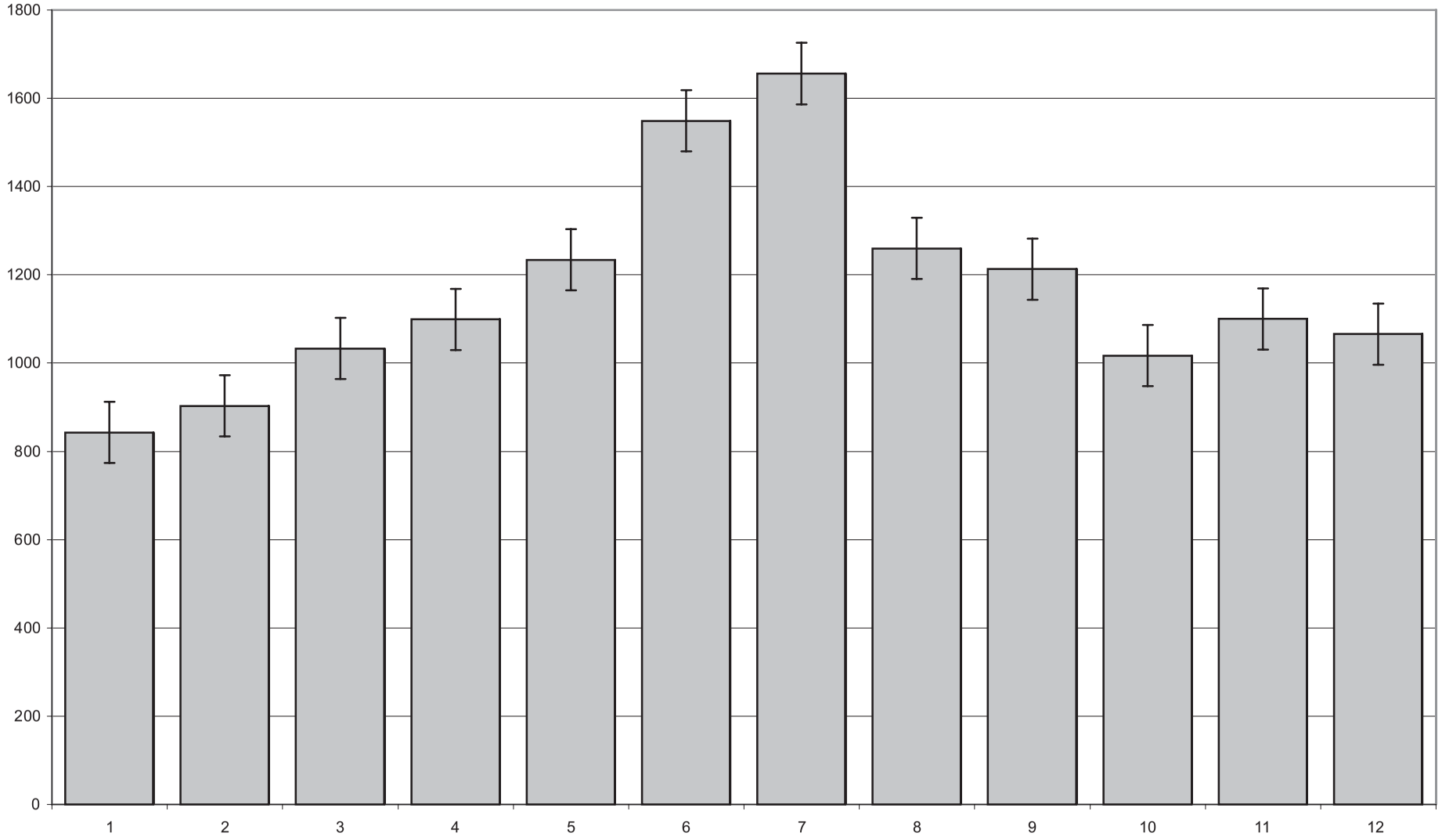


Figure 20a. All PODS - Porpoise Positive Hours Classified by Tide State

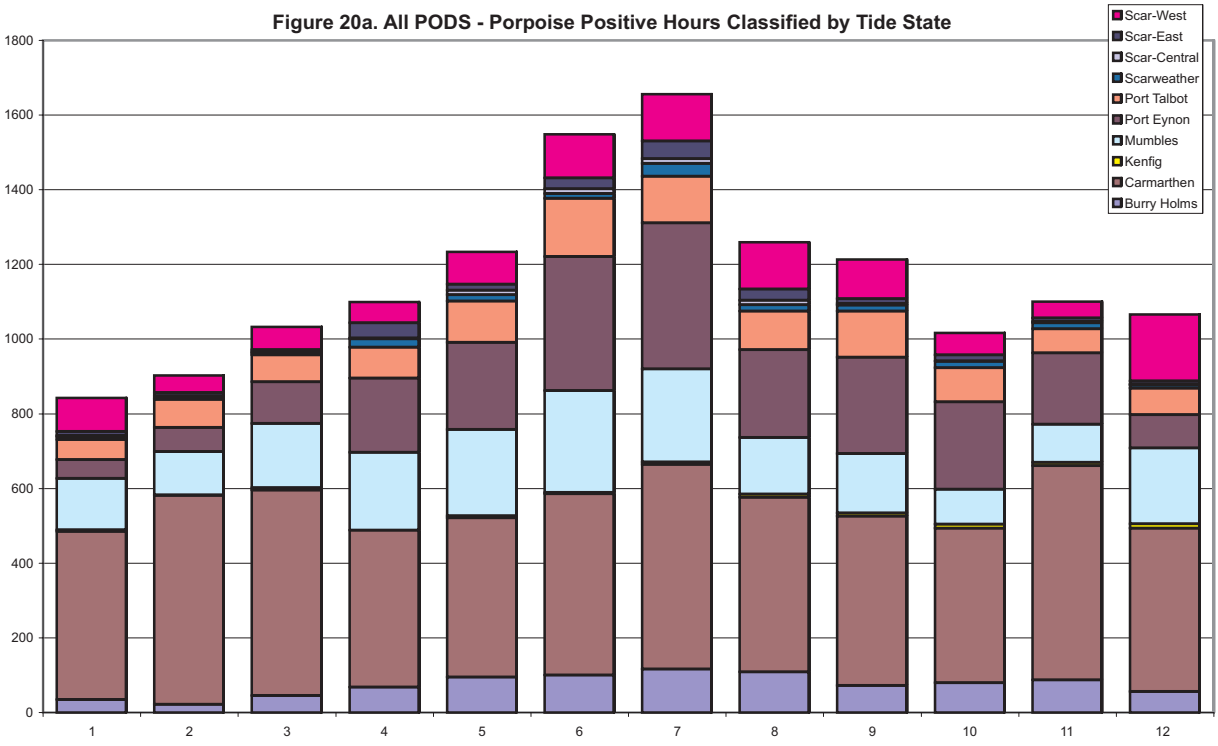
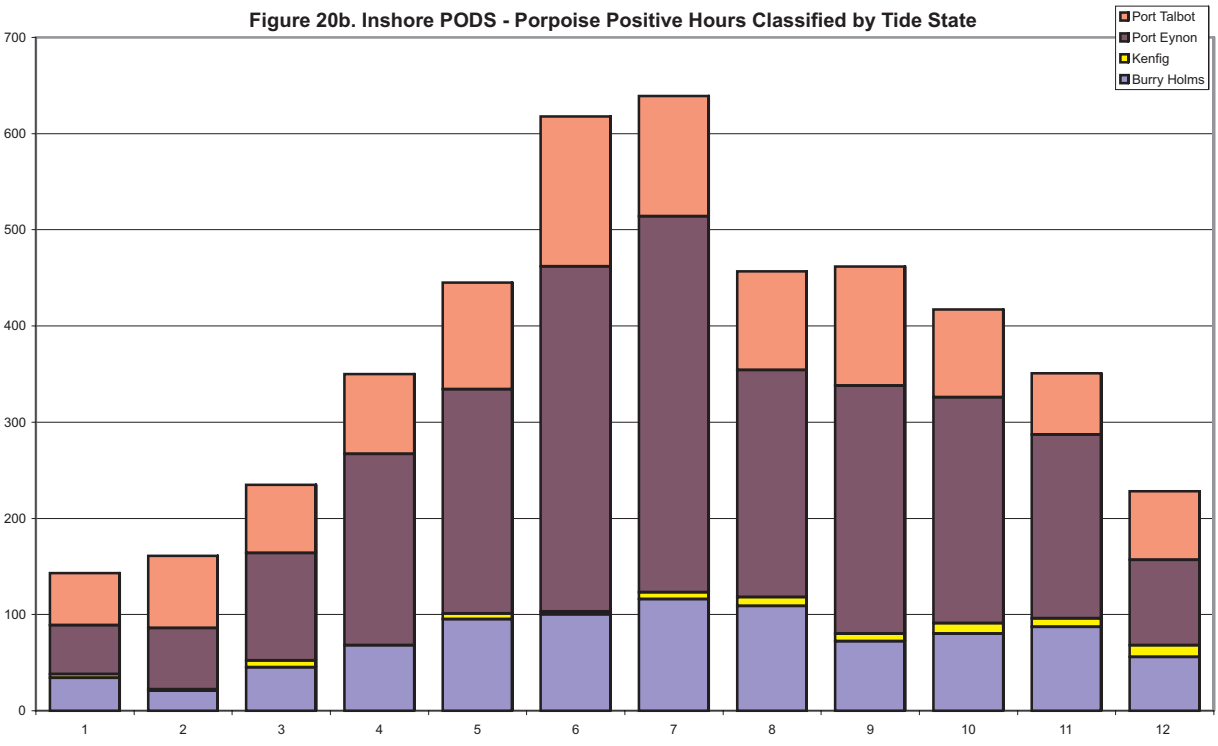



Figure 20b. Inshore PODS - Porpoise Positive Hours Classified by Tide State



# Table 10. POD - Porpoise Positive Minutes Classified by Tide State

Tide state 1 is the first period of approximately 1 hour after low water: period 12 is the last hour down the following low water.

| Tide State | Burry Holms | Carmarthen | Kenfig | Mumbles | Port Eynon | Port Talbot | Scarweather | Scar-Central | Scar-East | Scar-West | Total: |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 34 | 451 | 4 | 137 | 51 | 54 | 7 | 3 | 11 | 91 | **843** |
| **2** | 21 | 560 | 1 | 117 | 64 | 75 | 3 | 7 | 8 | 47 | **903** |
| **3** | 45 | 550 | 7 | 172 | 112 | 71 | 6 | 3 | 5 | 62 | **1033** |
| **4** | 68 | 420 | 0 | 208 | 199 | 83 | 22 | 3 | 40 | 56 | **1099** |
| **5** | 95 | 426 | 6 | 231 | 233 | 111 | 17 | 11 | 17 | 87 | **1234** |
| **6** | 100 | 486 | 3 | 273 | 359 | 156 | 12 | 13 | 29 | 118 | **1549** |
| **7** | 116 | 548 | 7 | 249 | 391 | 125 | 34 | 13 | 47 | 126 | **1656** |
| **8** | 109 | 467 | 9 | 151 | 236 | 103 | 17 | 12 | 30 | 126 | **1260** |
| **9** | 72 | 454 | 8 | 159 | 258 | 124 | 16 | 4 | 13 | 105 | **1213** |
| **10** | 80 | 413 | 11 | 93 | 235 | 91 | 17 | 1 | 17 | 59 | **1017** |
| **11** | 87 | 574 | 9 | 102 | 191 | 64 | 17 | 3 | 9 | 44 | **1100** |
| **12** | 56 | 437 | 12 | 203 | 89 | 71 | 9 | 2 | 9 | 178 | **1066** |
| **Total:** | **883** | **5786** | **77** | **2095** | **2418** | **1128** | **177** | **75** | **235** | **1099** | **13973** |

# Figure 21a-j. POD Porpoise Positive Minutes Classified by Tide State

Error bars set at 1 standard error of mean.



Figure 21a. Burry Holms POD - Porpoise Positive Trains Classified by Tide State

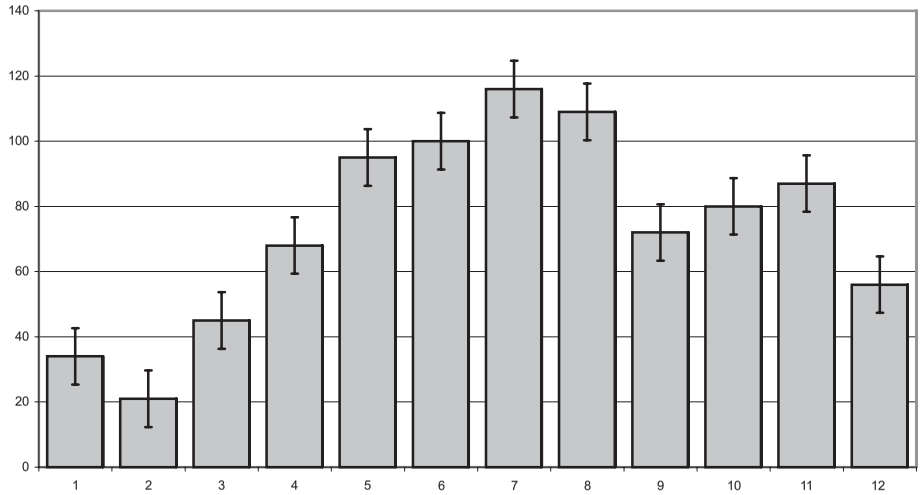
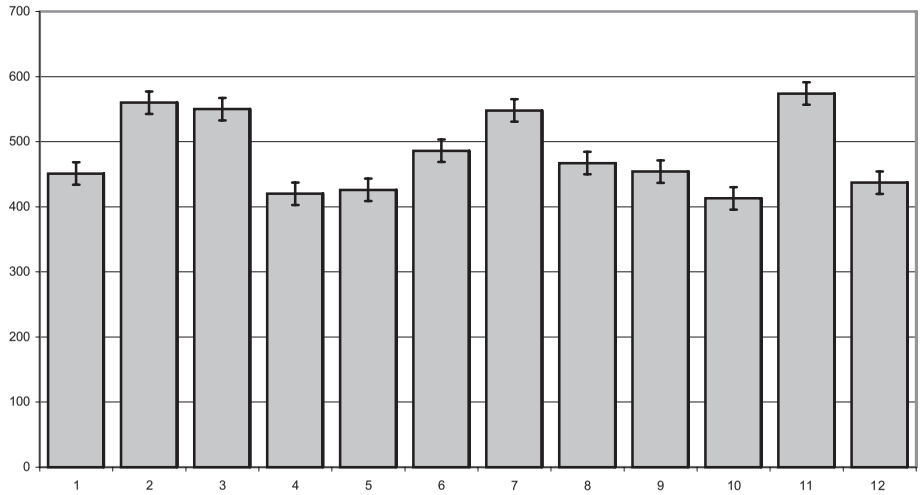



Figure 21b. Carmarthen Bay POD - Porpoise Positive Trains Classified by Tide State



# Figure 21a-j. POD Porpoise Positive Minutes Classified by Tide State

Error bars set at 1 standard error of mean.

Figure 21c. Kenfig POD - Porpoise Positive Trains Classified by Tide State

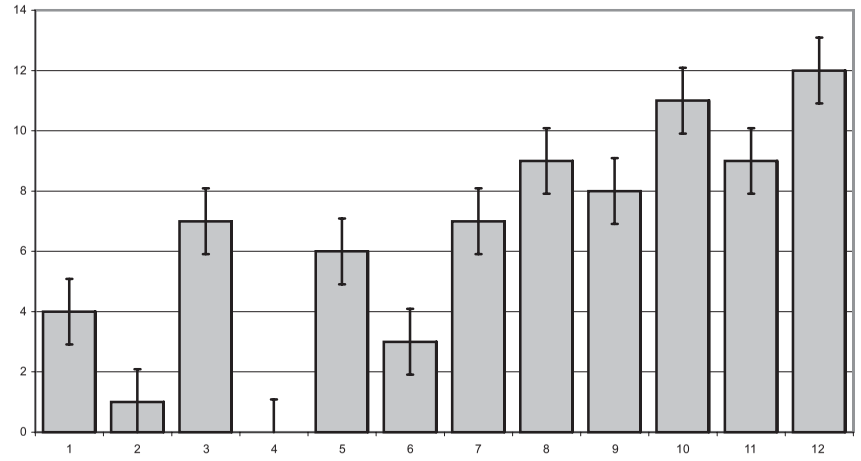



Figure 21d. Mumbles POD - Porpoise Positive Trains Classified by Tide State

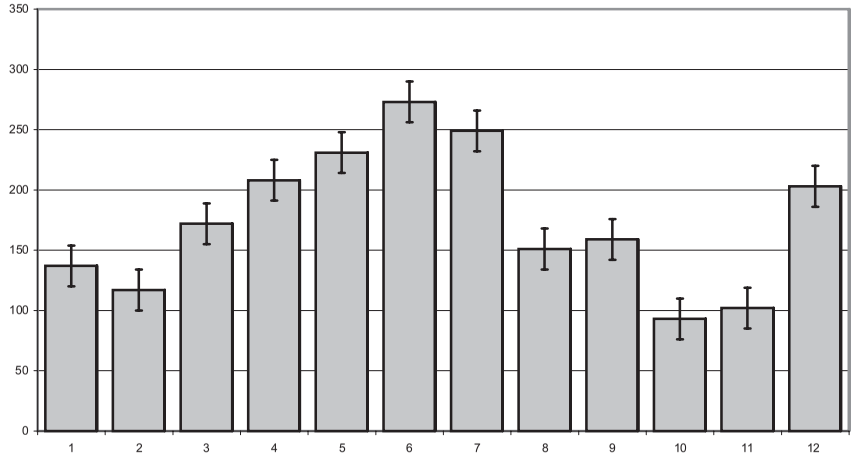



Figure 21e. Port Eynon POD - Porpoise Positive Trains Classified by Tide State

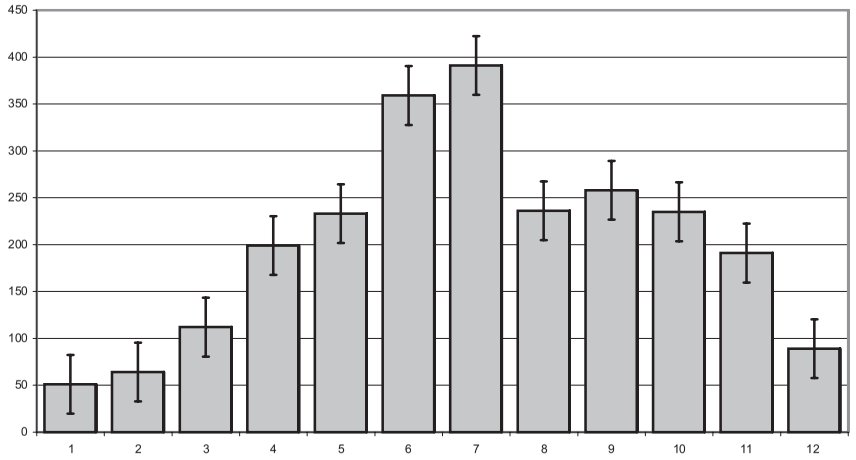
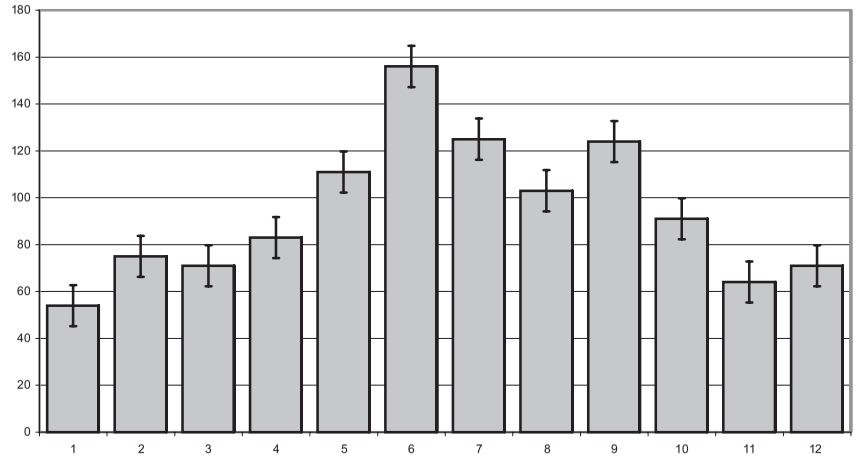



Figure 21f. Port Talbot POD - Porpoise Positive Trains Classified by Tide State



# Figure 21a-j. POD Porpoise Positive Minutes Classified by Tide State

Error bars set at 1 standard error of mean.

Figure 21g. Scarweather POD - Porpoise Positive Trains Classified by Tide State

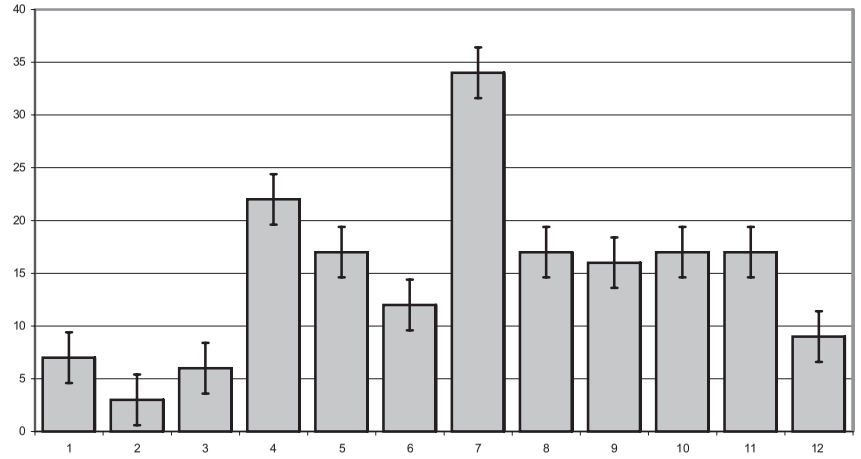



Figure 21h. Scarweather (Central) POD - Porpoise Positive Trains Classified by Tide State

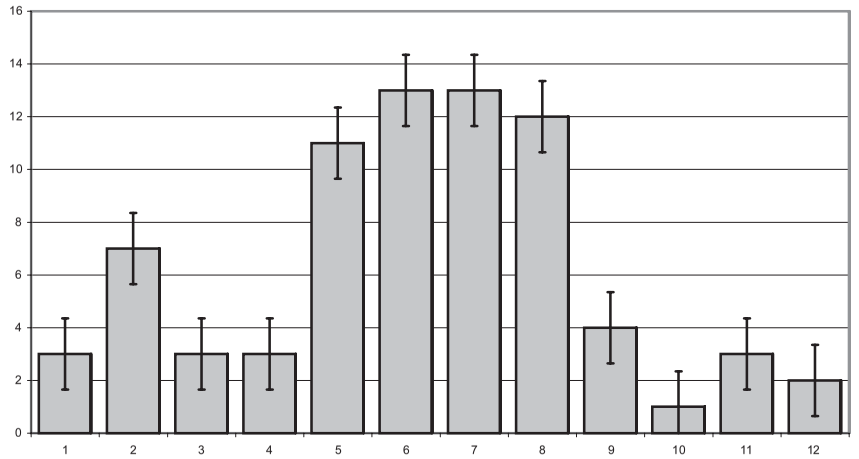



Figure 21i. Scarweather (Eastern) POD - Porpoise Positive Trains Classified by Tide State

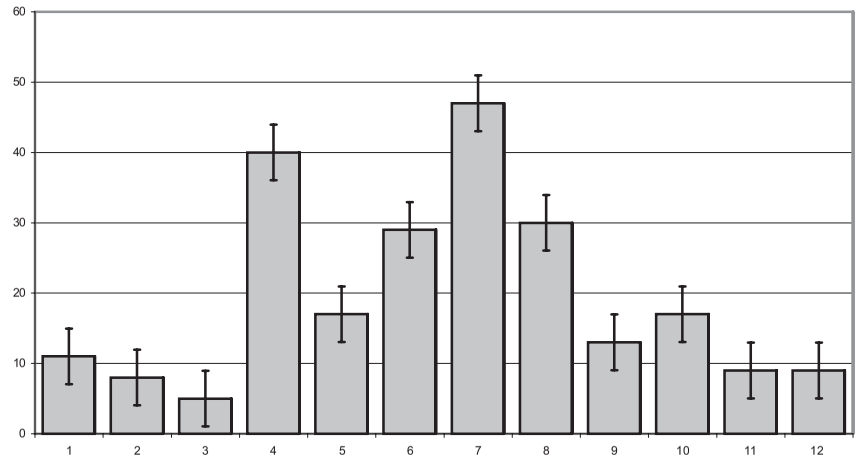



Figure 21j. Scarweather (Western) POD - Porpoise Positive Trains Classified by Tide State

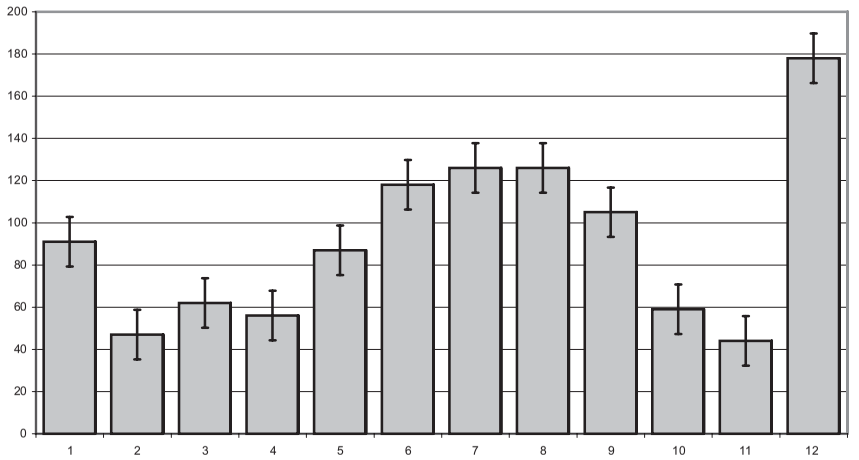
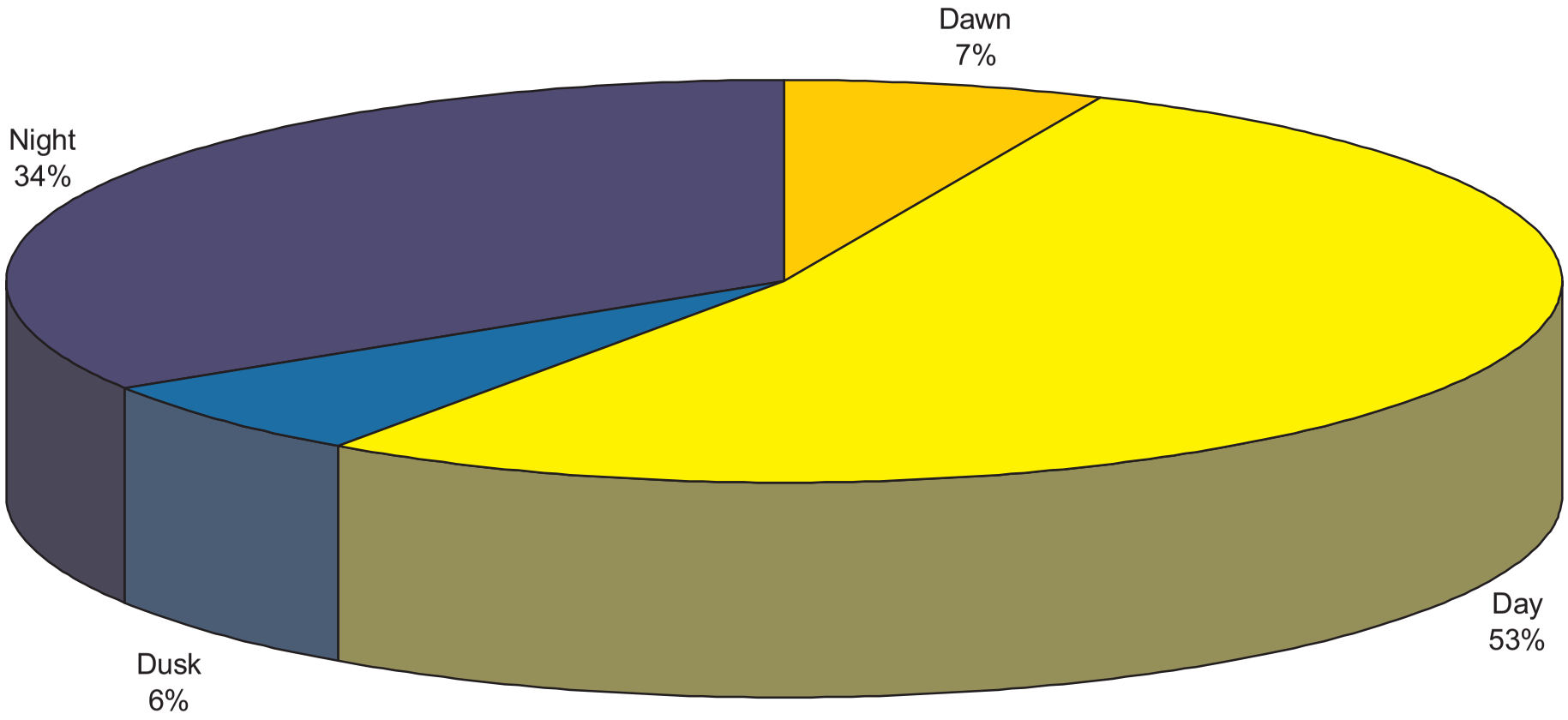


Figure 22. POD - Porpoise Positive Minutes Classified by Day State



# Table 11. POD - Porpoise Positive Minutes Classified by Day State

UKHO dataset for Mumbles station used to define periods of day, night and nautical twilight.

Porpoise Positive Minutes Classified by Day-state

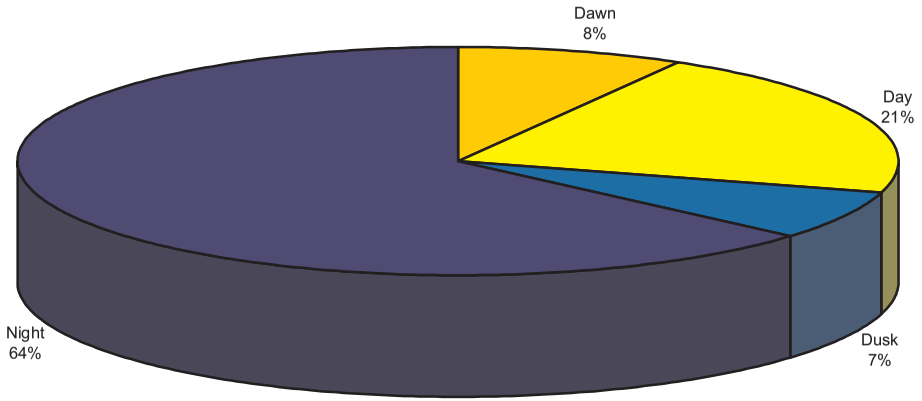
| Month | Burry Holms | Carmarthen | Kenfig | Mumbles | Port Eynon | Port Talbot | Scarweather | Scar-Central | Scar-East | Scar-West | Total: |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dawn** | 73 | 258 | 9 | 209 | 174 | 62 | 9 | 7 | 25 | 117 | **943** |
| **Day** | 187 | 3275 | 14 | 1319 | 1140 | 578 | 91 | 58 | 152 | 602 | **7416** |
| **Dusk** | 61 | 256 | 0 | 163 | 208 | 72 | 9 | 5 | 24 | 89 | **887** |
| **Night** | 562 | 1997 | 54 | 404 | 896 | 416 | 68 | 5 | 34 | 291 | **4727** |
| **Total:** | **883** | **5786** | **77** | **2095** | **2418** | **1128** | **177** | **75** | **235** | **1099** | **13973** |



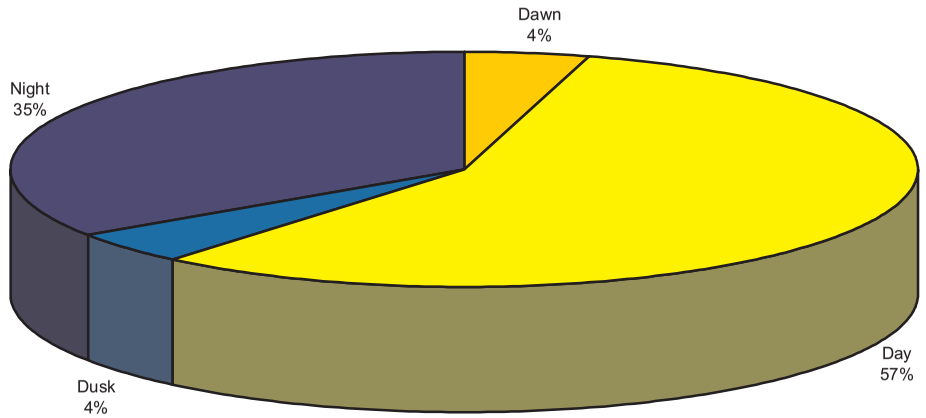
# Figure 23a-j. POD Porpoise Positive Minutes Classified by Daylight State

Twilight, sunset and sunrise times calculated from UKHO data for Mumbles station.

**23a. Burry Holms POD - Porpoise Positive Minutes Classified by Day State**

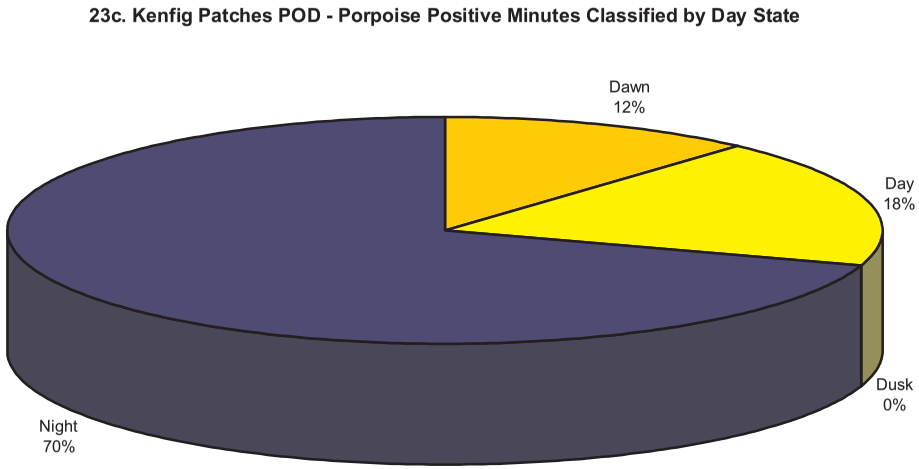


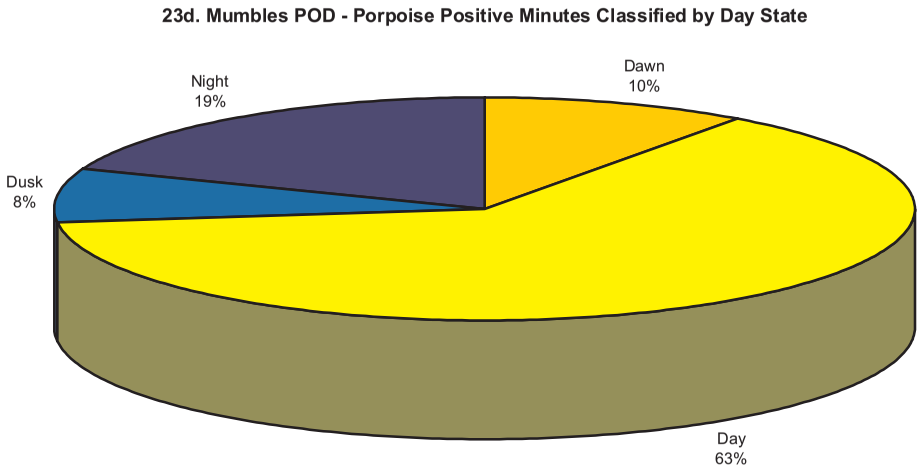

**23b. Carmarthen Bay POD - Porpoise Positive Minutes Classified by Day State**

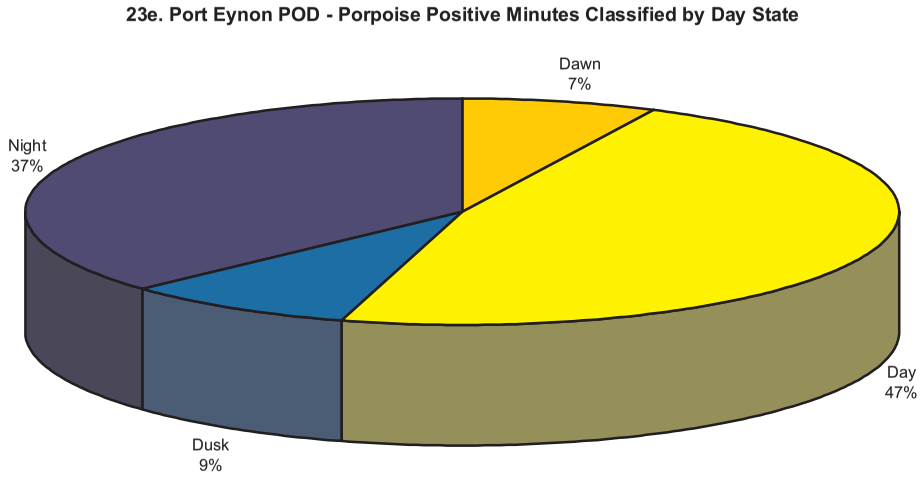


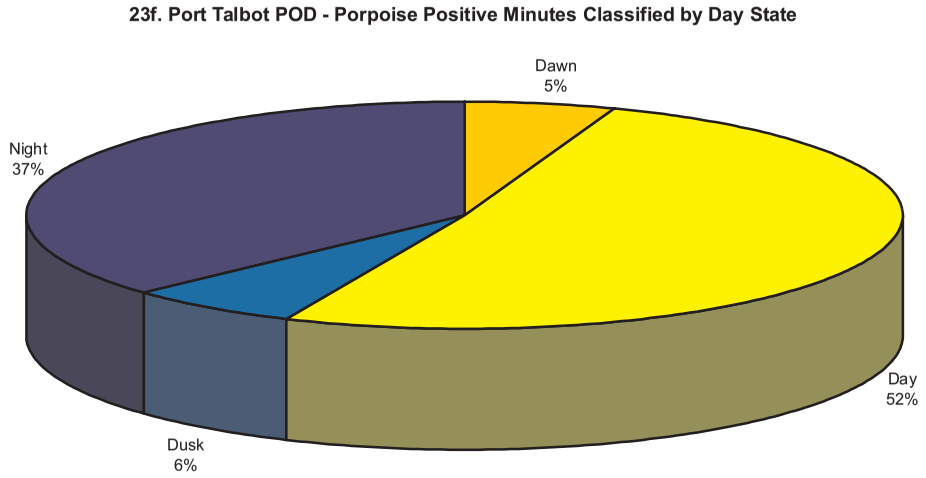
# Figure 23a-j. POD Porpoise Positive Minutes Classified by Daylight State

Twilight, sunset and sunrise times calculated from UKHO data for Mumbles station.



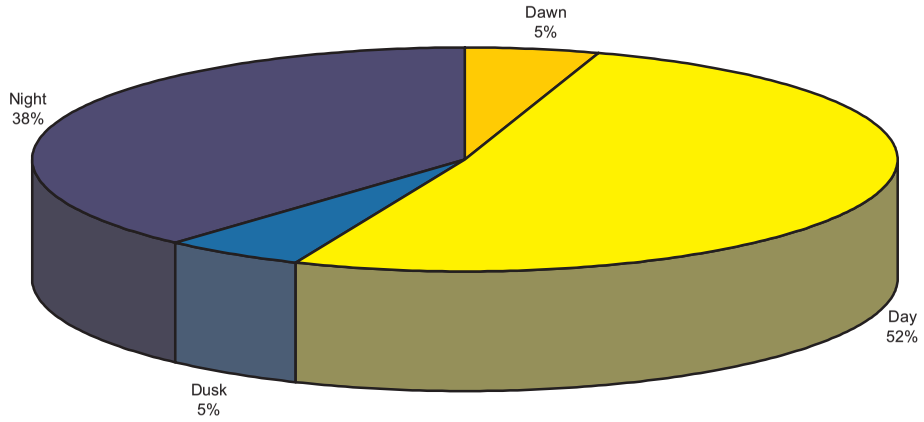



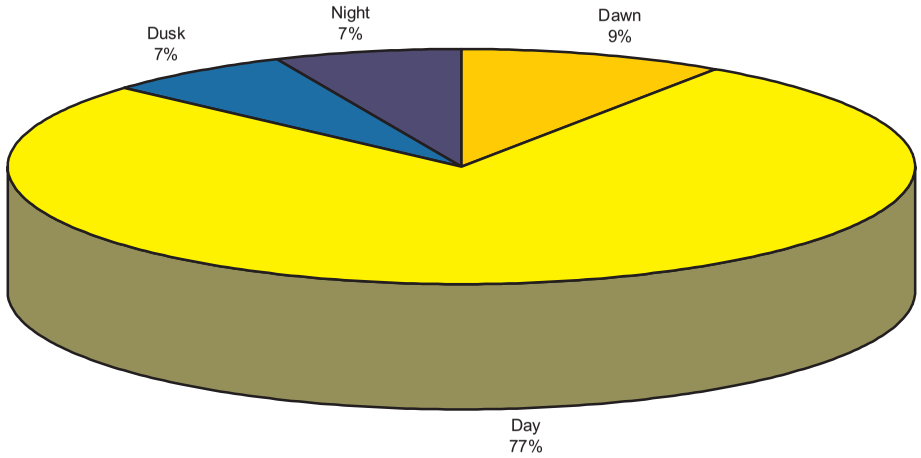
# Figure 23a-j. POD Porpoise Positive Minutes Classified by Daylight State

Twilight, sunset and sunrise times calculated from UKHO data for Mumbles station.

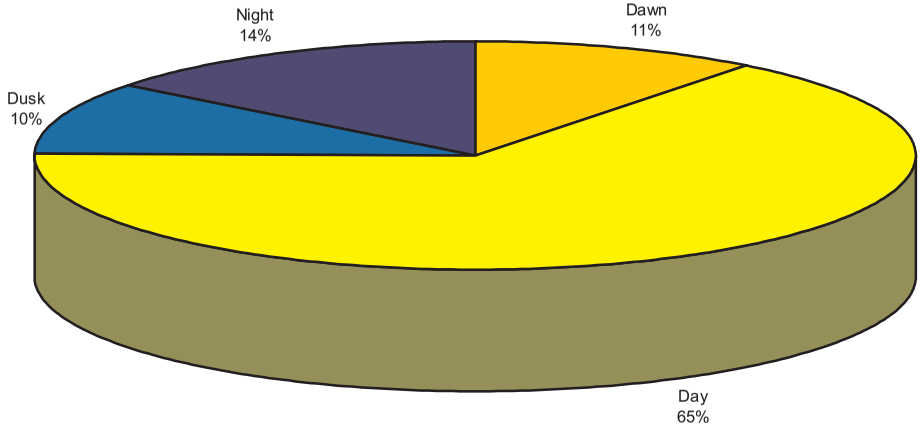
**23g. Scarweather POD - Porpoise Positive Minutes Classified by Day State**



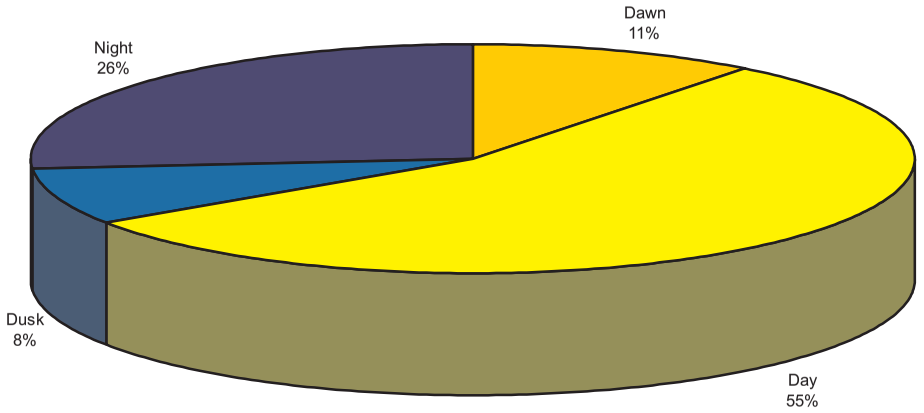

**23h. Scarweather (Central) POD - Porpoise Positive Minutes Classified by Day State**




**23i. Scarweather (Eastern) POD - Porpoise Positive Minutes Classified by Day State**




**23j. Scarweather (Western) POD - Porpoise Positive minutes Classified by Day State**



# Table 12. POD - Porpoise Positive Minutes Classified by Lunar Day

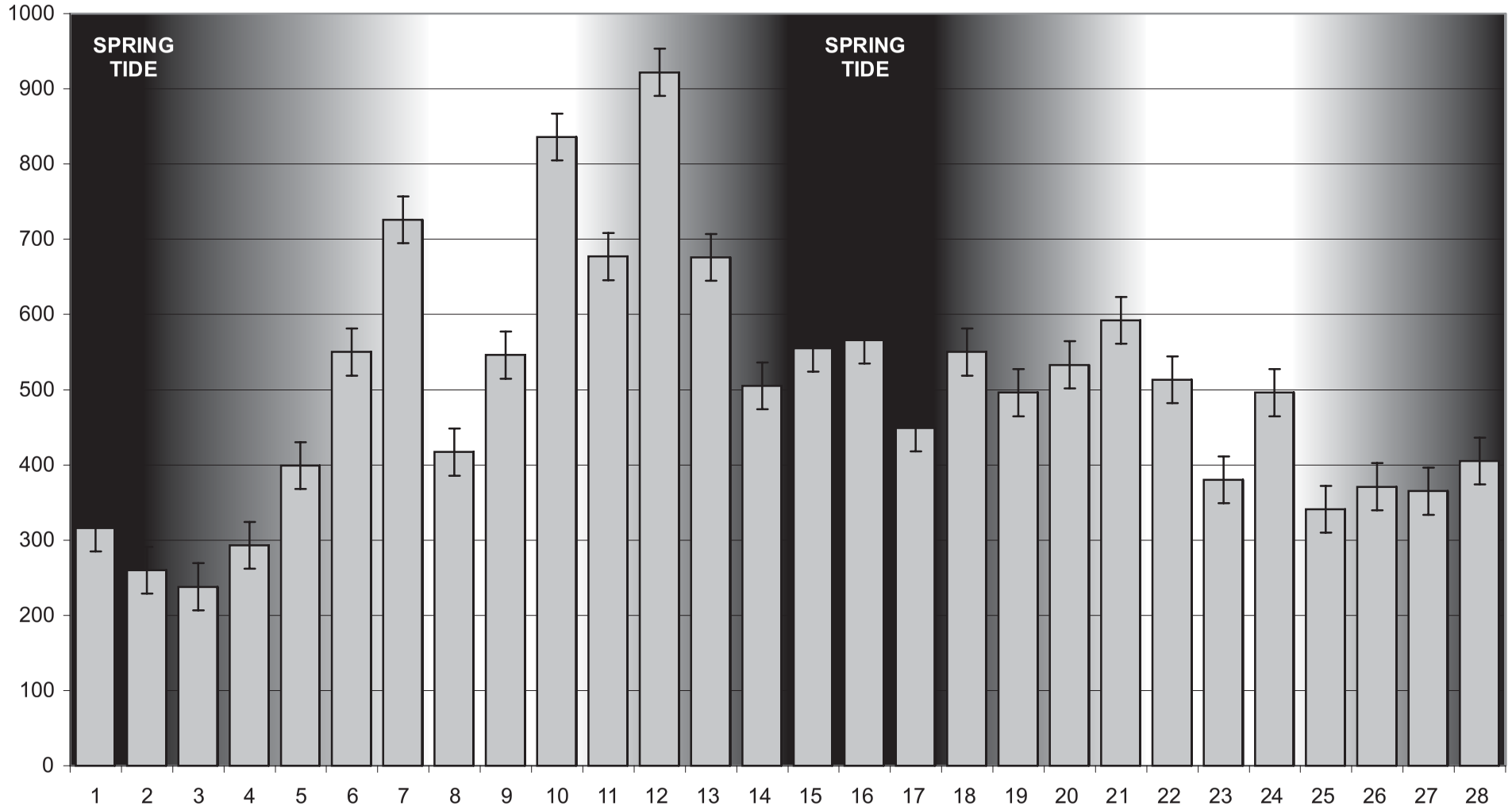
Lunar state 1 is the first lunar period (1/28th of a lunar month) from the rise of the new moon: 28 is the is the last hour up to the rise of the following new moon.

Table 12. Porpoise Positive Minutes Classified By Lunar Day

| Lunar Day | Burry Holms | Carmarthen | Kenfig | Mumbles | Port Eynon | Port Talbot | Scarweather | Scar-Central | Scar-East | Scar-West | Total: |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 0 | 149 | 0 | 60 | 69 | 27 | 1 | 0 | 5 | 5 | **316** |
| **2** | 0 | 65 | 1 | 45 | 65 | 23 | 18 | 4 | 6 | 33 | **260** |
| **3** | 0 | 58 | 0 | 56 | 35 | 29 | 0 | 0 | 6 | 54 | **238** |
| **4** | 22 | 76 | 6 | 41 | 71 | 9 | 11 | 0 | 16 | 41 | **293** |
| **5** | 10 | 121 | 10 | 65 | 63 | 11 | 2 | 2 | 6 | 109 | **399** |
| **6** | 22 | 226 | 5 | 41 | 63 | 9 | 1 | 0 | 3 | 180 | **550** |
| **7** | 29 | 294 | 1 | 23 | 121 | 45 | 4 | 1 | 9 | 199 | **726** |
| **8** | 37 | 201 | 7 | 23 | 92 | 25 | 1 | 0 | 5 | 26 | **417** |
| **9** | 33 | 223 | 8 | 54 | 106 | 40 | 3 | 4 | 20 | 55 | **546** |
| **10** | 26 | 499 | 7 | 90 | 77 | 85 | 4 | 8 | 9 | 31 | **836** |
| **11** | 36 | 280 | 7 | 109 | 105 | 59 | 4 | 8 | 5 | 64 | **677** |
| **12** | 162 | 418 | 3 | 141 | 70 | 77 | 6 | 2 | 19 | 24 | **922** |
| **13** | 48 | 310 | 2 | 133 | 87 | 72 | 9 | 1 | 5 | 9 | **676** |
| **14** | 56 | 232 | 2 | 83 | 51 | 37 | 5 | 4 | 18 | 17 | **505** |
| **15** | 157 | 218 | 9 | 38 | 55 | 46 | 14 | 0 | 9 | 9 | **555** |
| **16** | 155 | 157 | 1 | 91 | 85 | 48 | 5 | 3 | 6 | 15 | **566** |
| **17** | 20 | 255 | 3 | 19 | 76 | 42 | 2 | 0 | 16 | 16 | **449** |
| **18** | 29 | 278 | 5 | 29 | 129 | 47 | 1 | 0 | 5 | 27 | **550** |
| **19** | 31 | 278 | 0 | 58 | 81 | 32 | 1 | 1 | 0 | 14 | **496** |
| **20** | 10 | 299 | 0 | 59 | 124 | 27 | 3 | 1 | 5 | 5 | **533** |
| **21** | 0 | 193 | 0 | 190 | 150 | 23 | 18 | 3 | 2 | 13 | **592** |
| **22** | 0 | 115 | 0 | 168 | 151 | 37 | 6 | 5 | 7 | 24 | **513** |
| **23** | 0 | 87 | 0 | 81 | 108 | 50 | 7 | 1 | 9 | 37 | **380** |
| **24** | 0 | 125 | 0 | 157 | 109 | 56 | 23 | 4 | 5 | 17 | **496** |
| **26** | 0 | 143 | 0 | 40 | 52 | 53 | 14 | 1 | 9 | 29 | **341** |
| **26** | 0 | 137 | 0 | 84 | 85 | 35 | 9 | 1 | 2 | 18 | **371** |
| **27** | 0 | 162 | 0 | 8 | 94 | 61 | 5 | 11 | 19 | 5 | **365** |
| **28** | 0 | 187 | 0 | 109 | 44 | 23 | 0 | 10 | 9 | 23 | **405** |
| **Total:** | **883** | **5786** | **77** | **2095** | **2418** | **1128** | **177** | **75** | **235** | **1099** | **13973** |

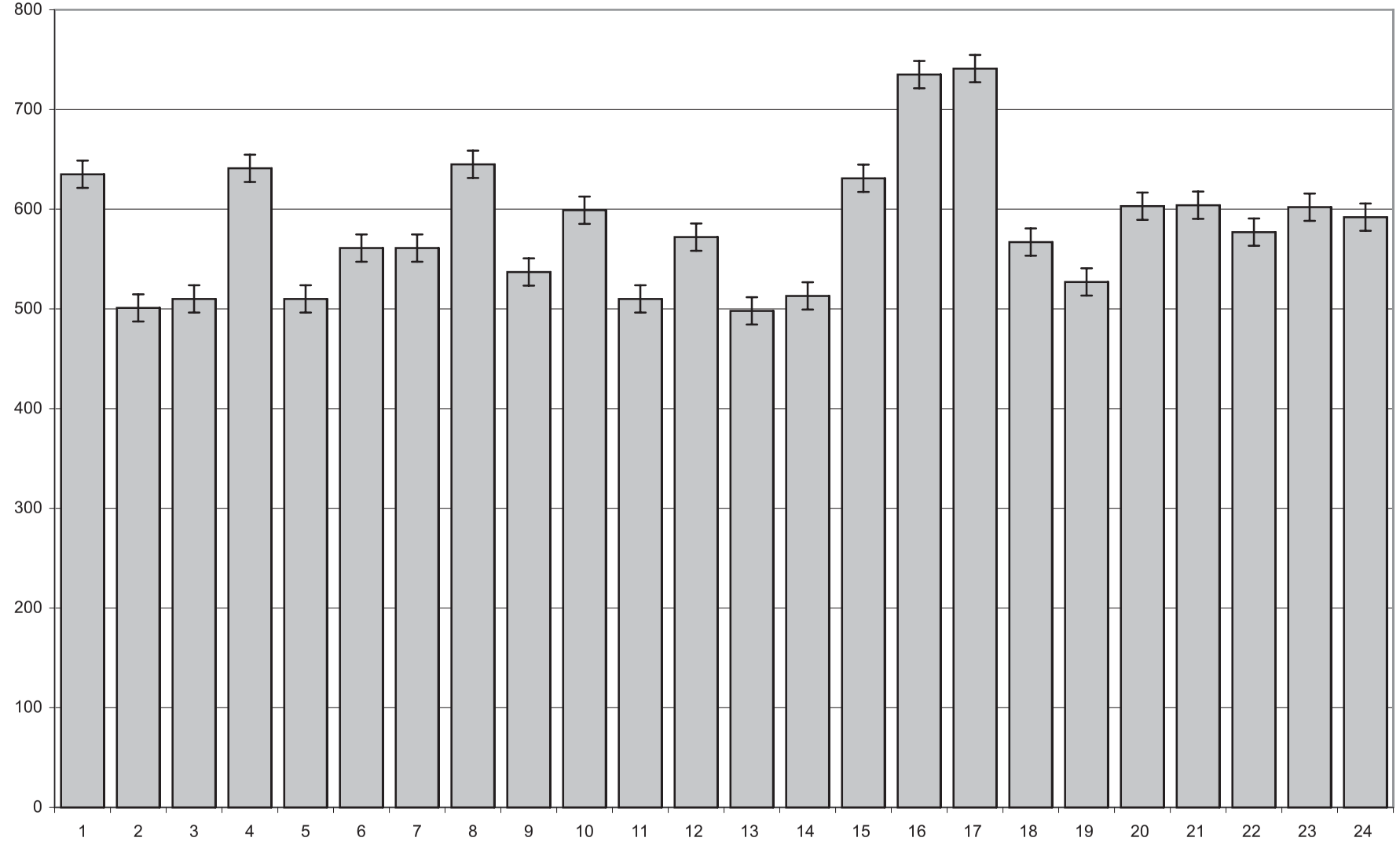
# Figure 24. POD - Porpoise Positive Minutes Classified by Lunar Day

Tide state 1 is the first lunar period (1/28th of a lunar month) from the rise of the new moon: 28 is the is the last hour up to the rise of the following new moon.
Error bars set at 1 Standard Error of mean frequency



# Figure 25. POD - Porpoise Positive Minutes Classified by 24 Hour Clock

Error bars set at 1 Standard Error of mean frequency

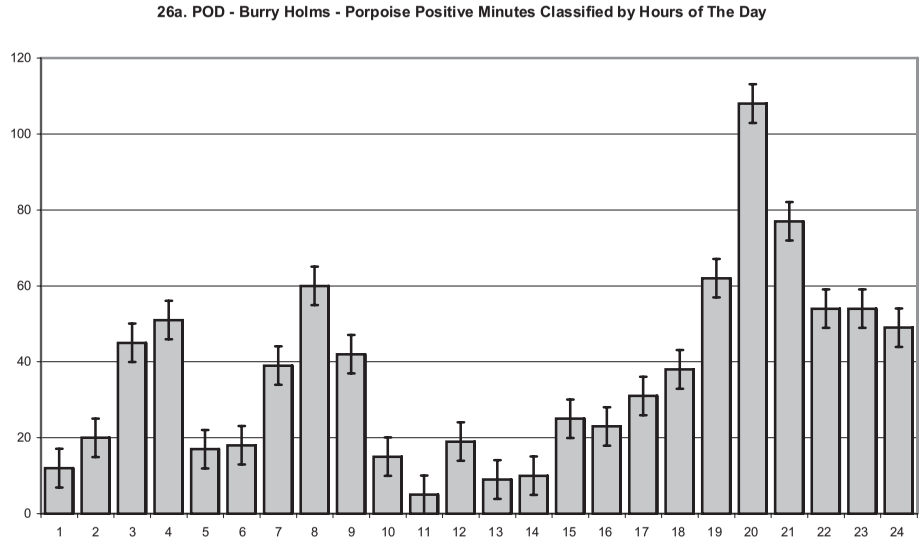


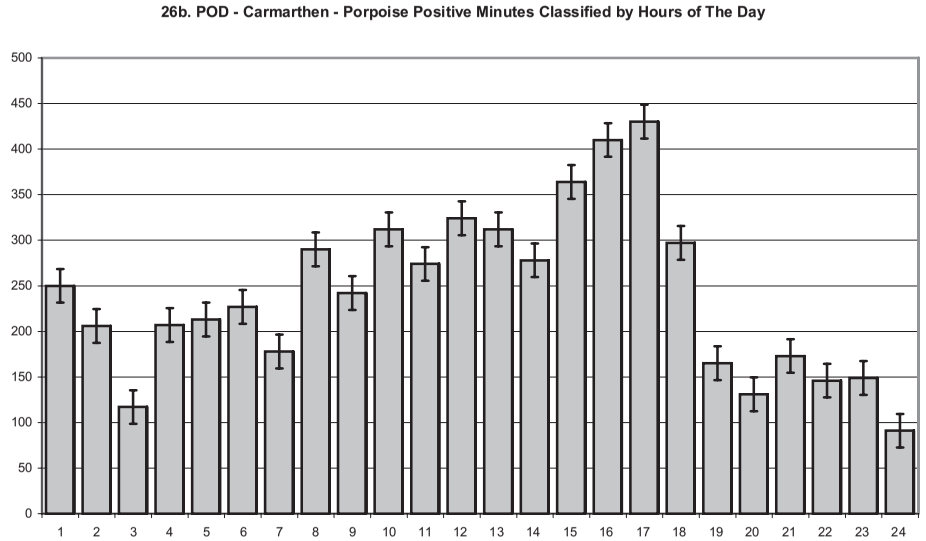
# Table 13. POD - Porpoise Positive Minutes Classified by Hour of Day (24 Hour).

| Location | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Burry Holms** | 12 | 20 | 45 | 51 | 17 | 18 | 39 | 60 | 42 | 15 | 5 | 19 | 9 | 10 | 25 | 23 | 31 | 38 | 62 | 108 | 77 | 54 | 54 | 49 | **883** |
| **Carmarthen** | 250 | 206 | 117 | 207 | 213 | 227 | 178 | 290 | 242 | 312 | 274 | 324 | 312 | 278 | 364 | 410 | 430 | 297 | 165 | 131 | 173 | 146 | 149 | 91 | **5786** |
| **Kenfig** | 7 | 5 | 13 | 2 | 3 | | 2 | 9 | 3 | 3 | | 4 | | | 2 | 2 | | 2 | 4 | 3 | 3 | 1 | 9 | | **77** |
| **Mumbles** | 80 | 57 | 81 | 136 | 90 | 82 | 109 | 86 | 81 | 125 | 93 | 53 | 56 | 74 | 65 | 78 | 93 | 85 | 62 | 110 | 101 | 104 | 93 | 101 | **2095** |
| **Port Eynon** | 177 | 124 | 130 | 104 | 89 | 85 | 102 | 86 | 57 | 54 | 64 | 107 | 43 | 60 | 63 | 74 | 100 | 56 | 94 | 143 | 130 | 113 | 150 | 213 | **2418** |
| **Port Talbot** | 41 | 45 | 32 | 55 | 44 | 90 | 64 | 47 | 47 | 31 | 22 | 27 | 29 | 28 | 45 | 73 | 48 | 23 | 77 | 56 | 60 | 64 | 40 | 40 | **1128** |
| **Scarweather** | 4 | 1 | 13 | 8 | 10 | 8 | 9 | 5 | 4 | 4 | 15 | 5 | 4 | 4 | 9 | 10 | 16 | 12 | 10 | 2 | 13 | 4 | 4 | 3 | **177** |
| **Scar-Central** | 1 | 4 | 5 | 2 | 9 | 7 | 2 | 3 | | 3 | 6 | 7 | 2 | | 2 | 1 | 3 | 4 | 8 | 1 | | 4 | 1 | | **75** |
| **Scar-East** | 10 | 11 | 6 | 15 | 10 | 14 | 13 | 8 | 11 | 10 | 3 | 5 | 12 | 18 | 10 | 7 | 2 | 12 | 3 | 14 | 19 | 10 | 4 | 8 | **235** |
| **Scar-West** | 53 | 28 | 68 | 61 | 25 | 30 | 43 | 52 | 50 | 42 | 28 | 21 | 31 | 41 | 46 | 57 | 18 | 38 | 42 | 35 | 28 | 77 | 98 | 87 | **1099** |
| **Total** | 635 | 501 | 510 | 641 | 510 | 561 | 561 | 646 | 537 | 599 | 510 | 572 | 498 | 513 | 631 | 735 | 741 | 567 | 527 | 603 | 604 | 577 | 602 | 592 | **13973** |

# Figure 26a-j. POD Porpoise Positive Minutes Classified by Hour of Day (24 Hour)

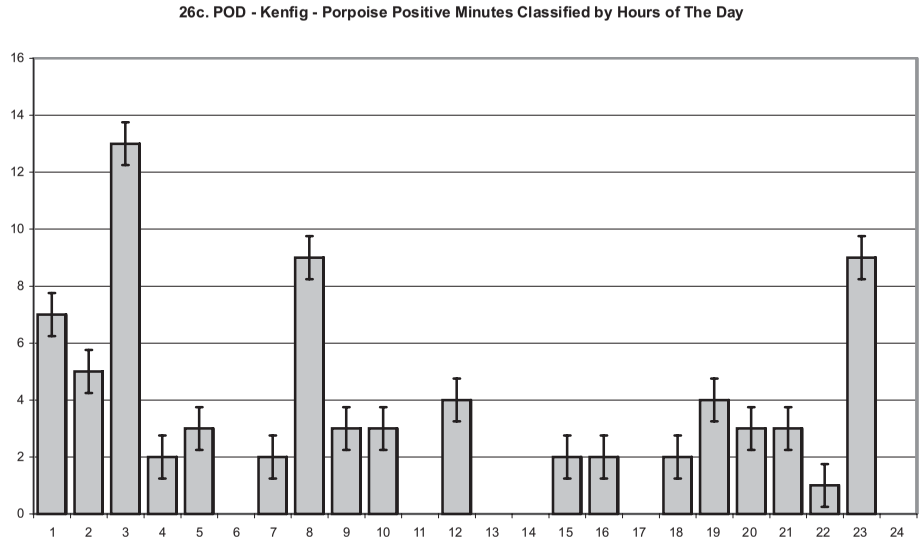
Error bars set at 1 standard error of mean.

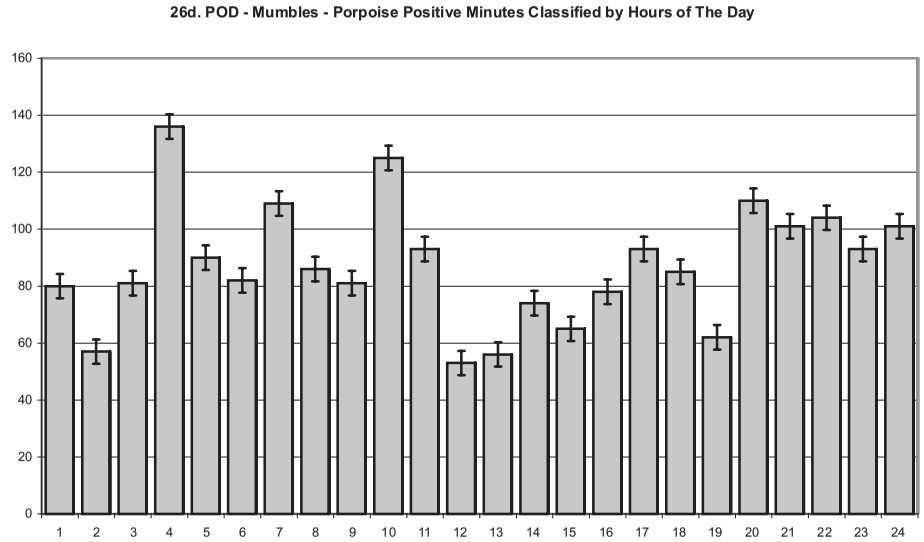


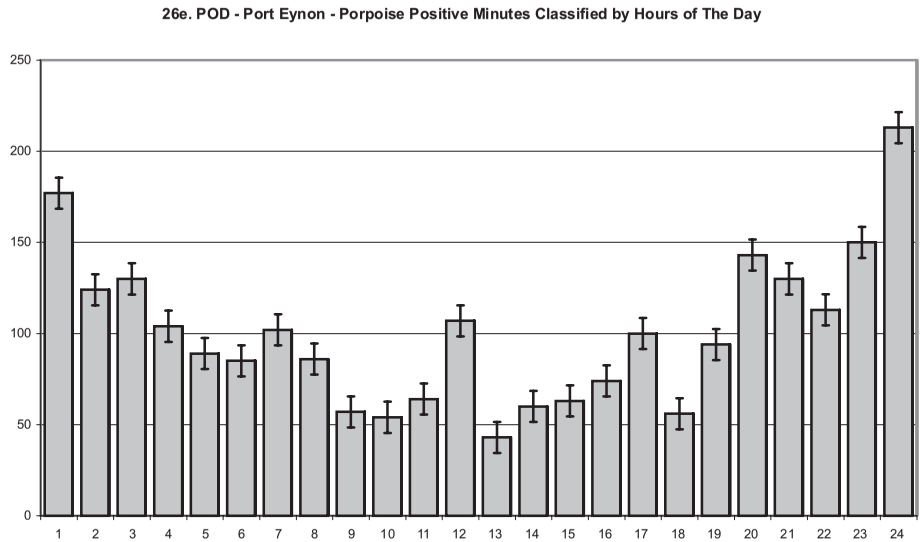



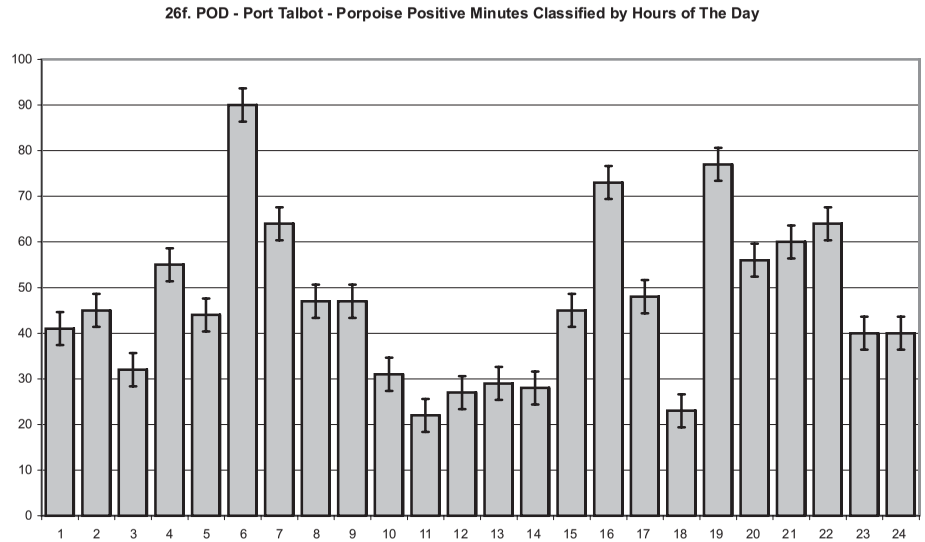
# Figure 26a-j. POD Porpoise Positive Minutes Classified by Hour of Day (24 Hour)

Error bars set at 1 standard error of mean.



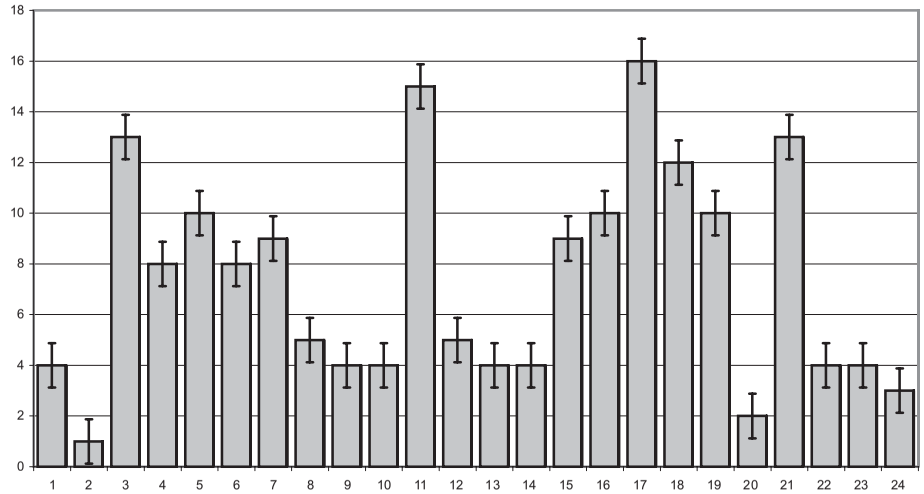



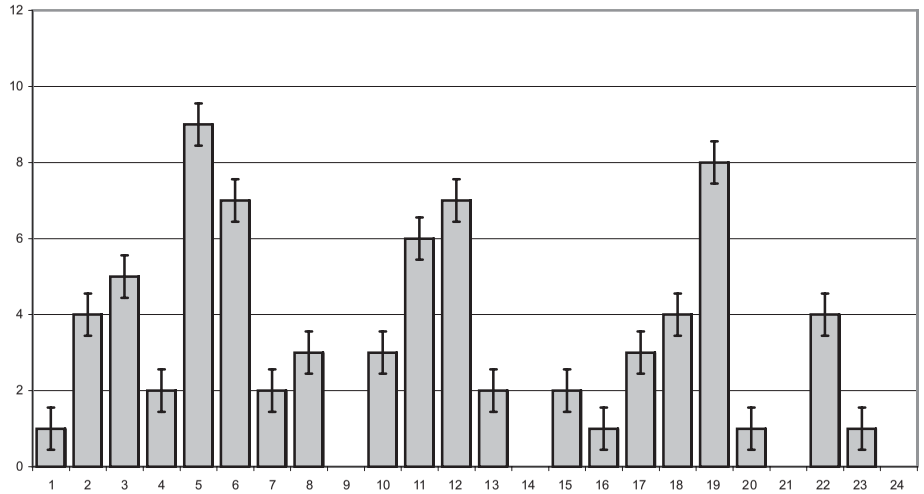



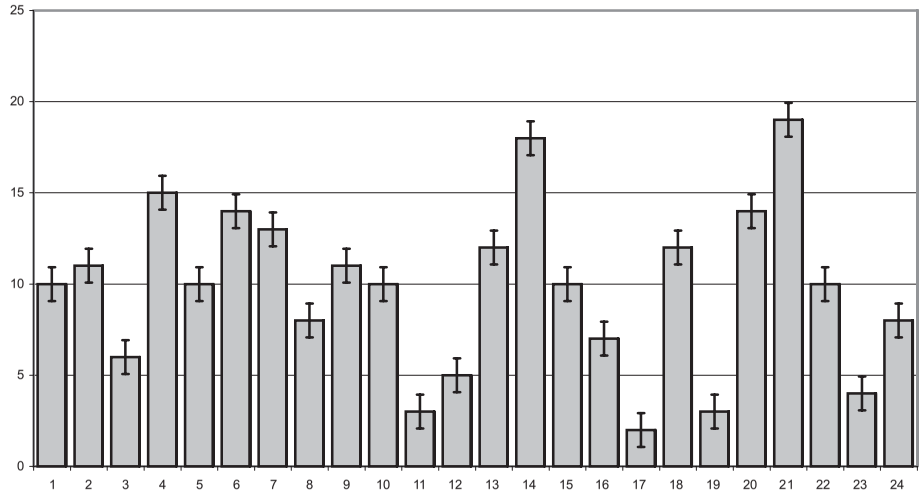



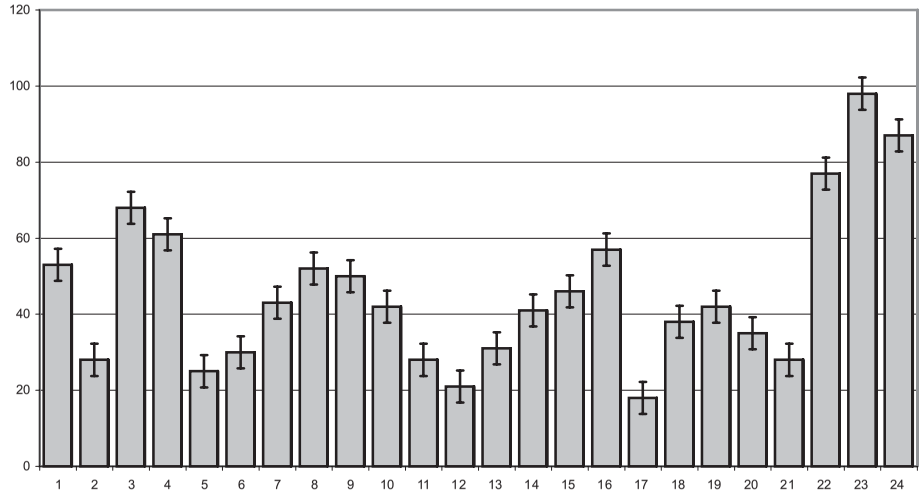
# Figure 26a-j. POD Porpoise Positive Minutes Classified by Hour of Day (24 Hour)

Error bars set at 1 standard error of mean.



# Simultaneous Detection Hours

## Table 14a. Simultaneous Detection Hours

| Year | Simultaneous POD Hours | POD + Shorewatch |
|---|---|---|
| **2002** | 0 | 0 |
| **2003** | 179 | 8 |
| **2004** | 114 | 0 |
| **Total** | **293** | **8** |

## Table 14b. Simultaneous Porpoise Positive Project Hours including Shorewatch

| Project Date | No. | POD | POD | Shore |
|---|---|---|---|---|
| 14/02/2003 14:00 | 3 | Carmarthen | Port Talbot | Shorewatch - LK : LK : LK : LK |
| 21/06/2003 16:00 | 2 | Port Eynon | | Shorewatch - PT : PT : PT : PT : PT |
| 21/06/2003 17:00 | 2 | Port Eynon | | Shorewatch - PT |
| 25/06/2003 19:00 | 2 | Port Eynon | | Shorewatch - PE |
| 07/08/2003 14:00 | 2 | Port Eynon | | Shorewatch - PE : PE : PE |
| 23/08/2003 14:00 | 2 | Scarweather | | Shorewatch - PE : PE : PE |
| 06/09/2003 15:00 | 2 | Port Talbot | | Shorewatch - PE : PE : PE |
| 01/11/2003 12:00 | 2 | Carmarthen | | Shorewatch - BH : BH |

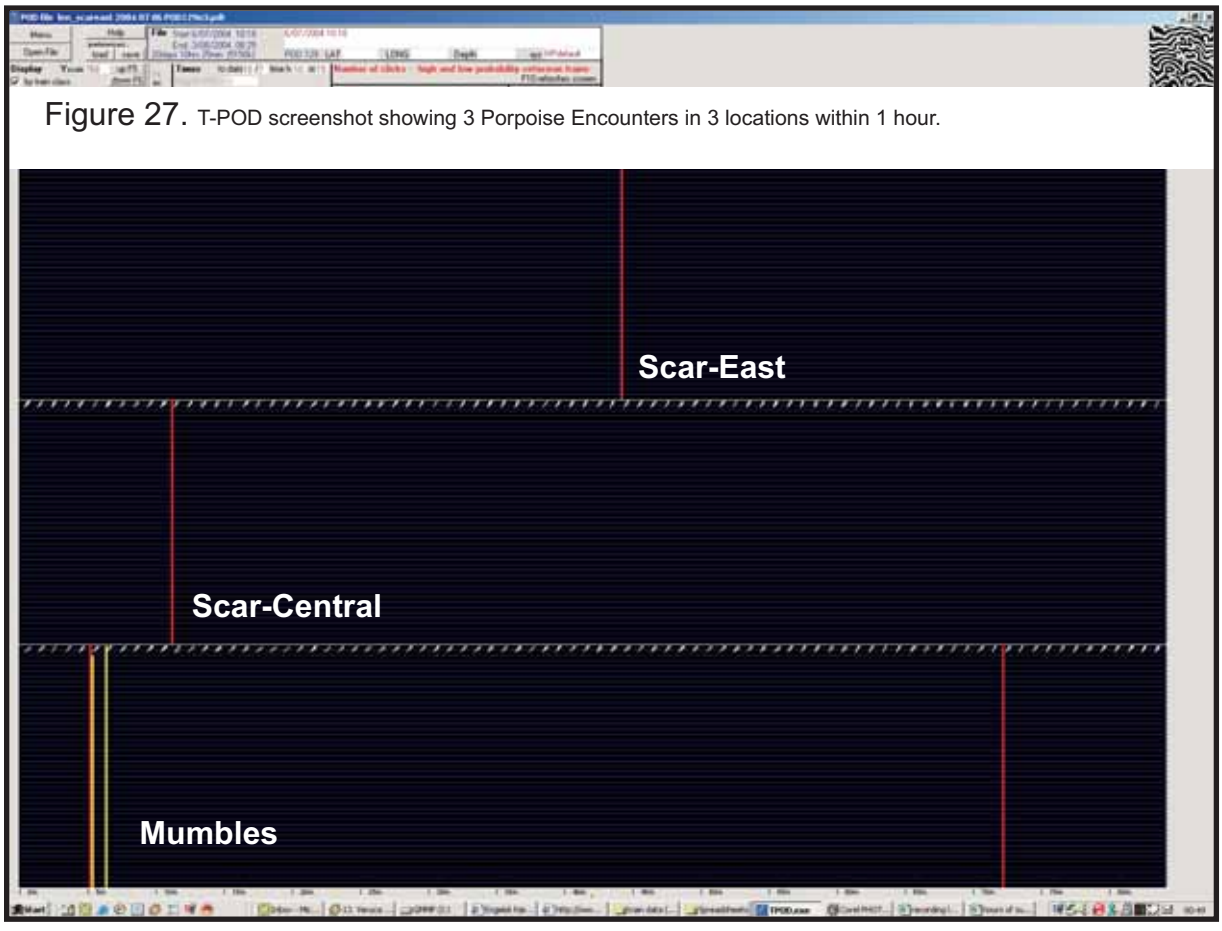
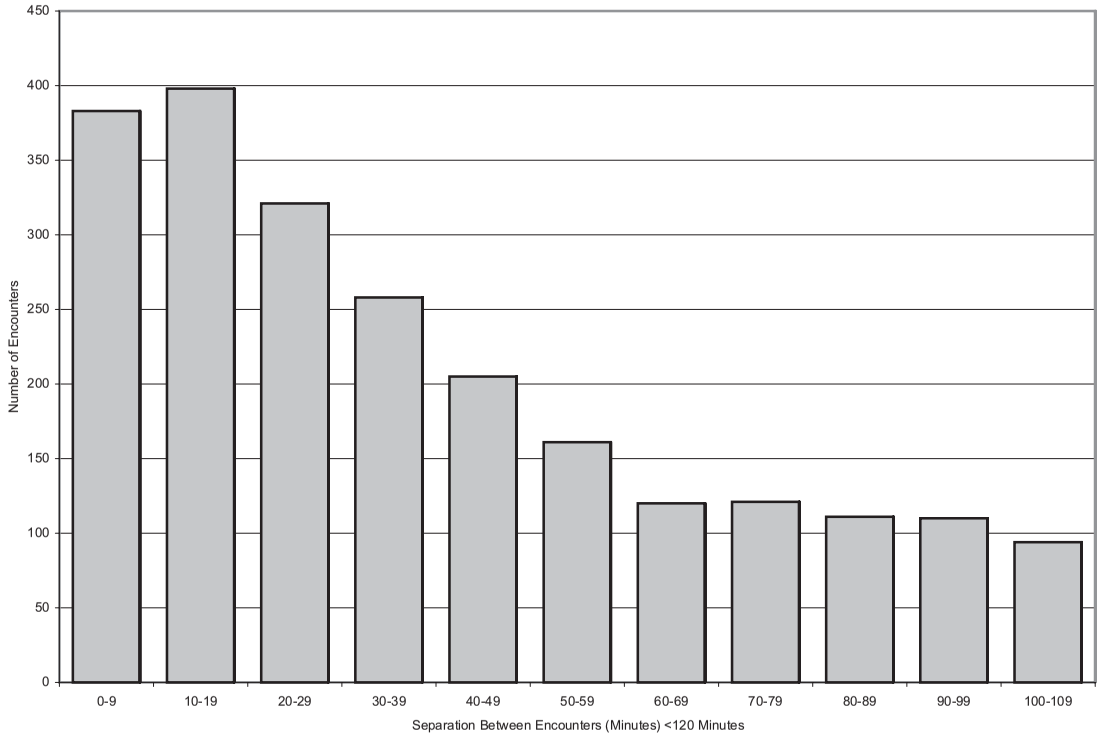



Figure 27. T-POD screenshot showing 3 Porpoise Encounters in 3 locations within 1 hour.

# Table 15. Separation of Encounters (Detections in Same Locations)

| Separation (minutes) | 0-9 | 10-19 | 20-29 | 30-39 | 40-49 | 50-59 | 60-69 | 70-79 | 80-89 | 90-99 | 100-109 | 110-119 | >120 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| frequency of occurences | 0 | 383 | 398 | 321 | 258 | 205 | 161 | 120 | 121 | 111 | 110 | 94 | 1548 | 3830 |
| % of total encounters | 0% | 10% | 10% | 8% | 7% | 5% | 4% | 3% | 3% | 3% | 3% | 2% | 40% | 100% |

# Figure 28. Encounter Intervals For Consecutive Encounters Occuring at the Same Location



# Table 16. Separation of Encounters (Detections in Separate Locations)

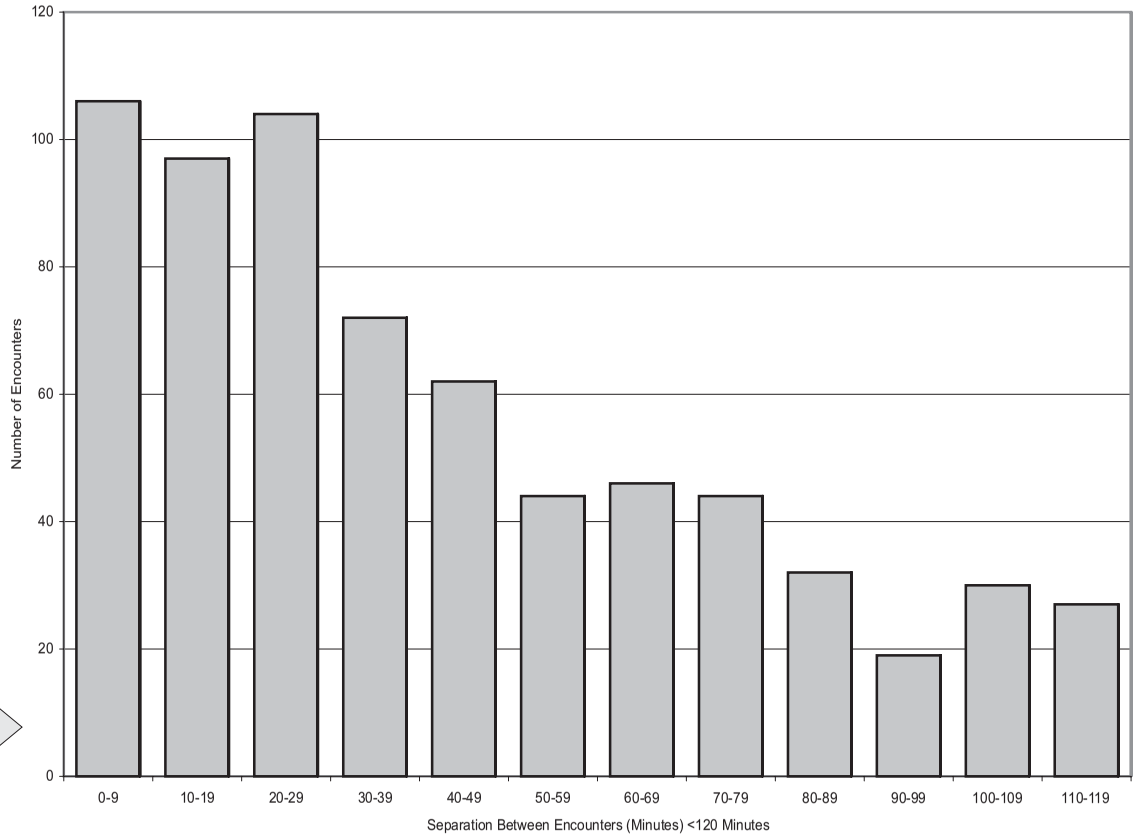
| Separation (minutes) | 0-9 | 10-19 | 20-29 | 30-39 | 40-49 | 50-59 | 60-69 | 70-79 | 80-89 | 90-99 | 100-109 | 110-119 | >120 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| frequency of occurences | 106 | 97 | 104 | 72 | 62 | 44 | 46 | 44 | 32 | 19 | 30 | 27 | 372 | 1055 |
| % of simultaneous encounters | 10% | 9% | 10% | 7% | 6% | 4% | 4% | 4% | 3% | 2% | 3% | 3% | 35% | 100% |
| % of total encounters | 3% | 3% | 3% | 2% | 2% | 1% | 1% | 1% | 1% | 0% | 1% | 1% | 10% | 28% |

# Table 17. Summary

| | Same Location | | Different Locations | |
|---|---|---|---|---|
| Encounters with a separation of <30 minutes | 781 | 20% | 307 | 8% |
| Encounters with a separation of <60 minutes | 1565 | 41% | 485 | 13% |
| Encounters with a separation of <120 minutes | 2282 | 60% | 683 | 18% |



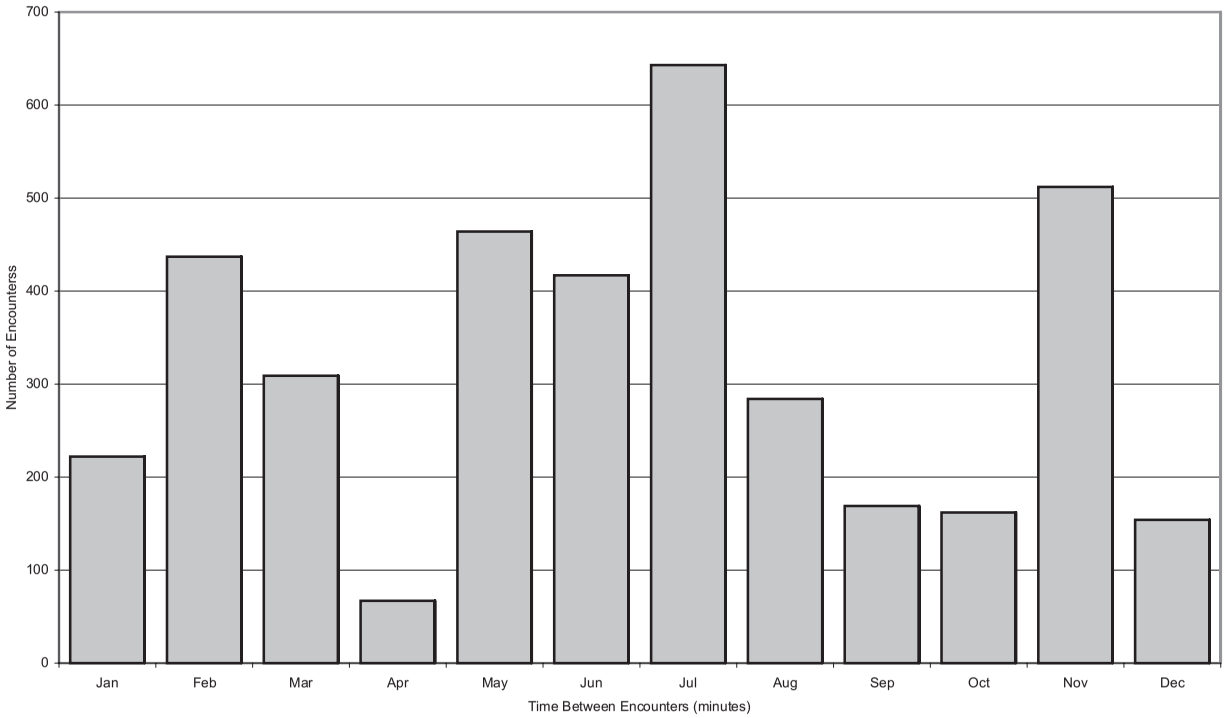
Figure 29. Inter-Encounter Intervals For Consecutive Encounters Occurring at Different Locations



# Table 18. Number of Encounters

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Burry Holms** | 136 | 119 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **255** |
| **Carmarthen Bay** | 0 | 261 | 187 | 0 | 0 | 0 | 0 | 0 | 0 | 82 | 493 | 123 | **1146** |
| **Kenfig Patches** | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 31 | **40** |
| **Mumbles** | 0 | 0 | 0 | 40 | 184 | 0 | 357 | 28 | 18 | 0 | 0 | 0 | **627** |
| **Port Eynon** | 0 | 0 | 98 | 0 | 0 | 192 | 227 | 173 | 83 | 0 | 0 | 0 | **773** |
| **Port Talbot** | 77 | 57 | 24 | 5 | 69 | 75 | 1 | 51 | 50 | 56 | 0 | 0 | **465** |
| **Scarweather** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28 | 18 | 24 | 19 | 0 | **89** |
| **Scar (Central)** | 0 | 0 | 0 | 0 | 7 | 28 | 10 | 0 | 0 | 0 | 0 | 0 | **45** |
| **Scar (East)** | 0 | 0 | 0 | 3 | 15 | 54 | 48 | 4 | 0 | 0 | 0 | 0 | **124** |
| **Scar (West)** | 0 | 0 | 0 | 19 | 189 | 68 | 0 | 0 | 0 | 0 | 0 | 0 | **276** |
| **Total:** | **222** | **437** | **309** | **67** | **464** | **417** | **643** | **284** | **169** | **162** | **512** | **154** | **3840** |

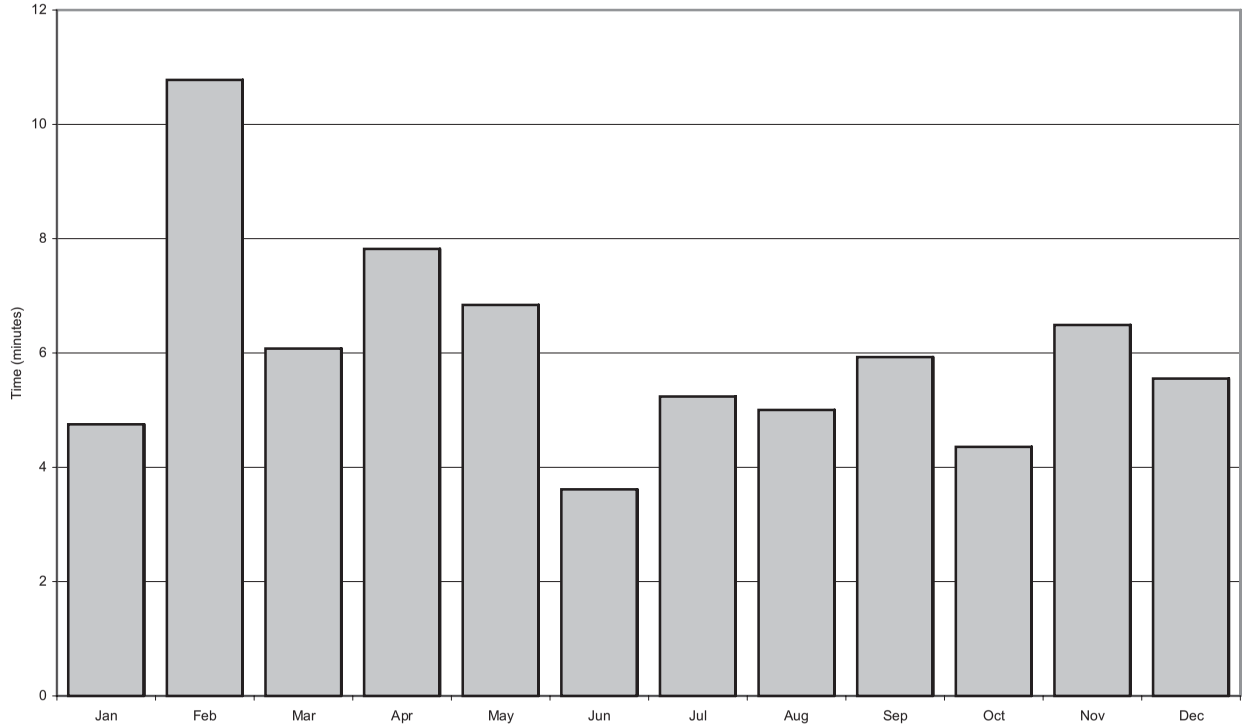
# Figure 30.
# POD - Number of Encounters Per Month



# Table 19. Average Length of Encounters

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Burry Holms** | 5.84 | 8.98 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | **7.31** |
| **Carmarthen Bay** | #DIV/0! | 13.27 | 6.18 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | 6.05 | 6.64 | 6.46 | **8.01** |
| **Kenfig Patches** | 3.89 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | 1.97 | **2.40** |
| **Mumbles** | #DIV/0! | #DIV/0! | #DIV/0! | 9.82 | 7.09 | #DIV/0! | 5.80 | 10.25 | 14.61 | #DIV/0! | #DIV/0! | #DIV/0! | **6.89** |
| **Port Eynon** | #DIV/0! | #DIV/0! | 6.60 | #DIV/0! | #DIV/0! | 4.62 | 5.00 | 5.26 | 5.45 | #DIV/0! | #DIV/0! | #DIV/0! | **5.22** |
| **Port Talbot** | 2.94 | 3.11 | 3.13 | 4.20 | 4.96 | 3.13 | 1.00 | 2.67 | 4.50 | 2.82 | #DIV/0! | #DIV/0! | **3.43** |
| **Scarweather** | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | 2.96 | 3.44 | 2.17 | 2.53 | #DIV/0! | **2.75** |
| **Scar (Central)** | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | 1.14 | 2.93 | 2.30 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | **2.51** |
| **Scar (East)** | #DIV/0! | #DIV/0! | #DIV/0! | 2.67 | 1.20 | 2.33 | 2.85 | 1.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | **2.37** |
| **Scar (West)** | #DIV/0! | #DIV/0! | #DIV/0! | 5.37 | 7.95 | 2.59 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | **6.45** |

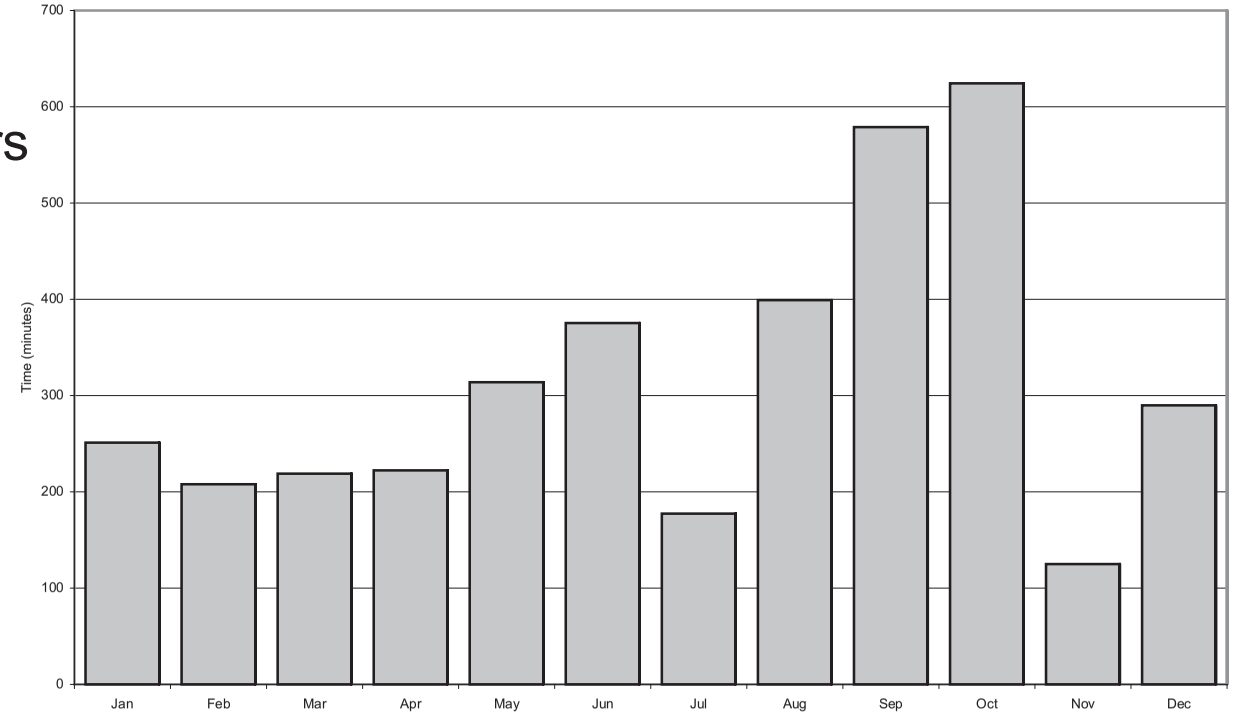
Figure 31.
POD - Average Duration of Encounters



# Table 20. Average Wait Times Between Encounters

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Burry Holms** | 115.01 | 173.82 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | **142.45** |
| **Carmarthen Bay** | #DIV/0! | 118.71 | 175.13 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | 303.87 | 87.85 | 163.93 | **132.75** |
| **Kenfig Patches** | 934.56 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | 789.74 | **822.33** |
| **Mumbles** | #DIV/0! | #DIV/0! | #DIV/0! | 86.98 | 109.34 | #DIV/0! | 102.23 | 116.32 | 49.94 | #DIV/0! | #DIV/0! | 0.00 | **102.47** |
| **Port Eynon** | #DIV/0! | #DIV/0! | 273.84 | #DIV/0! | #DIV/0! | 99.82 | 104.52 | 153.40 | 213.31 | #DIV/0! | #DIV/0! | #DIV/0! | **147.44** |
| **Port Talbot** | 411.73 | 687.39 | 335.67 | 725.00 | 612.77 | 579.61 | 0.00 | 837.18 | 787.66 | 716.30 | #DIV/0! | #DIV/0! | **624.75** |
| **Scarweather** | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | 1432.11 | 2213.50 | 1504.33 | 1086.79 | #DIV/0! | **1535.90** |
| **Scar (Central)** | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | 2909.43 | 1179.00 | 1353.80 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | **1487.02** |
| **Scar (East)** | #DIV/0! | #DIV/0! | #DIV/0! | 1385.33 | 1221.93 | 781.46 | 839.85 | 194.25 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | **853.02** |
| **Scar (West)** | #DIV/0! | #DIV/0! | #DIV/0! | 191.26 | 235.58 | 274.68 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | **242.16** |

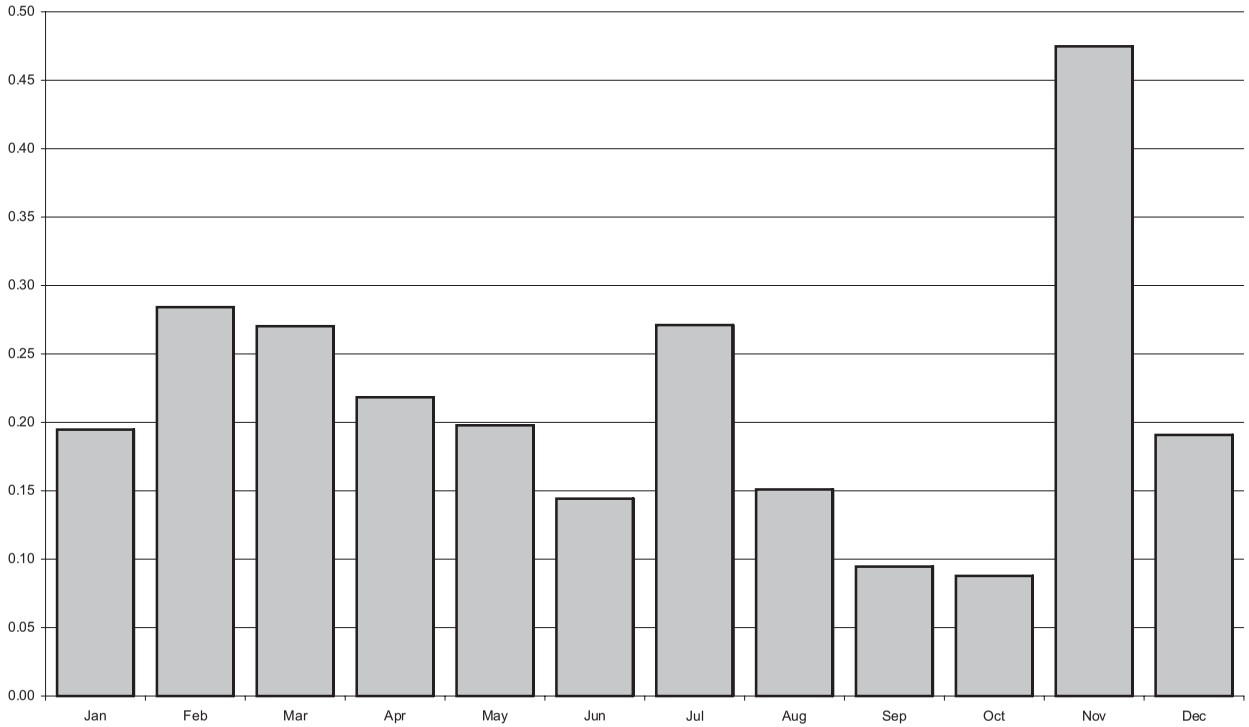
Figure 32.
POD - Average Waiting Times Between Encounters (Same Location)



# Table 21. Encounters Per Recording Hour

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Burry Holms** | 0.39 | 0.34 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| **Carmarthen Bay** | #DIV/0! | 0.51 | 0.34 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | 0.19 | 0.68 | 0.33 |
| **Kenfig Patches** | 0.06 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | 0.07 |
| **Mumbles** | #DIV/0! | #DIV/0! | #DIV/0! | 0.66 | 0.55 | #DIV/0! | 0.59 | 0.50 | 0.93 | #DIV/0! | #DIV/0! | #DIV/0! |
| **Port Eynon** | #DIV/0! | #DIV/0! | 0.21 | #DIV/0! | #DIV/0! | 0.56 | 0.56 | 0.39 | 0.25 | #DIV/0! | #DIV/0! | #DIV/0! |
| **Port Talbot** | 0.12 | 0.08 | 0.18 | 0.08 | 0.09 | 0.10 | 0.04 | 0.08 | 0.07 | 0.08 | #DIV/0! | #DIV/0! |
| **Scarweather** | 0.00 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | 0.04 | 0.03 | 0.03 | 0.05 | #DIV/0! |
| **Scar (Central)** | #DIV/0! | #DIV/0! | #DIV/0! | 0.00 | 0.03 | 0.04 | 0.02 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| **Scar (East)** | #DIV/0! | #DIV/0! | #DIV/0! | 0.05 | 0.05 | 0.08 | 0.07 | 0.07 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| **Scar (West)** | #DIV/0! | #DIV/0! | #DIV/0! | 0.32 | 0.25 | 0.21 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| **Average:** | **0.19** | **0.28** | **0.27** | **0.22** | **0.20** | **0.14** | **0.27** | **0.15** | **0.09** | **0.09** | **0.47** | **0.19** |

Figure 33.
POD - Average Number of Encounters Per Hour of Recording



# Figure 34. Porpoise Encounters Detected by IFAW Hydrophone

ranked by confidence (probability of accurate detection)

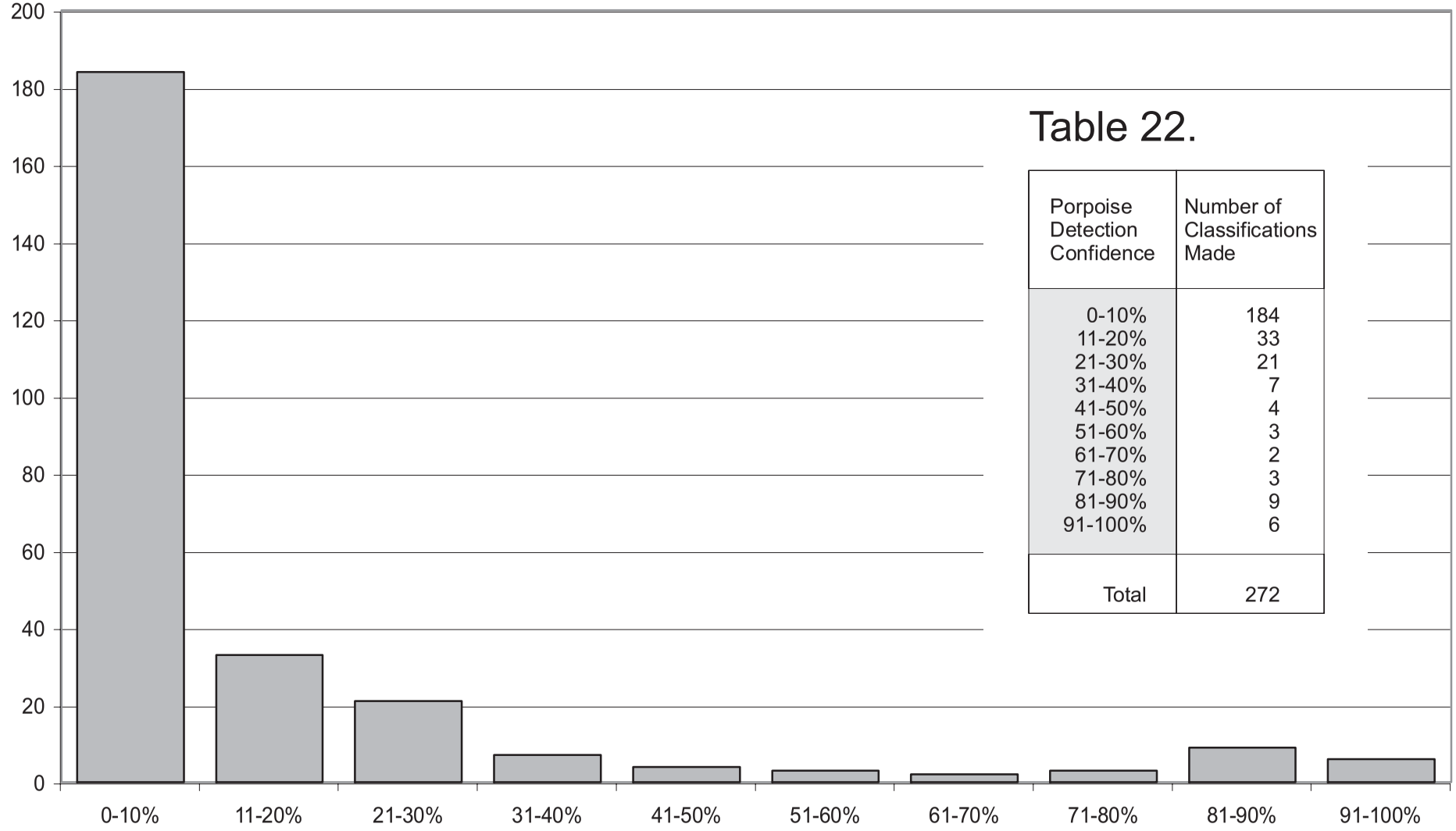
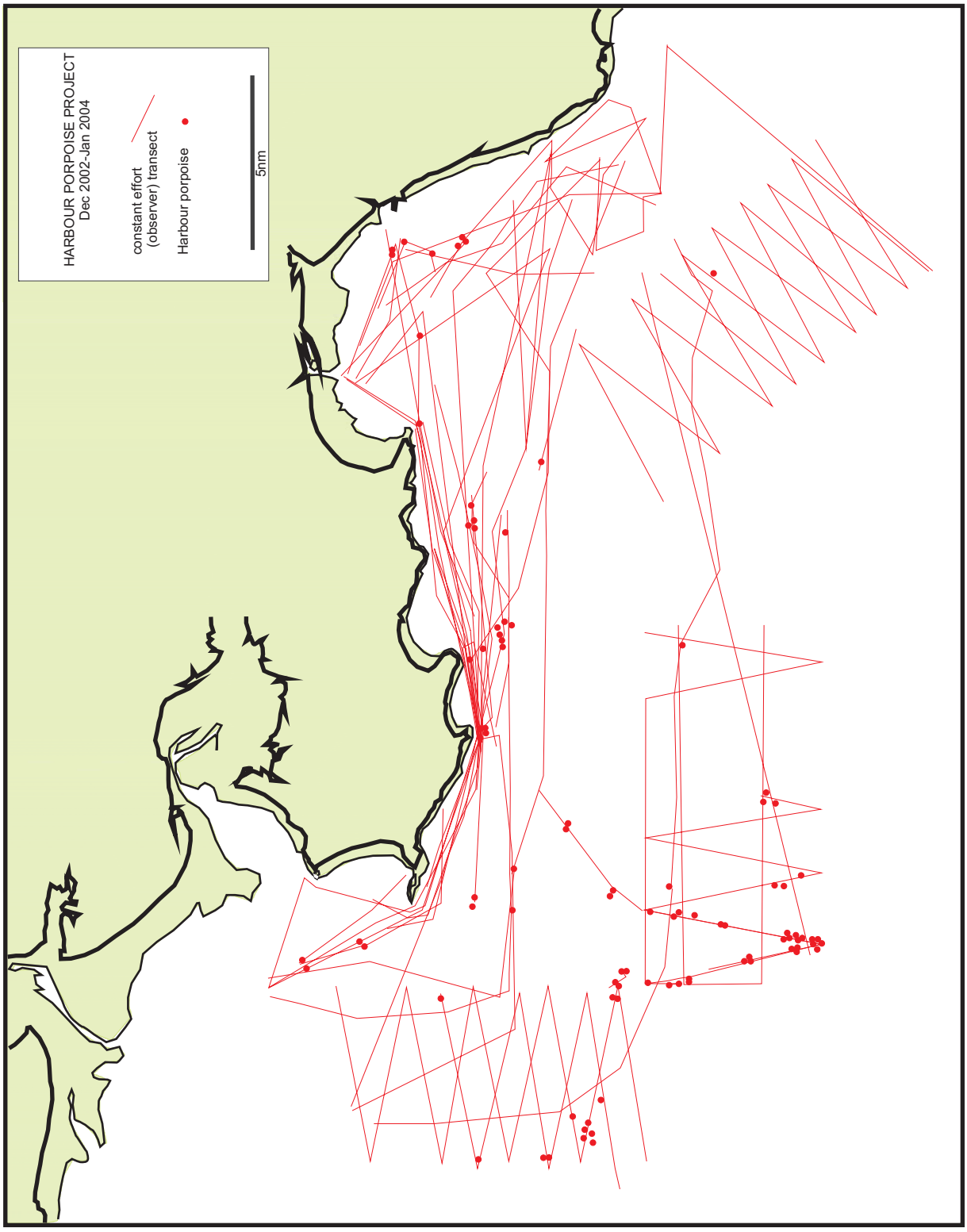



Table 22.

| Porpoise Detection Confidence | Number of Classifications Made |
|---|---|
| 0-10% | 184 |
| 11-20% | 33 |
| 21-30% | 21 |
| 31-40% | 7 |
| 41-50% | 4 |
| 51-60% | 3 |
| 61-70% | 2 |
| 71-80% | 3 |
| 81-90% | 9 |
| 91-100% | 6 |
| Total | 272 |

Figure 35. Schematic of Survey Area Showing Observer Constant Effort Transects

Total Track 778.25nm (1441km)



# Figure 36. Schematic of Survey Area Showing Casual Sightings

Other than Harbour porpoise, the only cetacean species recorded during the project was Common dolphin (*Delphinus delphis):* three adults and two juveniles were recorded in the entrance to Swansea Docks at 19:30hrd on 19th December 2003.

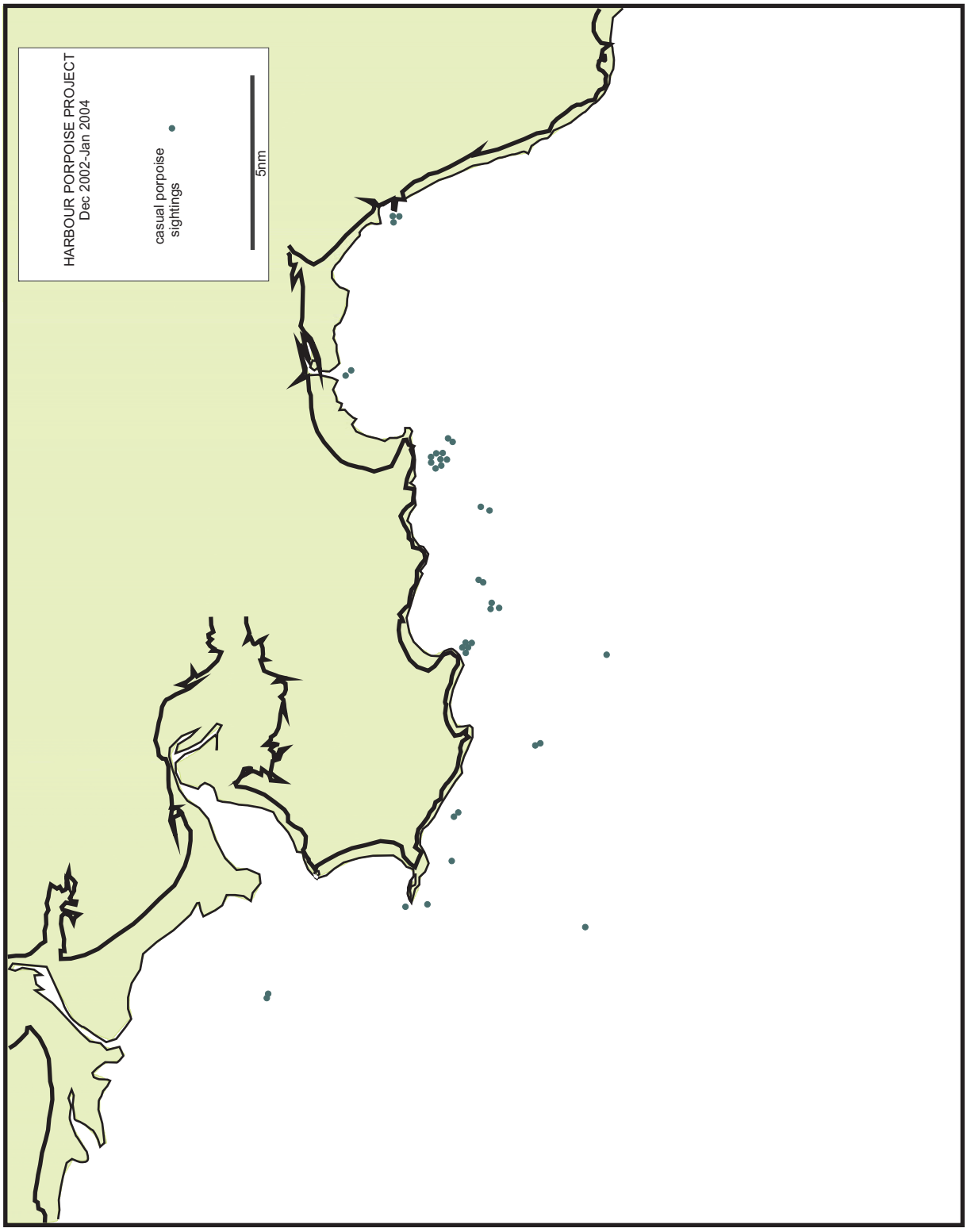


Table 23a. Shorewatch Effort by year

| Shorewatch Effort by year | Porpoise Positive Observation Periods | Porpoise Negative Observation Periods | Total Detection Periods | % Positive Detection | % Contribution to dataset |
|---|---|---|---|---|---|
| **1996** | 85 | 348 | 433 | 20% | **21%** |
| **1997** | 43 | 290 | 333 | 13% | **16%** |
| **1998** | 34 | 247 | 281 | 12% | **14%** |
| **1999** | 47 | 153 | 200 | 24% | **10%** |
| **2000** | 33 | 146 | 179 | 18% | **9%** |
| **2001** | 43 | 120 | 163 | 26% | **8%** |
| **2002** | 43 | 76 | 119 | 36% | **6%** |
| **2003** | 73 | 246 | 319 | 23% | **16%** |
| | **401** | **1626** | **2027** | | |

Table 23b. Shorewatch Total Effort (1996-2003)

| Month | Porpoise Positive Observation Periods | Porpoise Negative Observation Periods | Total Detection Periods | % Positive Detection | % Overall |
|---|---|---|---|---|---|
| **January** | 27 | 113 | 140 | 19% | 1% |
| **February** | 32 | 89 | 121 | 26% | 2% |
| **March** | 50 | 86 | 136 | 37% | 2% |
| **April** | 54 | 152 | 206 | 26% | 3% |
| **May** | 29 | 222 | 251 | 12% | 1% |
| **June** | 21 | 83 | 104 | 20% | 1% |
| **July** | 40 | 241 | 281 | 14% | 2% |
| **August** | 57 | 180 | 237 | 24% | 3% |
| **September** | 24 | 148 | 172 | 14% | 1% |
| **October** | 20 | 112 | 132 | 15% | 1% |
| **November** | 11 | 104 | 115 | 10% | 1% |
| **December** | 36 | 96 | 132 | 27% | 2% |
| **Total:** | **401** | **1,626** | **2,027** | **20%** | **20%** |

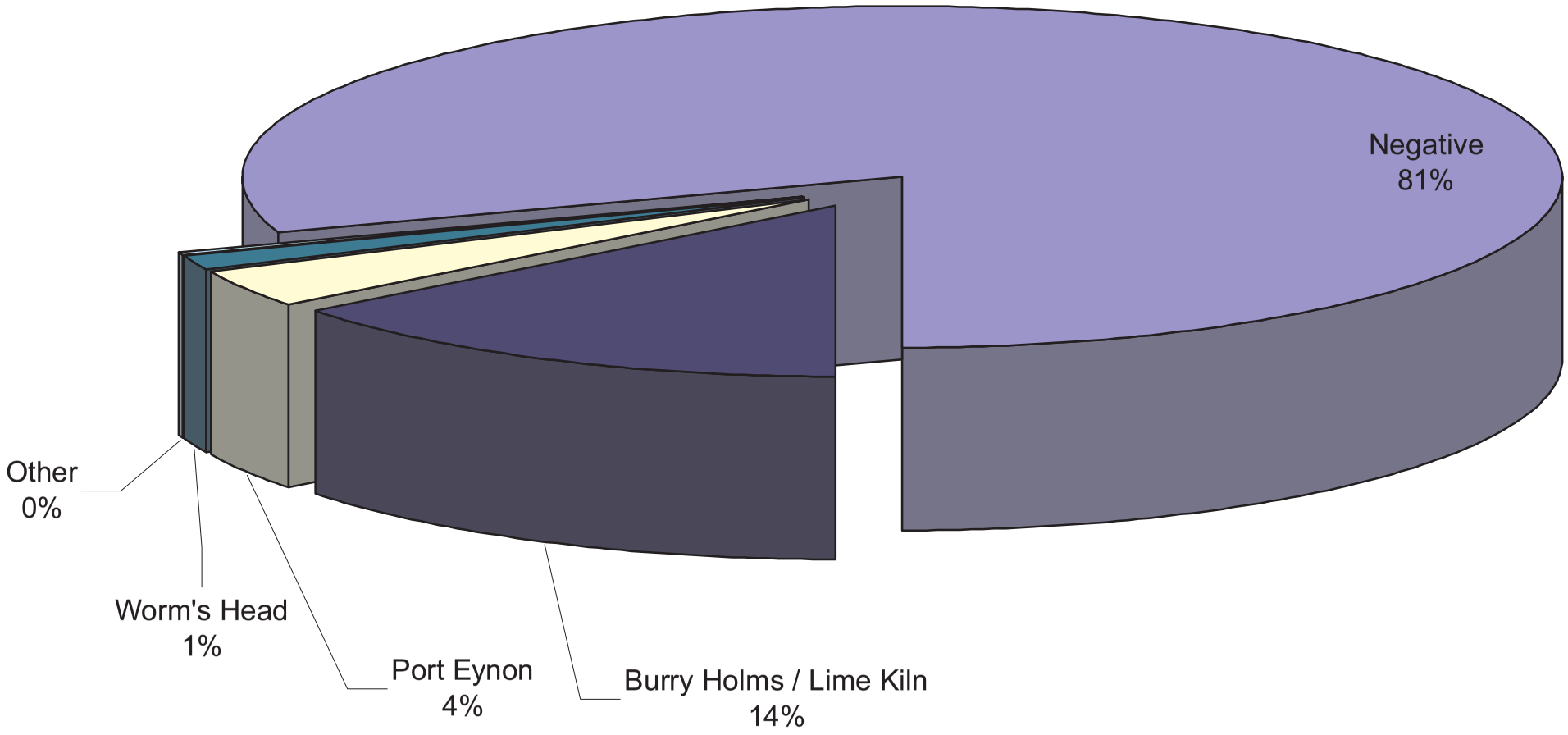
Table 23c. Shorewatch Total Effort (1996-2003)

| Location | Porpoise Positive Observation Periods | Porpoise Negative Observation Periods | Total Detection Periods | % Positive Detection | % Overall |
|---|---|---|---|---|---|
| **Burry Holms / Lime Kiln** | 290 | 1295 | 1,585 | 18% | 14% |
| **Port Eynon** | 74 | 201 | 275 | 27% | 4% |
| **Worm's Head** | 30 | 110 | 140 | 21% | 1% |
| **Other** | 7 | 20 | 27 | 26% | 0% |
| **Negative** | **401** | **1626** | **2,027** | | **80%** |

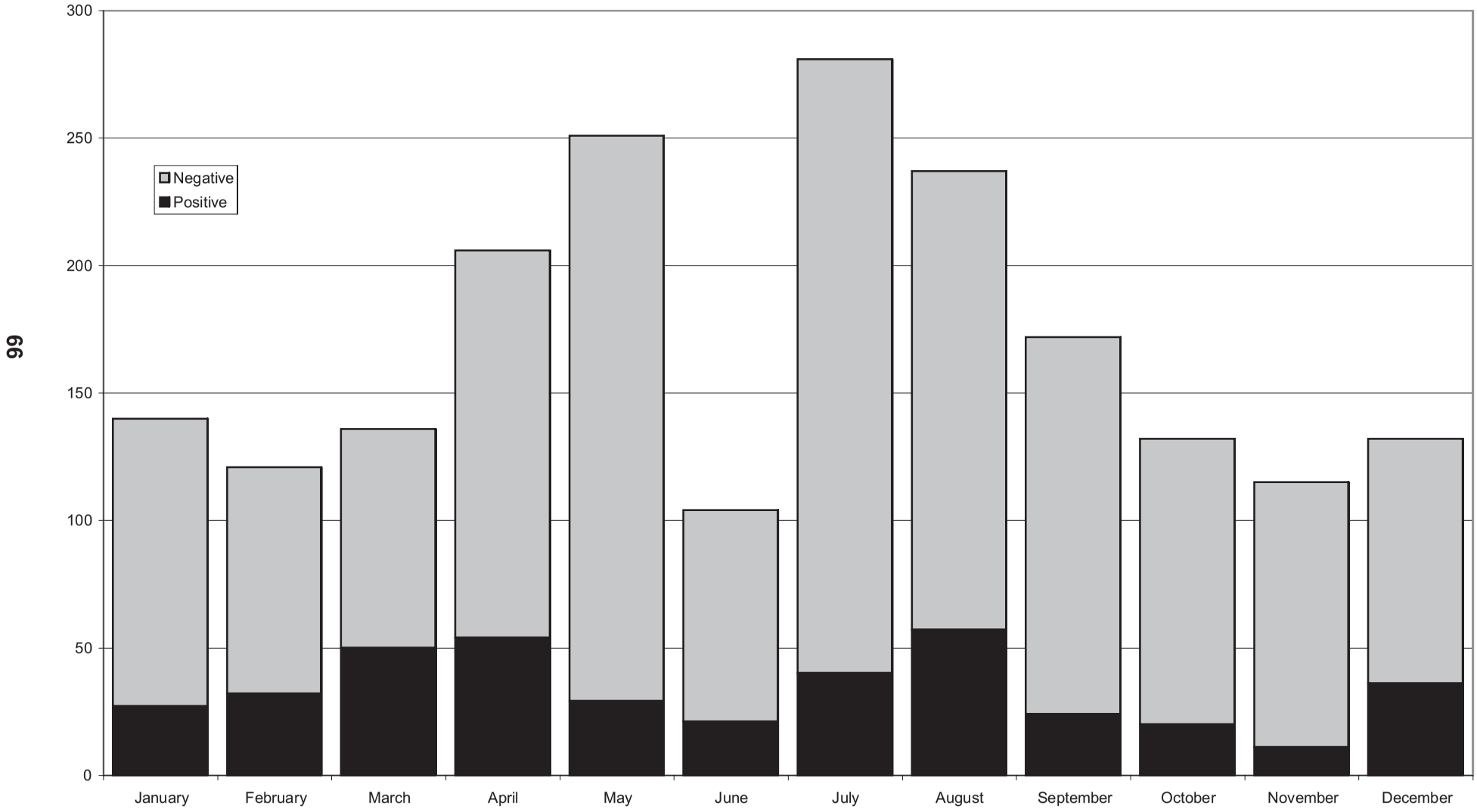
Table 24. Shorewatch Observations Classified by Month of Survey

| Month | Other | | Burry Holms / Lime Kiln | | Port Eynon | | Worm's Head | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **NEG** | **POS** | **NEG** | **POS** | **NEG** | **POS** | **NEG** | **POS** | **NEG** | **POS** | **Combined** |
| **January** | 0 | 0 | 101 | 22 | 12 | 5 | 0 | 0 | 113 | 27 | 140 |
| **February** | 0 | 0 | 64 | 32 | 16 | 0 | 9 | 0 | 89 | 32 | 121 |
| **March** | 0 | 1 | 81 | 38 | 5 | 9 | 0 | 2 | 86 | 50 | 136 |
| **April** | 0 | 0 | 145 | 50 | 7 | 4 | 0 | 0 | 152 | 54 | 206 |
| **May** | 0 | 0 | 205 | 20 | 0 | 0 | 17 | 9 | 222 | 29 | 251 |
| **June** | 9 | 5 | 36 | 0 | 20 | 14 | 18 | 2 | 83 | 21 | 104 |
| **July** | 11 | 1 | 172 | 27 | 21 | 6 | 37 | 6 | 241 | 40 | 281 |
| **August** | 0 | 0 | 153 | 35 | 27 | 22 | 0 | 0 | 180 | 57 | 237 |
| **September** | 0 | 0 | 112 | 19 | 24 | 4 | 12 | 1 | 148 | 24 | 172 |
| **October** | 0 | 0 | 77 | 20 | 35 | 0 | 0 | 0 | 112 | 20 | 132 |
| **November** | 0 | 0 | 80 | 5 | 17 | 0 | 7 | 6 | 104 | 11 | 115 |
| **December** | 0 | 0 | 69 | 22 | 17 | 10 | 10 | 4 | 96 | 36 | 132 |
| **Total:** | **20** | **7** | **1295** | **290** | **201** | **74** | **110** | **30** | **1626** | **401** | **2027** |

Figure 37. Total Shorewatch Effort (1996-2004)
Showing Percentage of Porpoise Positive Observation Periods



# Figure 38. Shorewatch - Porpoise Positive Observation Periods Per Month



# Figure 39. Shorewatch - Porpoise Positive Observation Periods Per Month

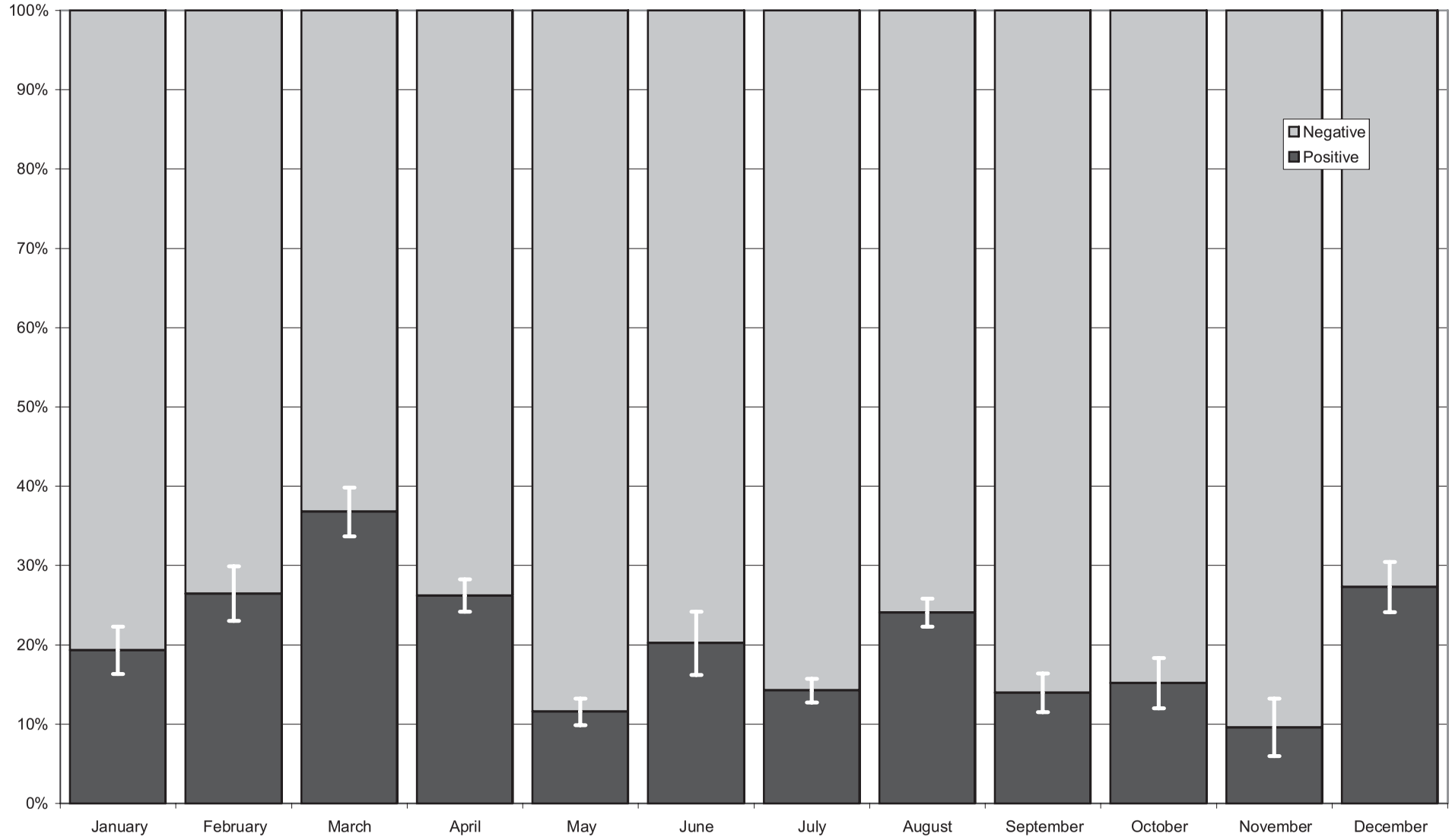


**Figure 40a. Shorewatch - Porpoise Positive Observation Periods / Month (Burry Holms / Lime Kiln)**

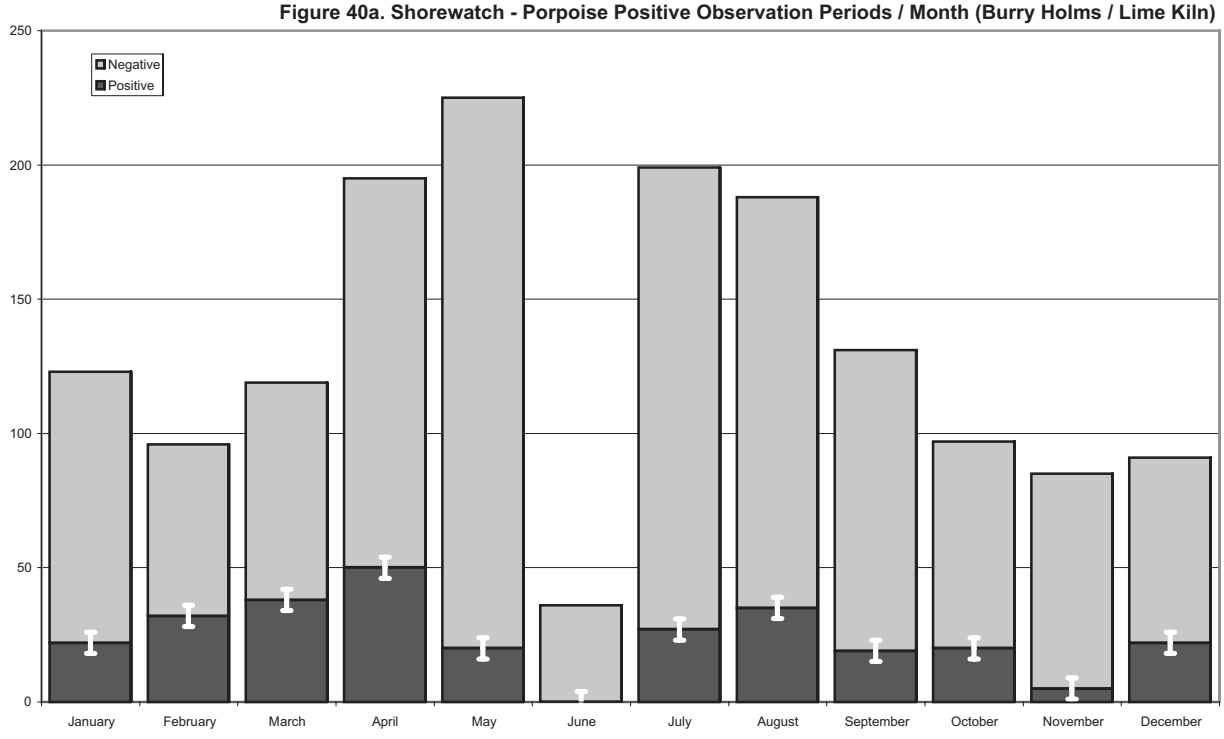



**Figure 40b. Shorewatch - Porpoise Positive Observation Periods / Month (Port Eynon)**

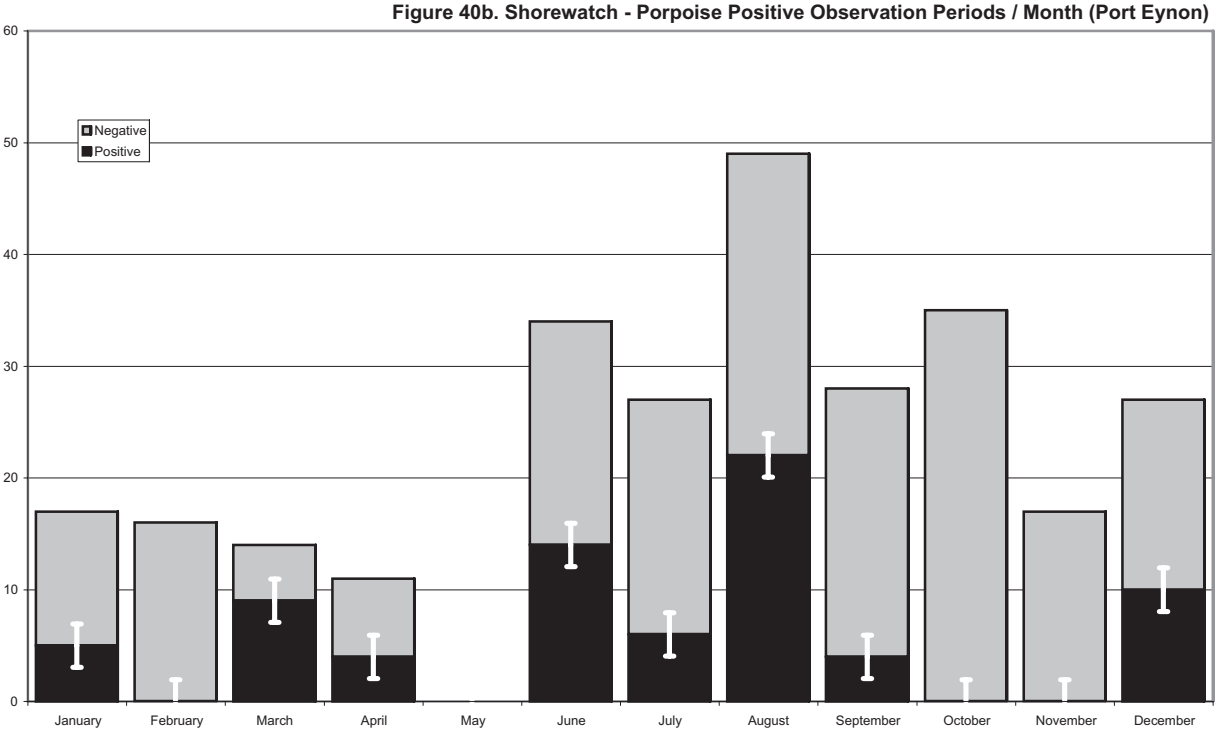


Table 25. Shorewatch: Observations Classified By GMT

| Hour of Day | Other | | Burry Holms / | | Port Eynon | | Worm's | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | NEG | POS | NEG | POS | NEG | POS | NEG | POS | NEG | POS | Combined |
| **1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **3** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **4** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **5** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **6** | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 2 | 3 |
| **7** | 0 | 0 | 0 | 0 | 9 | 6 | 0 | 0 | 9 | 6 | 15 |
| **8** | 0 | 0 | 0 | 0 | 5 | 3 | 1 | 0 | 6 | 3 | 9 |
| **9** | 0 | 0 | 2 | 0 | 8 | 0 | 4 | 0 | 14 | 0 | 14 |
| **10** | 0 | 0 | 9 | 1 | 6 | 0 | 5 | 2 | 20 | 3 | 23 |
| **11** | 0 | 0 | 13 | 0 | 3 | 0 | 8 | 1 | 24 | 1 | 25 |
| **12** | 0 | 0 | 26 | 5 | 3 | 0 | 11 | 1 | 40 | 6 | 46 |
| **13** | 0 | 0 | 52 | 16 | 18 | 3 | 13 | 5 | 83 | 24 | 107 |
| **14** | 0 | 0 | 87 | 12 | 19 | 8 | 14 | 3 | 120 | 23 | 143 |
| **15** | 4 | 1 | 252 | 47 | 34 | 12 | 23 | 1 | 313 | 61 | 374 |
| **16** | 10 | 1 | 422 | 84 | 47 | 19 | 18 | 9 | 497 | 113 | 610 |
| **17** | 3 | 3 | 162 | 60 | 25 | 13 | 5 | 0 | 195 | 76 | 271 |
| **18** | 3 | 2 | 144 | 44 | 18 | 4 | 7 | 3 | 172 | 53 | 225 |
| **19** | 0 | 0 | 91 | 16 | 5 | 4 | 1 | 5 | 97 | 25 | 122 |
| **20** | 0 | 0 | 27 | 4 | 0 | 0 | 0 | 0 | 27 | 4 | 31 |
| **21** | 0 | 0 | 8 | 1 | 0 | 0 | 0 | 0 | 8 | 1 | 9 |
| **22** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **23** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **24** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total:** | **20** | **7** | **1295** | **290** | **201** | **74** | **110** | **30** | **1626** | **401** | **2027** |

Table 26. Shorewatch Observations Classified By Tides

| Tide State | Other | | Burry Holms / Lime Kiln | | | | Worm's Head | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | NEG | POS | NEG | POS | NEG | POS | NEG | POS | NEG | POS | Combined |
| **1** | 4 | 1 | 105 | 11 | 24 | 0 | 17 | 13 | 150 | 25 | 175 |
| **2** | 4 | 0 | 133 | 11 | 19 | 2 | 16 | 8 | 172 | 21 | 193 |
| **3** | 1 | 0 | 134 | 15 | 16 | 7 | 9 | 1 | 160 | 23 | 183 |
| **4** | 0 | 1 | 140 | 23 | 17 | 7 | 12 | 0 | 169 | 31 | 200 |
| **5** | 0 | 0 | 156 | 51 | 13 | 10 | 8 | 1 | 177 | 62 | 239 |
| **6** | 0 | 0 | 141 | 51 | 19 | 8 | 7 | 1 | 167 | 60 | 227 |
| **7** | 0 | 0 | 120 | 38 | 22 | 5 | 7 | 0 | 149 | 43 | 192 |
| **8** | 0 | 0 | 83 | 35 | 10 | 16 | 4 | 0 | 97 | 51 | 148 |
| **9** | 2 | 0 | 80 | 20 | 11 | 10 | 2 | 1 | 95 | 31 | 126 |
| **10** | 4 | 0 | 58 | 19 | 13 | 7 | 0 | 0 | 75 | 26 | 101 |
| **11** | 3 | 2 | 60 | 12 | 20 | 0 | 9 | 0 | 92 | 14 | 106 |
| **12** | 2 | 3 | 85 | 4 | 17 | 2 | 19 | 5 | 123 | 14 | 137 |
| **Total:** | **20** | **7** | **1295** | **290** | **201** | **74** | **110** | **30** | **1626** | **401** | **2027** |

**Figure 41. Shorewatch - Porpoise Positive Observation Periods Classed by Tide (Combined)**

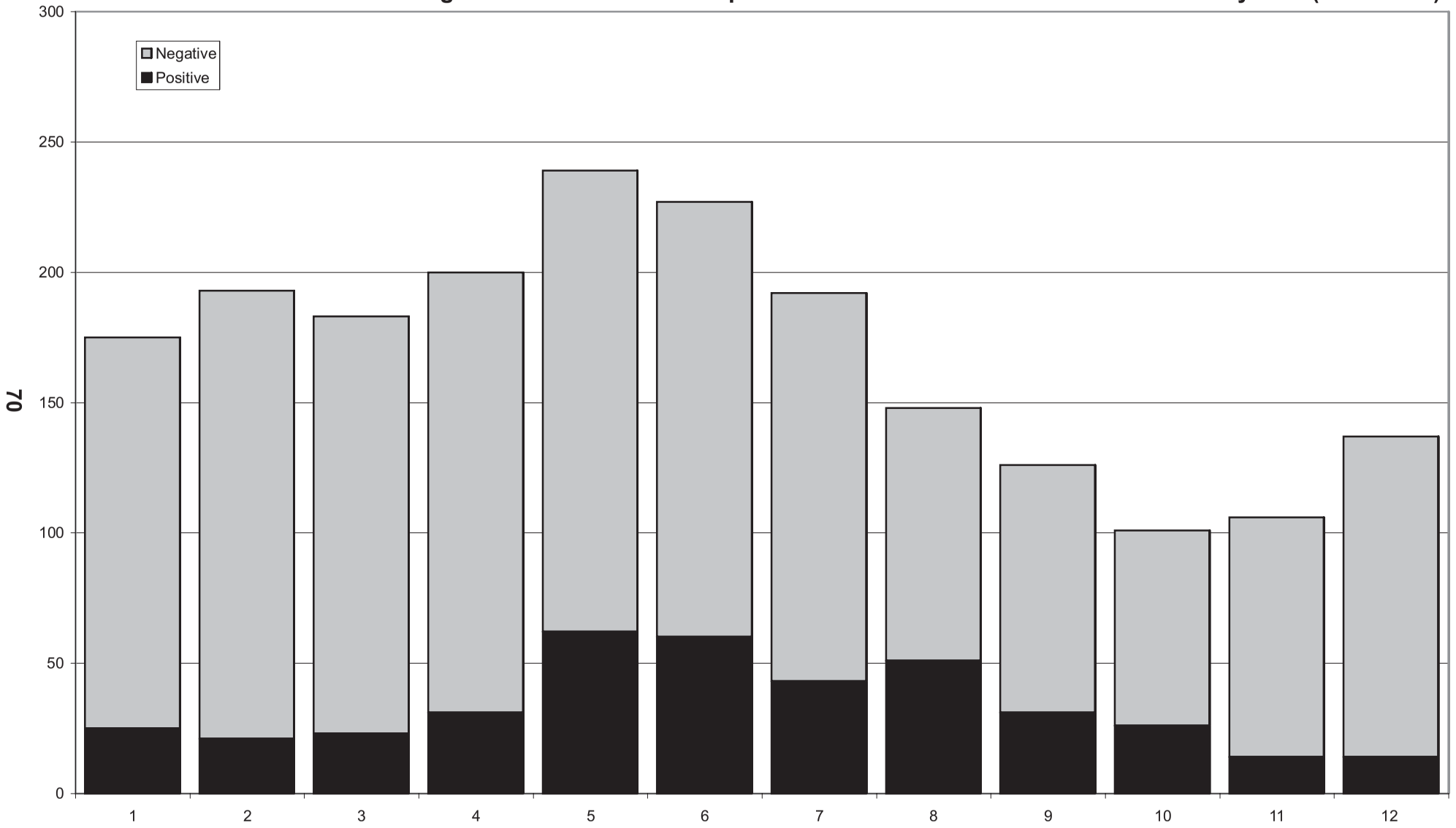


**Figure 42. Shorewatch - Porpoise Positive Observation Periods Classed by Tide (Combined)**

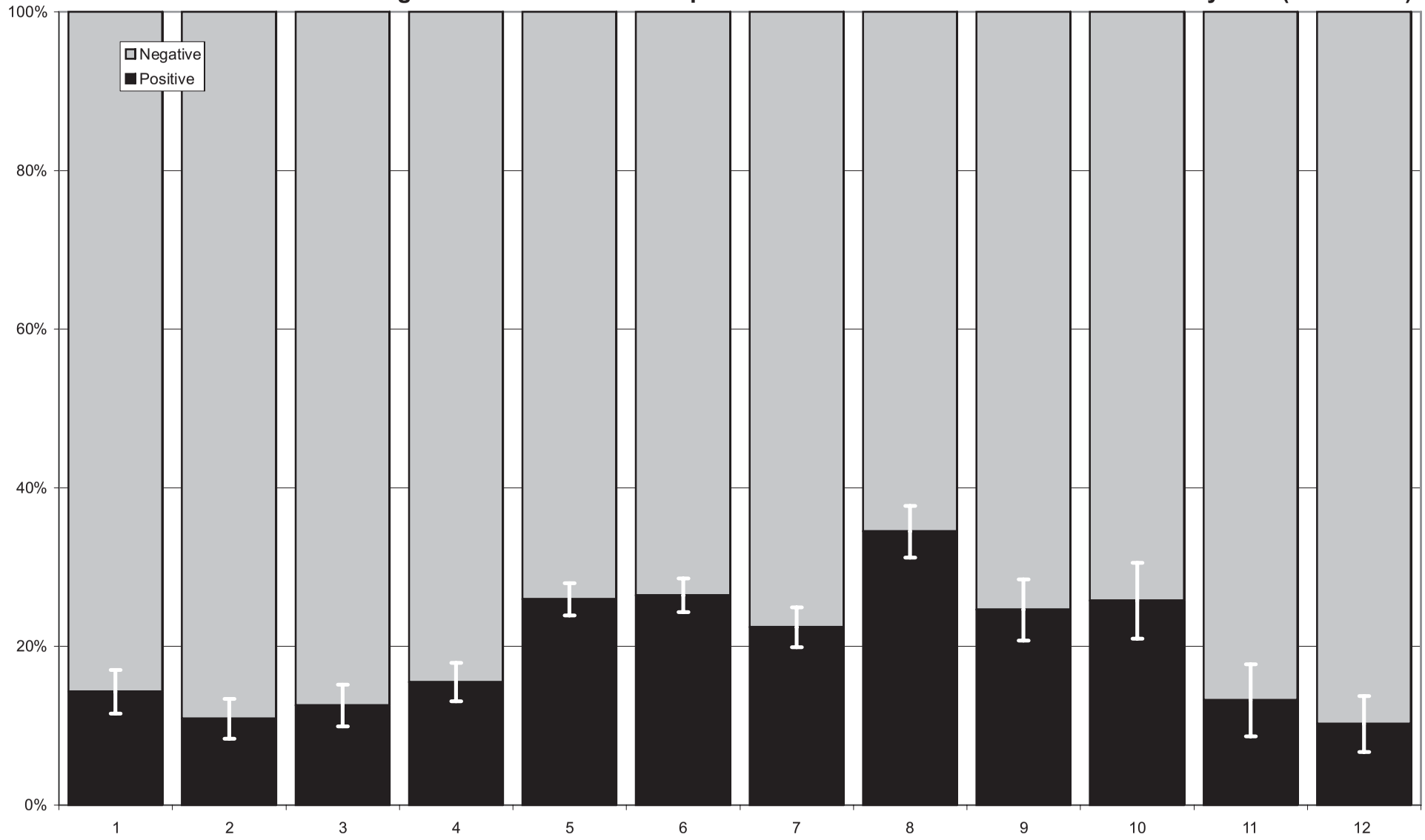


**Figure 43a. Shorewatch - Porpoise Positive Periods Classed by Tide (Burry Holms / Lime Kiln)**

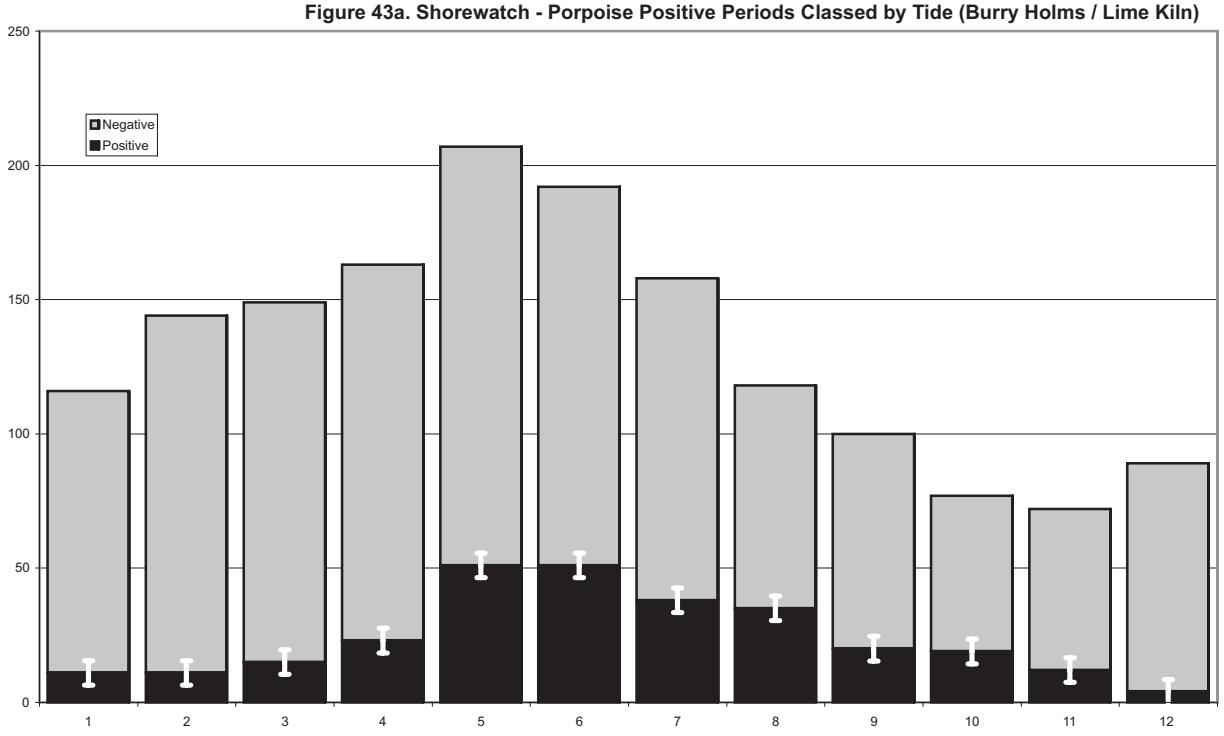



**Figure 43b. Shorewatch - Porpoise Positive Periods Classed by Tide (Port Eynon)**

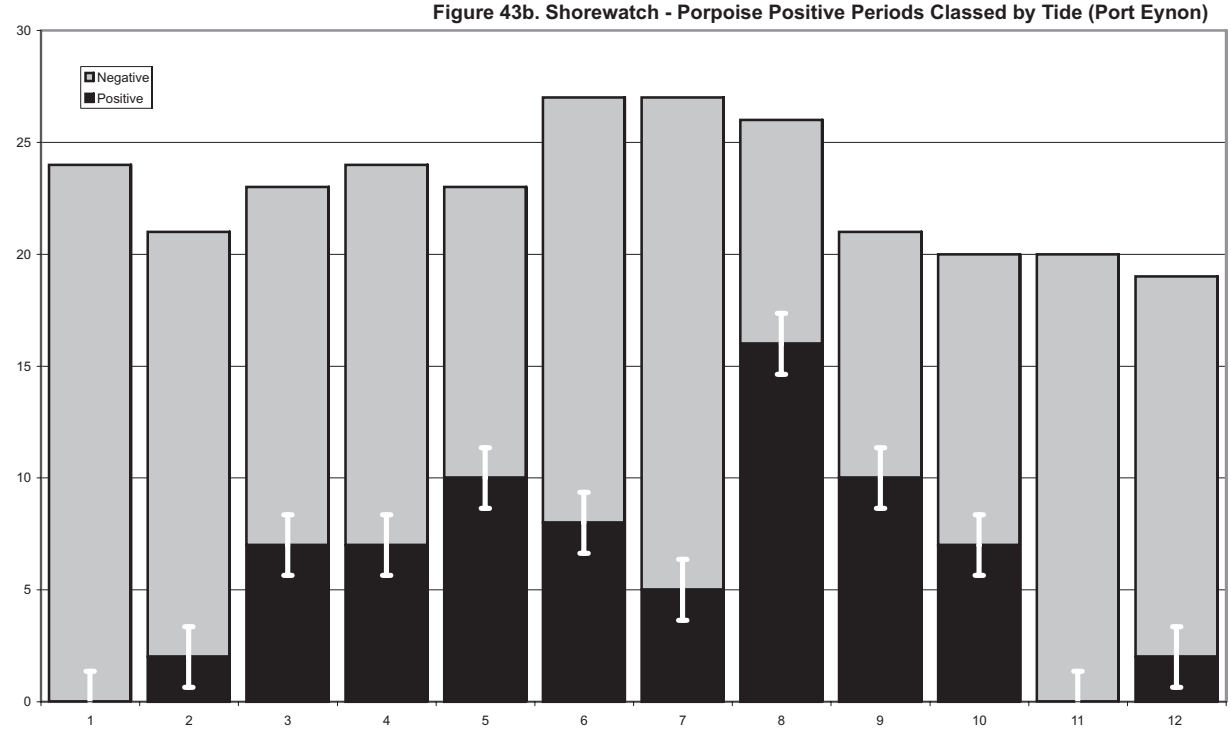
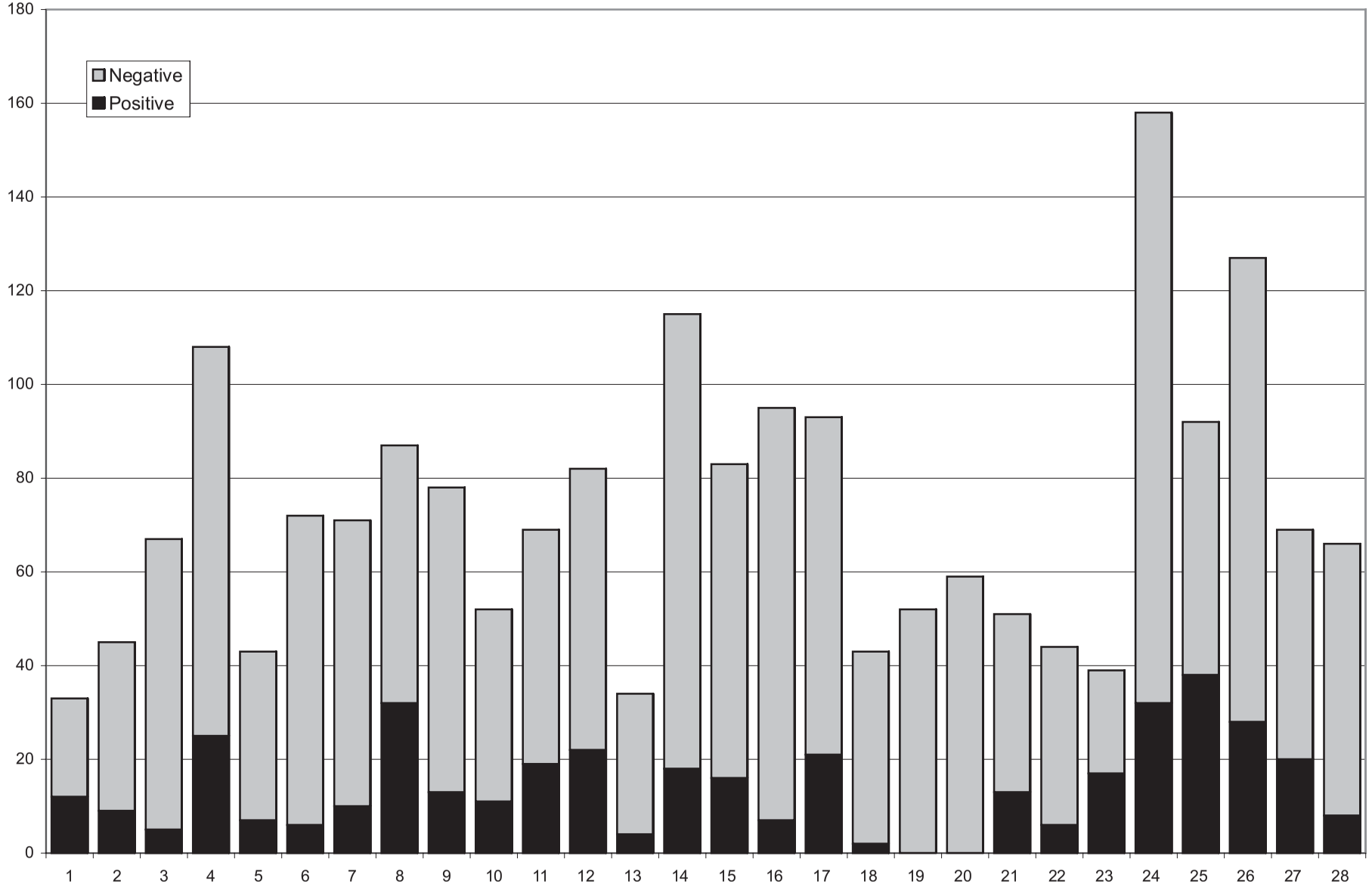


Table 27. Shorewatch Observations Classified By Lunar Day

| Lunar Day | Other | | Burry Holms / Lime Kiln | | Port Eynon | | Worm's Head | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | NEG | POS | NEG | POS | NEG | POS | NEG | POS | NEG | POS | Combined |
| **1** | 0 | 0 | 21 | 12 | 0 | 0 | 0 | 0 | 21 | 12 | 33 |
| **2** | 0 | 0 | 36 | 9 | 0 | 0 | 0 | 0 | 36 | 9 | 45 |
| **3** | 0 | 2 | 38 | 0 | 12 | 2 | 12 | 1 | 62 | 5 | 67 |
| **4** | 0 | 0 | 42 | 0 | 6 | 14 | 35 | 11 | 83 | 25 | 108 |
| **5** | 0 | 0 | 34 | 7 | 2 | 0 | 0 | 0 | 36 | 7 | 43 |
| **6** | 0 | 0 | 42 | 4 | 24 | 2 | 0 | 0 | 66 | 6 | 72 |
| **7** | 0 | 0 | 46 | 3 | 0 | 5 | 15 | 2 | 61 | 10 | 71 |
| **8** | 0 | 0 | 53 | 24 | 0 | 0 | 2 | 8 | 55 | 32 | 87 |
| **9** | 0 | 0 | 56 | 11 | 9 | 2 | 0 | 0 | 65 | 13 | 78 |
| **10** | 0 | 0 | 26 | 7 | 15 | 4 | 0 | 0 | 41 | 11 | 52 |
| **11** | 0 | 0 | 50 | 17 | 0 | 0 | 0 | 2 | 50 | 19 | 69 |
| **12** | 0 | 0 | 54 | 14 | 6 | 8 | 0 | 0 | 60 | 22 | 82 |
| **13** | 0 | 0 | 30 | 4 | 0 | 0 | 0 | 0 | 30 | 4 | 34 |
| **14** | 0 | 0 | 78 | 18 | 17 | 0 | 2 | 0 | 97 | 18 | 115 |
| **15** | 0 | 0 | 35 | 8 | 20 | 3 | 12 | 5 | 67 | 16 | 83 |
| **16** | 0 | 0 | 76 | 5 | 12 | 2 | 0 | 0 | 88 | 7 | 95 |
| **17** | 0 | 0 | 72 | 21 | 0 | 0 | 0 | 0 | 72 | 21 | 93 |
| **18** | 0 | 0 | 32 | 2 | 9 | 0 | 0 | 0 | 41 | 2 | 43 |
| **19** | 11 | 0 | 41 | 0 | 0 | 0 | 0 | 0 | 52 | 0 | 52 |
| **20** | 0 | 0 | 56 | 0 | 0 | 0 | 3 | 0 | 59 | 0 | 59 |
| **21** | 9 | 5 | 20 | 0 | 3 | 8 | 6 | 0 | 38 | 13 | 51 |
| **22** | 0 | 0 | 21 | 6 | 17 | 0 | 0 | 0 | 38 | 6 | 44 |
| **23** | 0 | 0 | 22 | 17 | 0 | 0 | 0 | 0 | 22 | 17 | 39 |
| **24** | 0 | 0 | 96 | 18 | 7 | 13 | 23 | 1 | 126 | 32 | 158 |
| **26** | 0 | 0 | 40 | 30 | 14 | 8 | 0 | 0 | 54 | 38 | 92 |
| **26** | 0 | 0 | 80 | 25 | 19 | 3 | 0 | 0 | 99 | 28 | 127 |
| **27** | 0 | 0 | 49 | 20 | 0 | 0 | 0 | 0 | 49 | 20 | 69 |
| **28** | 0 | 0 | 49 | 8 | 9 | 0 | 0 | 0 | 58 | 8 | 66 |
| **Total:** | **20** | **7** | **1295** | **290** | **201** | **74** | **110** | **30** | **1626** | **401** | **2027** |

**Figure 44. Shorewatch - Porpoise Positive Periods Classed by Lunar Day (Combined)**



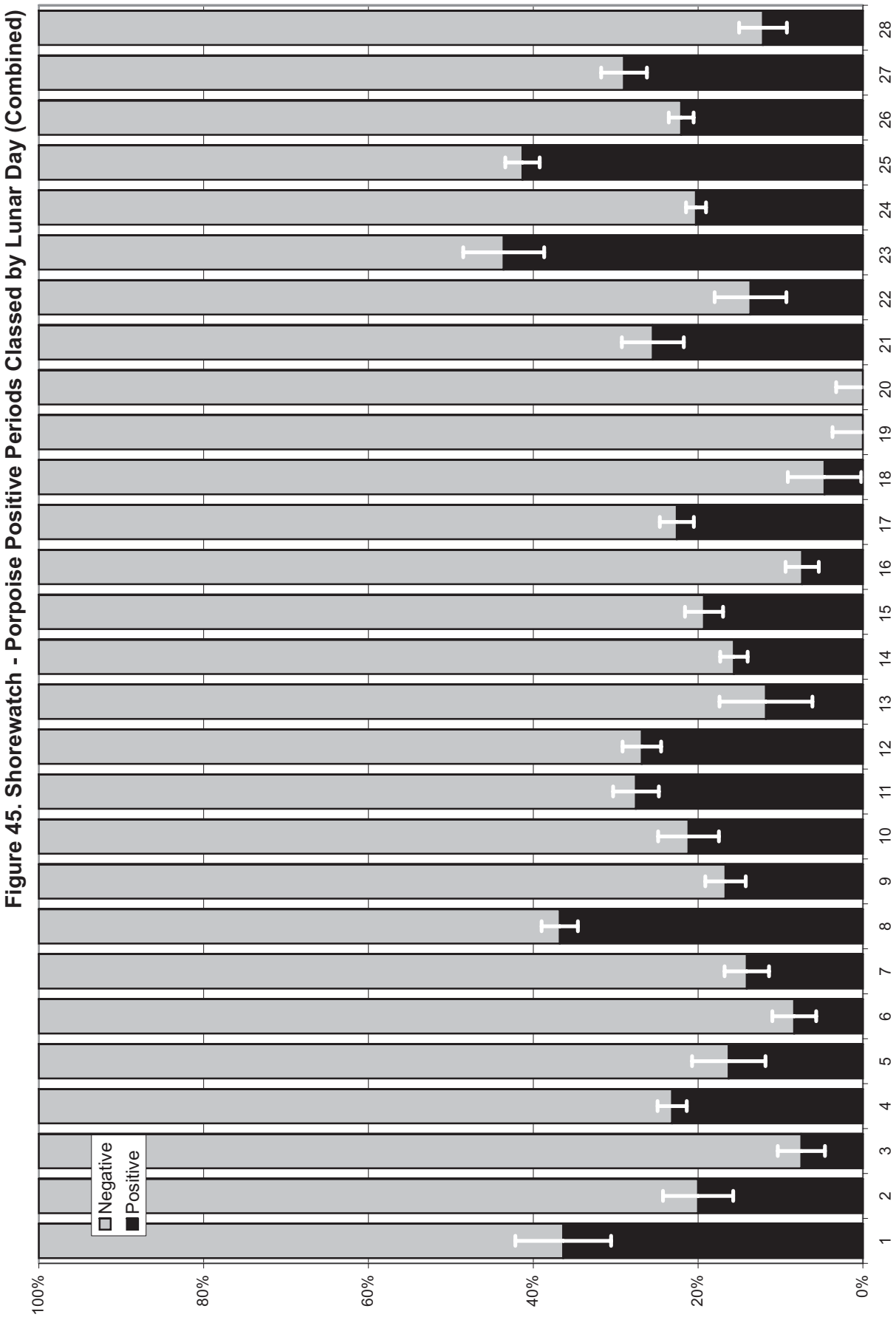


Figure 45. Shorewatch - Porpoise Positive Periods Classed by Lunar Day (Combined)
Negative
Positive
100%
80%
60%
40%
20%
0%
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28

**Figure 46a. Shorewatch - Porpoise Positive Periods by Lunar Day (Burry Holms / Lime Kiln)**

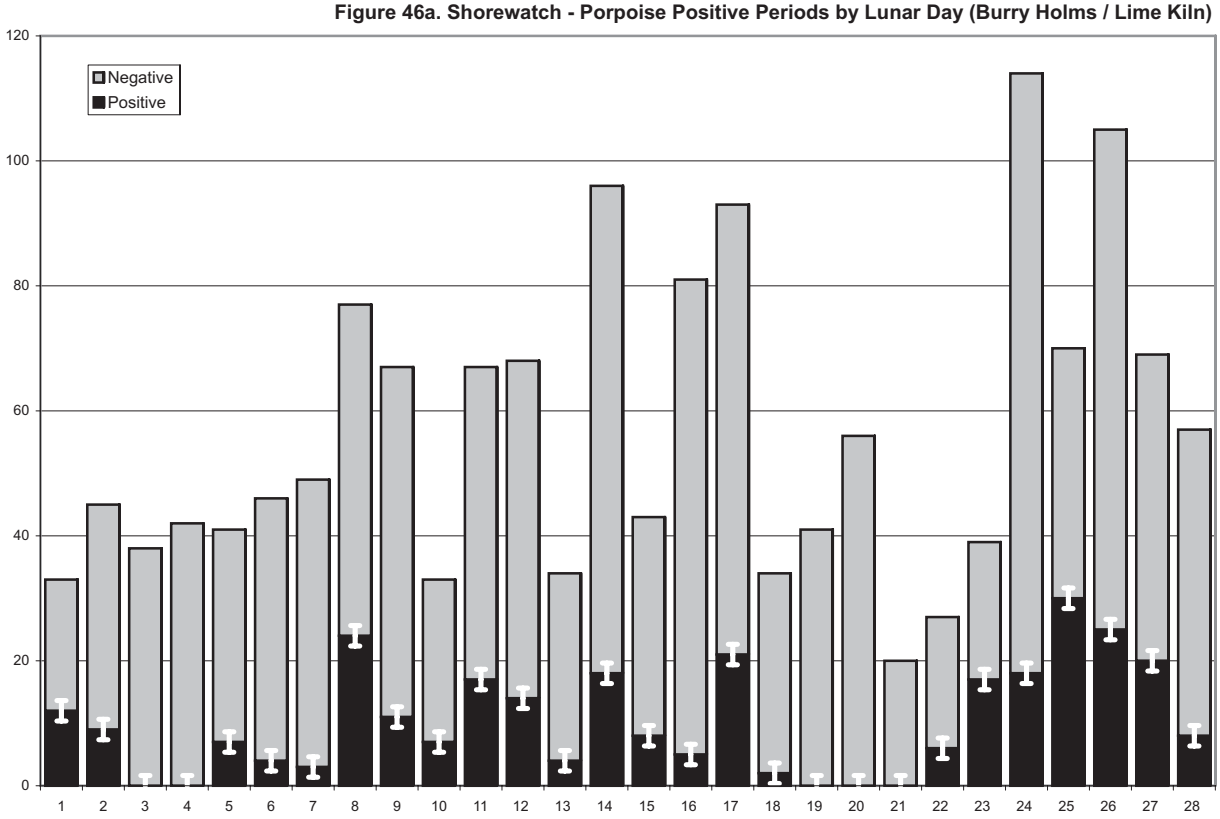



**Figure 46b. Shorewatch - Porpoise Positive Periods by Lunar Day (Port Eynon)**

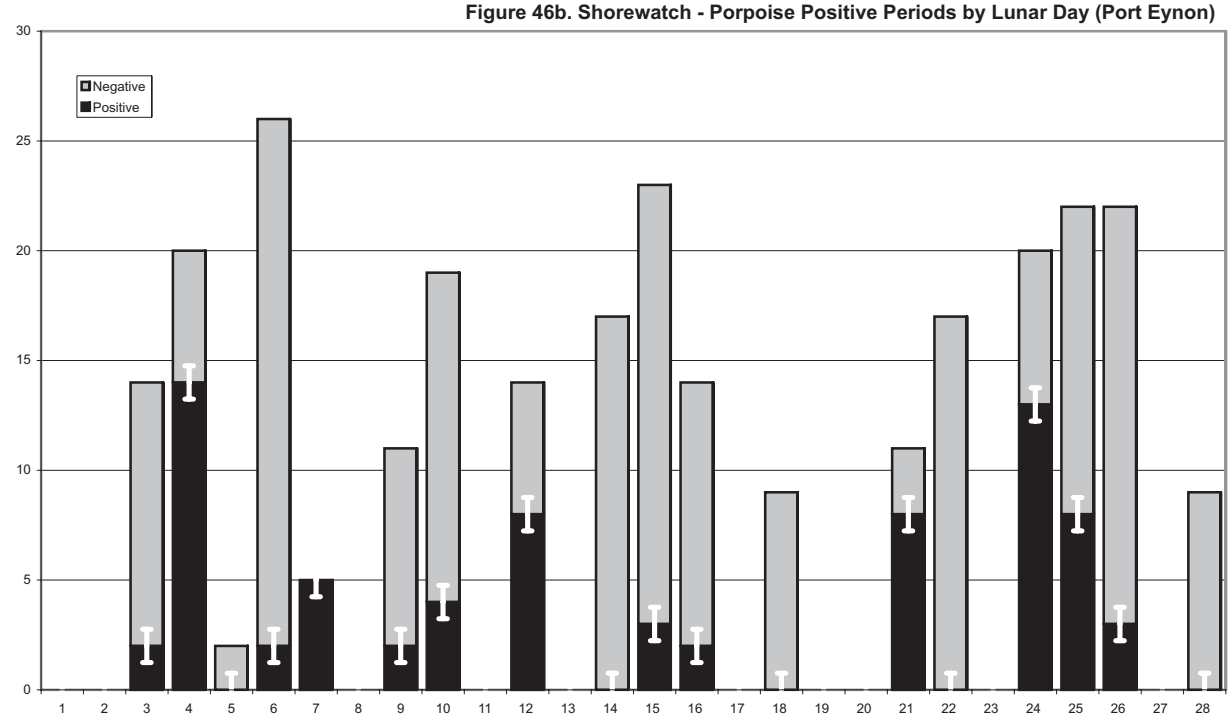


Table 28a. Shorewatch. Variance in group size with tide using all "estimated number" observations

| Tide | Group Size | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | >11 | Total | % |
| T01 | 4 | 7 | 9 | 1 | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 25 | 6% |
| T02 | 4 | 4 | 1 | 3 | 5 | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 21 | 5% |
| T03 | 4 | 1 | 11 | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 23 | 6% |
| T04 | 4 | 6 | 13 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 31 | 8% |
| T05 | 11 | 18 | 17 | 4 | 10 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 62 | 15% |
| T06 | 11 | 25 | 8 | 7 | 6 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 60 | 15% |
| T07 | 8 | 9 | 8 | 8 | 7 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 43 | 11% |
| T08 | 8 | 23 | 14 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 51 | 13% |
| T09 | 6 | 11 | 2 | 5 | 5 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 31 | 8% |
| T10 | 5 | 1 | 7 | 5 | 1 | 2 | 4 | 1 | 0 | 0 | 0 | 0 | 26 | 6% |
| T11 | 0 | 3 | 5 | 2 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 14 | 3% |
| T12 | 4 | 1 | 4 | 3 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 14 | 3% |
| Total: | 69 | 109 | 99 | 44 | 48 | 9 | 11 | 7 | 0 | 0 | 5 | | 401 | |

Table 28b. Shorewatch. Variance in group size with month of year using all "estimated number" observations

| Month | Group Size | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | >11 | Total | % |
| January | 9 | 4 | 10 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 27 | 7% |
| February | 7 | 9 | 4 | 10 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 32 | 8% |
| March | 5 | 16 | 9 | 16 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 50 | 12% |
| April | 7 | 20 | 9 | 1 | 8 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 54 | 13% |
| May | 6 | 7 | 8 | 2 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 29 | 7% |
| June | 4 | 0 | 5 | 5 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 5% |
| July | 9 | 20 | 6 | 0 | 1 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 40 | 10% |
| August | 12 | 10 | 18 | 3 | 9 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 57 | 14% |
| September | 3 | 3 | 10 | 0 | 3 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 24 | 6% |
| October | 2 | 9 | 6 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 5% |
| November | 1 | 3 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 3% |
| December | 4 | 8 | 9 | 5 | 5 | 0 | 2 | 3 | 0 | 0 | 0 | 0 | 36 | 9% |
| Total: | 69 | 109 | 99 | 44 | 48 | 9 | 11 | 7 | 0 | 0 | 5 | 0 | 401 | |

Table 28c. Shorewatch. Variance in group size with tide using all "definate number" observations

| Tide | Group Size | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | >11 | Total | % |
| T01 | 8 | 9 | 4 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 6% |
| T02 | 4 | 4 | 6 | 5 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 21 | 5% |
| T03 | 4 | 11 | 3 | 0 | 1 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 23 | 6% |
| T04 | 7 | 7 | 15 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 31 | 8% |
| T05 | 18 | 16 | 17 | 4 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 62 | 15% |
| T06 | 17 | 22 | 10 | 6 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 60 | 15% |
| T07 | 9 | 10 | 15 | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 42 | 10% |
| T08 | 9 | 29 | 7 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 49 | 12% |
| T09 | 7 | 15 | 3 | 3 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 31 | 8% |
| T10 | 5 | 5 | 9 | 1 | 4 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 26 | 6% |
| T11 | 0 | 5 | 3 | 2 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 3% |
| T12 | 5 | 2 | 2 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 3% |
| Total: | 93 | 135 | 94 | 37 | 25 | 5 | 3 | 2 | 4 | 0 | | 0 | 398 | |



Table 28d. Shorewatch. Variance in group size with month of year using all "definate number" observations

| Month | Group Size | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | >11 | Total | % |
| January | 13 | 6 | 7 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 27 | 7% |
| February | 7 | 12 | 10 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 32 | 8% |
| March | 10 | 13 | 19 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 12% |
| April | 11 | 20 | 6 | 10 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 54 | 13% |
| May | 8 | 9 | 10 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 29 | 7% |
| June | 4 | 8 | 2 | 6 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 5% |
| July | 11 | 24 | 0 | 1 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 40 | 10% |
| August | 14 | 13 | 15 | 2 | 5 | 0 | 1 | 0 | 4 | 0 | 0 | 0 | 54 | 13% |
| September | 3 | 5 | 9 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 6% |
| October | 3 | 8 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 5% |
| November | 2 | 4 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 3% |
| December | 7 | 13 | 2 | 11 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 36 | 9% |
| Total: | 93 | 135 | 94 | 37 | 25 | 5 | 3 | 2 | 4 | 0 | 0 | 0 | 398 | |

Table 29a. Shorewatch Data. Variance in group size using all "estimated number" observations

| Group Size | BH/LK | PE | Worm | Other | Total |
|---|---|---|---|---|---|
| **1** | 45 | 19 | 5 | 0 | 69 |
| **2** | 84 | 20 | 4 | 1 | 109 |
| **3** | 73 | 17 | 8 | 1 | 99 |
| **4** | 33 | 2 | 4 | 5 | 44 |
| **5** | 32 | 11 | 5 | 0 | 48 |
| **6** | 9 | 0 | 0 | 0 | 9 |
| **7** | 10 | 0 | 1 | 0 | 11 |
| **8** | 4 | 0 | 3 | 0 | 7 |
| **9** | 0 | 0 | 0 | 0 | 0 |
| **10** | 0 | 0 | 0 | 0 | 0 |
| **11** | 0 | 5 | 0 | 0 | 5 |
| **>11** | 0 | 0 | 0 | 0 | 0 |
| **Total:** | 290 | 74 | 30 | 7 | 401 |

**Table 29b Shorewatch Data: Group Size, All +ve Observation Periods**

| Site | # pos. obs. | range | mean min. | mean est. | mode |
|---|---|---|---|---|---|
| **BH/LK** | 286 | 1-8 | 2.55 | 3.04 | 2 |
| **Worm** | 30 | 1-8 | 2.53 | 3.53 | 3 |
| **PE** | 74 | 1-11 | 2.67 | 3.23 | 1 |
| **Other** | 9 | 2-4 | 2.88 | 2.88 | 2 |
| **Totals:** | **390** | **1-11** | **2.65** | **3.17** | |

**Table 29c Shorewatch Data: Group Size, All +ve Days**

| Site | # pos. days | range | mean | mode |
|---|---|---|---|---|
| **BH/LK** | 66 | 1-8 | 3.18 | 2 |
| **Worm** | 13 | 1-8 | 3.46 | 2 & 3 |
| **PE** | 13 | 1-11 | 3.38 | 4 & 5 |
| **Other** | 2 | 2-4 | 3 | |
| **Totals:** | **94** | **1-11** | **3.24** | |

**Table 30a. Shorewach: Burry Holms / Lime Kiln (definate)**

| Tide State | Group Size | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | >11 | Total |
| 1 | 2 | 7 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 |
| 2 | 4 | 3 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 |
| 3 | 2 | 9 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 |
| 4 | 4 | 6 | 11 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 23 |
| 5 | 15 | 13 | 15 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 51 |
| 6 | 15 | 19 | 10 | 3 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 51 |
| 7 | 6 | 8 | 15 | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 37 |
| 8 | 6 | 19 | 5 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33 |
| 9 | 4 | 8 | 3 | 3 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 20 |
| 10 | 2 | 1 | 9 | 1 | 4 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 19 |
| 11 | 0 | 5 | 3 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 12 |
| 12 | 1 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| Total | 61 | 100 | 75 | 23 | 20 | 5 | 1 | 2 | 0 | 0 | 0 | 0 | 287 |

**Table 30b. Shorewach: Port Eynon (definate)**

| Tide State | Group Size | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | >11 | Total |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 2 |
| 3 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 7 |
| 4 | 2 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| 5 | 3 | 2 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |
| 6 | 2 | 3 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| 7 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| 8 | 3 | 10 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 |
| 9 | 2 | 7 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |
| 10 | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Total | 22 | 31 | 8 | 4 | 4 | 0 | 1 | 0 | 4 | 0 | 0 | 0 | 74 |

**Table 30c. Shorewach: Worm (definate)**

| Tide State | Group Size | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | >11 | Total |
| 1 | 6 | 2 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 |
| 2 | 0 | 1 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 6 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | 2 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| Total | 9 | 4 | 10 | 5 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 30 |

**Table 30d. Shorewach: Other (definate)**

| Tide State | Group Size | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | >11 | Total |
| 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 12 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Total | 1 | 0 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |

**Table 30e. Shorewach: Totals (definate)**

| Tide State | Group Size | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | >11 | Total |
| 1 | 8 | 9 | 4 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| 2 | 4 | 4 | 6 | 5 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 21 |
| 3 | 4 | 11 | 3 | 0 | 1 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 23 |
| 4 | 7 | 7 | 15 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 31 |
| 5 | 18 | 16 | 17 | 4 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 62 |
| 6 | 17 | 22 | 10 | 6 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 60 |
| 7 | 9 | 10 | 15 | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 42 |
| 8 | 9 | 29 | 7 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 49 |
| 9 | 7 | 15 | 3 | 3 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 31 |
| 10 | 5 | 5 | 9 | 1 | 4 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 26 |
| 11 | 0 | 5 | 3 | 2 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 14 |
| 12 | 5 | 2 | 2 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 |
| Total | 93 | 135 | 94 | 37 | 25 | 5 | 3 | 2 | 4 | 0 | 0 | 0 | 398 |

**Table 30f. Shorewach: Burry Holms / Lime Kiln (estimate)**

| Tide State | Group Size | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | >11 | Total |
| 1 | 0 | 5 | 4 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 11 |
| 2 | 4 | 3 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 |
| 3 | 2 | 1 | 9 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 |
| 4 | 2 | 5 | 8 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 23 |
| 5 | 10 | 14 | 14 | 4 | 7 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 51 |
| 6 | 9 | 22 | 8 | 4 | 5 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 51 |
| 7 | 6 | 6 | 8 | 8 | 7 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 38 |
| 8 | 5 | 15 | 11 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 35 |
| 9 | 4 | 8 | 0 | 5 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 20 |
| 10 | 2 | 1 | 4 | 5 | 0 | 2 | 4 | 1 | 0 | 0 | 0 | 0 | 19 |
| 11 | 0 | 3 | 5 | 0 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 12 |
| 12 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 |
| Total | 45 | 84 | 73 | 33 | 32 | 9 | 10 | 4 | 0 | 0 | 0 | 0 | 290 |

**Table 30g. Shorewach: Port Eynon (estimate)**

| Tide State | Group Size | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | >11 | Total |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 |
| 3 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 7 |
| 4 | 2 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| 5 | 1 | 3 | 3 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |
| 6 | 2 | 3 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| 7 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| 8 | 3 | 8 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 |
| 9 | 2 | 3 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |
| 10 | 3 | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Total | 19 | 20 | 17 | 2 | 11 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 74 |

**Table 30h. Shorewach: Worm (estimate)**

| Tide State | Group Size | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | >11 | Total |
| 1 | 4 | 2 | 4 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 13 |
| 2 | 0 | 1 | 0 | 2 | 3 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 8 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 6 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | 1 | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| Total | 5 | 4 | 8 | 4 | 5 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 30 |

**Table 30i. Shorewach: Other (estimate)**

| Tide State | Group Size | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | >11 | Total |
| 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 12 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Total | 0 | 1 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |

**Table 30j. Shorewach: Totals (estimate_**

| Tide State | Group Size | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | >11 | Total |
| 1 | 4 | 7 | 9 | 1 | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 25 |
| 2 | 4 | 4 | 1 | 3 | 5 | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 21 |
| 3 | 4 | 1 | 11 | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 23 |
| 4 | 4 | 6 | 13 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 31 |
| 5 | 11 | 18 | 17 | 4 | 10 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 62 |
| 6 | 11 | 25 | 8 | 7 | 6 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 60 |
| 7 | 8 | 9 | 8 | 8 | 7 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 43 |
| 8 | 8 | 23 | 14 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 51 |
| 9 | 6 | 11 | 2 | 5 | 5 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 31 |
| 10 | 5 | 1 | 7 | 5 | 1 | 2 | 4 | 1 | 0 | 0 | 0 | 0 | 26 |
| 11 | 0 | 3 | 5 | 2 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 14 |
| 12 | 4 | 1 | 4 | 3 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 14 |
| Total | 69 | 109 | 99 | 44 | 48 | 9 | 11 | 7 | 0 | 0 | 5 | 0 | 401 |

# Shorewatch Data Summary

Table 31a. Burry Holms / Limekiln Point
Average group size at different tide hours (1=LW), using all observation periods, minimum and estimated numbers:

| tide | # +ve obs | range | min mean | est mean | mode |
|---|---|---|---|---|---|
| 1 | 11 | 1-7 | 2.36 | 3.27 | 2 |
| 2 | 11 | 1-6 | 2.27 | 2.45 | 1 |
| 3 | 14 | 1-5 | 2.28 | 3.07 | 3 |
| 4 | 23 | 1-5 | 2.47 | 3.13 | 3 |
| 5 | 52 | 1-7 | 2.35 | 2.74 | 2 |
| 6 | 62 | 1-7 | 1.95 | 2.35 | 2 |
| 7 | 30 | 1-6 | 2.63 | 3.13 | 3 |
| 8 | 35 | 1-5 | 2.23 | 2.51 | 2 |
| 9 | 23 | 1-8 | 2.86 | 3.26 | 2 |
| 10 | 19 | 1-8 | 3.63 | 4.42 | 4 |
| 11 | 12 | 1-7 | 3.3 | 3.75 | 3 |
| 12 | 10 | 1-7 | 2.5 | 2.6 | |

Table 31b. Average group size at different tide hours using estimated (maximum) numbers:

| group size:day, est number: tide hour | | | | |
|---|---|---|---|---|
| tide | positive days | range | mean | mode |
| 1 | 2 | 3-7 | 5 | 3&7 |
| 2 | 2 | 2 | 2 | 2 |
| 3 | 6 | 1-5 | 2.5 | 1&3 |
| 4 | 3 | 2-5 | 4 | 5 |
| 5 | 13 | 1-8 | 2.77 | 1 |
| 6 | 13 | 1-7 | 2.69 | 2 |
| 7 | 7 | 1-6 | 3.71 | 5 |
| 8 | 9 | 1-3 | 1.87 | 2 |
| 9 | 5 | 2-5 | 3.6 | 2&5 |
| 10 | 2 | 4-8 | 6 | 4&8 |
| 11 | 3 | 3-7 | 5.33 | 3&6&7 |
| 12 | 2 | 2-3 | 2.5 | 2&3 |

Table 31c. Percentage frequency of group size, using estimated (maximum) number, all +ve days

| gp size | days | % |
|---|---|---|
| 1 | 13 | 19.4 |
| 2 | 20 | 29.8 |
| 3 | 13 | 19.4 |
| 4 | 4 | 5.9 |
| 5 | 10 | 14.9 |
| 6 | 2 | 2.9 |
| 7 | 3 | 4.4 |
| 8 | 2 | 2.9 |

# Shorewatch Data Summary

Table 32a. Port Eynon Point
Average group size at different tide hours (1=LW), using all observation periods, minimum and estimated numbers:

| tide | # +ve obs | range | min mean | est mean | mode |
|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 |
| 2 | 2 | 3-5 | 4 | 4 | 3&5 |
| 3 | 6 | 2-5 | 2.66 | 3 | 3&5 |
| 4 | 7 | 1-11 | 5.43 | 7 | 11 |
| 5 | 10 | 1-11 | 2.9 | 3.5 | 3 |
| 6 | 7 | 1-4 | 2.71 | 2.71 | 2&3&4 |
| 7 | 4 | 1-2 | 0.8 | 0.8 | 1&2 |
| 8 | 11 | 1-3 | 2.57 | 2.85 | 2 |
| 9 | 7 | 1-3 | 1.71 | 1.85 | 2 |
| 10 | 8 | 1-5 | 1.6 | 2.2 | 1&3 |
| 11 | 5 | 2-5 | 2.8 | 4.6 | 5 |
| 12 | 3 | 1-5 | 1.5 | 2 | 1 |

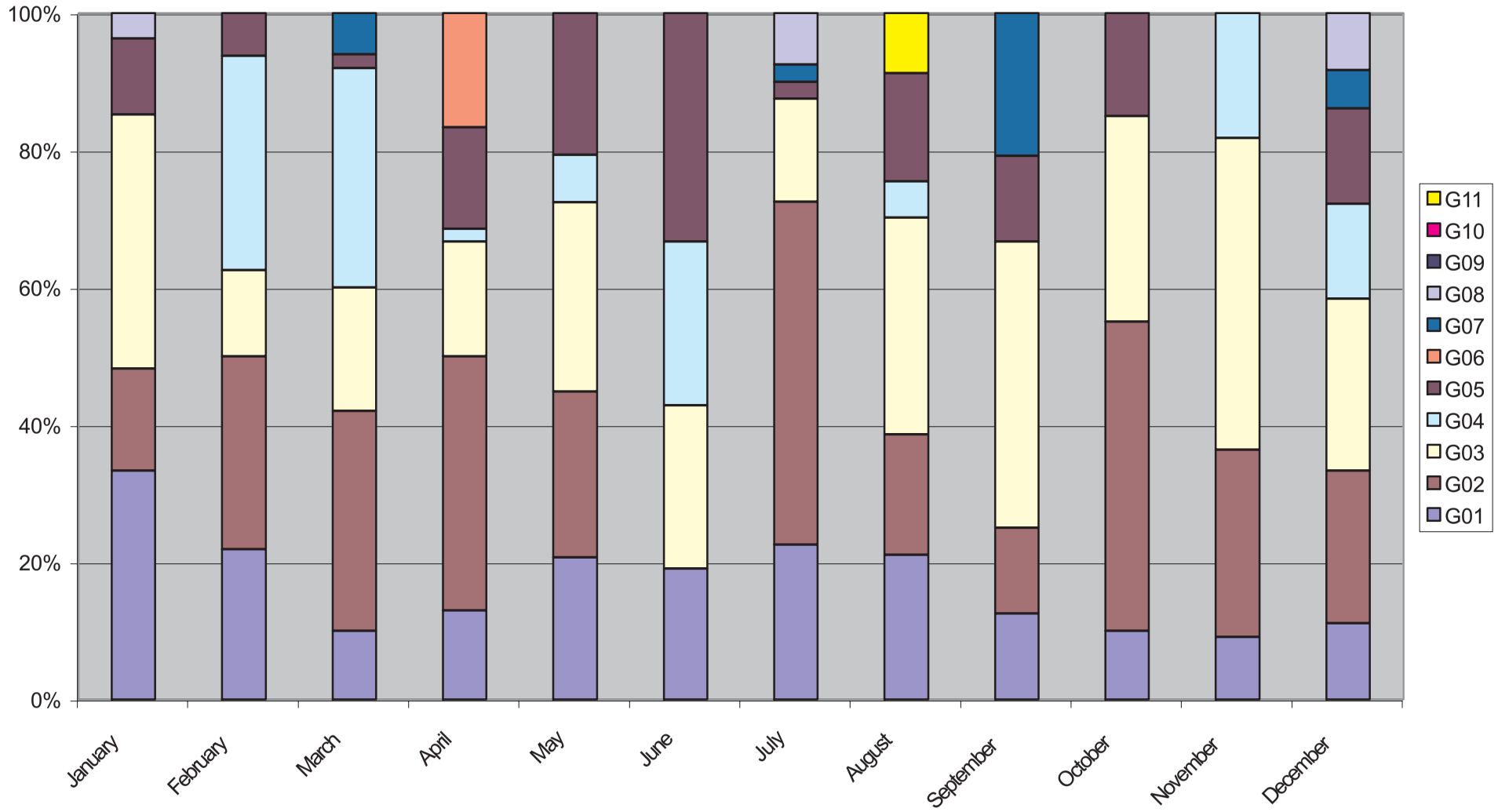
Table 32b. Average group size at different tide hours using estimated (maximum) numbers:

| tide | positive days | range | mean | mode |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 1 | 1 | 1 | 1 |
| 4 | 1 | 1 | 1 | 1 |
| 5 | 2 | 5-11 | 8 | 5&11 |
| 6 | 1 | 4 | 4 | 4 |
| 7 | 1 | 2 | 2 | 2 |
| 8 | 2 | 1-3 | 2 | 1&3 |
| 9 | 2 | 2 | 2 | 2 |
| 10 | 2 | 1-3 | 2 | 1&3 |
| 11 | 0 | 0 | 0 | 0 |
| 12 | 2 | 1-5 | 3 | 1&5 |

Table 32c. Percentage frequency of group size, using estimated (maximum) number, all +ve days

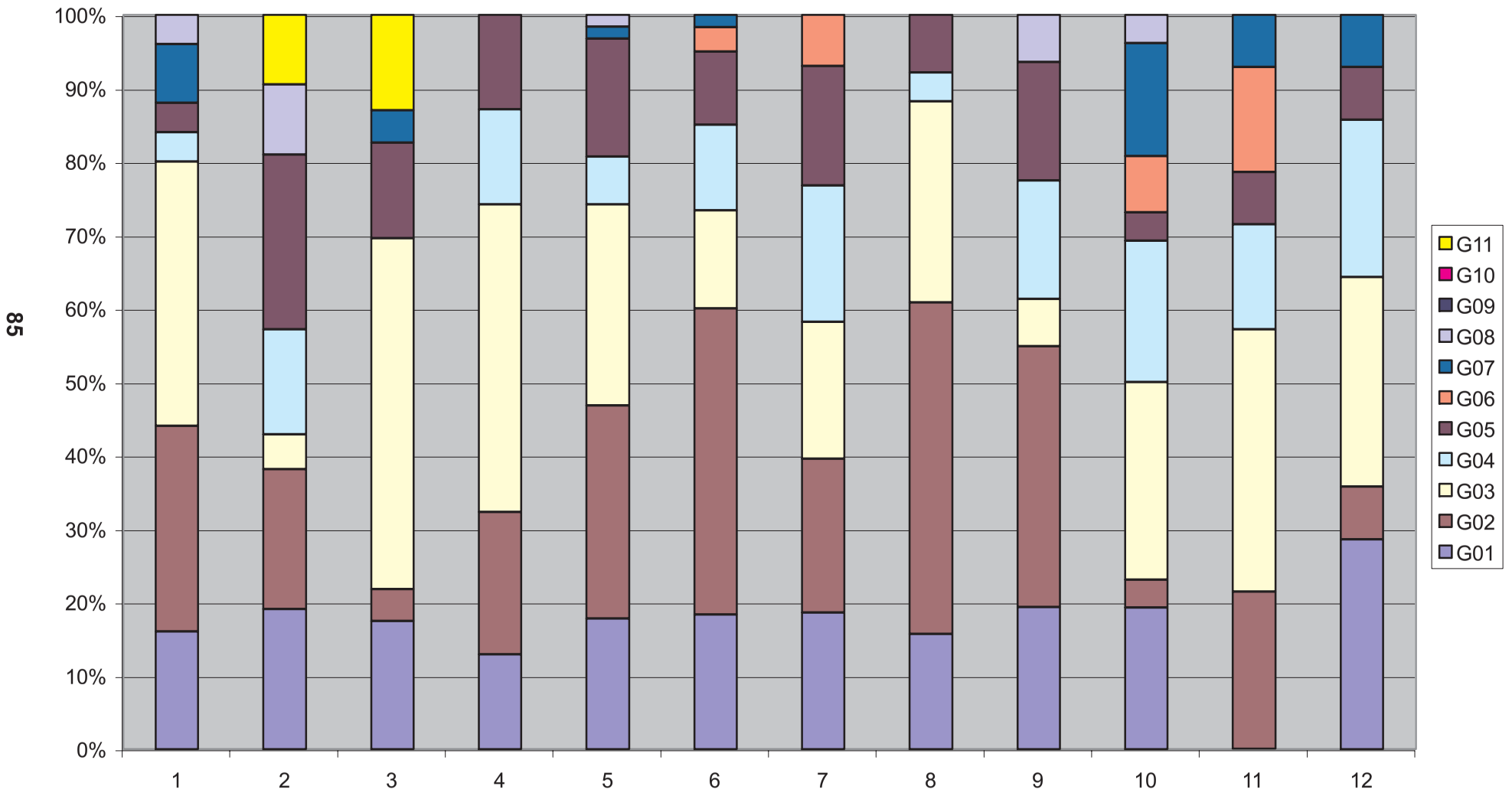
| gp size | days | % |
|---|---|---|
| 1 | 4 | 28 |
| 2 | 3 | 21 |
| 3 | 3 | 21 |
| 4 | 1 | 7 |
| 5 | 2 | 14 |
| 6 | 0 | |
| 7 | 0 | |
| 8 | 0 | |
| 9 | 0 | |
| 10 | 0 | |
| 11 | 1 | 7 |

# Figure 47. Shorewatch: Variation in Observed Group Size With Month



# Figure 48. Shorewatch: Variation in Observed Group Size WithTide State

Tide state 1 is the first period of approximately 1 hour after low water: period 12 is the last hour down the following low water.



# Shorewatch Data Summary - Juveniles

Table 33.

| | | | |
|---|---|---|---|
| one | 12-Jul-96 | | from Limekiln shore watch |
| one | 11-Jul-97 | | from Limekiln shore watch |
| one | 19-Aug-97 | | from Limekiln shore watch |
| one | 19-Sep-98 | from Limekiln shore watch | |
| one | 20-Oct-98 | from Limekiln shore watch | |
| one | 09-Jul-97 | | from Limekiln shore watch |
| one | 05-Sep-99 | from Limekiln shore watch | |
| one | 17-Oct-99 | from Limekiln shore watch | |
| one | 01-Jan-00 | | from Limekiln shore watch |
| one | 16-Sep-03 | from boat, 7 miles south of Worm's Head | |
| one | 16-Sep-03 | from boat, 6.5 miles south of Worm's Head. | |

*one neonate, 5th November 2004; casual observation from boat, 800m off Swansea Dock mouth.*

# Summary Discussion

This study shows porpoise occurrence throughout the surveyed area, throughout the year: this was confirmed by all survey methods used. Porpoise were recorded at all specific investigation sites (POD or shorewatch), and throughout the study area by boat-based survey

## Study area

It should be noted that the “study area” (Figure 1) has no geographical integrity, and is defined by considerations of practicality (distance from home port) and relevance to Local Authority funding partners. Whilst the summed data presented here are offered as an indication of porpoise status in the northern-central Bristol Channel, comparable data for sea areas immediately west, south and east are not available.

## Porpoise occurrence throughout the study area

Porpoise were recorded from all specific investigation sites (POD / shorewatch), and from throughout the study area by boat-based survey. The apparent higher frequency of (POD) occurrences/recordings in the west of the study area and off the south Gower coast (figure 49) is not statistically significant but this could be a consequence of weakness in the survey data (eg. POD perturbation was higher in the east).

- Burry Holms: porpoise recorded at 31% of POD recording hours (Table 7), with 255 encounters (Table 18), of an average duration >7 minutes (Table 19). Shorewatch effort recorded porpoise activity in all months except June (Table 40), with a clear activity peak around high water (Fig.43) also shown by POD data (Fig.21). Sixty four per cent of recorded activity was during darkness (Fig.23).
- Carmarthen Bay: porpoise recorded at 39% of POD recording hours (Table 7), with 1146 encounters (Table 18), of an average duration >8 minutes (Table 19). Recorded activity is constant across tide state (Fig.21), and is roughly equal during day/night (Fig.23).
- Port Eynon: porpoise recorded at 31% of POD recording hours (Table 7), with 773 encounters (Table 18), of an average duration of 5.22 minutes (Table 19). Shorewatch effort recorded porpoise activity in eight months (Table 40), with least activity recorded either side of low water (Fig.43) also being shown by POD data (Fig.21).
- Mumbles: porpoise recorded at 46% of POD recording hours (Table 7), with 627 encounters (Table 18), of an average duration of 6.89 minutes (Table 19). Activity was recorded at all tide states (Fig.21), with weak peaks at both high- and low-water. Day-night activity is roughly equal (Fig.23).
- Port Talbot: porpoise recorded at 9% of POD recording hours (Table 7), with 465 encounters (Table 18), of an average duration of 3.43 minutes (Table 19). Activity was recorded at all tide states (Fig.21), with a peak around high-water.
- Kenfig Patches: porpoise recorded at 7% of POD recording hours (Table 7), with 40 encounters (Table 18), of an average duration of 2.4 minutes (Table 19). Limited data collection here shows 70% of activity occurring during darkness.
- Scarweather west: porpoise recorded at 24% of POD recording hours (Table 7), with 276 encounters (Table 18), of an average duration 6.45 minutes (Table 19). Activity was recorded at all tide states (Fig.21), with a peak around high-water.
- Scarweather central (“Scarweather” & “Scarweather central”): porpoise recorded at 3% of POD recording hours (Table 7), with 134 encounters (Table 18), of an average duration of 2.63

minutes (Table 19). Activity was recorded at all tide states (Fig.21), with a strong peak around high-water.

- Scarweather east (Hugo buoy): porpoise recorded at 7% of POD recording hours (Table 7), with 124 encounters (Table 18), of an average duration of 2.37 minutes (Table 19). Activity was recorded at all tide states (Fig.21), with a peak around high-water.

Boat transects, with constant observer effort, through the study area (Fig. 35) detected 86 porpoise during 778.25nm (6 porpoise/100km).

Inshore transects (<5nm from coast) totalled 536nm, and recorded 34 animals (3.42 porpoise/100km). Offshore transects (5-10nm off coast) totalled 242nm, and recorded 52 animals (11.6 porpoise/100km).

Offshore transects showed a marked difference in results between the three blocks, with far more animals seen in the south and western blocks. The western block recorded 17 animals in 74nm (12.4 porpoise/100km); the south Gower block recorded 34 animals in 79nm (23.3 porpoise/100km); the Port Talbot-Porthcawl block recorded 1 animal in 89nm (0.6 porpoise/100km).

Porpoise sightings were recorded as:

i. 48 sighting events, where "event" is defined as 7.5 or more minutes between sightings (ie. one nm or more, at tow-speed 8kn),

ii. 63 sighting events, where “event” is defined as a separate data line entered by the on-board observer. Equating "event" here with "school" (Pierpoint, 2001) gives the following comparison:

| area | schools/100km i | schools/100km ii | schools/100km | Reference |
|---|---|---|---|---|
| **Overall** | 2.84 | 4.36 | | This study |
| **Inshore** | 1.9 | 2.3 | | This study |
| **Offshore** | 6.46 | 8.9 | | This study |
| **west/south Gower offshore** | 9.9 | 13.7 | | This study |
| **Glamorgan coast offshore** | 0.6 | 0.6 | | This study |
| **south west Wales** | | | 22 | Pierpoint 2001 |
| **Celtic Shelf** | | | <2 | cited in Pierpoint 2001 |
| **Gulf of Maine** | | | 11 | cited in Pierpoint 2001 |
| **Bay of Fundy** | | | 35 | cited in Pierpoint 2001 |

Further resolution of these data will be pursued, beyond this report, to allow abundance estimation via line transect sampling formulae, but the above comparisons suggest that the study area has a relative importance within a Celtic Shelf context and that areas within the study site- eg. within the west/south Gower blocks- host significant numbers.

In the absence of understanding of porpoise movements, short- or long-term, it remains unclear whether the animals reported here are “local residents” or “transitory migrants/visitors”. Radio-tagging studies in north east USA/ and eastern Canada (cited in Evans, '87) report that porpoise “typically followed a similar pattern of movement from day to day”, suggesting the use of a “home” range by “local” animals. During the course of the study reported here, workers came to believe that they were seeing near-predictable, tide-influenced, on/offshore movements: this belief is also consistent with the suggestion of “local” animals but further investigation is needed to confirm this.

# Important sites

The following sites/areas are suggested as being of particular importance to porpoise:

based on percentage porpoise-positive hours from all POD sites:

- Mumbles Head
- Carmarthen Bay
- Port Eynon Head
- west end of Shord channel
- Burry Holms.

based on shore-watch data:

- Burry Holms
- Worm's Head
- Mumbles Head

all had porpoise presence at more than 20% of observations: these figures are significantly higher at hours close to HW. It seems likely that tide-runs at any rocky Gower headland are used by feeding porpoise (a suggestion supported by clusters of casual sightings off e.g. Oxwich Point).

based on observer transects/casual sightings:

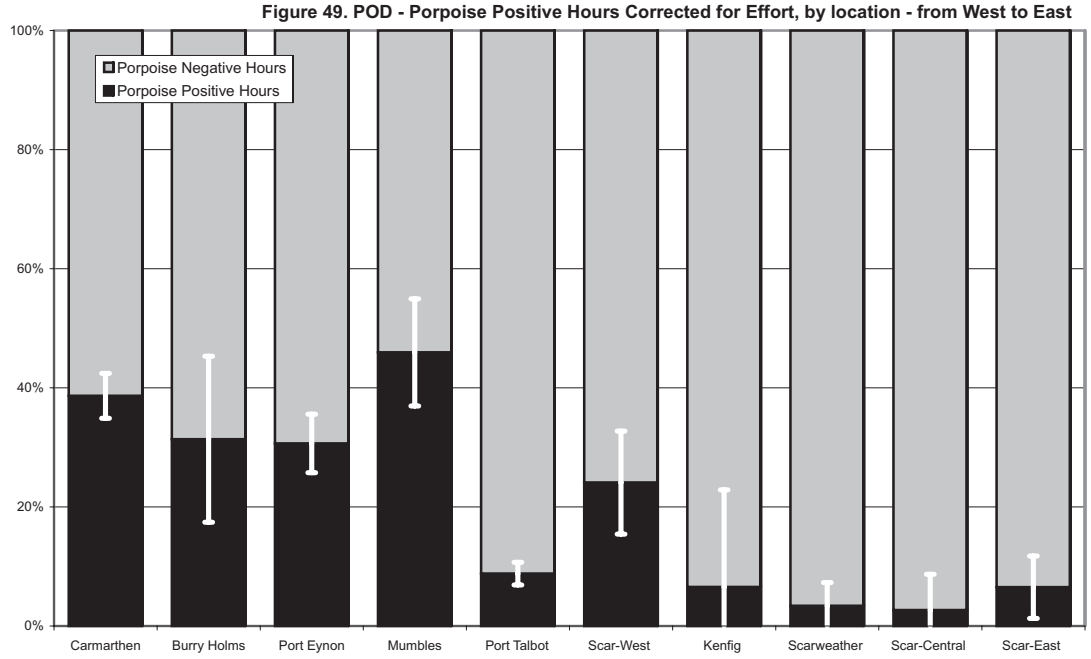
clear concentrations of recordings are visible at an area of complex bottom topography (c. centred at 51.27.50 x 4.25.00) south and west of the Helwick Bank, with an apparent association with LW (figure 50).

Additionally, porpoise were recorded at the mouth of Port Talbot deep harbour at one-of-one shorewatch session, at one constant-effort transect, and as casual sightings (Fig. 36) on two occasions. Further investigation of this site is desirable.

# Seasonality

There is no significant seasonal pattern discernable in the summed POD dataset (Figs.17 & 18) or in the summed shorewatch dataset (Fig.49). A possible summertime decrease in occurrence at Mumbles and its possible correlation with the increase of small boat traffic is currently being investigated.

**Figure 49. POD - Porpoise Positive Hours Corrected for Effort, by location - from West to East**



An apparent decline in activity in November at the two main shorewatch sites (Fig.40) is mirrored by a November increase in POD detected activity in Carmarthen Bay (Table 8, Fig. 18) suggesting the possibility of a seasonal aggregation of animals.

# Influence of tide

Variation in the frequency of POD porpoise-positive minutes with tide state (Fig.19) is statistically significant for the summed data set. This variation is most noticeable at PODs located close to shore e.g. Mumbles (Fig.21), where peaks are apparent at and around high water. First pass statistical analysis shows that the data do not fit Normal, Poisson or equal distributions. PODs located offshore in sandy bays, e.g. Carmarthen (Fig.21), when examined in isolation, show no significant tidal differences. This suggests that these areas are important for transiting or feeding animals at all states of tide. Further analysis is planned, in order that any possible non-linear relationship can be modeled.

Shorewatch data at the two headland sites (Fig.43) are in broad accord with POD data, with a Burry Holms activity peak either side of high water, and a Port Eynon peak on the hours of strongest flow (particulary on the ebb).

# Diel variation

The summed POD dataset shows porpoise activity to be evenly distributed between day and night (Fig.22), with some possible differentiation (eg. 77% of activity during daylight at Scarweather central; 64% of activity during darkness at Burry Holms) remaining to be further investigated.

At the summed dataset, there is no significant variation in porpoise activity at different hours of the day (Fig.25). A pattern of activity-decrease between mid-morning and late afternoon can be seen at some individual sites (Fig.26), including Burry Holms and Port Eynon where recreational boat traffic can be substantial during summer days. Carmarthen Bay, where a military “danger zone” prevents boat passage during most hours, shows least hour-of-day variation.

# Influence of lunar cycle

POD data were examined against lunar cycles, to investigate possible activity correlations with spring-neap cycles. There is considerable variance in recorded activity throughout the lunar month (Fig.24). This does not appear to correlate with the spring-neap cycle. Attempts to analyse by lunar quarter have not been helpful as this classification masks the possible inter-quarter variation.

# Simultaneous detections

There was only one site-specific POD-shorewatch correlation observed, but 8 spatially separated simultaneous POD-shorewatch correlations indicate the presence of at least two “groups” in the study area (Table 14). Two hundred and ninety three shared porpoise positive hours POD-POD correlations suggest a minimum of three, probably more, “groups” within the area.

The encounter- data derived figure of 106 “close encounters” occurring, at different locations, within 10 minutes are particularly noteworthy.

# Encounters

Encounter details were examined to give indications of encounter frequency, duration and inter-encounter intervals at both same- and different-locations. Further analysis and modelling, based on a

suggested porpoise travel speed of 9-17kmh (Au, D. and Perryman, W. (1982) ) of the convergent encounter data is on-going. Encounter data are being used for these analyses as they provide a higher resolution indication of possible group movement/activity patterns than the porpoise positive hour index used in this study.

# Group size

Harbour porpoise social organisation is little understood, and the use of collective nouns has the potential to mislead. In this report, "group" is used loosely, to indicate animals present/visible at the same site at the same time: no social or behavioural affinities are suggested.

At shorewatch, group sizes between 1-11 were recorded (Tables 28-30; Fig. 48). Ninety two per cent of sightings were of groups of five or fewer animals: 50% of observation periods recorded groups of two or three. A single shorewatch that recorded an estimated 11 animals off Port Eynon Head appears atypical. An average group size of 2-3 animals is suggested.

Using 7.5 minutes (ie. one nm at tow speed 8kn) between sightings as a "boundary" definition, constant-effort watches from the Noctiluca recorded 86 porpoise in 48 "groups" during transect survey, giving a mean group size of 1.79 animals.

# Infant/juvenile sightings

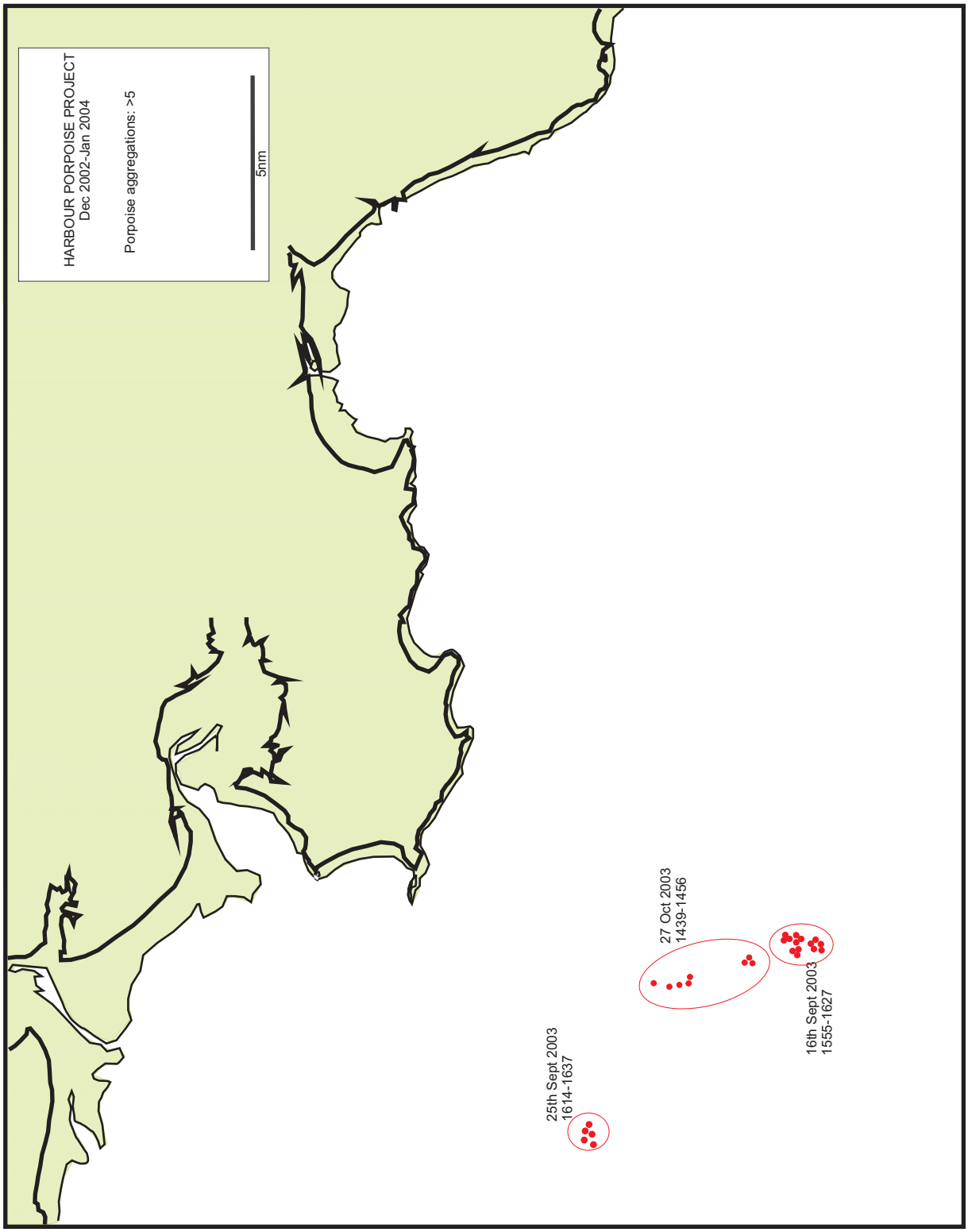
Size difference was used to identify young porpoise. In practice, this requires two animals swimming flank-to-flank, when size difference can be apparent. When, in such circumstances, one of the pair was clearly <c.60% of the length of the second animal, the smaller was presumed to be a calf/juvenile of the year. It should be noted that neonates alongside their mothers can be difficult to see, particularly when animals are distant: the records could understimate the presence of young porpoise in the area.

Twelve young porpoise were noted during shorewatch and boat transects (Table 33). No obvious calving season is apparent, with records from six different months: the September, October, November and January records are notable for a species believed to calve in summer months.

# Other cetacean species

Other than harbour porpoise, the only cetacean species recorded during the project was Common dolphin *Delphinus delphis*. Three adults and two juveniles were recorded in the entrance to Swansea docks, at 19:30, 19th December 2003.

# Figure 50. Schematic of Survey Area Showing Position of Porpoise Hotspots



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GMMP, 1999. an informally distributed newsletter

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# Appendix 1

## Porpoise Acoustics

### From the T-POD help files, Nick Tregenza

Porpoise sonar clicks are around 120 - 150kHz in pitch. This is the quietest part of the marine sound spectrum. A porpoise click about 1m ahead of a porpoise will occupy about 9 cm of water in its direction of travel, and will extend sideways to about the width of a dinner plate. Within it there are about 9 wavefronts (roughly like a stack of dinner plates on its edge). It has a much wider spread of sound of lower intensity, but the intense area only subtends an angle of about 15deg horizontally and 7deg vertically.

Variations in the physical characteristics of water, especially temperature and solutes, affect the speed of sound waves through it. So as a wave propagates it reaches more distant points by more and more diverse paths and interference occurs between waves arriving with different delays along different paths. So the sound reception become more and more uneven - it is like the twinkling of stars. The signal degradation affects both frequency and phase characteristics.

Above porpoise sonar frequencies underwater sound is dominated by thermal noise - pressure waves generated by the random jostling of water molecules. At lower frequencies breaking waves, rain, moving sediments, and biological noises dominate, with ships and other man-made noises being major sources in many places.

There are about 80 species of cetaceans (whales, dolphins and porpoises). 14 species are the baleen whales (Mysticetes) and do not use high frequency sonar (echo-detection) while most of the rest are toothed whales (Odontocetes) and produce sonar clicks at 40kHz or above.

Porpoise clicks are distinctive in being high pitched, narrow band width ( = pure tone ) and low power. Delphinids generally produce shorter higher power clicks.  Short clicks inevitably appear to be spread over a wider band.

### From the IFAW help files, IFAW

A number of researchers have measured harbour porpoise source levels. Møhl (1973) measured peak pressure levels ranging between 132 and 149 dBrms re.1mPa at 1m for captive animal. Akamatsu et al. (1994) give measured source levels for a captive animal which were mostly above 150 dBrms re. 1mPa at 1m, and as high as 178 dBrms re.1mPa at 1m. More recently Goodson and Sturtivant (1996) state that the rms. Source Levels, measured on-axis, for two juvenile porpoises held in a small reverberant enclosure, varied between 140 and 166 dBrms re.1mPa at 1m, but that the mean peak values for each individual were closely matched at 149.5 dBrms re.1mPa at 1m. Source levels from one of the individuals measured by Goodson were re-measured by Au (1999) in open water when the animal had reached maturity, giving a source level averaging 148.2 6.9 dBrms re.1mPa at 1m  with the highest peak source level being 163 dBrms re.1mPa at 1m.

### Further Reading:

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Goodson, A. D. & Sturtivant, C. R. 1996. Sonar characteristics of the harbour porpoise (Phocoena phocoena), source levels and spectrum. ICES Journal of Marine Science 53, 465-472.

Møhl, B. and Anderson, S. 1973. Echolocation: high frequency component in the click of the harbour porpoise (phocoena ph. L.). J. Acoust. Soc. Am. 54: 1368-1372

# Appendix 2

## POD anchoring

POD anchoring methodology evolved throughout the course of this project, in response to evident equipment shortcomings and to a range of problems, real or presumed. At all stages, a compromise was sought between on-deck handling practicality and resistance to environmental and anthropogenic factors.

Initial POD deployment followed the methodology successfully used by Mick Baines at early, west Wales, POD development trials. A 30kg five-link length of heavy chain (ex Trinity House) was used as a ground anchor, with a further five metres of light chain attaching this to a 20mm nylon rope leading to an A4 marker buoy with a smaller pick-up buoy on a 3m tether. Rope length was calculated as maximum water depth (HW spring) + 50%; c0.5kg of lead weight was attached to the rope c5m below the surface buoy, in order to prevent floating slack rope at LW. This arrangement was easily liftable, over the boat stern, by two workers, and held PODs on station through December '02 (with the exception of a 100m drag at Kenfig Patches).

Problems, of our own making, were experienced. Thinking to minimise potential (mechanical) background noise on the POD recorder, it was decided not to use swivels at the ground chain or surface buoy, with the inevitable (with hindsight) result that the cable-laid rope tended to untwist. Ropes were replaced by sheathed nylon: these twisted and balled. Five-eighths swivels were then fitted at the light ground chain end and below the surface buoys, and no noise problems were noted. A second problem was experienced with cable ties (used to secure all shackle pins and the 5m weights used to hold rope off the surface) when the loose ends were trimmed: unless this is done entirely flush, the remaining stub acts as a knife blade, with obvious consequences for any rope coming into contact. Following this realisation, all cable ties were, subsequently, untrimmed; a 5m light chain was fitted between the surface buoy and the mooring rope, to avoid the need to tie weights directly to the rope whilst still avoiding slack rope on the surface.

Following the (temporary, subsequently recovered in N Ireland) loss of the Kenfig POD in Jan/Feb, the witnessing of the lifting and dismantling of the Burry Holms POD and gear in March, and the 1.5nm movement of the Port Talbot POD (with no sign of dragging) in March, all PODs were subsequently re-deployed with much heavier ground tackle as a discouragement to casual lifting. This arrangement precluded hand-hauling, and the boat winch became necessary to lift gear: this proved problematic with the light chain at the surface buoy, and this was removed to give all-rope between the surface and the ground tackle. Subsequent problems were limited to the loss- theft?- of surface buoys and rope, necessitating diver retrieval of PODs: this was addressed by separating ground weights with a 50m length of ground rope, allowing grapple-retrieval should surface gear go missing.

The current anchoring methodology has, at the time of writing, given consecutive trouble free months, during the small boat season:

- a 60kg chain weight is placed, and a 50m 24mm polypropylene rope laid from this across the sea bed to a 30kg chain weight; this ground rope can be grappled should surface gear be lost
- hese ground anchors are connected via 2m of light chain to a 5/8 Blueline swivel
- 18mm Nutech hi-tensile polypropylene rope leads to an A4 surface buoy with a smaller pick-up buoy on a 3m tether, with a second swivel immediately below the surface buoy
- swivels and shackles are replaced at 2 month intervals
- POD is attached to the main rope (knotted twice, to allow shacle/loop to move on c30cm length) by i) a shackle to the POD-lid rope loop, ii) by a second free running loop through the POD lid
- short lengths of light chain (c2kg) are rope-tied at 5m below the surface buoy, to prevent floating slack.

# Appendix 3

Poster to inform boat users (commercial and recreational) about the project

## Have You Seen Our U.F.O?

( Unidentified Floating Object )



The **South Wales Porpoise Project** has placed 5 submarine hydrophones (PODS) in the Bristol Channel to help us understand more about the movements and numbers of Harbour porpoise around our coasts. All the PODS are identified by floats labelled "Scientific Equipment - 01639 710239".

The PODS are passive detectors. They are weighted to the sea bed and record the ultrasound clicks of passing porpoise. The PODS are battery powered and will be serviced monthly during our twelve month study period. They do not affect or disturb sealife.

The PODS are spread in a rough line from Kenfig round to Carmarthen Bay (see map). If you see one, please leave it where it is.

Would you like to help us? We are always interested to hear about any porpoise you encounter whilst at sea. Your observations are of immense value to us.

If we've placed a POD on a patch of water you regularly visit, you could also help us by letting us know if it wanders off (exact GPS co-ordinates of PODS on request).

The South Wales Porpoise Project is a joint effort between the Gower Marine Mammals Project, Local Authorities, CCW and others. To find out more about us or tell us what you've seen, contact Rob Colley on 01639-710239. Alternatively, visit our website: **www.gmmp.org.uk** or email **office@gmmp.org.uk**.

# Appendix 4

## Terms and Conditions of Use

### IFAW Analysis Software (Logger, NMEA Server & Porpoise Monitor)

This software is made available courtesy of the International Fund for Animal Welfare (IFAW). Our mission is to improve the welfare of wild and domestic animals throughout the world by reducing commercial exploitation of animals, protecting wildlife habitats and assisting animals in distress. We seek to motivate the public to prevent cruelty to animals and to promote animal welfare and conservation policies that advance the well-being of both animals and people.

There is no financial payment for researchers to use this software but it is licensed to you on the following terms:

The conduct and objectives of any use of the software and its associated equipment will not conflict with the above-stated aims of IFAW.

If you publish any report or paper based on research which uses this software and/or equipment the report or paper will contain the following acknowledgement or one with a similar effect:
“This research was conducted using software Logger 2000/RainbowClick/[other] developed by the International Fund for Animal Welfare (IFAW) to promote benign and non-invasive research”.

You will send within one month of publication one copy of every such report or paper to IFAW at the following address:
Song of the Whale Research Team, 87-90 Albert Embankment, London SE1 7UD, UK, or by email to

You may not without the prior written approval of IFAW suggest or imply that IFAW supports the work you have undertaken.

This software licence is personal to you and may not be transferred or sub-licensed to any other user. You agree that you will not allow the software to be used by any person who has not registered on this website.

As damages may not be an adequate remedy for IFAW if you fail to comply with these licence terms you accept that IFAW may be entitled to alternative “equitable” remedies including an injunction to stop any use of the software or associated equipment for unapproved purposes.

Except in relation to death or personal injury caused by IFAW’s negligence IFAW accepts no liability for any loss or damage caused by use of this software or of the equipment on which it is intended to run.

### WTIDE, Tide prediction software: www.flaterco.com/pol.html

51° 34.0' N, 3° 58.0' W (Mumbles, Wales, UK)

Harmonic constants derived by harmgen 2.2 2003-11-20 16:33 EST using 131540 observations from 1999-01-01 to 2002-12-31 limit 40 out of 84 constituents, max dropped amp 0.0110, total 0.2217

| | |
|---|---|
| Port: | P932, Site: Mumbles, Wales, Latitude: 51.5667, Longitude: -3.9667 |
| Contributor: | Proudman Oceanographic Laboratory |
| Datum information: | The data refer to Admiralty Chart Datum (ACD) |
| Parameter code: | ASLVBG02 = Sea level, Bubbler tide gauge (second sensor) |

The harmonic constants used to perform tide predictions for locations in the U.K. are derived from sea level data obtained from the British Oceanographic Data Centre (BODC) based at the Proudman Oceanographic Laboratory, Liverpool. The predictions are not the same as those computed by the Proudman Oceanographic Laboratory, which uses its own sets of harmonic constants.

The data were supplied by the British Oceanographic Data Centre as part of the function of the National Tidal & Sea Level Facility, hosted by the Proudman Oceanographic Laboratory and funded by the Department for Environment, Food & Rural Affairs and the Natural Environment Research Council.

# Appendix 5

## T-POD Towing Experiments

T-PODs have been towed successfully by a number of groups - eg. Jefferson, Hung et al (working with Finless porpoises in Hong Kong), Save Our Seas (working with Harbour porpoises in Angelsey).

The generally accepted towing method involves adapting the POD by attaching hydroplanes to it (in order to steer it into a dive), adding a “tail” to give it stability in the water column and attaching a buoyant surfboard to aid towing and to keep the POD near the surface. This arrangement forces the POD to fly through the water at a controlled depth.

Figure 4 (page 16) shows the first towing rig employed in this project. The hydroplanes were made from adapted metal shelf brackets and attached using jubilee clips. The “tail” was made from 1” dowel. To achieve buoyancy a variety of floats and wooden surfboards were tested at a variety of tow distances and speeds. The rig was towed at 25, 50 and 75m behind the survey vessel at a range of speeds from 6 to 12 knots (speed through the water).

This rig had to be abandoned as it failed to tow the POD through the water predictably. Analysis of the click files downloaded from the PODs showed that this rig caused PODs to climb and dive constantly. This caused problems with the internal boards and the batteries and PODs failed to behave predictably or reliably under tow.

Attempts were made to attach the POD to a variety of hydroplaning weights, designed for towing sample nets at defined depths. These attempts also failed to create stable towing conditions.

Finally, a towing rig developed and tested by Nick Tregenza was loaned to the project (see diagram below) and this was used, in conjunction with the IFAW hydrophones to compare and contrast detection performance. It was found that the POD still failed to cope with the perturbations of towing at the survey speeds in use and so all POD towing was abandoned at this point.