Llywodraeth Cynulliad Cymru
Welsh Assembly Government
CORFF NODDEDIG | SPONSORED BODY

Cyngor Cefn Gwlad Cymru
Countryside Council for Wales

ATLAS OF THE MARINE MAMMALS OF WALES
M.E. Baines and P.G.H. Evans
CCW Marine Monitoring Report No. 68

with contributions from:

Cardigan Bay Marine Wildlife Centre
Ceredigion County Council
Countryside Council for Wales
JNCC/European Seabirds at Sea database
E.ON UK
Eurydice
Friends of Cardigan Bay
Gower Marine Mammal Project
Irish Whale & Dolphin Group
Manx Whale & Dolphin Watch
Marine Awareness North Wales
Marine Environmental Monitoring
RWE nPower
Sea Mammal Research Unit/SCANS
University of Swansea
Whale & Dolphin Conservation Society

Recommended citation for this volume: Baines, M.E. and Evans, P.G.H. (2009). *Atlas of the Marine Mammals of Wales.* CCW Monitoring Report No. 68.

Plate 1. TL: Long-finned Pilot Whale (C. Swann); TC: Short-beaked Common Dolphin (P. Anderwald); TR: Fin Whale (P.G.H. Evans); ML: Bottlenose Dolphin (P. Anderwald); MC: Atlantic Grey Seal (P. Anderwald); MR: Harbour Porpoise (M.E. Baines); BL: Risso's Dolphin (P.G.H. Evans); BC: Minke Whale (P.G.H. Evans), BR: Killer Whale (F. Ugarte)

Report series: **Marine Monitoring**

Report number: 68

Publication date: 2009

Lead officer: Mandy McMath

Title: Atlas of the Marine Mammals of Wales

Contractors: Sea Watch Foundation

Authors: Mick E. Baines & Peter G.H. Evans

Series editors: Bill Sanderson & Mandy McMath

Restrictions: None

Distribution list (core):

CCW HQ Library, Bangor
CCW North Region Library, Mold
CCW North Region Library, Bangor
CCW West Region Library, Aberystwyth
CCW South East Region, Cardiff
National Library of Wales
Welsh Assembly Government Library
Joint Nature Conservation Committee Library
Scottish Natural Heritage Library
Natural England Library
British Library

Distribution list (others):

UW Bangor SOS Library
UW Aberystwyth Library
UW Swansea Library
UW Cardiff Library
PML Library, Plymouth
Natural History Museum Library, London
Wildlife Trust S&W Wales Library
North Wales Wildlife Trust Library
National Trust, Pembrokeshire
Pembrokeshire National Park
Louise George, WAG
Peter Evans, Sea Watch Foundation
Giovanne Pesante, Sea Watch Foundation
Mick Baines, Sea Watch Foundation
Pia Anderwald, Sea Watch Foundation
Steve Hartley, CBMWC, New Quay
Mark Simmonds, WDCS
Simon Berrow, IWDG, Ireland
Dave Wall, IWDG, Ireland
Phil Hughes, Friends of Cardigan Bay
Janet Baxter, Friends of Cardigan Bay
Dave Powell
Nia Jones, Marine Awareness North Wales
Cliff Benson, Sea Trust
Lyndon Lomax, Sea Trust
Chris Pierpoint, Eurydice
Rod Penrose, Marine Environmental Monitoring
Rob Colley, Gower Marine Mammal Group
Ivor Rees
Nick Tregenza, Chelonia Limited
John Goold, JNCC
John Galpin, Manx Whale & Dolphin Watch
Eleanor Stone, Manx Whale & Dolphin Watch
Eleri Owen, E.ON UK renewables
Carol Cooper, RWE nPower Renewables
Sue Gubbay, CCW
Catherine Duigan, CCW
Keith Davies, CCW
Bill Sanderson, CCW
Andrew Hill, CCW
Mandy McMath, CCW
Aethne Cooke, CCW
Charlie Lindenbaum, CCW
Tom Stringell, CCW
Mike Camplin, CCW
Jenny Higgins, CCW
Ziggy Otto, CCW

Rebecca Wright, CCW
David Parker, CCW
John Taylor, CCW
Roger Thomas, CCW
Lucy Kay, CCW
Kate Smith, CCW
Neil Smith, CCW
Eunice Pinn, JNCC
Sonia Mendes, JNCC
Tim Dunn, JNCC
Gary Burrows, NIEA
Victoria Copley, NE
David Lyons, NPWS, Ireland
Phil Hammond, Sea Mammal Research Unit
Simon Northridge, Sea Mammal Research Unit
Callan Duck, Sea Mammal Research Unit
Len Thomas, CREEM, St Andrews
Emer Rogan, University College Cork
Fiona Gell, Isle of Man Government
Mick Green, Ecology Matters, Ceredigion
Alan Gray, Shearwater Cruises
Jon Shaw, Marine Services
Devon Wildlife Trust
Cardigan Bay SAC Officer
Pen Llyn a'r Sarnau SAC Officer
Pembrokeshire Marine SAC Officer
Carmarthen Bay SAC Officer
Paul Turkentine, Waterline
James Gray, Defra
Jo Myers, Defra
Andy Robinson, Royal Navy, Portsmouth
Dave Hartley, UKHO, Southampton
David Hedgeland, IAGC, London
John Hartley, Hartley Anderson
European Topic Centre, Paris
ASCOBANS/UNEP Secretariat, Bonn

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Rhagair

Foreword

Crynodeb gweithredol

Mae un deg chwech grŵp / prosiect arolygu wedi cyfrannu at gronfa ddata prosiect sy'n sail i'r Atlas Cymreig hwn o Famaliaid Morol. Mae 37,266 o oriau o ymdrech yn cael eu dadansoddi, a wnaed dros gyfnod o 18 mlynedd rhwng 1990 a 2007. O ran gofod, roedd yn ymdrin â 376 o'r 414 o gelloedd yn y rhanbarth yr ymchwilir iddo (Môr Iwerddon, Sianel San Siôr a'r rhan fwyaf o Fôr Hafren). Ar hyn o bryd mae cronfa ddata prosiect yn cynnwys 22,422 o droeon y gwelwyd mamaliaid a 77,799 o unigolion o 12 rhywogaeth forfilaidd. Hefyd adolygwyd cronfa ddata tiriadau Cymru, a reolir gan Marine Environmental Monitoring: ar ddyddiad y dadansoddiad, roedd yn hon gofnodion 1,724 o unigolion o 15 rhywogaeth forfilaidd. Cafwyd data am forloi llwyd oddi wrth CCGC, heblaw 2,586 o droeon y'u gwelwyd ar y môr (oedd yn cynnwys 3,424 o unigolion) yng nghronfa ddata prosiect.

Defnyddiwyd grid gyda chydraniad o 10' lledred a 10' hydred, a rhannwyd yr ymdrech i segmentau y gellid eu neilltuo i gell benodol ar y grid. Roedd yr ymdrech a'r troeon y gwelwyd mamaliaid yn ffurfio dau dabl ar wahân, ac yna cafodd y rhain eu cysylltu â thrydydd tabl ac ynddo ddata am leoliad ac ardal môr pob cell. Cyfrifwyd cyfraddau troeon y gwelwyd mamaliaid (a fynegwyd yn nhermau'r nifer pob awr) ar gyfer y rhywogaethau hynny (dolffiniaid trwyn potel, cyffredin a Risso) lle mae grwpiau fel arfer yn cynnwys mwy nag 1-2 unigolyn, a chyfraddau cyfrif (nifer yr unigolion pob awr) ar gyfer llamhidyddion a morfilod pigfain. Gwnaethpwyd ymchwiliadau ar gyfer tuedd bosibl o ran pa mor hawdd oedd gweld mamaliaid oherwydd ffactorau amgylcheddol megis cyflwr y môr, yn ogystal â'r math o arolwg/platfform a'i gyflymder, gan ddefnyddio data a gasglwyd trwy wahanol weithgareddau yn yr un ardal dros yr un cyfnod o amser. Daethpwyd i'r casgliad na ellid cymhwyso ffactorau cywiro yn realistig ond ar gyfer cyflwr y môr (a gwnaethpwyd hynny fesul rhywogaeth), gwylio o'r tir gan ddefnyddio samplu sgan, ac ar gyfer arolygon o'r awyr o'u cymharu ag arolygon o gychod neu longau. Yna cafodd y canlyniadau terfynol eu plotio ar fapiau gan ddefnyddio system gwybodaeth ddaearyddol Arc View. Cynhyrchwyd 1,523 o fapiau i gyd, ac fe'u ceir mewn Atodiad electronig.

Mae deunaw rhywogaeth forfilaidd wedi cael eu cofnodi yn nyfroedd Cymru ers 1990. Mae pum rhywogaeth (y llamhidydd, y dolffin trwyn potel, y dolffin cyffredin pig fer, dolffin Risso a'r morfil pigfain) yn gymharol gyffredin ac mae eu dosbarthiadau'n cael eu mapio yma, gan gynnwys amrywiadau yn dymhorol a thros y tymor hir. Mae'r rhywogaethau prin yn cynnwys y morfil asgellog llwyd, y lleiddiad a'r morfil pengrwn, ac ymwelwyr achlysurol â'r rhanbarth: y morfil cefngrwm, morfil asgellog sei, y morfil sberm lleiaf, y morfil trwyn potel, morfilod gylfinog Cuvier, Sowerby a Blainville, y dolffin rhesog, y dolffin ystlyswyn a'r dolffin pigwyn. Ceir mapiau o'r rhywogaethau hynny yn yr Atodiad.

Y llamhidydd yw'r rhywogaeth fwyaf cyffredin a'r un a geir dros yr ardal ehangaf yn nyfroedd Cymru. Mae yma drwy gydol y flwyddyn, er mae'n debyg ei fod heb ei gofnodi digon yn y gaeaf. Nid yw'r rhywogaeth yn wastad ei dosbarthiad ym Môr Iwerddon. Gellir nodi mannau da o gwmpas Ynys Môn a ger arfordir Sir Benfro, ac i raddau llai ger arfordir deheuol Pen Llŷn, yn rhan ddeheuol Bae Ceredigion, ac ym Môr Hafren ger arfordir deheuol Cymru (o gwmpas Penrhyn Gŵyr ac ym Mae Casnewydd). Mae'r ardaloedd hyn â dwysedd cymharol uchel yn aros yr un peth gan fwyaf dros gyfnodau o amser. Ceir lloi llamhidyddion drwy'r rhanbarth i gyd. Barnwyd bod nodi ardaloedd â chyfran uwch o anifeiliaid ifanc yn annibynadwy, oherwydd nad oedd pob arsyllwr wedi cofnodi presenoldeb anifeiliaid ifanc yn systematig. Dyma'r rhywogaeth sy'n tirio amlaf, a'r achos marwolaeth yn bennaf yw ymosodiadau gan ddolffiniaid trwyn potel.

Y dolffin trwyn potel yw'r rhywogaeth a gofnodir amlaf ar ôl y llamhidydd. Arfordirol yw ei ddosbarthiad yn bennaf, er bod dwyseddau isel wedi cael eu cofnodi ar y môr, yn arbennig yn Sianel San Siôr a rhan dde-orllewinol ardal yr astudiaeth. Yn rhan ddeheuol Bae Ceredigion ac ymhellach i'r gogledd ym Mae Tremadog yr oedd y nifer fwyaf o droeon y'u gwelwyd, er bod y rhywogaeth hefyd i'w chael ger arfordir gogleddol Cymru, yn arbennig i'r gogledd a'r dwyrain o Ynys Môn. Nodir gwahaniaethau tymhorol ym maint a gwasgariad grwpiau, gyda dolffiniaid yn yr haf i'w cael yn bennaf mewn grwpiau bach ger yr arfordir, a'u canolbwynt gan fwyaf ym Mae Ceredigion, gan wasgaru'n helaethach ac yn gyffredinol i'r gogledd, lle gallant ffurfio grwpiau mawr iawn yn y gaeaf. Fodd bynnag, gellir gweld y rhywogaeth ar unrhyw adeg o'r flwyddyn ar hyd a lled dyfroedd arfordirol Cymru. Ni welwyd unrhyw newid sylfaenol i'w dosbarthiad ers 1990. Mae dolffiniaid trwyn potel yn bridio ar hyd a lled eu dosbarthiad ger Cymru, a gwelir lloi yn y rhan fwyaf o fisoedd y flwyddyn. Dim ond nifer fach sydd wedi cael eu cofnodi'n tirio.

Mae dosbarthiad y dolffin cyffredin pig fer gan fwyaf ar y môr, a'i ganolbwynt yn y Dyfnder Celtaidd ar ben deheuol Môr Iwerddon, lle mae dyfnder y dŵr yn amrywio o 50 i 150 o fetrau. Mae'r ardal hon â dwyseddau uchel yn ymestyn i'r dwyrain tuag arfordir ac ynysoedd gorllewin Sir Benfro. Mewn mannau eraill ym Môr Iwerddon, ceir y rhywogaeth ar ddwyseddau isel, ar y môr yn bennaf, mewn band canolog sy'n ymestyn i'r gogledd tuag Ynys Manaw. Cafwyd patrymau dosbarthiad tebyg dros y pedwar cyfnod o amser a archwiliwyd. Ymwelydd haf yw'r dolffin hwn gan fwyaf, er ei fod yn aros yn y Dyfnder Celtaidd hyd fis Tachwedd o leiaf. Gall grwpiau o anifeiliaid ifanc heidio i mewn yn hwyr yn yr haf. Mae'r rhan fwyaf o'r tiriadau'n digwydd ar hyd glannau de-orllewin Cymru.

Mae dosbarthiad dolffiniaid Risso yn gymharol leol, gan ffurfio band llydan sy'n rhedeg o'r de-orllewin i'r gogledd-ddwyrain ac sy'n cwmpasu gorllewin Sir Benfro, pen gorllewinol Pen Llŷn ac Ynys Môn yng Nghymru, arfordir de-ddwyreiniol Iwerddon yn y gorllewin, a dyfroedd o gwmpas Ynys Manaw yn y gogledd. Ymddengys fod y dosbarthiad cyffredinol hwn wedi parhau dros y tymor hir, er y gall y nifer sy'n ymweld â glannau Cymru amrywio'n fawr iawn rhwng blynyddoedd. Yn yr haf a'r hydref mae'n ymweld yn bennaf, a cheir y cyfraddau uchaf o droeon y'i gwelwyd yn y cyfnod o fis Gorffennaf i fis Medi. Mae dolffiniaid Risso yn bridio yn y rhanbarth, a gwelwyd anifeiliaid ifanc lle bynnag y gwelwyd grwpiau. Ychydig o diriadau a gafwyd, yn bennaf ar draws gorllewin Cymru.

Mae dosbarthiad y morfil pigfain ar y môr gan fwyaf, gyda dwyseddau uchaf y troeon y'i gwelwyd yn ardal y Dyfnder Celtaidd, er y'i ceir hefyd mewn mannau dyfnach (fel arfer >50 m) i'r gogledd tuag Ynys Manaw. Gwelir y patrwm dosbarthiad hwn ar draws y cyfnodau o amser a archwiliwyd. Ymddengys mai yn yr haf yn bennaf mae'r rhywogaeth yn ymweld â'r rhanbarth, ac ychydig o droeon yn unig y'i gwelwyd yn y gaeaf, er gallai hyn fod yn rhannol oherwydd mai ychydig o ymdrech a wnaed yn y cyfnod hwnnw. Nid oes unrhyw dystiolaeth eto bod y rhywogaeth yn bridio yn nyfroedd Cymru.

O gwmpas y Dyfnder Celtaidd y mae amrywiaeth rhywogaethau morfilaidd ar ei mwyaf. Yr ardaloedd o gwmpas arfordir Cymru â’r amrywiaeth fwyaf o rywogaethau yw gorllewin Sir Benfro, pen gorllewinol Pen Llŷn, ac i’r gorllewin o Ynys Môn – y mannau sydd agosaf i ddyfroedd dyfnach a dylanwad posibl y ddwy brif system ffryntiau ym Môr Iwerddon, ffryntiau’r Môr Celtaidd a Môr Iwerddon.

Y morlo llwyd yw’r unig rywogaeth adeindroed (pinnipedia) sy’n bridio yng Nghymru. Mae ei ddosbarthiad yn eang, ac mae’n bridio mewn ogofau ac ar gildraethau bach ar ynysodd yn y môr a rhannau llai poblog o lannau’r tir mawr. Genir y nifer fwyaf o loi bach yng ngogledd-orllewin Sir Benfro, yn arbennig ar Ynys Dewi, ond yn ymestyn i’r de tuag Ynys Sgomer ac i’r gogledd i ran ddeheuol Ceredigion. Ceir crynoadau llai o gwmpas Pen Llŷn a glannau Ynys Môn. Defnyddir yr un mannau fel lleoedd i ddod allan o’r dŵr ar adegau ar wahân i’r tymor bridio. Mae astudiaethau telemetreg yn awgrymu ei bod yn bosibl bod morloi’n teithio i chwilio am fwyd i fannau lleol iawn, gyda'r anifeiliaid o fan penodol yn tueddu i aros yn yr ardal honno. Mae’r troeon y’u gwelwyd ar y môr yn awgrymu bod nifer helaeth i’w cael oddi ar arfordir Gogledd Cymru, a dengys hyn yng ngwybodaeth yr astudiaethau telemetreg hefyd. Fodd bynnag, gan nad yw’r wybodaeth yn gyson, oherwydd nad yw’r arsyllwyr yn cofnodi morloi’n systematig, nid oes modd dod i gasgliadau pendant ar gyfer yr holl ardal.

Er bod mwy na 90% o’r celloedd yn ardal yr astudiaeth wedi bod yn destun rhywfaint o ymdrech arolygu, mae’r ymdriniaeth yn annigonol o hyd ym mhob un ond ychydig o ardaloedd bach. Yn 38% o’r celloedd, bu llai na phedair awr o ymdrech. Bu’r ymdrech mwyaf yn yr ardaloedd arfordirol, yn bennaf yn rhan ddeheuol Bae Ceredigion o Gei Newydd i Benmaendewi, ac o gwmpas Ynys Enlli. Hefyd bu tuedd dymhorol i ddosbarthiad yr ymdrech, gydag 85% o’r holl ymdrech yn y chwe mis o fis Ebrill i fis Medi. Byddai’n fuddiol cael mwy o ymdrech arolygu yn yr holl ardaloedd, ond mae yna fylchau penodol ym Mae Caernarfon, de Sir Benfro, ac arfordir Gwent yn ne-ddwyrain Cymru, yn ogystal â nifer o ardaloedd ar y môr.

Er bod y mwyafrif o’r grwpiau bellach yn casglu data mewn fformat safonol tebyg, mae’n dal i fod yn anodd cyfuno setiau data o safleoedd ar y tir, arolygon o longau neu gychod ar y môr, ac arolygon o’r awyr. Nid yw’n hawdd integreiddio platfformau sy’n digwydd cynnig cyfle wrth deithio ar hyd bandiau cul ar y môr neu sydd wedi’u cyfeirio at ddod o hyd i grynoadau o famaliaid morol, gydag arolygon sy’n gweithio ar draws ardaloedd ehangach yn fwy systematig. Lle bynnag y bo modd, dylid amcangyfrif y pellter rhwng y mamal neu’r mamaliaid a welir a’r platfform, er mwyn galluogi rhywun i ffitio ffwythiannau canfod, ac felly deillio amcangyfrifon dwysedd absoliwt, ond wedyn dylai’r arsyllwyr gael yr hyfforddiant priodol ar amcangyfrif pellter yn gywir.

Executive Summary

Sixteen groups / survey projects have contributed to the project database that forms the basis for this Atlas of the Marine Mammals of Wales. A total of 37,266 hours of effort are analysed, spanning the 18-year period 1990-2007. Spatial coverage amounted to 376 of the 414 cells that encompass the region under investigation (the Irish Sea, St George's Channel and greater part of the Bristol Channel). The project database currently comprises 22,422 sightings and 77,799 individual cetaceans of 12 species. In addition, the Welsh stranding database, managed by Marine Environmental Monitoring, was reviewed: at the date of the analysis, this contained records of 1,724 individual cetaceans of 15 species. Grey seal data were sourced from CCW, besides 2,586 at-sea sightings (comprising 3,424 individuals) in the project database.

A grid with resolution of 10' latitude and 10' longitude was used, and effort partitioned into segments that could be assigned to a particular grid cell. Effort and sightings formed two separate tables, and these were then linked to a third table holding data on position and sea area of each cell. Sightings rates (expressed in terms of numbers per hour) were calculated for those species (bottlenose, common and Risso's dolphin) where group sizes commonly exceed 1-2 individuals, and count rates (numbers of individuals per hour) for harbour porpoise and minke whale. Examinations were made for potential bias in sightability due to environmental factors such as sea state, as well as survey/platform type and speed, using data gathered by different activities in the same area over the same time period. It was concluded that correction factors could only realistically be applied for sea state (and this was done on a species by species basis), land based watches using scan sampling, and for aerial vs vessel surveys. The final results were then plotted onto maps using Arc View GIS. A total of 1,523 maps were produced, and these are contained in an electronic Appendix.

Eighteen species of cetacean have been recorded in Welsh waters since 1990. Five species (harbour porpoise, bottlenose dolphin, short-beaked common dolphin, Risso's dolphin and minke whale) are relatively common and their distributions are mapped here, including variations both seasonally and over the long term. Rare species include fin whale, killer whale, and long-finned pilot whale, and as casual visitors to the region: humpback whale, sei whale, pygmy sperm whale, northern bottlenose whale, Cuvier's, Sowerby's and Blainville's beaked whales, striped dolphin, Atlantic white-sided dolphin, and white-beaked dolphin. Maps of those species are contained in the Appendix.

The harbour porpoise is the commonest and most widespread species in Welsh waters. It is present year round, although probably under-recorded in winter. The species is not evenly distributed within the Irish Sea. Hot spots can be identified around Anglesey and off the Pembrokeshire coast, and to a lesser extent off the south coast of the Lleyn Peninsula, in southern Cardigan Bay, and in the Bristol Channel off the south coast of Wales (around the Gower Peninsula and in Newport Bay). These areas of relative high density largely persist across time periods. Porpoise calves occur throughout the region. Identifying areas with higher proportions of juveniles was considered unreliable, due to the fact that the presence of

young animals had not been recorded systematically by all observers. The species is the commonest to strand, with cause of death primarily bottlenose dolphin attack.

The bottlenose dolphin is the next most frequently recorded species, with a predominantly coastal distribution, although low densities have been recorded offshore, particularly in St George's Channel and the southwest sector of the study area. The main concentrations of sightings were southern Cardigan Bay and further north in Tremadog Bay although the species also occurs off the north coast of Wales, particularly north and east of Anglesey. Seasonal differences in group size and dispersion are noted, with dolphins in summer occurring mainly in small groups near the coast, centred upon Cardigan Bay, dispersing more widely and generally northwards, where they may form very large groups in winter. However, the species can be seen at any time of the year throughout Welsh coastal waters. No fundamental change in distribution has been observed since 1990. Bottlenose dolphins breed throughout their Welsh range, with calves observed in most months of the year. Only small numbers have been recorded stranding.

The short-beaked common dolphin has a largely offshore distribution centred upon the Celtic Deep at the southern end of the Irish Sea, where water depths range from 50-150 metres. This high-density area extends eastwards towards the coast and islands of west Pembrokeshire. Elsewhere in the Irish Sea, the species occurs at low densities mainly offshore, in a central band that extends northwards towards the Isle of Man. Similar patterns of distribution have occurred across the four time periods examined. It is mainly a summer visitor although persisting in the Celtic Deep at least to November. An influx of juvenile groups may occur in late summer. Most stranding take place along the coasts of Southwest Wales.

Risso's dolphins have a relatively localised distribution, forming a wide band running SW-NE that encompasses west Pembrokeshire, the western end of the Lleyn Peninsula and Anglesey in Wales, the south-east coast of Ireland in the west, and waters around the Isle of Man in the north. This general distribution appears to have persisted over the long-term although numbers visiting the coasts of Wales can vary a great deal between years. The species is mainly a summer and autumn visitor, with the highest sightings rates in the period July to September. Risso's dolphins breed in the region, and young have been observed wherever groups have been sighted. There have been only a few stranding, mainly across west Wales.

The minke whale has a largely offshore distribution, with highest densities of sightings occurring in the area of the Celtic Deep, although the species is found also in deeper areas (generally >50 m) northwards towards the Isle of Man. This distribution pattern is observed across the time periods under examination. The species appears to be a mainly summer visitor to the region, with few sightings in winter, although this may partly be due to low effort at that period. There is no evidence as yet that the species breeds in Welsh waters.

Cetacean species diversity is highest around the Celtic Deep. The areas of coastal Wales with highest species diversity are west Pembrokeshire, the western end of the Lleyn Peninsula, and west of Anglesey – the regions that are closest to deeper waters and the possible influence of the two major frontal systems in the Irish Sea, the Celtic Sea and Irish Sea Fronts.

The grey seal is the only pinniped species breeding in Wales. It is widely distributed, breeding in caves and small coves on offshore islands and less populated parts of the mainland coast. Pup production is greatest in Northwest Pembrokeshire, particularly on Ramsey Island, but extending southwards to Skomer Island and northwards to southern Ceredigion. Smaller concentrations occur around the Lleyn Peninsula and the coast of Anglesey. These same areas are used as haul-out sites during the non-breeding season. Telemetry studies indicate that seals may make foraging trips to very localised areas, with animals from a particular locality tending to remain in that region. Sightings at sea indicate an area of high usage off the North Wales coast that is also shown in the telemetry data, but as there is not even coverage, due to many observers not recording seal sightings systematically, conclusions cannot be drawn across the whole area.

Although more than 90% of cells in the study area have received some survey effort, coverage remains inadequate in all but a few small areas. In 38% of cells, there has been less than four hours of effort. Effort has been highest in coastal areas, mainly in southern Cardigan Bay from New Quay to St David's Head, and around Bardsey Island. There has also been a temporal bias to the distribution of effort, with 85% of all effort in the six months, April to September. All areas would benefit from greater survey effort, but particular gaps occur in Caernarfon Bay, south Pembrokeshire, and the coast of Gwent in South-east Wales, as well as several offshore areas.

Although the majority of groups are now collecting data in a similar, standardised format, it remains difficult to merge data sets from land based sites, offshore vessel surveys and aerial surveys. Platforms of opportunity that ply narrow bands of sea or are directed to finding concentrations of marine mammals are not easily integrated with surveys covering wider areas more systematically. Wherever possible, the distance of a sighting to the platform should be estimated to enable one to fit detection functions, and hence derive absolute density estimates, but observers should then receive the appropriate training for accurate distance estimation.

1. INTRODUCTION

There is a requirement for information on marine mammal distribution and abundance in Welsh waters to support environmental stewardship and help to determine appropriate mitigation measures in order to avoid or minimise impacts for future sustainable management. CCW is committed to working with BERR, developers and others to ensure that impacts upon features of nature conservation interest are avoided, and that development proceeds in an environmentally sustainable way.

The collation of this information is essential to meet our obligations under the EU Habitats and Species Directive: to advise on potential oil and gas exploitation and other marine activities including fisheries and renewable energy exploitation; and to undertake surveillance of the Favourable Conservation Status (FCS) of marine mammals in order to report on natural range, population size and habitat area.

Amendments to the Conservation (Natural Habitats &c.) Regulations 1994 and the new Offshore Marine Regulations (Natural Habitats, &c.) Regulations 2007 have a revised definition of disturbance and the Offshore Marine Regulations extend the offence to areas of UK jurisdiction beyond 12 nm. It is now an offence under both Directives to deliberately disturb wild animals of a European Protected Species (this includes all cetaceans) in such a way as to be likely significantly to affect: a) the ability of any significant group of animals of that species to survive, breed, rear or nurture their young; or b) the local distribution or abundance of that species. A consequence of this is that guidance is being developed by JNCC and the other UK nature conservation agencies, for those carrying out activities in the marine environment that is species-specific and includes best-practice guidelines. Interim guidance can be found on the JNCC website: http://www.jncc.gov.uk/page-4145

A recent collaborative exercise to produce an Atlas of Cetacean Distribution in North-west European Waters (Reid *et al*., 2003) has also resulted in a standard for managing cetacean data, currently termed the Joint Cetacean Protocol. That Atlas is a summary of the 28 species of cetacean that have been recorded in north-west European waters from the latter half of the 20th century. The data sources used to compile a Joint Cetacean Database (JCD) and the annual distribution maps were the European Seabirds at Sea (ESAS) database, the Sea Watch Foundation database, and the SCANS (I) Survey database. The maps in that Atlas depict data at a resolution of one-quarter International Council for the Exploration of the Sea (ICES) rectangles (15' latitude x 30' longitude – somewhat less than 1000 square kilometres (at this latitude). This resolution is very useful for making general statements about relative animal densities at a regional level. However, higher resolution data are required at a local level for cetaceans living in Welsh seas in order to meet both the amendments to the Habitats Regulations and FCS reporting.

Data on marine mammal occurrence in Wales and the southern Irish Sea, have been collected by a wide range of organisations, each of which may have used different survey methods and protocols for the recording of data in the field, reflecting their various interests, expertise and resources. The aim of this project is to collate as much as possible of these data, compiling a single unified database from which maps of marine mammal distribution at a resolution of 10' latitude x 10' longitude can be produced.

1.1 Objectives and scope

The principal objective is to describe the temporal and spatial distribution and relative abundance of all marine mammal species sighted, detected or stranded in Welsh waters but concentrating on species regularly sighted. Marine mammal distribution and abundance are determined based on occurrence data, and include sighting effort.

This report (including maps), the accompanying database and Geographic Information System (GIS) data layers will provide the most-up-to date and relevant information on distribution, abundance, and seasonality of marine mammals found in Welsh Seas. As the most common and widely distributed species, the harbour porpoise analysis will be treated as a priority.

An Inter-Agency initiative exists to develop a Joint Cetacean Protocol (JCP) with all holders of cetacean sightings and effort data in the UK and Ireland, and a project was set-up to analyse a sub-set of the JCP data for the Irish Sea to determine what questions the data could address and whether the quality and applicability of future datasets can be improved (Thomas, 2009). This project aims to meet the likely data structures and standards of the Joint Cetacean Protocol. The JCP will identify a requirement for a set of tools to improve, collate and analyse cetacean datasets, and for work to be undertaken to demonstrate whether such data can be used to produce indices of range and abundance for both SAC management and Habitats Directive reporting, and ultimately to support habitat modelling and sensitivity mapping.

METHODS

2.1 Spatial and temporal extent of the study area

The study area consists primarily of Welsh territorial seas out to the median line with Ireland and the Isle of Man, and English territorial seas. However, for practical purposes the study area extends beyond these limits and is bound by the extents listed in Table 1. Figure 1 shows the study area overlaid with a grid of 10’ x 10’ cells, together with the 12 nm territorial limit, the international median line, and the 100 m depth contour. The temporal extent of the data used in this Atlas is from 1990 to 2007, although some data from 2008 have been included where these augmented coverage in areas that previously had low levels of effort – primarily off the coast of North Wales.

Table 1 – Limits of the study area

Northerly limit	54.5º N
Southerly limit	51 º N
Easterly limit	2.25 º W
Westerly limit	7 º W

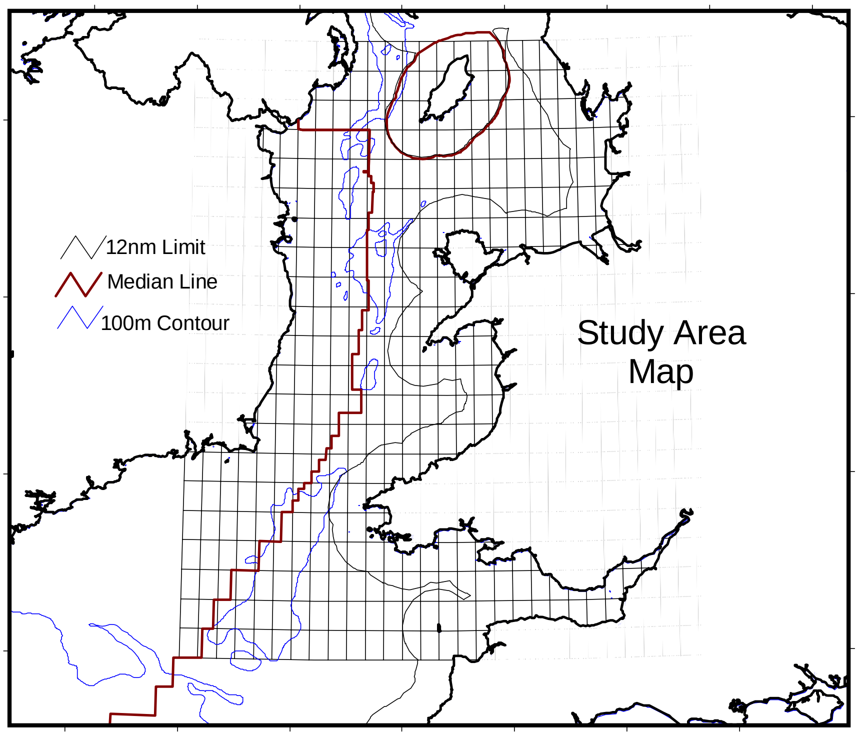


Figure 1 – The study area, showing the 12 nm territorial limit, the international median line, and the 100 m depth contour

2.2 Sources of data

The minimum requirements for sightings data contributed to the project were that they should include associated effort data, including data for effort periods when no sightings were made, and that the effort data should include records of sea state. Data meeting these basic requirements were incorporated from the organisations or projects in Table 2, listed in descending order of the volume of data contributed.

Table 2 – Organisations and projects contributing sightings data

Organisation / Project	Principal Contact
Sea Watch Foundation database	Mick Baines
Ceredigion County Council	Liz Allan
Whale and Dolphin Conservation Society	Mark Simmonds
European Seabirds at Sea	Andy Webb, JNCC
Cardigan Bay Marine Wildlife Centre	Steve Hartley
Eurydice	Chris Pierpoint
Friends of Cardigan Bay	Phil Hughes
RWE nPower windfarm surveys	Carol Cooper
Gower Marine Mammal Group	Rob Colley
Irish Whale and Dolphin Group	Dave Wall
E-ON UK Scarweather Sands surveys	Eleri Owen
Marine Awareness North Wales	Nia Haf Jones
Swansea University aerial surveys	John Houghton
Manx Whale & Dolphin Watch	John Galpin
SCANS I & II	Phil Hammond, SMRU

In addition to the sightings data, cetacean stranding data were contributed by Marine Environmental Monitoring (Rod Penrose). Grey seal data were sourced from the West Wales Grey Seal Census (Baines *et al*., 1995) and, for North Wales, from Westcott and Stringell (2003, 2004).

Table 3. Coverage by Contributors

Organisation / Project	Effort hours	Years	Cells
Sea Watch Foundation database*	23,176	18	335
Ceredigion County Council	8,108	13	3
Whale and Dolphin Conservation Society	2,609	9	26
European Seabirds at Sea	1,544	12	336
Cardigan Bay Marine Wildlife Centre	1,054	3	18
RWE nPower windfarm surveys	272	2	11
Irish Whale and Dolphin Group	210	7	50
E.ON UK Scarweather Sands surveys	124	3	7
Marine Awareness North Wales	85	5	4
Swansea University aerial surveys	32	2	145
Rhyl Flats mitigation monitoring (RWE nPower)	26	1	2
SCANS I & II	13	2	168

*Note that the Sea Watch Foundation database includes data from the following contributors: Eurydice, Friends of Cardigan Bay, Gower Marine Mammal Project and Manx Whale and Dolphin Watch

2.3 Data processing

A project database was constructed for the project, using Microsoft Access 2000, in which all the contributed data were compiled in a common format. A grid was defined for the study area with a resolution of 10’ latitude and 10’ longitude (Figure 1). Effort data from moving platforms were partitioned by dividing records into segments that could each be assigned to a grid cell. Two main data tables were set up for effort and sightings respectively, each record being associated with a grid cell. These tables were then linked to a third table holding data on the position and sea area of each grid cell. A series of queries was then set up to extract data, from which sightings rates could be calculated. The database was linked to an ArcView GIS project from which the maps were output.

Maps were projected using a customised Transverse Mercator projection centred on the study area, using the same parameters as the projection devised for the HABMAP project (Robinson *et al*., 2007).

For the three most common dolphin species in the study area (bottlenose, short-beaked common and Risso's dolphins), the units used for plotting sightings rates were sightings per hour. The assumption was therefore made that there is no spatial variation in group size. However, in the case of bottlenose dolphins there was evidence to suggest that there may be some spatially correlated variation in group size, so some maps for this species were repeated using rates based on individuals counted per hour, in addition to maps based on sightings rates. All maps of harbour porpoise and minke whale distribution use counts per hour rather than sightings per hour. In the case of harbour porpoises, this was because at some coastal locations surveyors have used a scan sampling method to count animals, in which single sightings records contain the sum total of all porpoises in view at one time. Thus a single scan sample record may include more than one group of animals. Note, therefore, that the scale used on the harbour porpoise and minke whale maps differ from that for other species. The method used to convert scan sampling data into a form compatible with other datasets is described in section 2.4.3.

2.4 Sources of bias

It was assumed that the data contributed were reliable with respect to species identification and had been checked for errors in date, time and position fields. However, a large number of factors can potentially influence sightings rates and the data were therefore investigated to assess the feasibility of devising correction factors. Factors affecting sightings rates can be grouped into three main categories, as follows.

1) *Factors affecting sightability*

E.g.: Sea state, swell height, precipitation, daylight, and glare.

2) *Survey characteristics*

E.g.: Platform height, field of view, speed, stability and comfort, observer experience, dedication & distraction; number of observers, length of watch and fatigue; use and quality of optical equipment, observation technique; bias towards observation at high density areas or times; and survey design.

3) *Ecological factors*

E.g.: Oceanographic or habitat features such as depth, seabed type and topography, distance from the coast or estuaries, current strength, sea water temperatures; temporal factors such as state of tide, time of day, season and year; prey and predator relationships, especially the abundance and distribution of prey species, but perhaps also predatory interactions between marine mammal species; and anthropogenic disturbance.

In addition, we should bear in mind that sightability varies between species, and with the behaviour of the animals at the time of the survey.

We wished to reveal in the data a realistic depiction of the distribution and, ideally, the relative abundance, of marine mammals under the influence of the various natural factors that shape their ecology, by controlling, as far as possible the environmental factors that affect sightability and survey characteristics that affect sightings rates. Unfortunately, many of these factors are partially or wholly confounded. For example, in any given data set the observers may have changed from one year to the next, thereby confounding observer characteristics with annual effects. The availability of survey vessels and survey methods such as the use of binoculars may also have changed at various times, potentially confounding these with seasonal or annual effects. The data contributed to this study were extremely heterogeneous, having been collected by a very large number of observers from many different platforms using a wide variety of survey and recording protocols. Realistically, it was only possible to examine the potential influence of two factors on sightings rates – sea state and broad categories of survey type.

Two approaches used to correct for the bias introduced by sea state or survey type were considered. Sightings rates can be modelled as a function of variables using generalized additive modelling (GAM) (Bravington *et al*., 2001); or by ratios of mean sightings rates, e.g. at a range of sea states, to the mean sightings rate at sea state 0 (Evans and Wang, 2005).

A generalised additive model (GAM) was fitted to the data, using sea state, survey type, year, month, latitude and longitude as variables to explain sightings rates, but this resulted in only 17% of the deviance explained and a very poor fit to the data (R^2 = 0.04). Clearly the GAM approach was not appropriate for such heterogeneous data, and the second method was therefore applied.

2.4.1. Sea state

Sea state correction factors were derived for each of the five main species represented in the database. In some data sets within the database there was no clear trend of decreasing sightings rates with increasing sea state, and there were even cases where rates increased with sea state. This was the case for example in the Ceredigion County Council (CCC) data for harbour porpoises, in which sightings rates were lowest at sea state 0. However, in the CCC data, harbour porpoises accounted for less than 5% of all cetacean sightings, reflecting a bias towards recording bottlenose dolphins, their main target species, since in other surveys in the same cells, 30% of cetacean sightings were of harbour porpoises. In this case, it did not seem reasonable to apply a correction factor for harbour porpoises that would have scaled effort up in higher sea states. The CCC data were therefore excluded from all subsequent analyses of harbour porpoise sea state correction factors and sightings rates. Correction factors were derived by dividing the mean sightings rate in each sea state category by the mean sightings rate at sea state 0.

Harbour porpoise

The data set used for calculating harbour porpoise sea state correction factors was the Sea Watch data from the entire study area. This was selected to avoid the potential bias introduced by the large data set from CCC, in which this species appears to have been under-recorded, while providing wide spatio-temporal coverage. The data comprised 5665 sightings collected during 16,898 hours of effort, including land-based watch data, *ad hoc* boat surveys, and line-transect surveys. Figure 2 plots sightings rates per hour for each sea state category and Table 4 gives the correction factors derived from these rates.

Table 4 – Sea state correction factors for harbour porpoises.

Sea state category	0	1	2	3 to 6
Correction factor	1	0.6	0.5	0.25

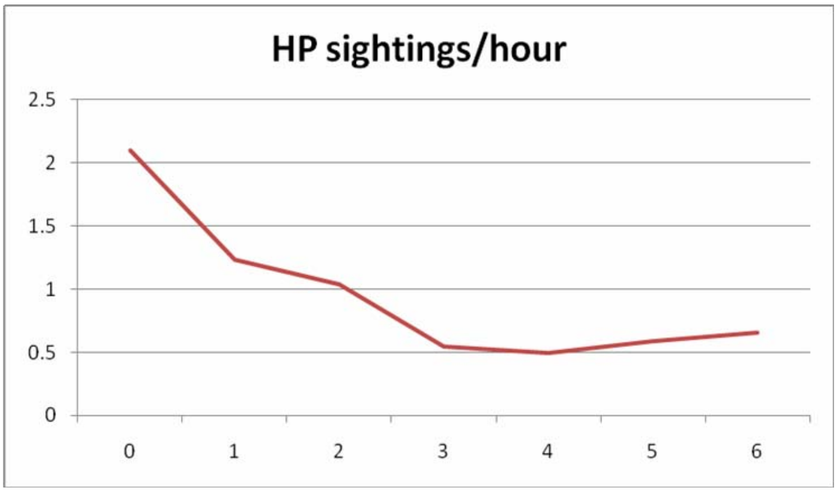


Figure 2 – Harbour porpoise sightings rates per hour for each sea state category

Bottlenose dolphin

For bottlenose dolphins, all data from each of the four cells containing more than 100 sightings were used to derive sea state correction factors. This data set comprised 9614 sightings collected during 12,128 hours of effort. Sightings rates at sea state 0 were in fact lower than for sea state 1, so in order to obtain correction factors with a consistent trend, some sea state categories were combined (Table 5).

Table 5 – Sea state correction factors for bottlenose dolphins

Sea state category	0 to 2	3	4 to 5	6
Correction factor	1	0.9	0.55	0.14

Short-beaked common dolphin

For this species, all data from each of the seven cells containing more than 90 sightings were used to derive sea state correction factors (Table 6). The data comprised 2211 sightings collected during 429 hours of effort. As with the previous species, it was necessary to combine sea state categories so as to avoid scaling effort down at lower sea states.

Table 6 – Sea state correction factors for short-beaked common dolphins

Sea state category	0 to 3	4 to 6
Correction factor	1	0.3

Risso's dolphin

For Risso's dolphins, data from a single cell in which 603 sightings were recorded during 2778 hours of effort, were used to calculate sea state correction factors (Table 7).

Table 7 – Sea state correction factors for Risso's dolphins

Sea state category	0 to 1	2 to 4
Correction factor	1	0.48

Minke whale

For this species, data from a single cell in which 35 sightings were recorded during 180 hours of effort were used to calculate sea state correction factors (Table 8).

Table 8 – Sea state correction factors for minke whales

Sea state category	0 to 1	>1
Correction factor	1	0.4

2.4.2 Land and sea survey types

It is likely that sightings rates are affected by the survey type. For example, land based and boat surveys differ in at least two fundamental respects: one is static while the other is mobile, and the difference in platform height can result in very different viewing areas. Also, dedicated surveys for cetaceans might be expected to yield higher sightings rates than tour boats or surveys in which cetaceans are not the primary taxon of interest. However, in order to estimate factors to correct for variation in sightings rates caused by the type of survey in which data were collected, spatio-temporal variation in the density of the species under consideration must be taken into account. Thus comparisons of sightings rates need to be made from the same area during the same time period. This constraint limits the possibility of deriving correction factors to the most common coastal species in the few areas where there may be sufficient spatio-temporal overlap between some of the different survey types represented in the project database.

A trial analysis was carried out using data from a single cell in Cardigan Bay where effort levels were particularly high and the following survey types were represented in the data: land watches

(STAT), *ad hoc* boat surveys (BOAT), line-transect surveys (LINE), and tour boat sightings (TOUR). Ten months holding the highest volumes of data were selected (Table 9), and sightings rates were calculated for bottlenose dolphins and harbour porpoises for each of the four survey types in each month.

When bottlenose dolphin sightings rates for STAT and BOAT survey types were compared, there was a relatively consistent ratio (mean 0.7:1 for BOAT : STAT) for the first six months in the series, but the ratio increased in the last four months (mean 1.9:1) giving an overall average ratio of 1.18:1 (Table 10). The equivalent comparison for harbour porpoise sightings rates in Table 11 produced widely varying results, with ratios ranging from approximately 1:1 to 50:1.

Table 9 – Effort levels in cell 406 by survey type in the ten months selected for the trial analysis.

Period		Effort hours			
Year	Month	STAT	BOAT	LINE	TOUR
1996	7	315	26.9		
1996	8	304.25	14.07		
1997	7	306.75	65.22		
1997	8	283.25	55.72		
1998	8	157.5	47.37		
2002	8	110.92	113.63	11.5	
2003	8	219	80.78	32.08	
2005	7	113.5	45.43	10.27	40.22
2005	8	86.75	33.05	22.37	59.08
2006	7	79.75	75.02	16.13	64.02

Table 10 – Monthly sightings rates of bottlenose dolphins for STAT and BOAT survey types and the ratio of BOAT to STAT sightings rates.

Year	Month	STAT	BOAT	Ratio
1996	7	0.85	0.59	0.70
1996	8	0.91	0.64	0.70
1997	7	0.71	0.51	0.71
1997	8	1.07	1.01	0.94
1998	8	0.93	0.38	0.41
2002	8	0.99	0.72	0.73
2003	8	0.24	0.74	3.13
2005	7	0.82	1.21	1.48
2005	8	0.40	0.82	2.02
2006	7	0.64	0.63	0.98

Table 11 – Monthly sightings rates of harbour porpoises for STAT and BOAT survey types and the ratio of BOAT to STAT sightings rates.

Year	Month	STAT	BOAT	Ratio
1996	7	0.04	0.11	2.51
1996	8	0.01	0.28	21.62
1997	7	0.04	0.12	3.14
1997	8	0.02	0.20	9.32
1998	8	0.08	0.08	1.02
2002	8	0.09	0.22	2.44
2003	8	0.01	0.05	5.42
2005	7	0.04	0.53	14.99
2005	8	0.01	0.61	52.50
2006	7	0.04	0.37	9.92

LINE and BOAT survey types were compared for the same two species using data from five months. Bottlenose dolphin sightings rates (Table 12) were consistently higher in the BOAT surveys than in LINE surveys, with a mean ratio of 0.53:1. The reverse was found when harbour porpoise sightings rates were compared (Table 13), with a mean ratio of 2.75:1.

Table 12 – Monthly sightings rates of bottlenose dolphins for BOAT and LINE survey types and the ratio of LINE to BOAT sightings rates.

Year	Month	BOAT	LINE	Ratio
2002	8	0.72	0.35	0.48
2003	8	0.74	0.50	0.67
2005	7	1.21	0.49	0.40
2005	8	0.82	0.67	0.82
2006	7	0.63	0.19	0.30

Table 13 – Monthly sightings rates of harbour porpoise for BOAT and LINE survey types and the ratio of LINE to BOAT sightings rates.

Year	Month	BOAT	LINE	Ratio
2002	8	0.22	0.43	1.98
2003	8	0.05	0.31	6.30
2005	7	0.53	0.68	1.29
2005	8	0.61	0.63	1.03
2006	7	0.37	1.18	3.16

TOUR and BOAT sightings rates were compared in three months for the two species. The ratio of bottlenose dolphin rates varied widely (Table 14); harbour porpoise rates were consistently higher in BOAT surveys than in TOUR data (Table 15).

Table 14 – Monthly sightings rates of bottlenose dolphins for BOAT and TOUR survey types and the ratio of TOUR to BOAT sightings rates.

Year	Month	BOAT	TOUR	Ratio
2005	7	1.21	0.37	0.31
2005	8	0.82	0.95	1.16
2006	7	0.63	0.59	0.95

Table 15 – Monthly sightings rates of harbour porpoises for BOAT and TOUR survey types and the ratio of TOUR to BOAT sightings rates.

Year	Month	BOAT	TOUR	Ratio
2005	7	0.53	0.20	0.38
2005	8	0.61	0.12	0.20
2006	7	0.37	0.20	0.54

The results of these trial analyses highlight some of the difficulties facing any attempt to correct for different survey types. There were high levels of variation within the data and few consistent trends. There may be ready explanations for some of the general trends: for example, line-transect effort is structured to sample an area evenly, while *ad hoc* surveys and tour operators may favour areas where animal densities are thought to be high. Land based watches tend to be carried out at known hot-spots such as headlands. The level of observer expertise is likely to be higher in line-transect data than in *ad hoc* boat surveys and this may particularly affect harbour porpoise sightings rates. However, the high degree of variation and lack of consistency in these results indicated that, at this stage, it would not be realistic to generate correction factors to account for all the different survey types represented in the project database.

2.4.3 Land based watches and scan sampling

Most land based data were recorded from surveys during which the start and end times of watches were recorded, and sightings were recorded as single events, sometimes with a start and end time but more usually with a single time. In the Sea Watch database there is a field indicating whether or not a sighting record is a repeat sighting. In the case of whales and dolphins, it is usually possible to discriminate between first and repeat sightings in the field, but this is less easy in harbour porpoise foraging habitats, where porpoises may be present for extended periods of time with a flux of individuals arriving and leaving. To overcome this problem, some observers have used a scan sampling method, in which the numbers of animals present are counted in a consecutive series of scans, each of a fixed duration. In order to make scan sampling data compatible with other land based watch data, each set of consecutive scans was considered as one effort period. Sightings of the same species (almost invariably harbour porpoise) from consecutive scans were considered as belonging to the same sighting event, with the sighting ending when a scan did not find any animals. The group size was taken as the highest count in any one scan from the series of scans making up the sighting.

2.4.4 Ferry data

Overall sightings rates of harbour porpoises tend to be higher from ferries than from other platforms (Table 16). The question is, can this be explained by differences in platform characteristics, i.e. higher viewpoint and faster speed on ferries, or in differences in the spatial distribution of effort, given that ferries ply a small number of fixed routes whereas the other data sets have been collected over wider areas?

Table 16 – Comparison of sightings rates (sightings / hour) of harbour porpoises from ferry surveys, European Seabirds at Sea data and the Sea Watch Foundation database, which includes both vessel and land based data

Source	Effort hours	Sightings rate
IWDG ferry data	210	0.89
ESAS database	1544	0.21
SWF database	22936	0.20

To investigate this issue further, only those cells from which data were available from both ferry and non-ferry sources were compared. There was overlap in 50 cells and when the rates were compared in all these cells, the ferry rate (1.44 porpoises / hour) was higher than that from other platforms (0.9 porpoises / hour) (Table 17). However, in many of the cells, effort was very low, with less than 1 hour of ferry effort in 22 (44%) cells. Sightings in such low effort cells tend to result in spuriously high sightings rates. When low effort cells were excluded, the rates tended to converge, such that when only those cells with 10 hours of effort were considered, the rates were virtually identical (ferry rate = 1.69 porpoises / hour; non- ferry rate = 1.71 porpoises / hour).

Table 17 – Comparison of sightings rates (counts / hour) from ferry and non-ferry data sources (excluding aerial surveys)

Filter	Number of cells	Ferry rate	Non-ferry rate
All overlapping cells	50	1.44	0.90
More than 5 hours effort per cell	10	1.66	1.54
More than 10 hours effort per cell	9	1.69	1.71

These results suggest the possibility that overall ferry rates for this species tend to be higher than overall rates collected from other platform types because the ferry routes between Wales and

Ireland happen to pass through areas of relatively high harbour porpoise density, off the coasts of Pembrokeshire and Anglesey.

Table 18 – The amount of effort from each survey or platform type in the project database

Platform / survey type	Effort hours	Percent of total effort
Land	24000.8	64.4%
Boat	7810.8	21.0%
Line transect	2903.1	7.8%
ESAS	1544.2	4.1%
Tour boats	577.8	1.6%
Ferry	210.1	0.6%
Scan sampling (from land)	155.6	0.4%
Aerial survey	37.6	0.1%
Pile driving mitigation monitoring	25.9	0.1%

Even if sightings rates aboard ferries may be biased upwards, it is worth noting that ferry surveys in fact contribute only 0.6% of the effort hours in the project database (Table 18).

We must therefore assume for the purposes of this project that with the exception of aerial surveys discussed below, survey type and related factors, such as platform height and speed, the number of observers and their experience, do not bias the results by area. This assumption needs to be borne in mind when interpreting the maps: care should be taken not to over-interpret the detail in the maps, particularly small differences in sightings rates.

2.4.5 Aerial surveys

SCANS surveys were designed to cover large survey blocks, so survey effort was relatively sparse within the grid of 10 minute cells of the project study area. While this raised no particular issues with regard to the ship based data, which could be directly amalgamated with data from other sources, the SCANS II aerial survey data differed significantly in that survey speed was relatively high, with consequent rapid passages across cells. The duration of cell transits averaged approximately 2 minutes, so any sightings made resulted in unreasonably high sightings rates (e.g. one sighting in a 2 minute transit equals 30 sightings / hour). A correction factor was therefore required to scale the aerial survey effort.

There was no spatial overlap in sightings between other data in the project database and the SCANS II aerial survey in July 2005, so sightings rates for July pooled from all years in the cells covered by SCANS were used to compare sightings rates. Harbour porpoises accounted for 66%

of all SCANS II aerial sightings and 82% of identified cetacean sightings, so this species was selected for the comparison. The counts of porpoises per hour in 25 cells for which there were data from both sources were on average 5.8 times higher during the SCANS II aerial surveys compared to the project data from other sources, although there was considerable variation about this mean (SD = 17.3). Mean survey speed during the SCANS II aerial survey was 6 times greater than that from vessels in the same area and time period, and thus transect length was on average 6 times longer during the aerial survey than in vessel surveys, for the same time interval. The effective strip width (ESW) estimates from the aerial survey ranged from 0.187 km under good conditions to 0.107 km when conditions were moderate (Hiby, 2005). This is comparable to ESW values estimated from line transect data collected by SWF from small vessels in the Cardigan Bay SAC, e.g. in 2005, an ESW of 0.183 km was estimated using harbour porpoise sightings data. The area surveyed during the aerial surveys was thus on average approximately 6 times greater than for vessel surveys in Cardigan Bay. Given the convergence of this factor and the comparison of sightings rates, a factor of 6 was used to scale the aerial survey effort.

2.5 Interpolation

A number of geostatistical processes are available to interpolate missing values in spatial data, including Inverse Distance Weighting, Kriging, Minimum Curvature, Natural Neighbour, Nearest Neighbour, Polynomial Regression, Radial Basis Function, Triangulation with Linear Interpolation, Moving Average, and Local Polynomial. Evans and Wang (2005) used Inverse Distance Weighted (IDW) interpolation. Webb *et al* (2003) used Kriging as it gave the best visual representation of their data and the best fit when comparing estimated and observed scoter densities. After comparison of two kriging methods (ordinary and universal) and IDW, the latter was selected on the basis of giving the best visual representation of the data and the best fit when compared with plots of raw sightings data.

The IDW method assumes that each input point has a local influence that diminishes with distance, weighting the influence of areas closer to the input point greater than those farther away. Input points within a specified radius of 20 km were used to determine the output value for each cell in a raster grid with 299 columns and 239 rows, equivalent to a resolution of approximately 50 seconds of latitude by 50 seconds of longitude. Input points were calculated as the mean position of sightings for any given species within each cell, rather than the cell centroid. This is illustrated in Figure 3, which maps the locations of input points for the interpolation of harbour porpoise sightings rates. Note that in Figure 3, for the sake of comparability the dots have been scaled to the same categories used in both the dot over effort maps and the interpolated maps, whereas the actual values of sightings rates were passed to the interpolation process.

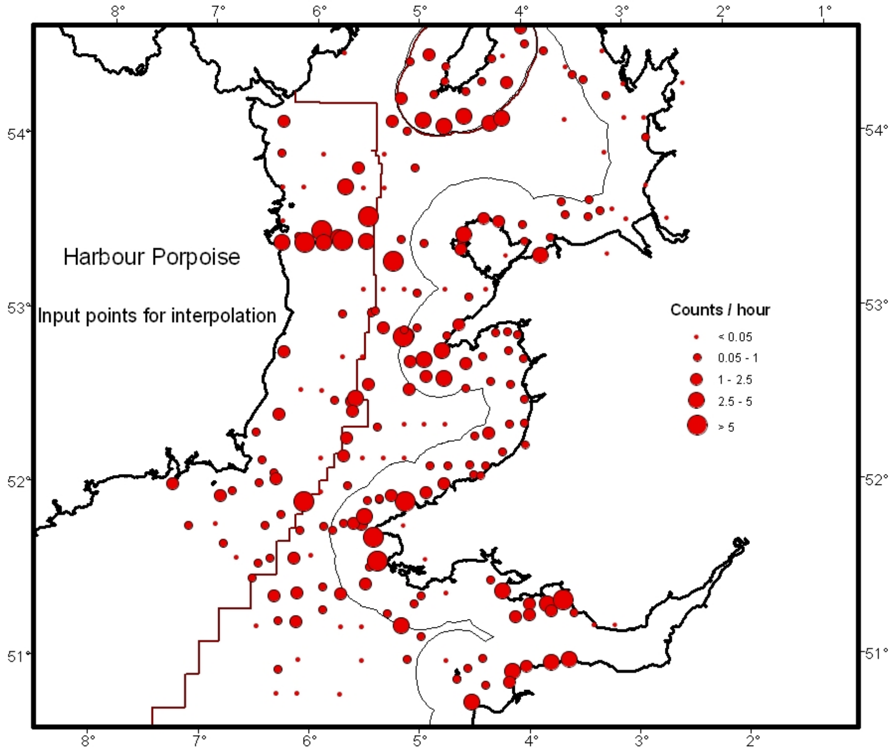


Figure 3 – Input points used for the interpolation of harbour porpoise sightings rates

Low levels of effort in many cells frequently gave rise to unreasonably high sightings rates. For example: 2 minutes of effort in cell 344 during September 2004, during which 4 porpoises were seen, resulted in a sightings rate of 200 per hour when the sea state correction factor had been applied. Interpolation could effectively spread such spuriously high values into neighbouring areas, clearly an undesirable result, so data from cells with low levels of effort were filtered out before applying the interpolation process. The effects on interpolated maps of varying the threshold of the low effort filter are illustrated for harbour porpoise in Figure 4: (a) with no filter applied a large area of high density appears between the Isle of Man and Northern Ireland, this is entirely spurious being based on a single sighting in a low effort cell; (b) when cells with less than 1 hour of effort are filtered out, this disappears; and with progressively higher filter thresholds (c) and (d), boundaries between different rate categories become progressively smoother. Note that in high effort areas, such as around the coast of Wales from Anglesey to south Pembrokeshire, there is very little perceptible change in the maps, but where a small locus of high effort adjoins a relatively large area of low effort, such as the Gower (high effort) and the inner Severn Estuary (low effort) the result of raising the threshold is to spread the relatively high rates from the Gower into the inner Estuary (Figure 4 (d)) which may be an artefact. Setting the threshold at 2 hours achieved a smoothed output without spurious areas of high density and this was the level selected for this species. However, caution should be taken not to over-interpret the interpolated maps and for critical purposes reference should always be made to the appropriate maps in which actual sightings rates are displayed overlaid on a shaded effort scale.

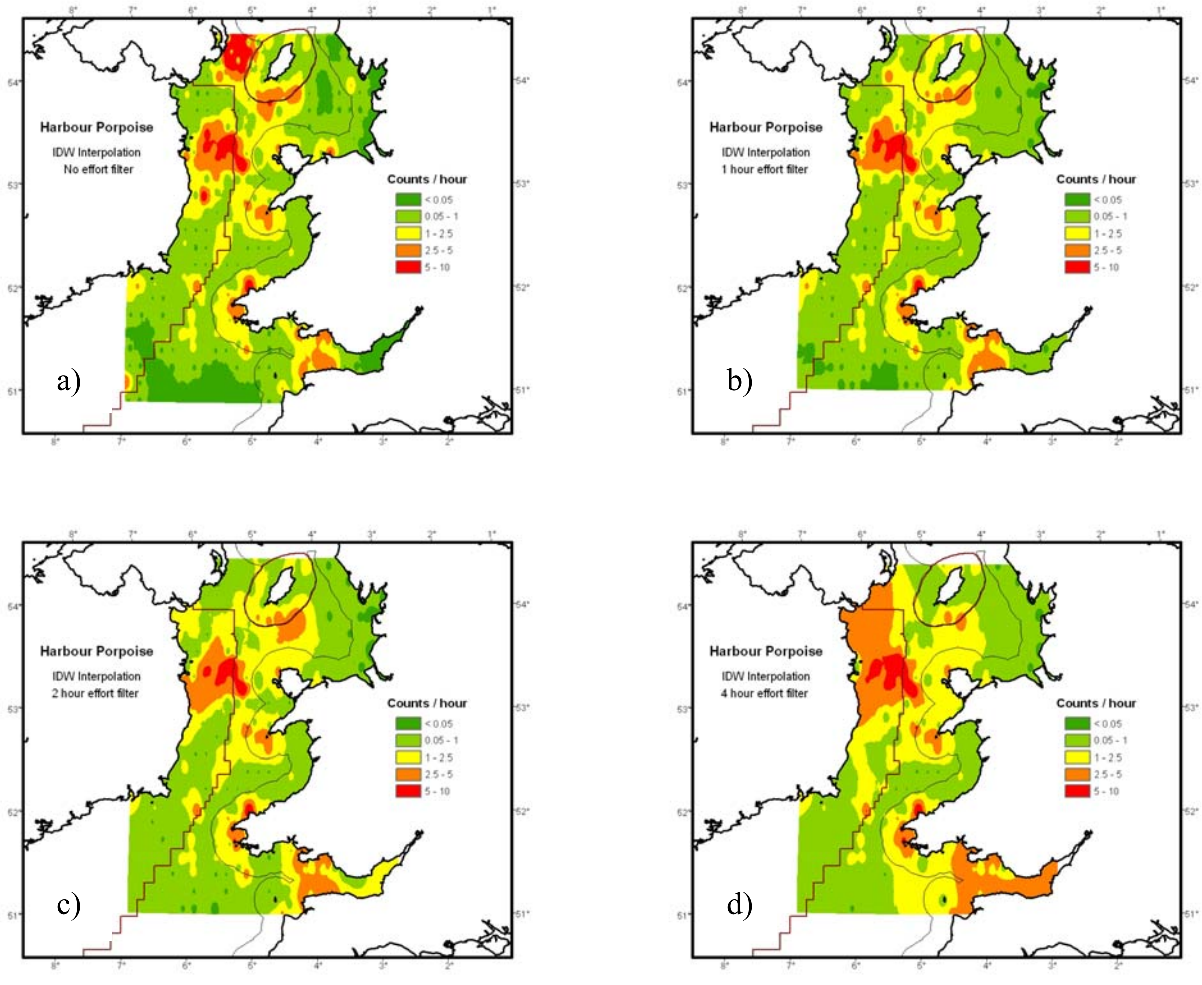


Figure 4 – Interpolated long-term mean sightings rates (counts per hour) of harbour porpoise with different levels of filtering to account for low effort: a) no filter applied; b) filter out cells with 1 hour of effort or less; c) filter out cells with 2 hours of effort or less; and d) filter out cells with 4 hours of effort or less.

3. RESULTS

A full set of 1,523 maps is provided as an electronic Appendix, comprising the following:

Effort

Overall cumulative total effort hours 1990 – 2007 (1 map)
Effort hours in five-year periods 1990 – 2007 (4 maps)
Long term total monthly effort hours 1990 – 2007 (12 maps)
Long term total quarterly effort hours 1990 – 2007 (4 maps)
Effort hours in each month 1990 – 2007 (216 maps)

Harbour porpoise, Risso's and **Short-beaked common dolphin**

Long term mean sightings rate – raw and interpolated data (2 maps)
Long term mean sightings rate in 5-year periods (4 maps)
Long term quarterly mean sightings rates (4 maps)
Long term monthly mean sightings rates (12 maps)
Single monthly sightings rates 1990 – 2007 (216 maps)
Long term mean monthly ratio of juveniles to adults May – September (5 maps)
Total number of strandings 1990 – 2007 (1 map)
Cumulative monthly strandings totals (12 maps) (not Risso's dolphin)

Bottlenose dolphin

Long term mean sightings rate – raw and interpolated data (2 maps)
Long term mean sightings rate in 5-year periods (4 maps)
Long term mean no. of individuals – raw and interpolated (2 maps)
Long term quarterly mean sightings rates (4 maps)
Long term monthly mean sightings rates (12 maps)
Single monthly sightings rates 1990 – 2007 (216 maps)
Long term mean monthly ratio of juveniles to adults (12 maps)
Total number of strandings 1990 – 2007 (1 map)

Minke whale

Long term mean sightings rate – raw and interpolated data (2 maps)
Long term mean sightings rate in 5-year periods (4 maps)
Long term quarterly mean sightings rates (4 maps)
Long term monthly mean sightings rates (12 maps)
Single monthly sightings rates 1990 – 2007 (216 maps)
Total number of strandings 1990 – 2007 (1 map)

Killer whale and **White-beaked dolphin**

Total number of sightings 1990 – 2007 (2 maps)

Striped dolphin, *Stenella/Delphinus* dolphins, Blainville's beaked whale, Cuvier's beaked whale, Sowerby's beaked whale, Long-finned pilot whale, Pygmy sperm whale

Total number of strandings 1990 – 2007 (6 maps)

Species diversity

The number of cetacean species recorded in each cell (1 map)

Grey seal

Annual pup production (1 map)
Non-breeding haul-out counts (1 map)
Long term mean sightings rate - raw and interpolated data (2 maps)
Long-term quarterly mean sightings rates (4 maps)
Long term monthly mean sightings rates (12 maps)

3.1 Effort

Overall effort in the database amounted to 37,266 hours in 376 of the 414 cells of which part or all covered areas of sea. However, the spatial distribution of effort (Figure 6) was far from evenly spread and 51% (19,101 hours) of the total effort was in only 3 cells, while 70% (26,253 hours) was in 10 cells. In just 35 cells did effort exceed 100 hours. Thus although the mean level of effort overall was just under 100 hours per cell, when the three cells with highest levels of effort were excluded, the average in the remaining cells was 49 hours. In 38 cells there was no effort at all, and in 158 cells there was less than 4 hours of effort. Effort was highest in coastal areas, particularly in southern Cardigan Bay from New Quay to St David’s Head, and around Bardsey Island. There was also a temporal bias to the distribution of effort, with 85% of all effort in the six months, April to September (Figure 6).

The confidence that can be placed on sightings rates in any cell increases with the level of effort in that cell. The higher the level of effort in any one cell, the more reliable the sightings rates are likely to be. Some cells with low effort but with just one or two sightings showed disproportionately high sightings rates, so care should be taken not to over-interpret the results where effort levels are low. This is particularly problematic in some of the monthly maps, but also affects the overall pooled data in cells with low levels of effort

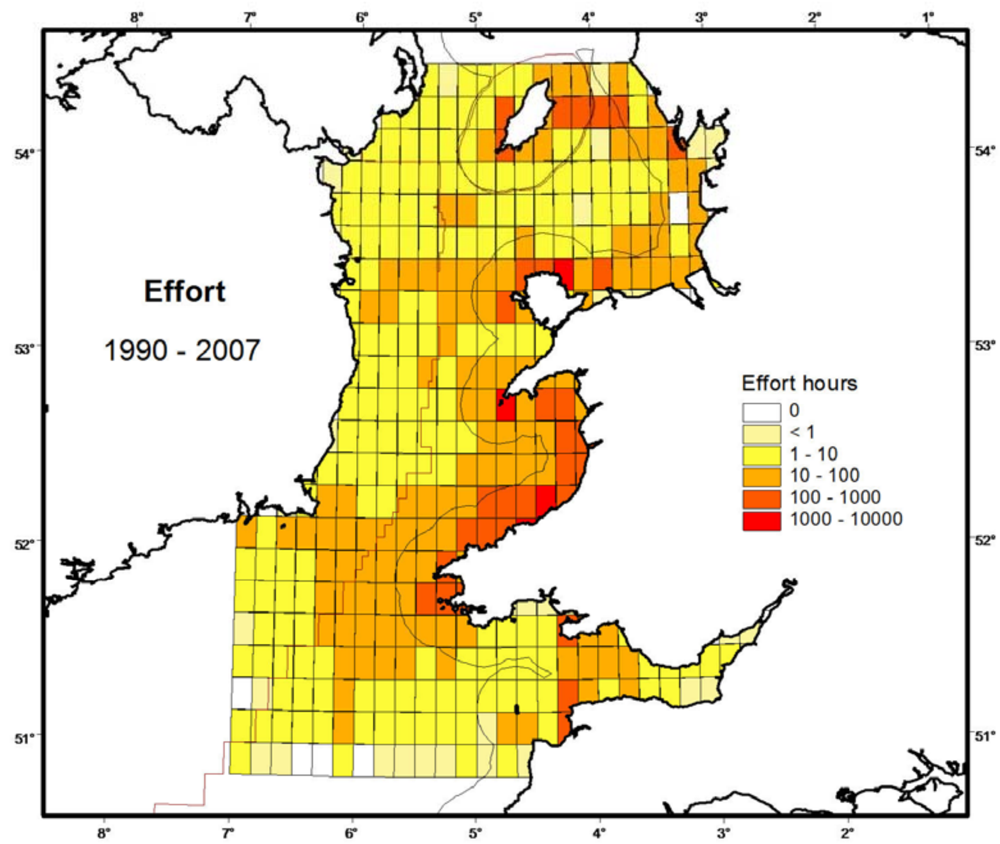


Figure 5 – Overall hours of effort in the study area from 1990 – 2007

.

Figure 6 – Monthly levels of effort in the study area from 1990 – 2007

3.2 Harbour porpoise *Phocoena phocoena*

This is a very widespread species, occurring throughout the study area, although sightings rates tend to be higher in coastal areas than offshore. Within the 12 nm territorial limit around the coast of Wales, sightings rates are highest in the vicinity of Strumble Head and the west Pembrokeshire islands. Rates were also high around the coast of Anglesey and off the south coast of the Lleyn Peninsula. Moderately high rates occur off the Gower Peninsula and extend in a band across the mouth of the Bristol Channel (Figure 7). Care should be taken not to over-interpret the map of interpolated sightings rates (Figure 7b); refer to section 2.5 for an explanation of the interpolation process and bias caused by low effort cells.

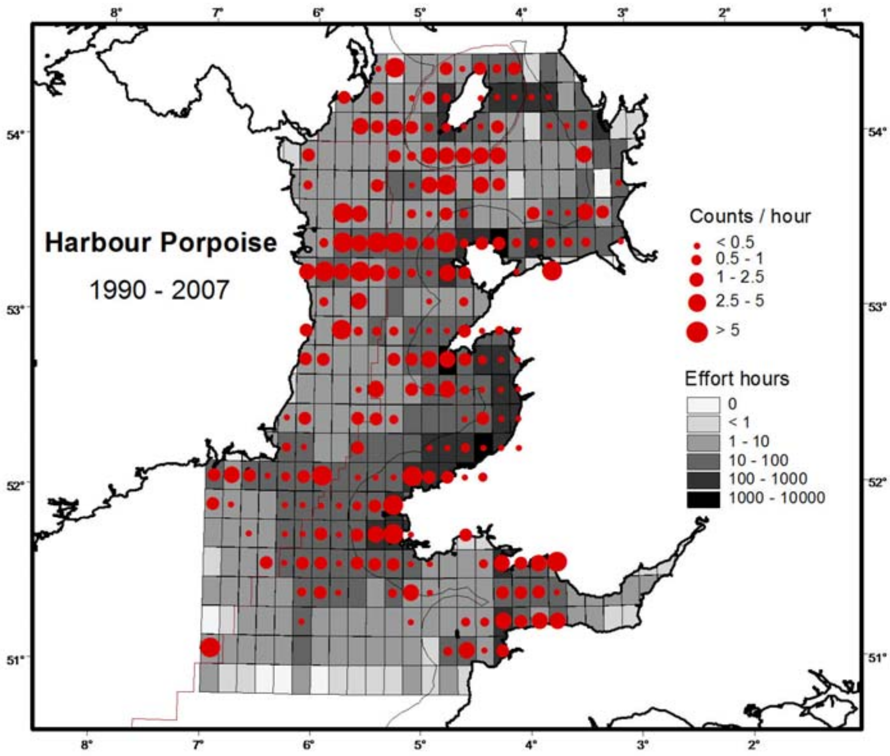
Sightings rates are generally higher in the most recent time period compared with earlier ones, particularly in the northern half of the Irish Sea (Figure 8), although effort has not been distributed similarly over the years, and some recent high rates are almost certainly a consequence of low effort in particular cells

Bearing in mind the low levels of effort over much of the year, especially the winter months, no clear seasonal trends emerge from the maps of long term monthly mean sightings rates (Figure 9) or the quarterly means (Figure 10). The species is clearly present in Welsh waters in all months of the year.

The maps of the long term monthly mean ratio of juveniles to adults for the months May to September indicate higher proportions of juveniles in south and southwest Wales (Figure 11). However, they should be interpreted with some caution for this, as for each of the other, species. The presence of juveniles has not been recorded systematically by all observers, and some have simply not recorded them at all. Young porpoise calves tend to swim close alongside their mothers making them difficult to observe in all but ideal conditions, so their presence is likely to be under-recorded in most data sets.

No particular spatial pattern exists for strandings, which occur along all sectors of the Welsh coastline (Figure 12). Given the fact that the original locations of animals on death is not known, and the prevailing currents may take them far from those sites (and generally from SSW to NNE), it is impossible to relate this to actual distribution of living animals. The cause of death for most porpoise strandings in Wales, where known, is currently bottlenose dolphin attack (Jepson, 2005).

a) Long-term mean sightings rates overlying effort



b) Interpolated long-term mean sightings rates

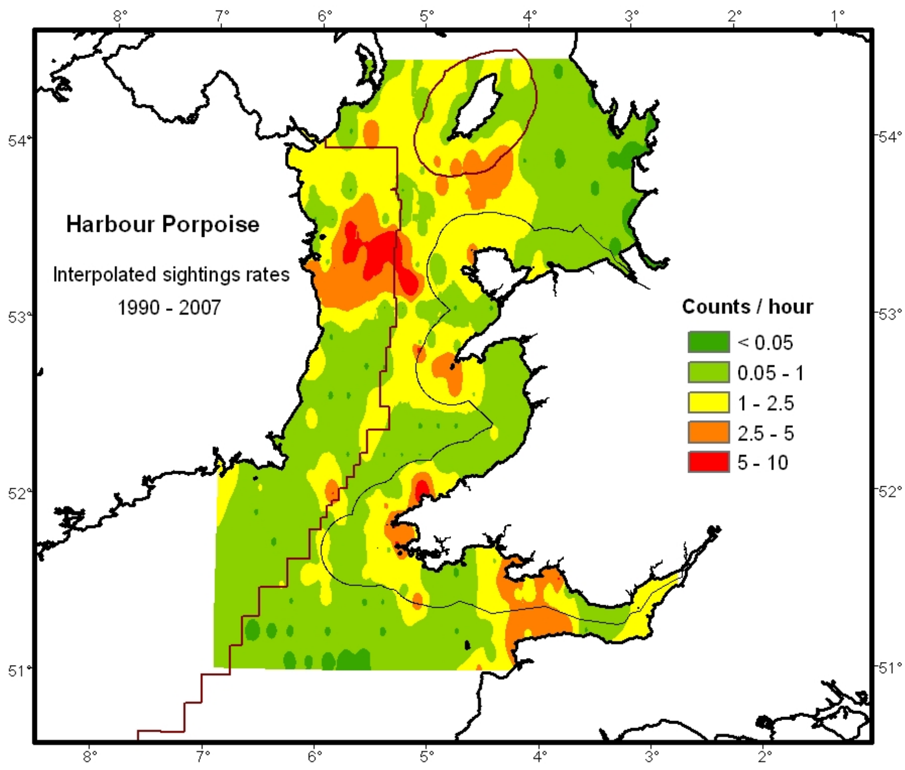


Figure 7 – Long-term mean sightings rates (counts per hour) of harbour porpoise

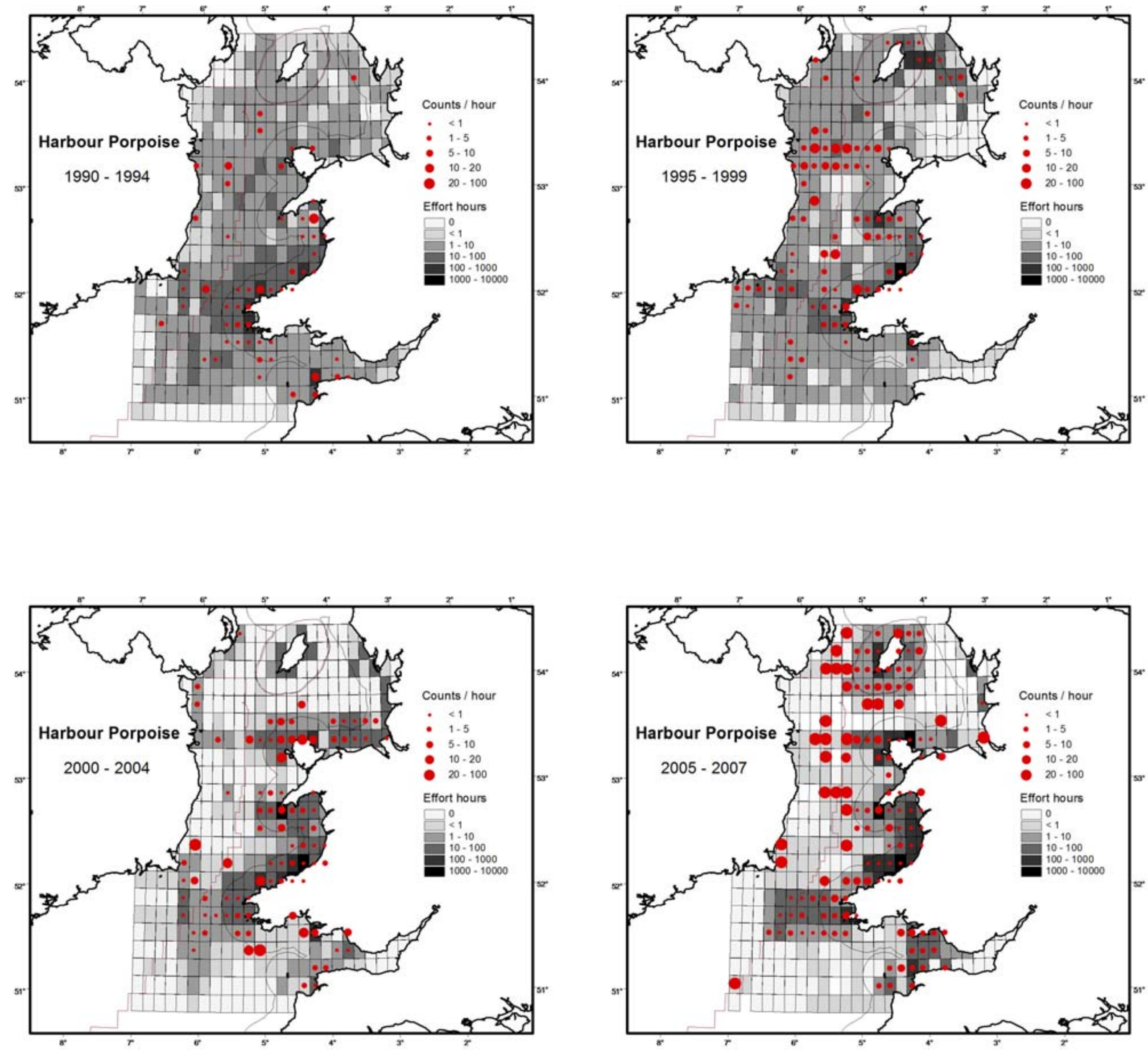


Figure 8 – Mean sightings rates of harbour porpoise for the time periods 1990-95, 1995-99, 2000-04, and 2005-07

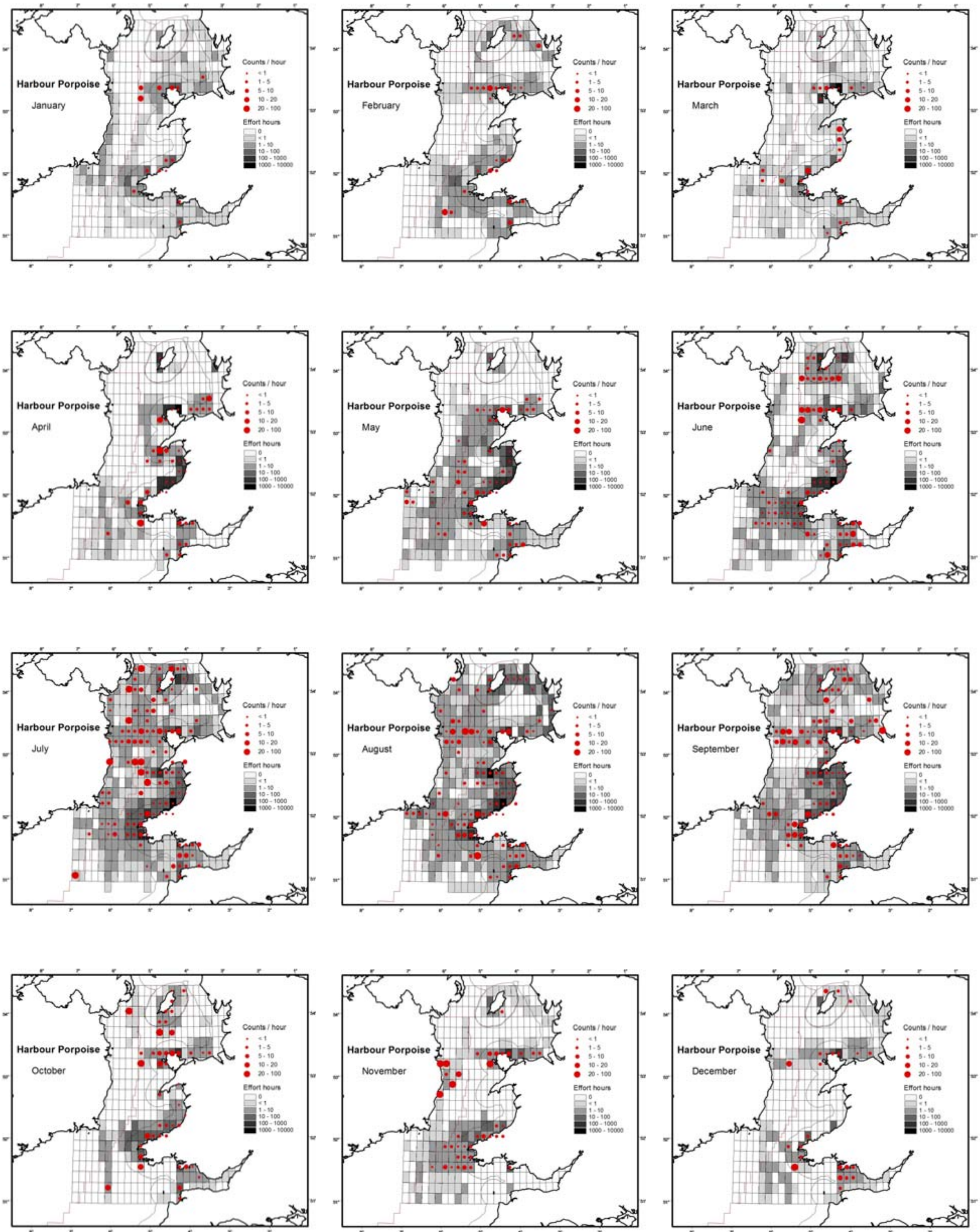


Figure 9 – Long term monthly mean sightings rates of harbour porpoise

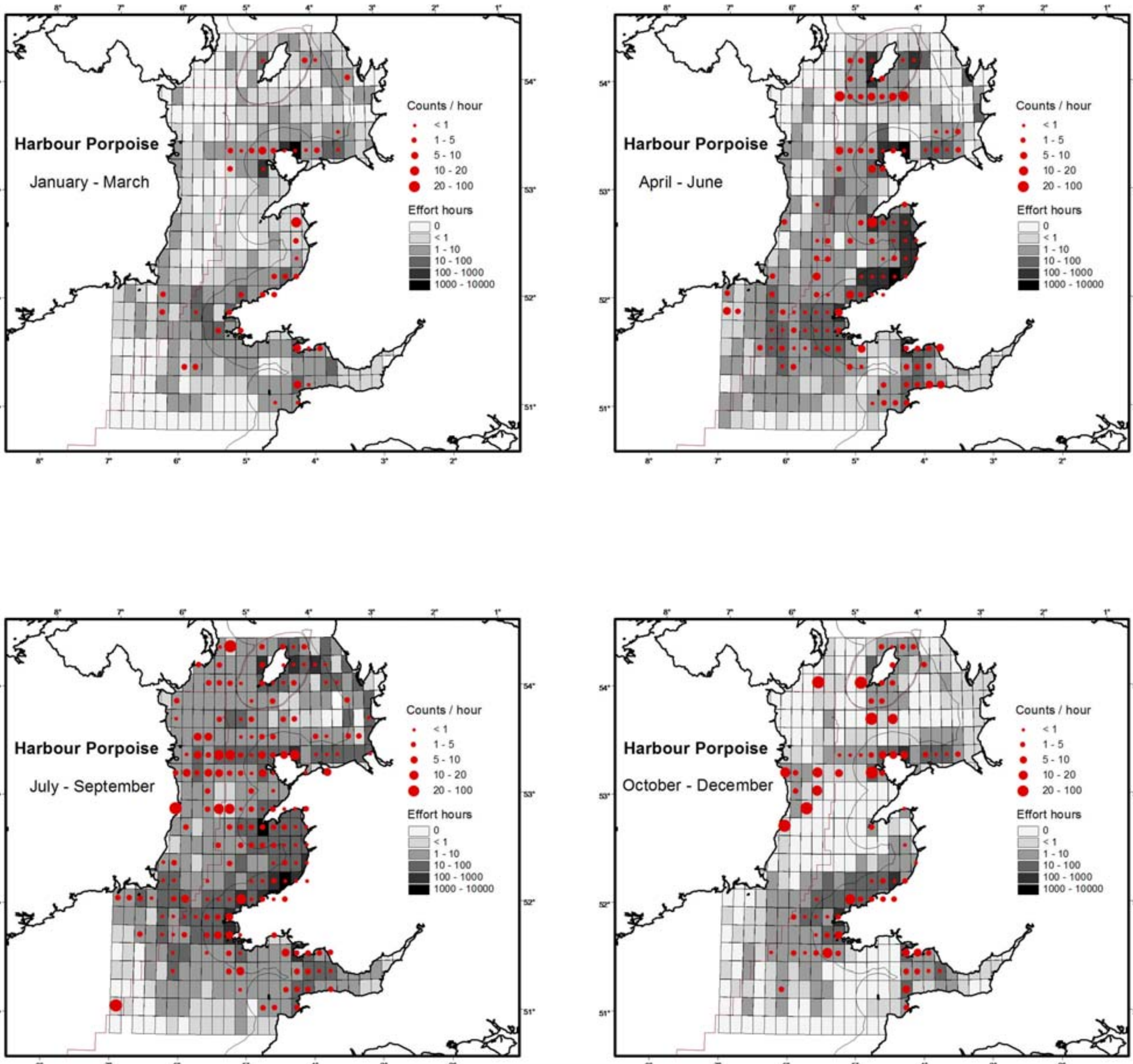


Figure 10 – Long term quarterly mean sightings rates of harbour porpoise

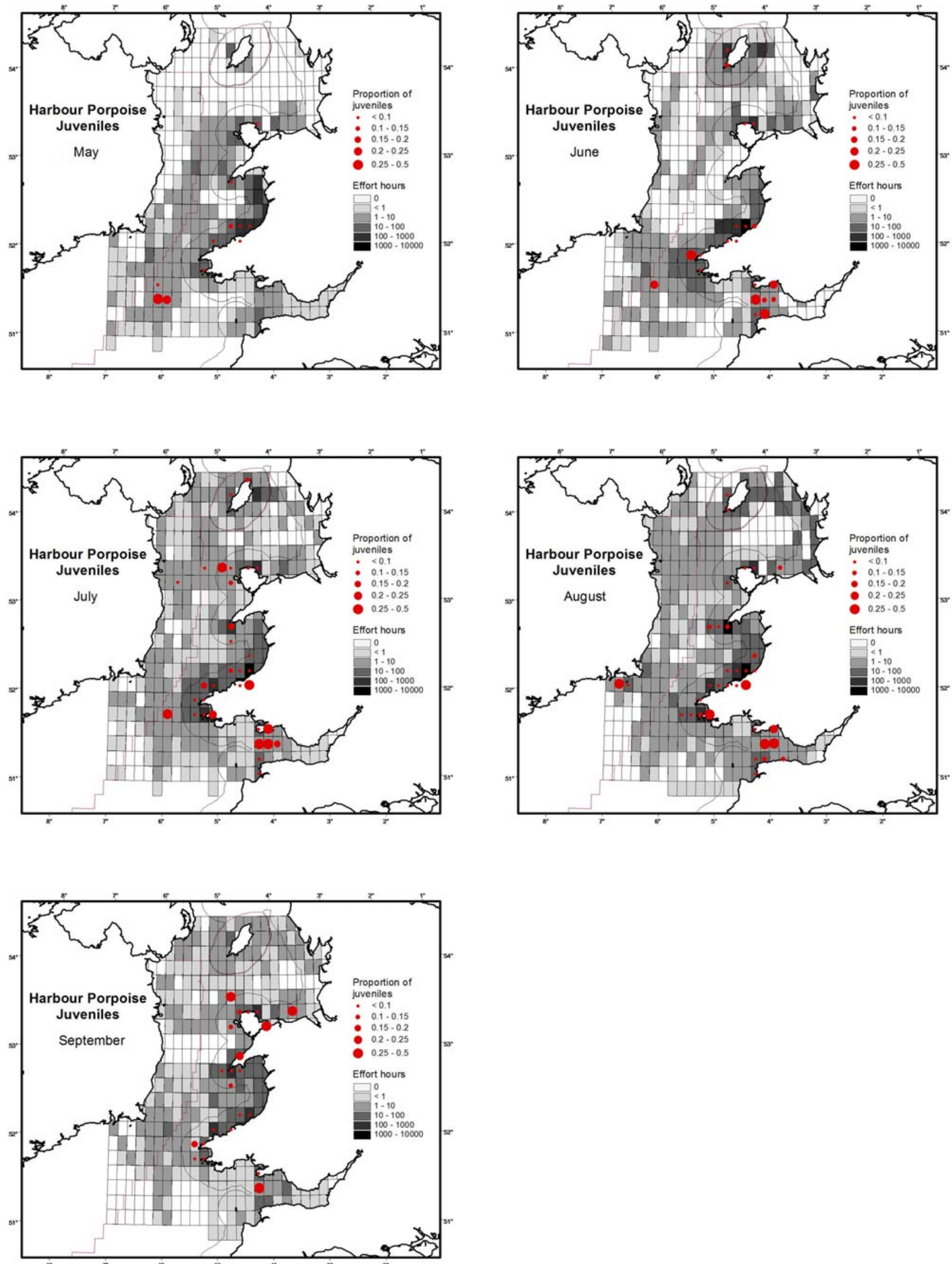


Figure 11 - Long term mean monthly ratio of juveniles to adults of harbour porpoise

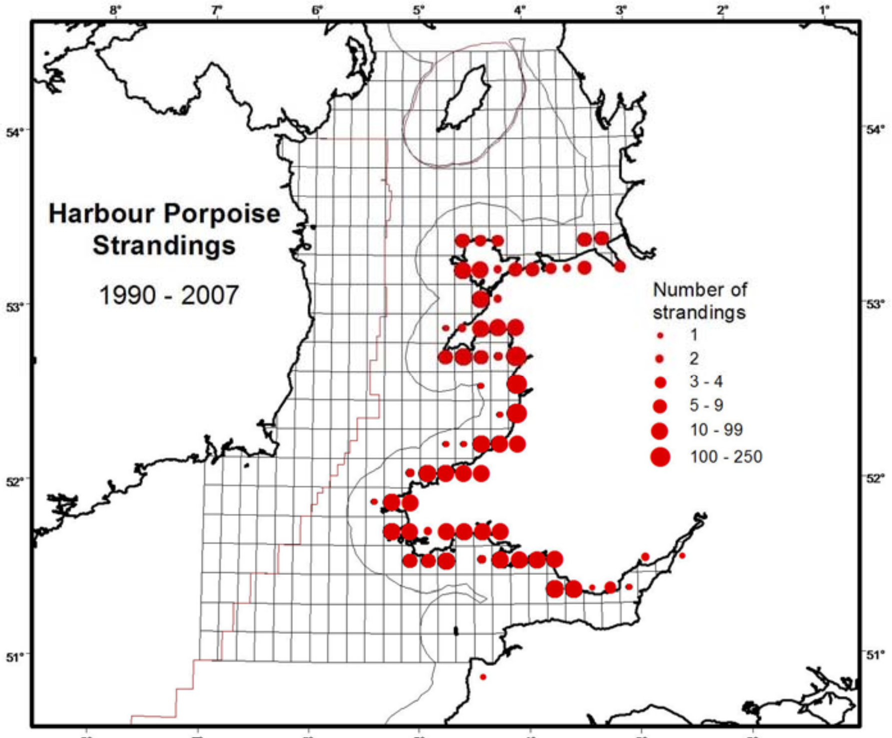


Figure 12 - Distribution of strandings of harbour porpoise on the coasts of Wales

3.3 **Bottlenose dolphin** *Tursiops truncatus*

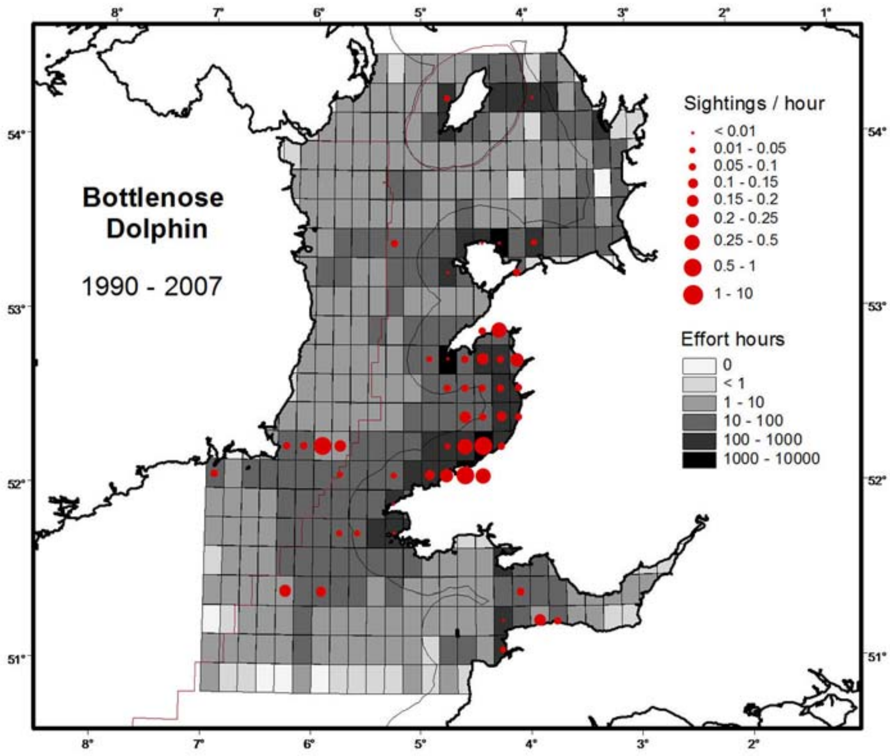
This is a species with a predominantly coastal distribution within the study area, although low densities have been recorded offshore, particularly in St George's Channel and the southwest sector of the study area (Figure 13). The main concentration of bottlenose dolphin sightings has been in southern Cardigan Bay, with moderately high sightings rates extending throughout Cardigan Bay. However, the species also occurs off the north coast of Wales, particularly north and east of Anglesey. Cardigan Bay has been important for bottlenose dolphins for many years, as reflected in the distribution patterns across time periods (Figure 15). Recent survey effort off North Wales has also indicated its regular presence there as well, which is supported by casual sightings records that have been submitted to Sea Watch over the last 30 years (Evans, 1980, 1992; Evans *et al*., 2003).

There are marked seasonal trends in bottlenose dolphin distribution, with high coastal sightings rates in the summer and autumn, contrasting with low rates in late winter and early spring (Figures 16 & 17). However, there appears to be a northward shift in distribution in the last quarter of the year that may suggest dispersal into the Irish Sea during the winter, and this is the period when largest group sizes have been recorded in North Wales and in Manx waters (Figure 14; Pesante *et al.*, 2008a, b). Generally, smaller groups are observed during summer months, particularly within Cardigan Bay, and these groups are predominantly coastal, whereas in winter they are more dispersed and much larger (Pesante *et al.*, 2008a, b).

Relatively high proportions of juveniles have been recorded throughout Cardigan Bay, and to a lesser extent in North Wales and in Manx waters (Figure 18). Young have been observed particularly in the months of May to July, although present most months of the year (Figure 18). However, the distinction between newborns and older calves has often not been made clearly, so these findings should be viewed only as a rough guide to areas where breeding is likely to have taken place.

The spatial pattern of bottlenose dolphin strandings (Figure 19) agrees largely with the distribution of sightings, occurring mainly within Cardigan Bay and around Anglesey.

a) Long-term mean sightings rates



b) Interpolated long-term mean sightings rates

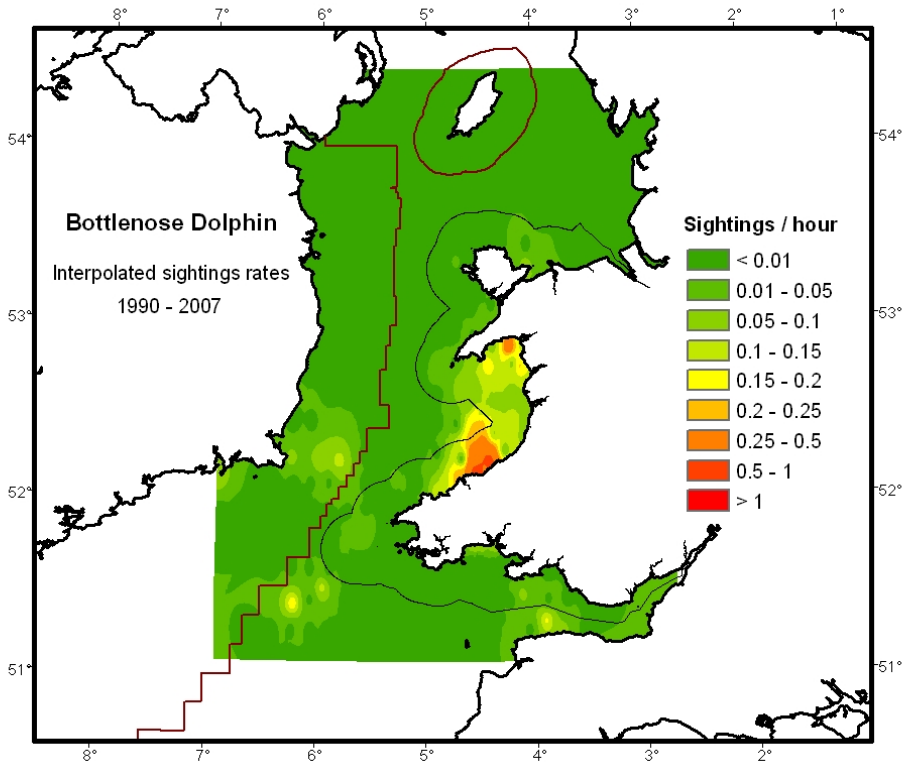
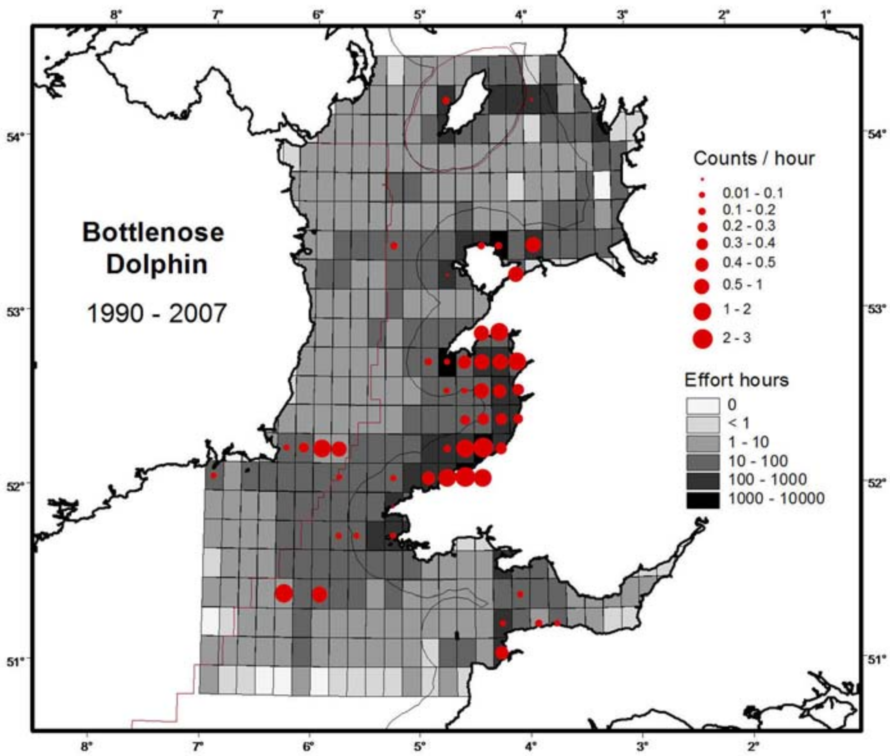


Figure 13 – Long-term sightings rates (sightings per hour) of bottlenose dolphins

a) Long-term mean count rates



b) Interpolated long-term mean count rates

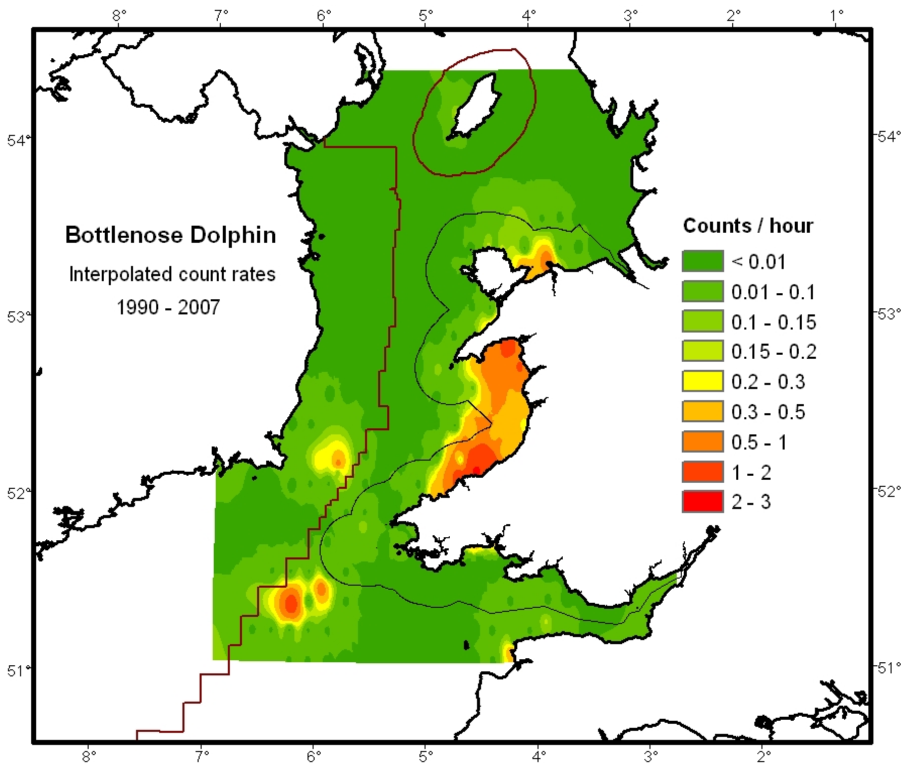


Figure 14 – Long-term sightings rates (no. of individuals per hour) of bottlenose dolphins

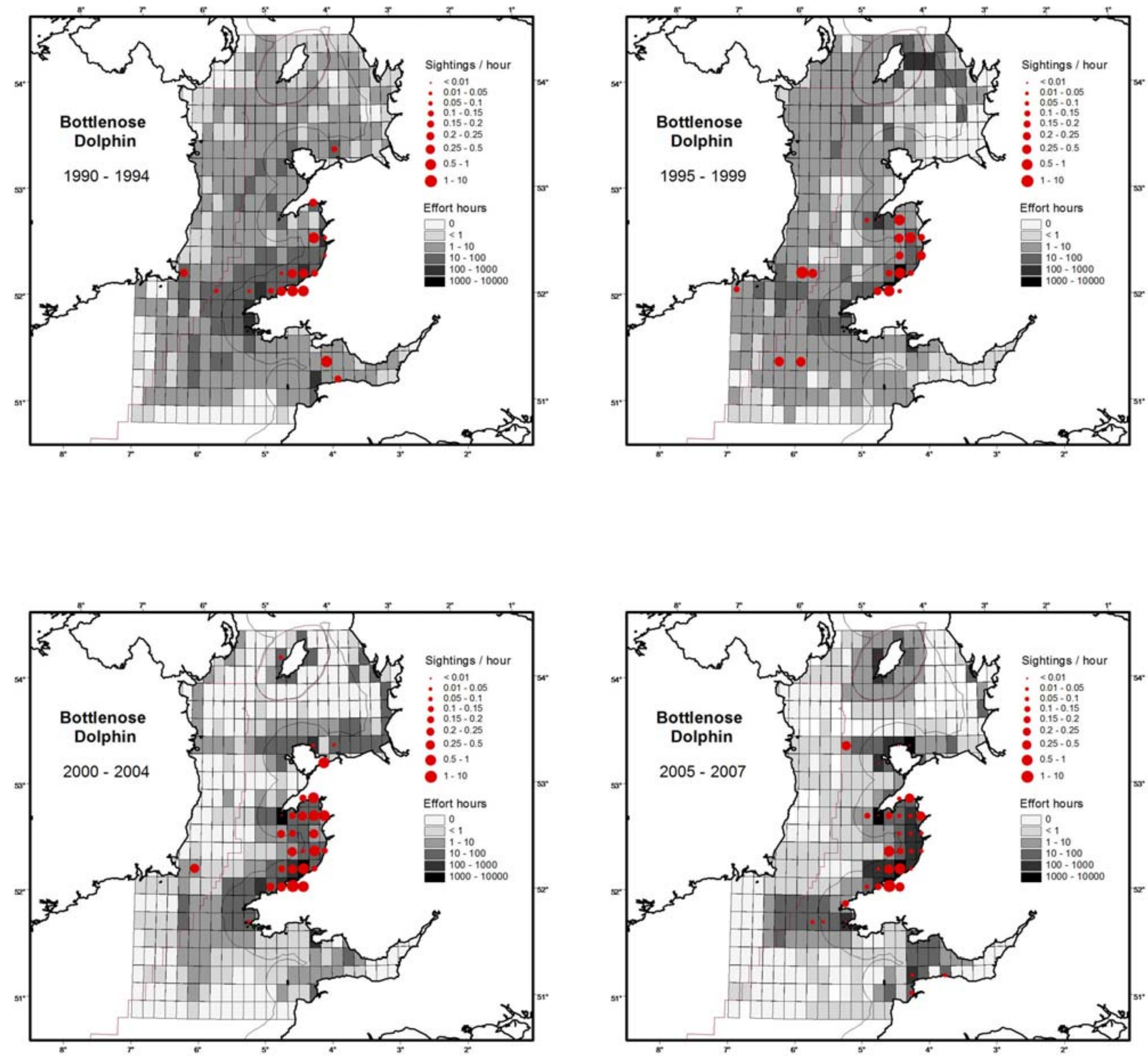


Figure 15. Mean sightings rates of bottlenose dolphin for the time periods 1990-94, 1995-99, 2000-04, and 2005-07

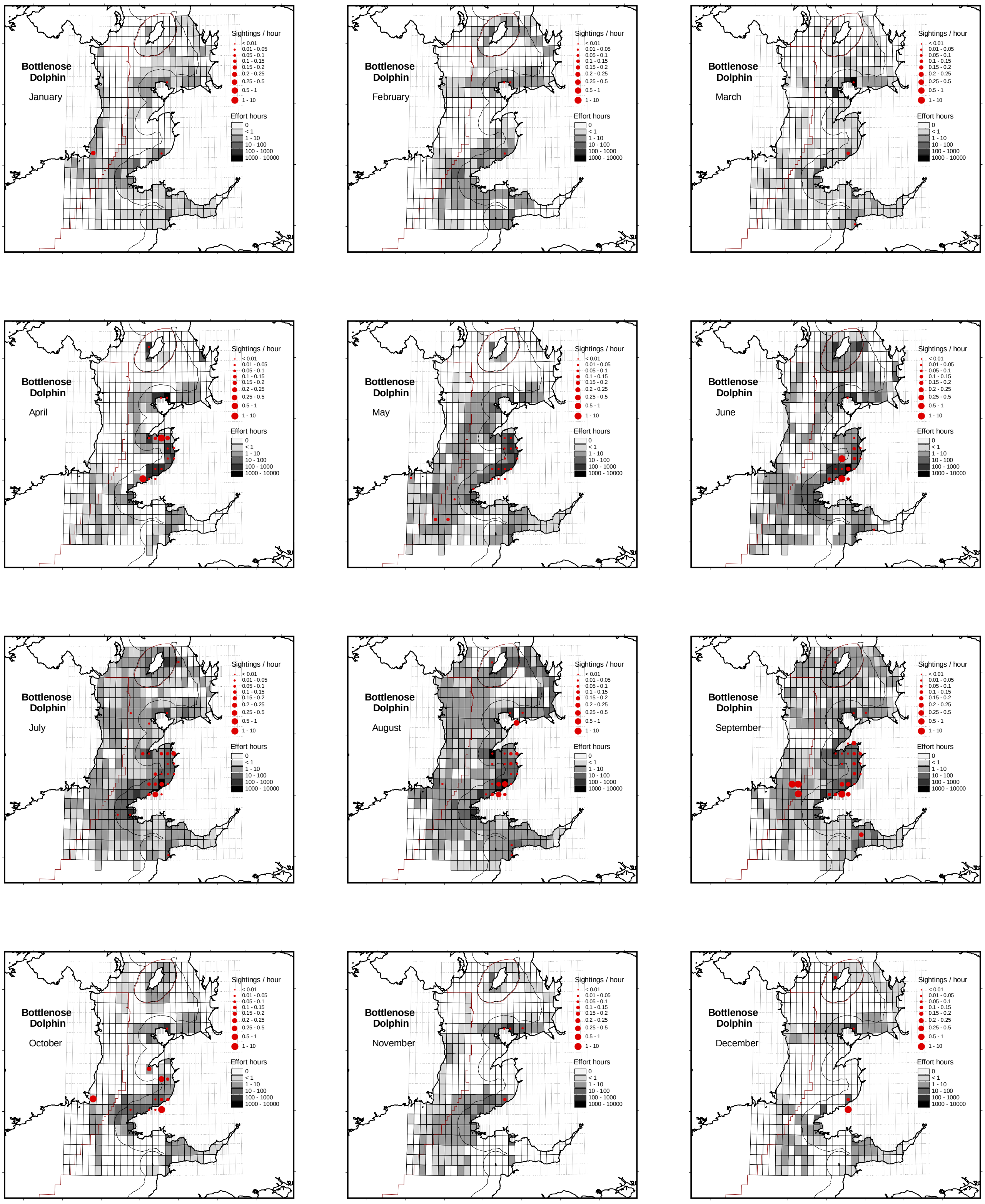


Figure 16 – Long term monthly mean sightings rates of bottlenose dolphin

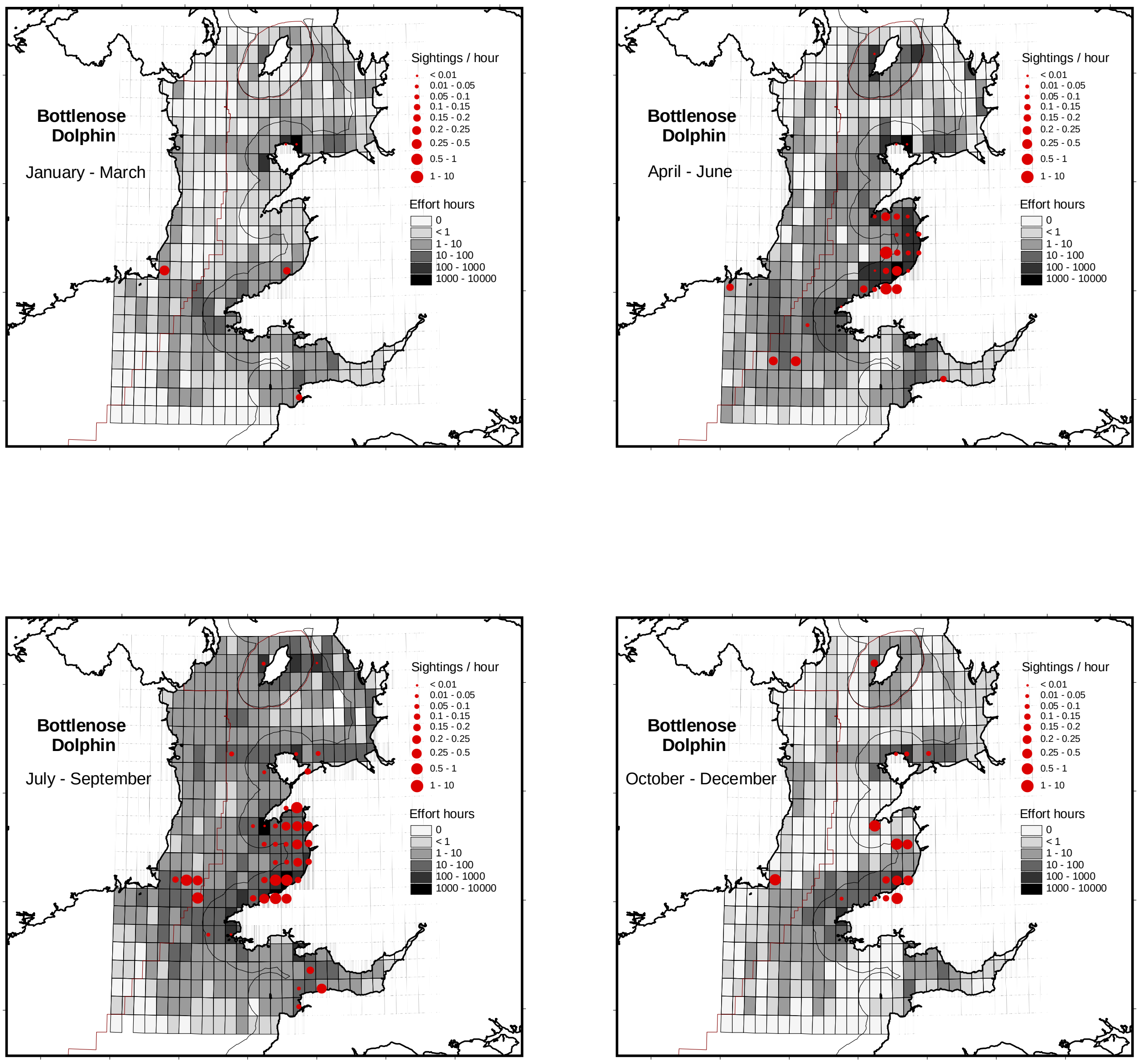


Figure 17 – Long term quarterly mean sightings rates of bottlenose dolphin

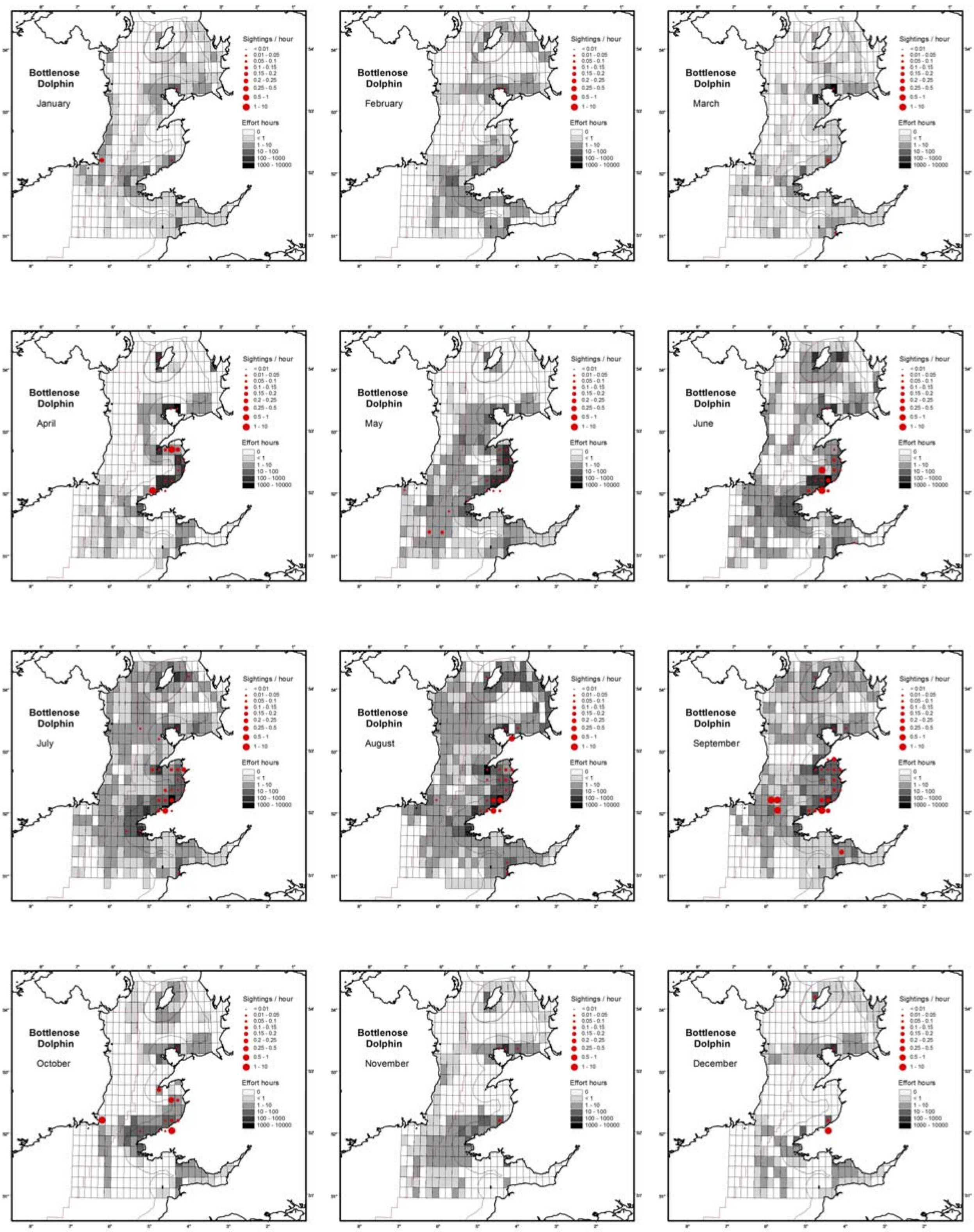


Figure 18 – Long term monthly ratio of juveniles to adults of bottlenose dolphin

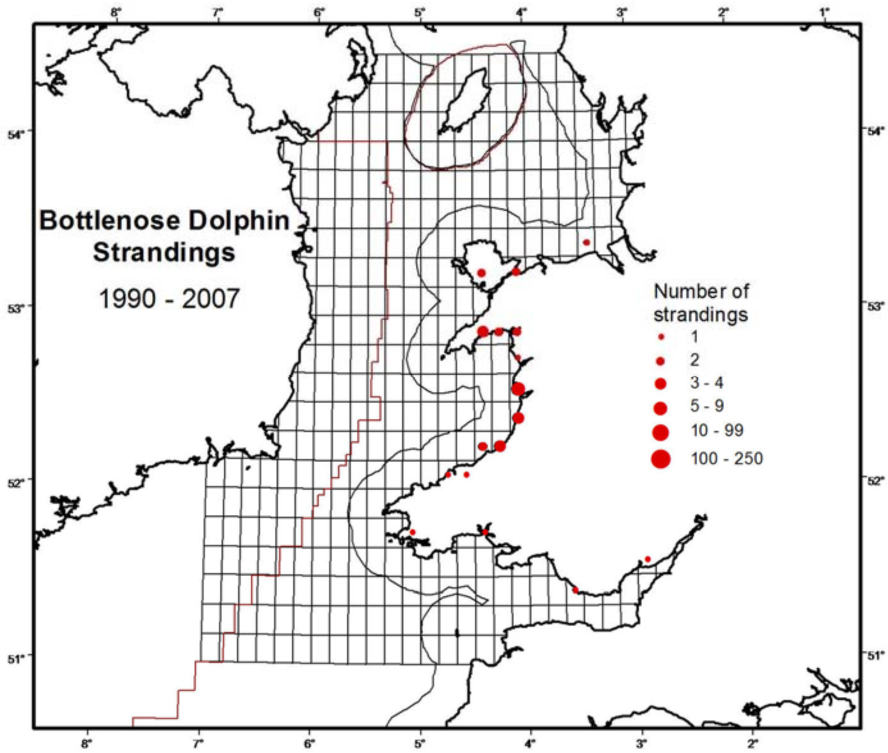


Figure 19 – Distribution of strandings of bottlenose dolphin on the coasts of Wales

3.4 Short-beaked common dolphin *Delphinus delphis*

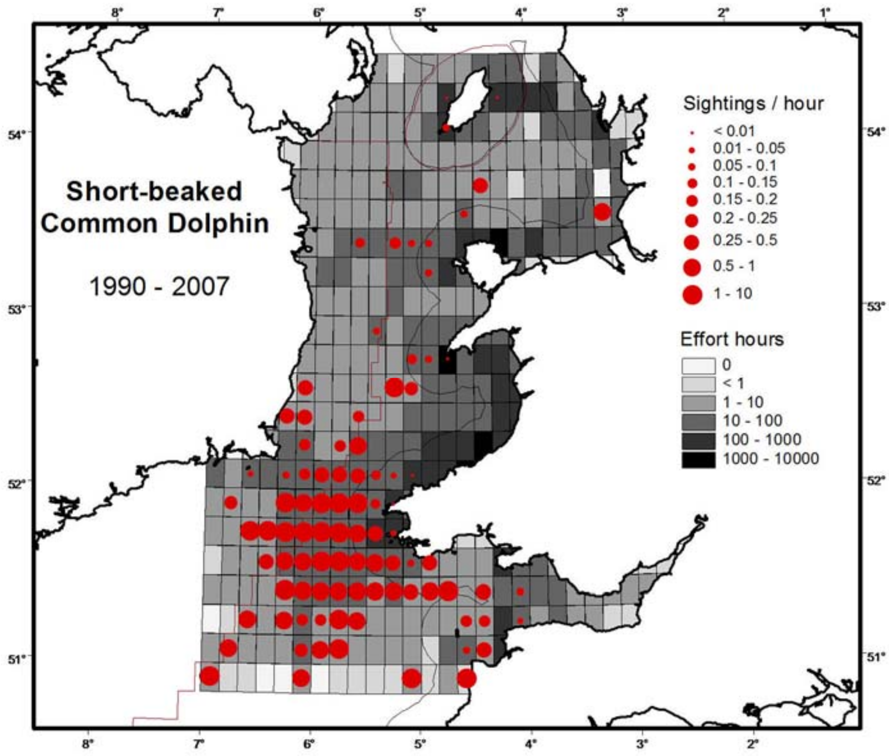
There is a clearly defined area of high sightings rates of common dolphins over the Celtic Deep, offshore to the west of Pembrokeshire. This high density area straddles the median line, although it falls largely on the Welsh side and extends partly within the 12 nm territorial limit of Wales. Moderately high densities have been recorded over the Celtic Shelf in the southwest of the study area, whereas only low densities occur through the Irish Sea (Figure 20). This southerly concentration for the species within the region is the case for all four time periods examined (Figure 21).

The maps of monthly and quarterly mean sightings rates indicate that common dolphins are mainly summer visitors to the study area, largely moving away to the southwest from December to April, although they have been recorded in the area in every month of the year, and one should note that effort in winter remains low (Figures 22 & 23).

Proportions of juveniles amongst sightings are highest in the months of July and August (Figure 24), which is when group sizes are also greatest, suggesting a post-breeding coalition of family groups (see also Evans *et al*., 2003).

Second to the harbour porpoise, the common dolphin is the most common cetacean species recorded stranding on the Welsh coasts. Most strandings occur in Pembrokeshire and along the southern Cardigan Bay coast (Figure 25a), mirroring the overall distribution of sightings, particularly bearing in mind the prevailing currents from the SSW. For a number of stranded specimens, it was not possible to determine with certainty whether the species was *Delphinus delphis* or the similar striped dolphin *Stenella coeruleoalba*. Thus we have also plotted the distribution of strandings of all *Delphinus* and *Stenella* dolphins, including those unidentified specimens (Figure 25b). The results are generally similar, with most strandings in Pembrokeshire and Cardigan Bay, but with slightly more further north and east than for definite common dolphin strandings.

a) Long-term mean sightings rate



b) Interpolated long-term mean sightings rate

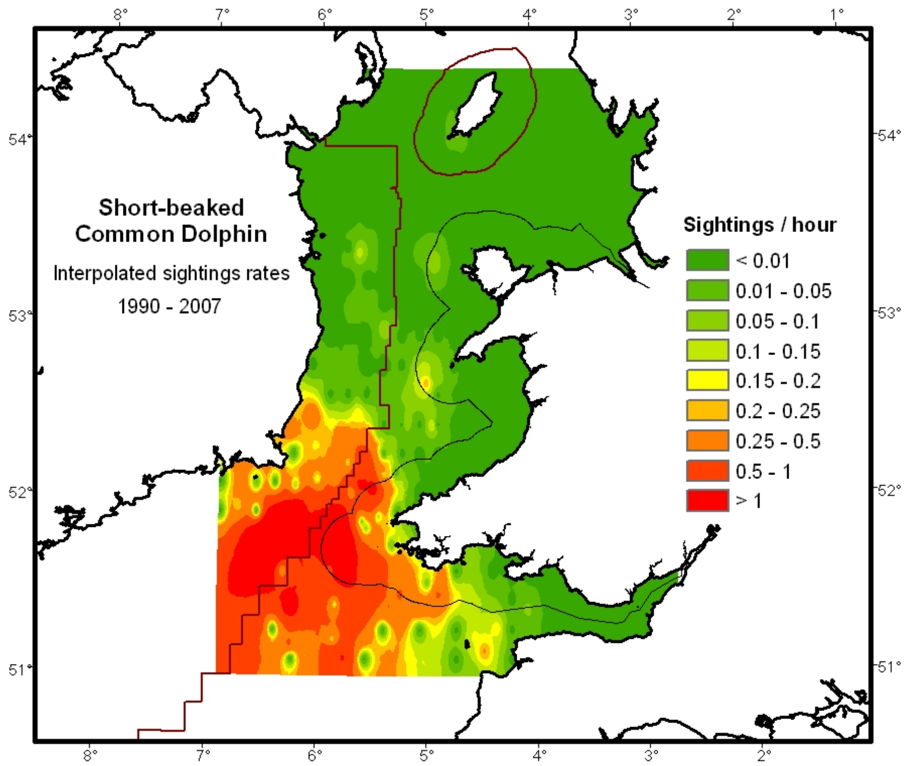


Figure 20 – Long-term sightings rates (sightings per hour) of common dolphins

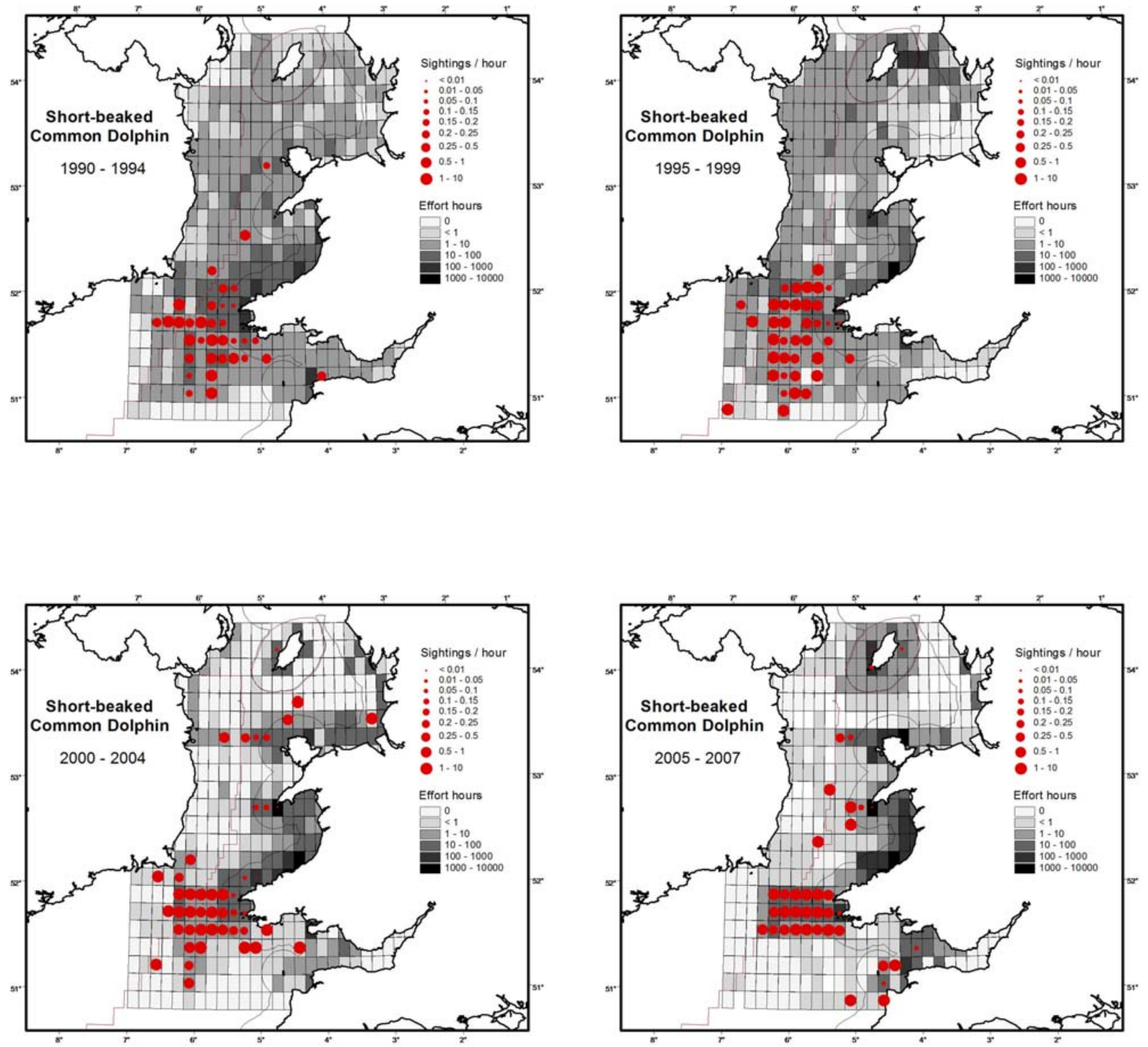


Figure 21 – Mean sightings rates of common dolphin for the time periods 1990-94, 1995-99, 2000-04, and 2005-07

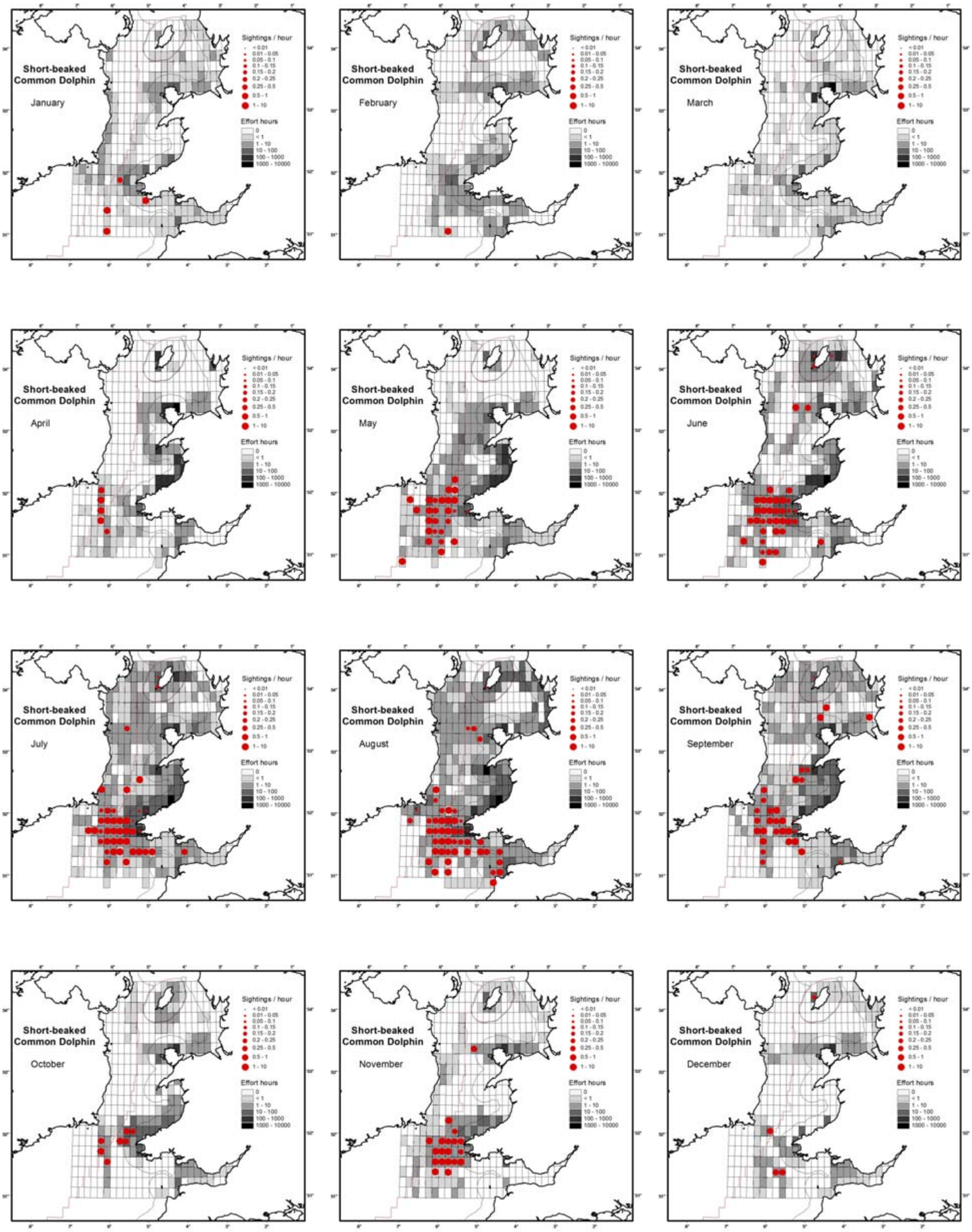


Figure 22 – Long term monthly mean sightings rates of common dolphin

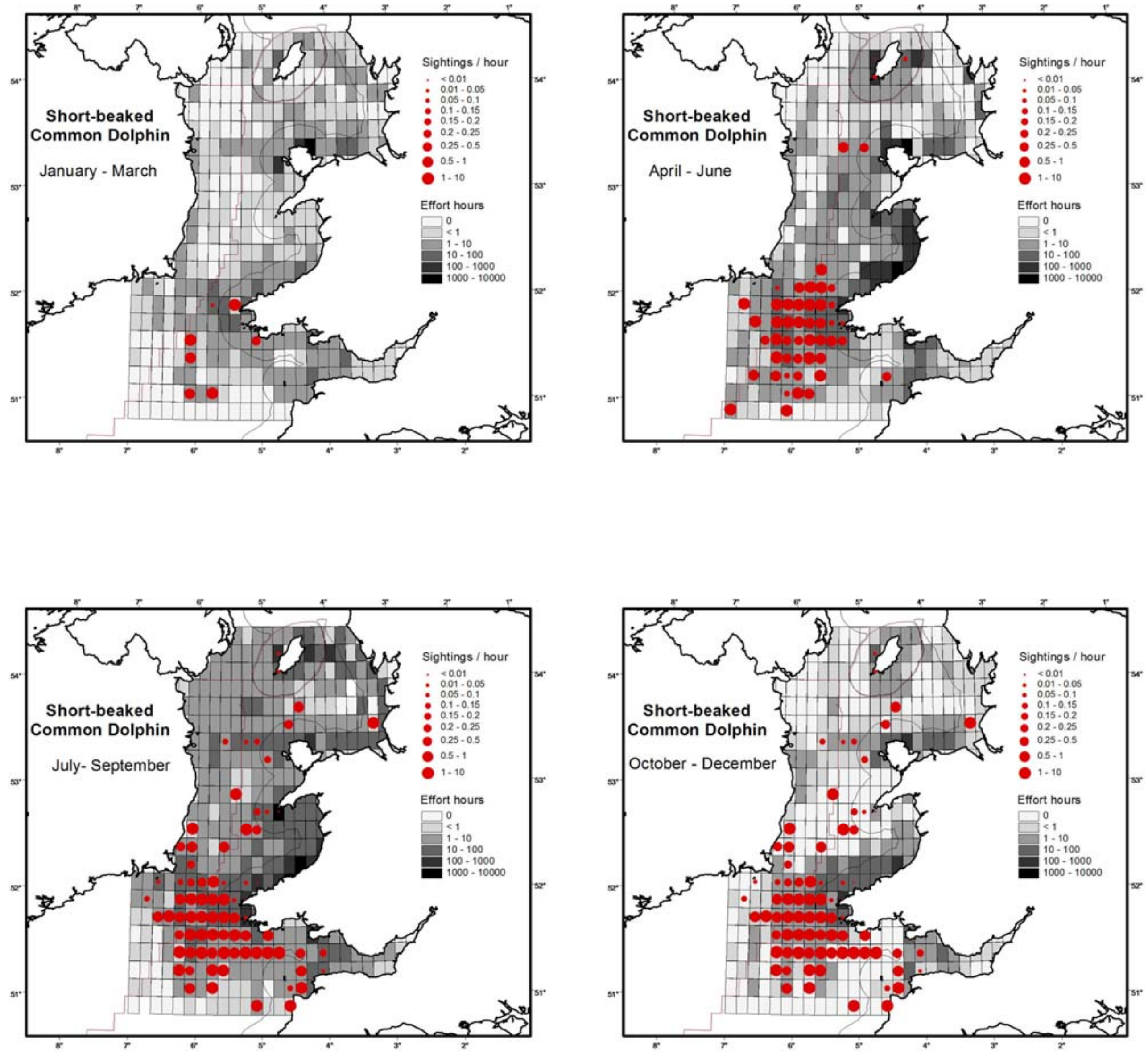


Figure 23 – Long term quarterly mean sightings rates of common dolphin

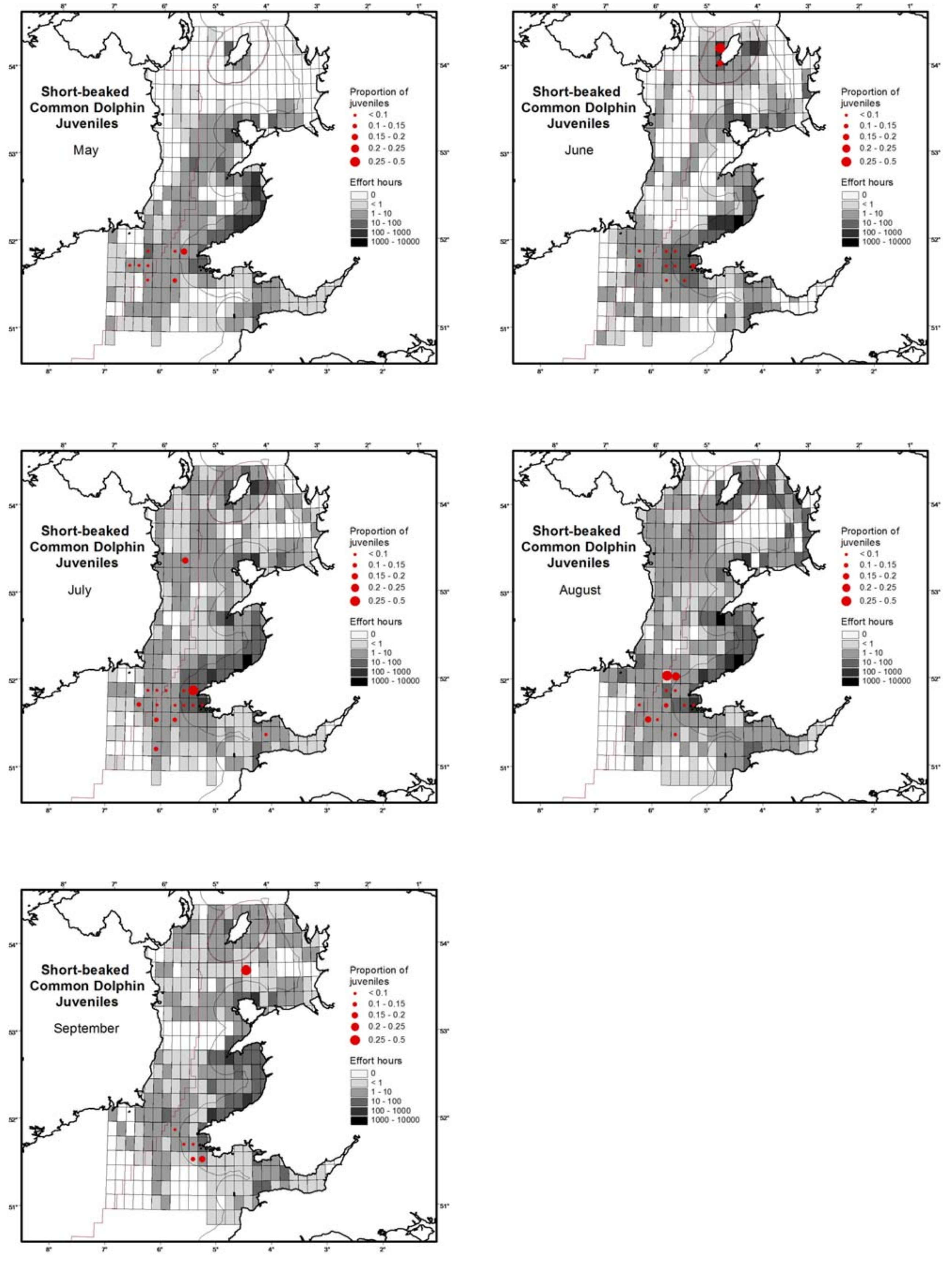


Figure 24 – Long term mean monthly ratio of juveniles to adults of common dolphin

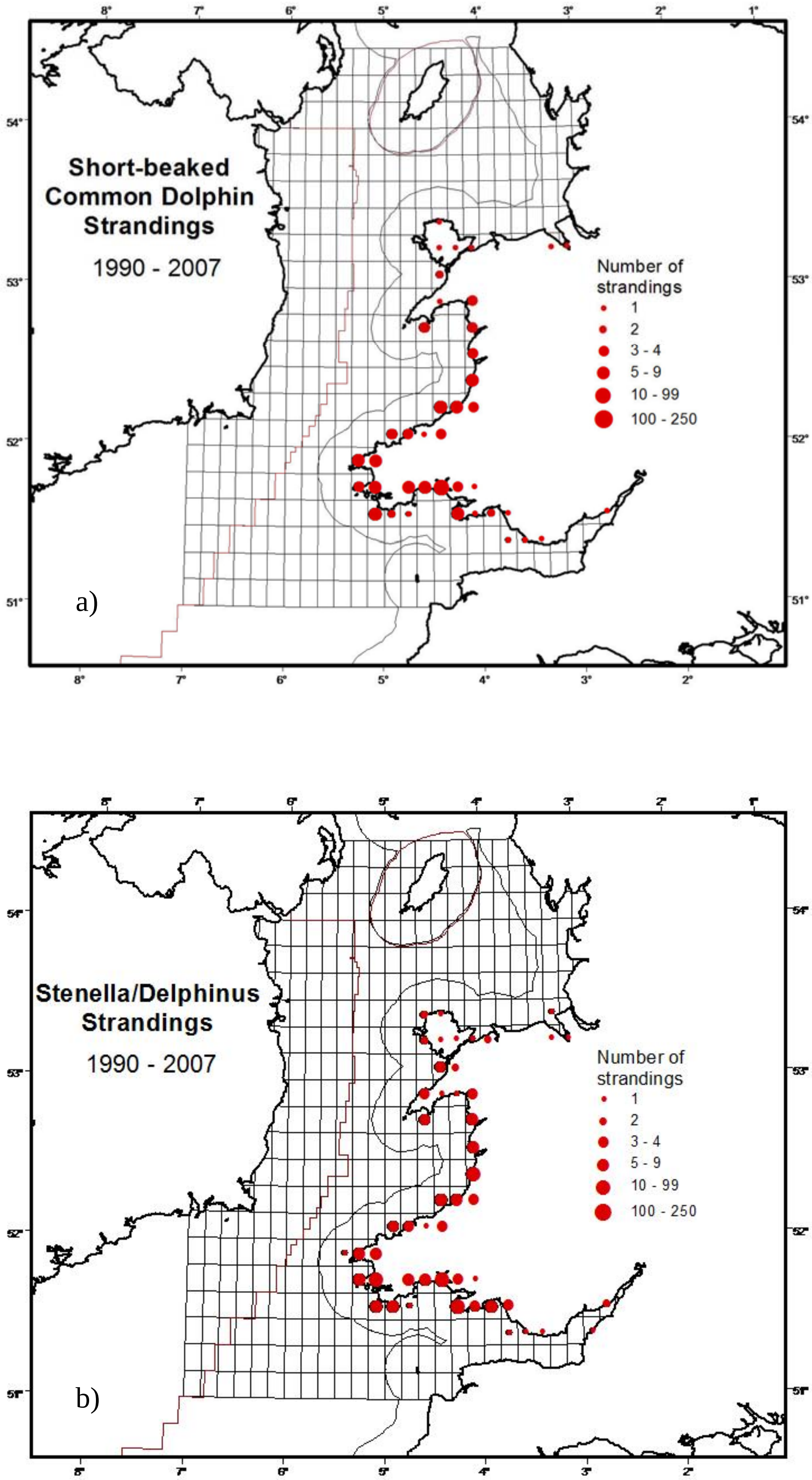


Figure 25 – Distribution of strandings of a) common dolphins and b) all *Stenella* and *Delphinus* dolphins on the coasts of Wales

3.5 Risso's dolphin *Grampus griseus*

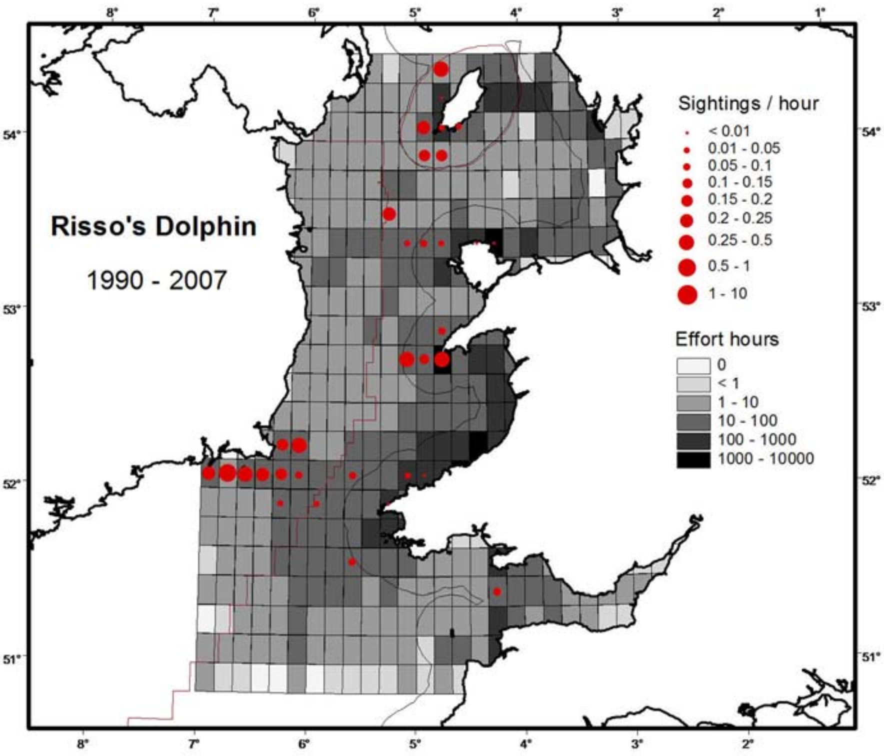
Within the 12 nm territorial limit of Wales, the highest density of sightings rates has been in the area of Bardsey Island off the western end of the Lleyn Peninsula. A second coastal area with lower sightings rates is located in north Pembrokeshire, whilst elsewhere the species has been recorded to the north-west and north of Anglesey up to the Isle of Man, as well as off south-east Ireland and St George's Channel (Figure 26). Together, these form a broad band of occurrence through the Irish Sea on a SW-NE axis. Bearing in mind variation in effort, the species has had similar spatial distributions for each of the four time periods (Figure 27).

Risso's dolphin is mainly a summer and autumn visitor to the study area, with the highest sightings rates in the period July to September, but some indication of a more westerly distribution (for example, around South-east Ireland and the Isle of Man) in April to June (Figures 28 & 29). Numbers visiting Welsh coastal waters can vary a large amount from year to year.

In Welsh waters, young have been recorded mainly in the vicinity of Bardsey Island, but also off Pembrokeshire and Anglesey, between July and September (Figure 30). Elsewhere, young have been seen in spring and early summer in Manx waters.

Strandings of Risso's dolphins have occurred in small numbers throughout western Wales, from Pembrokeshire in the south to Anglesey in the north (Figure 31).

a) Long-term mean sightings rate



b) Interpolated long-term mean sightings rate

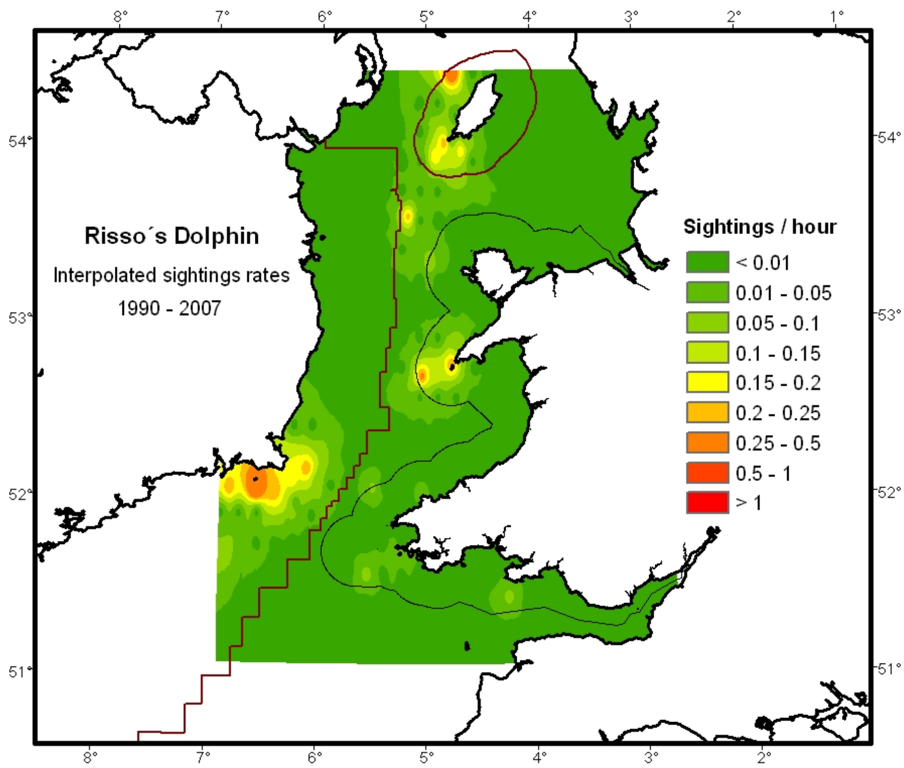


Figure 26 – Long-term sightings rates (sightings per hour) of Risso's dolphin

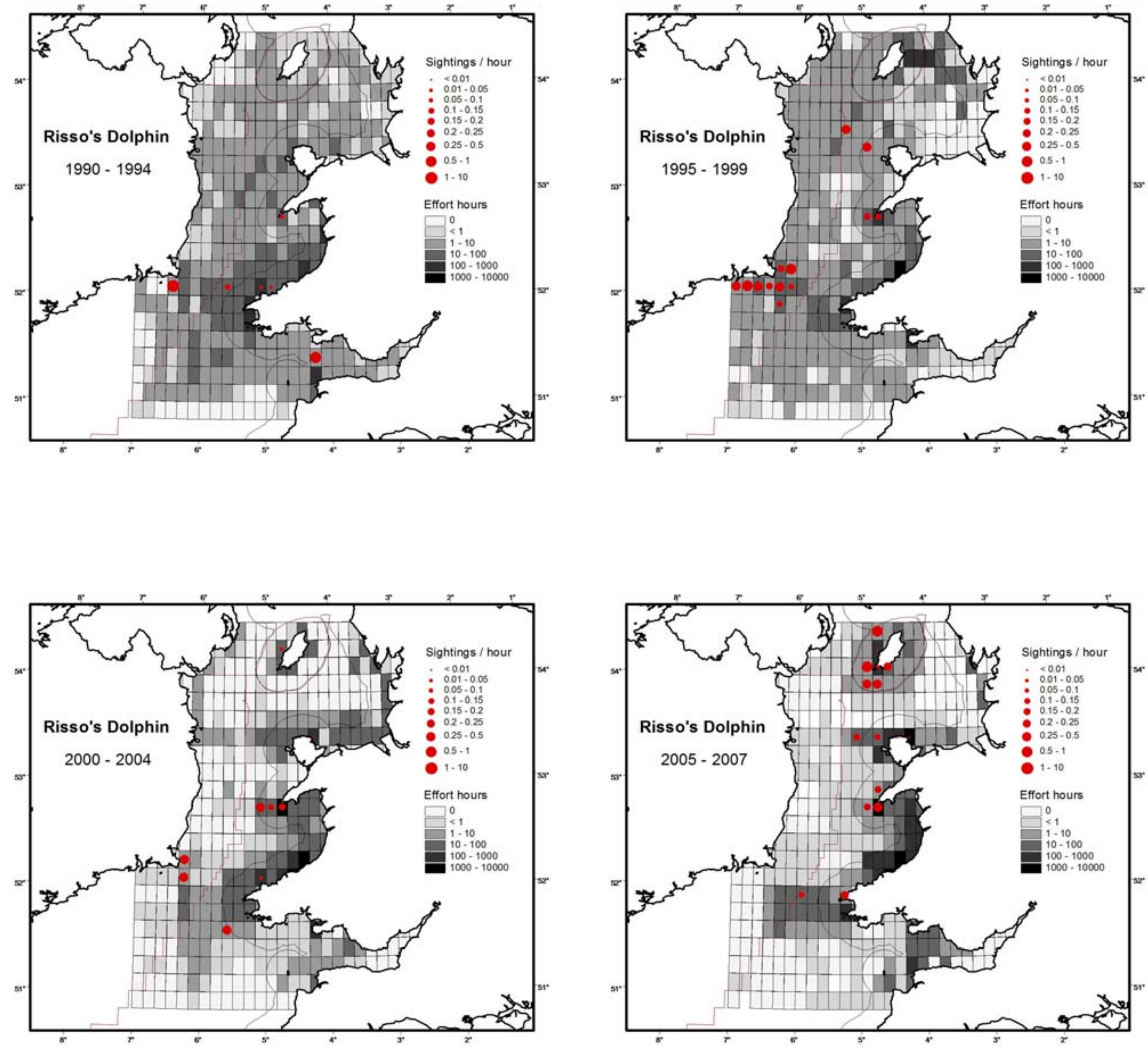


Figure 27 – Mean sightings rates of Risso's dolphin for the time periods 1990-94, 1995-99, 2000-04, and 2005-07

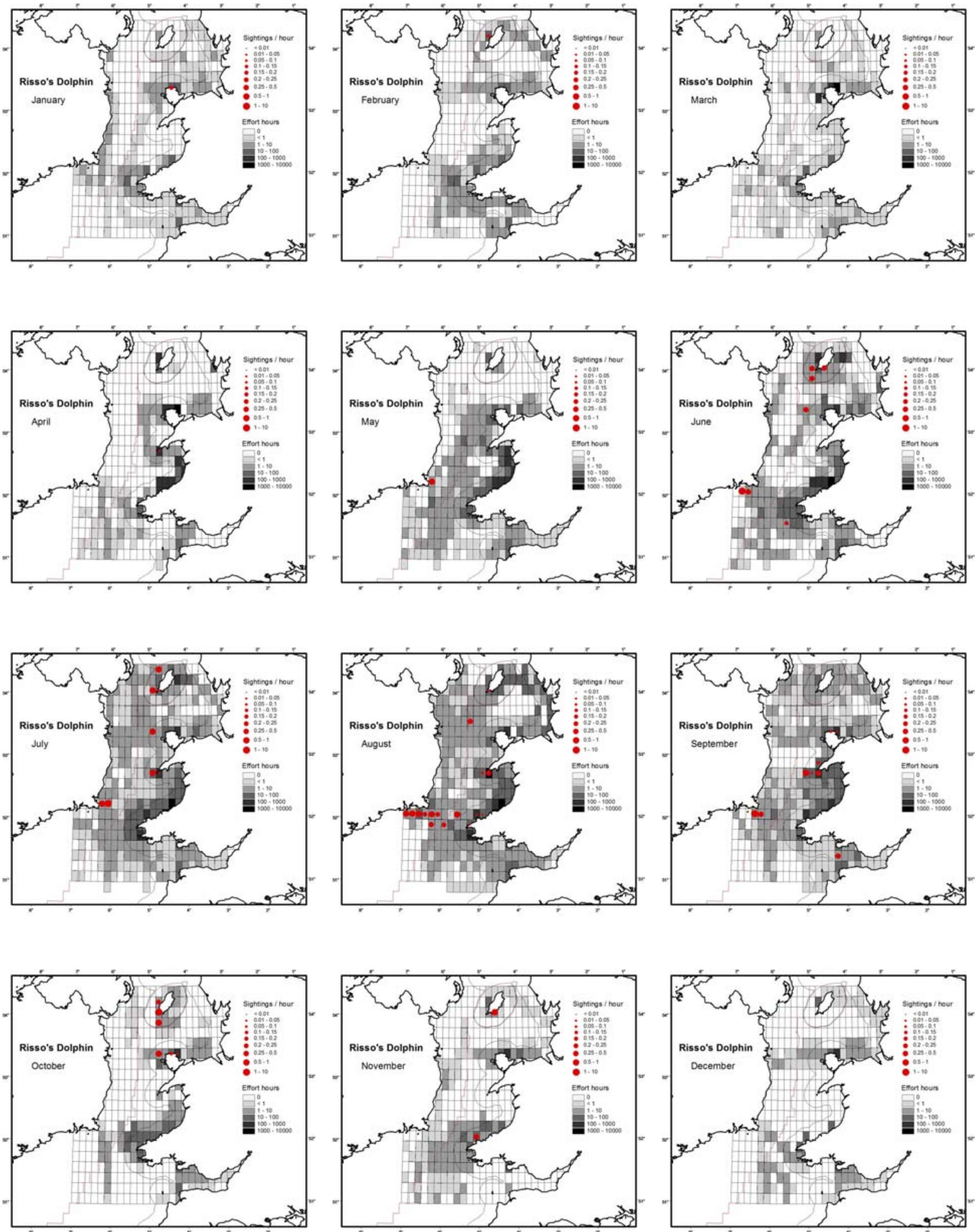


Figure 28 – Long term monthly mean sightings rates of Risso's dolphin

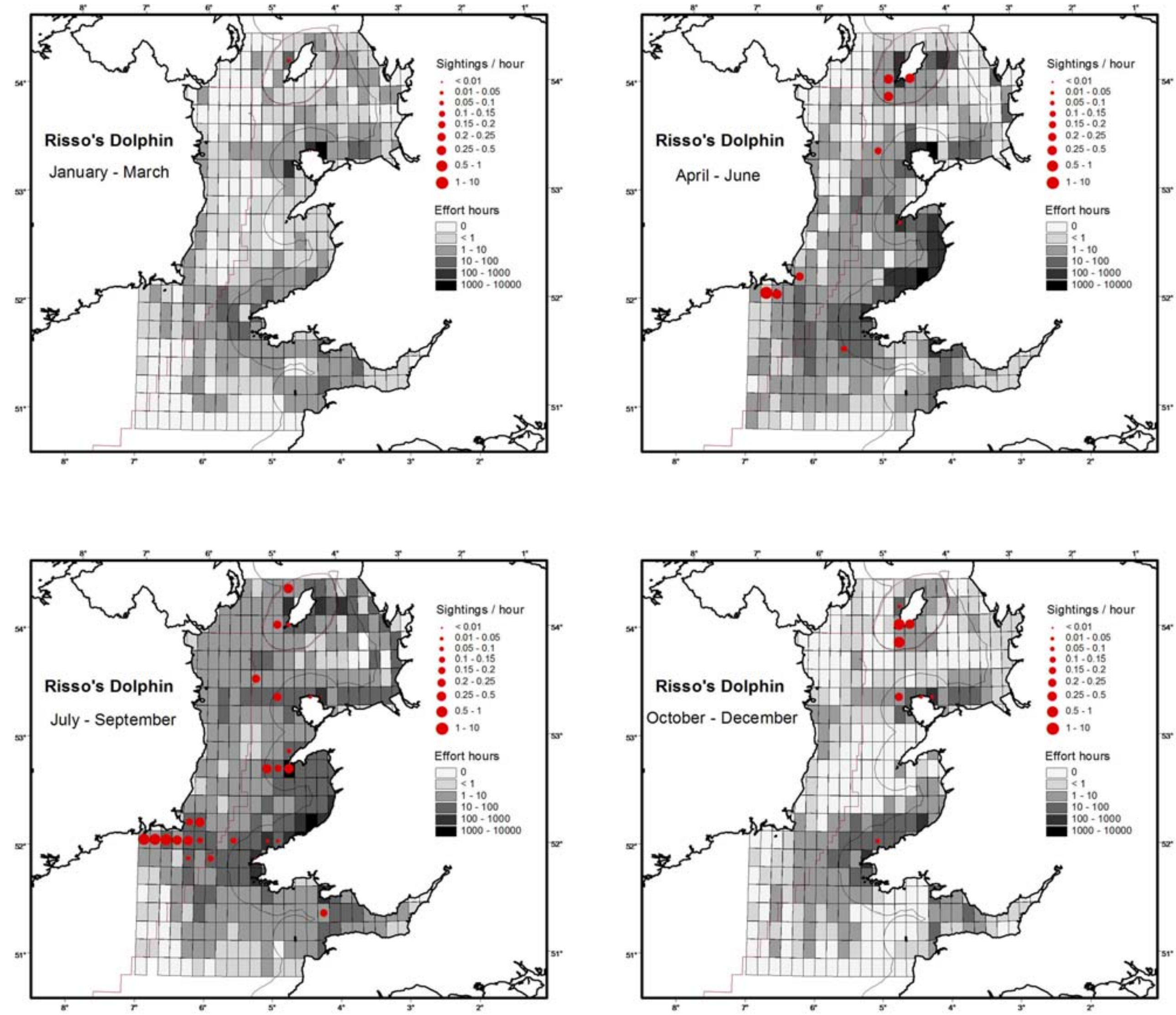


Figure 29 – Long term quarterly mean sightings rates of Risso’s dolphin

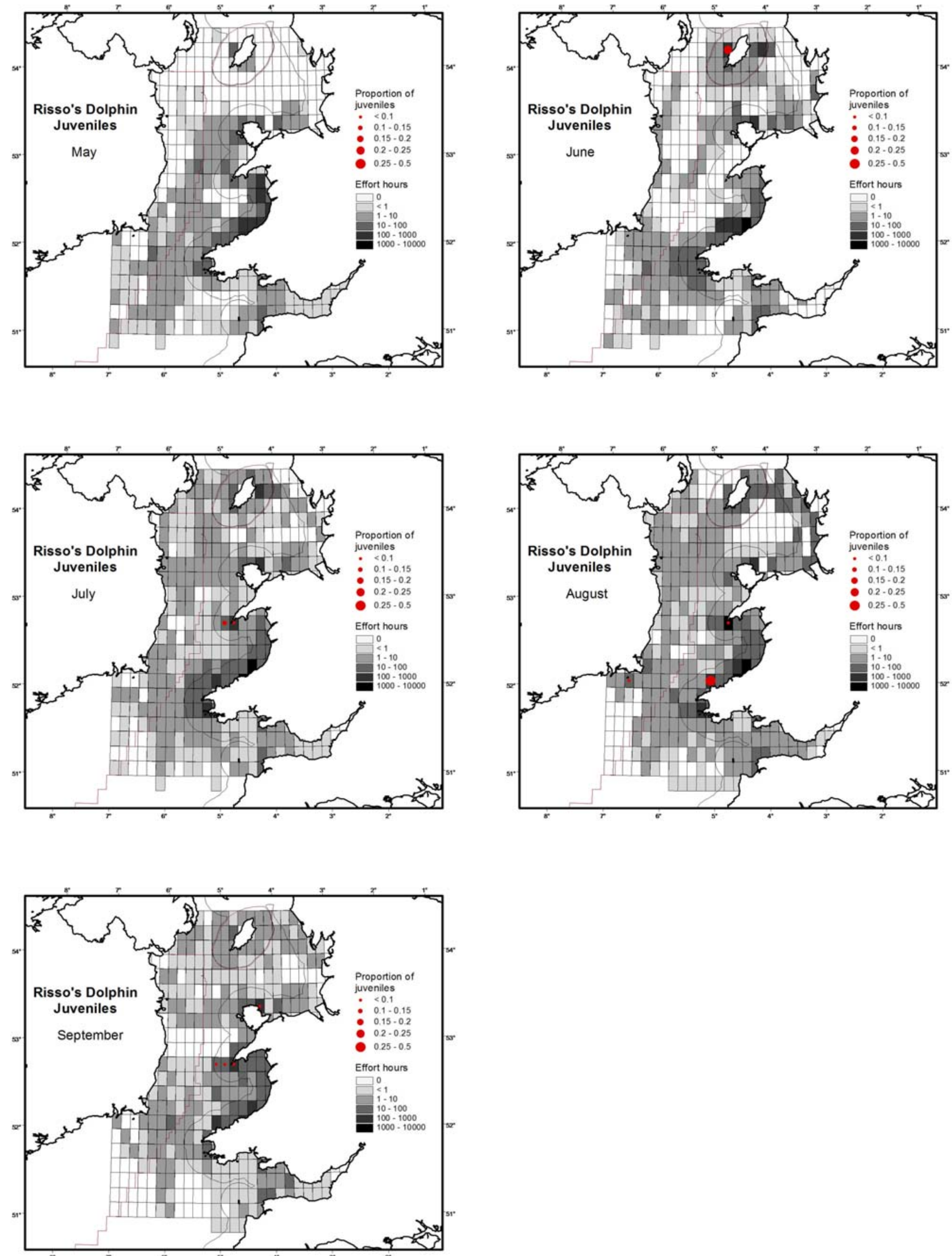


Figure 30 – Long term mean monthly ratio of juveniles to adults of Risso's dolphin

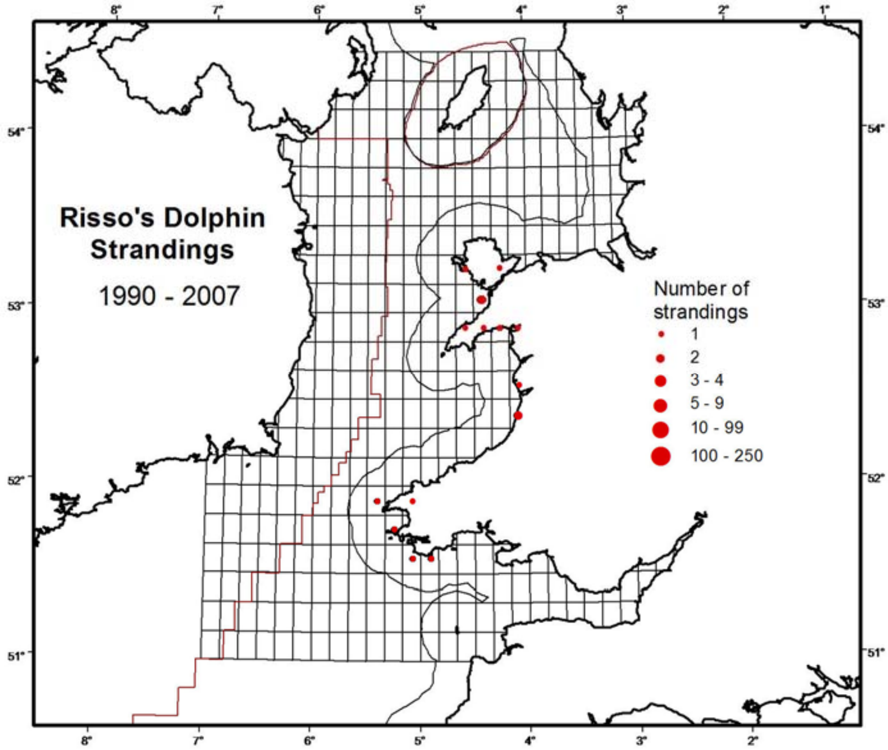


Figure 31 – Distribution of strandings of Risso's dolphin on the coasts of Wales

3.6 Minke whale *Balaenoptera acutorostrata*

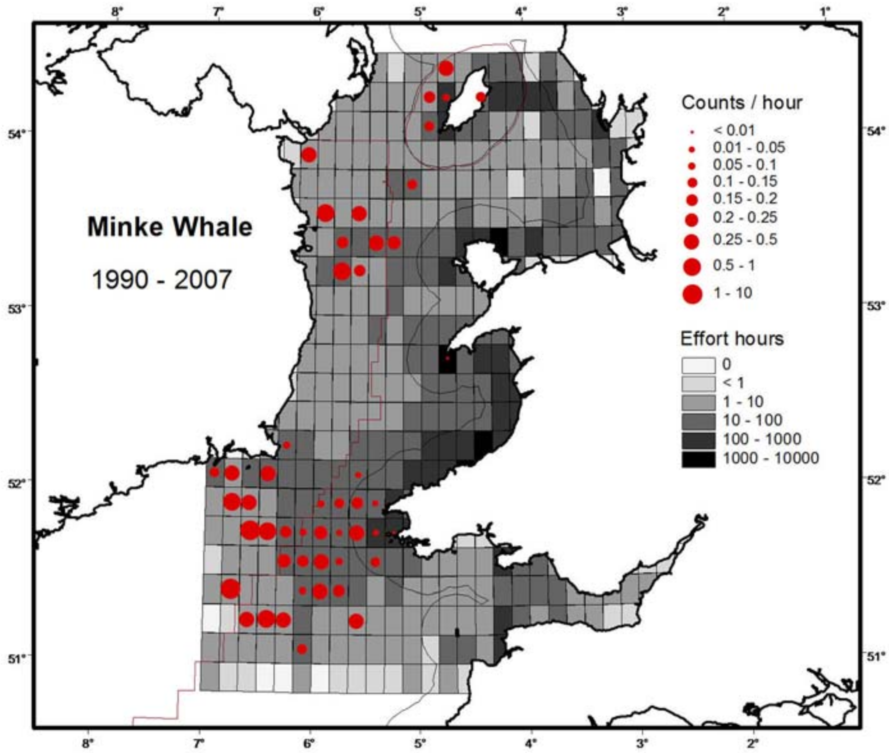
This species has a predominantly offshore distribution with the highest densities of sightings rates in the south-west of the study area over the Celtic Shelf. Within the 12 nm territorial limit of Wales, minke whales have been recorded predominantly to the west of Pembrokeshire (Figure 32). However, effort further north has been relatively low, and there is a cluster of sightings offshore in the triangle bounded by Anglesey, the east coast of Ireland and the Isle of Man. Distribution patterns for the species are similar for the four time periods under analysis (Figure 33).

Sightings rates are highest between April and September; outside this period, sightings are low (particularly for the northern part of the Irish Sea) (Figures 34 & 35). This fits with findings in other parts of the UK where the species becomes rare during winter months, apparently largely moving offshore (Evans *et al*., 2003; Anderwald and Evans, 2008).

Minke whale calves are born during winter months, presumably mainly outside the region, and so most sightings of juveniles are of uncertain age It is therefore not meaningful to plot proportions of juveniles to adults.

Only a few strandings of the species have occurred on the Welsh coasts, and these are distributed widely over the region with no particular area of concentration (Figure 36).

a) Long-term mean sightings rate



b) Interpolated long-term mean sightings rate

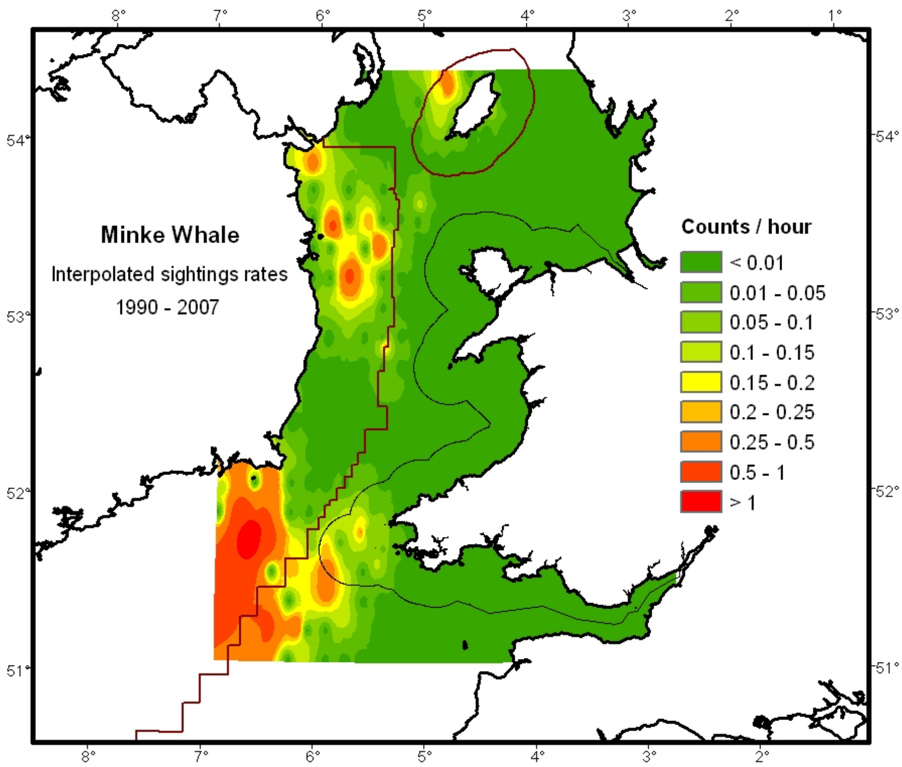


Figure 32 – Long term sightings rates (sightings per hour) of minke whale

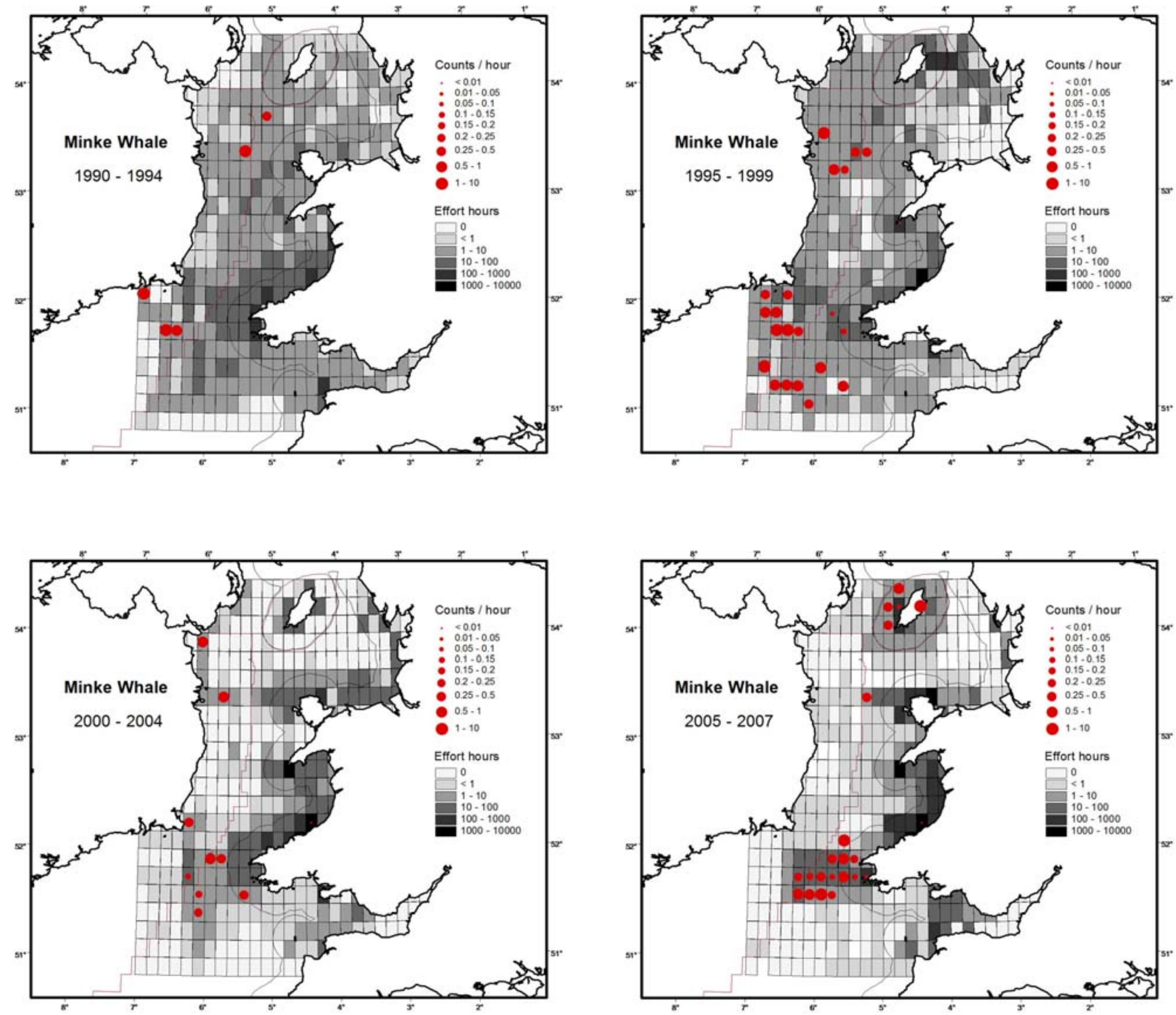


Figure 33 - Mean sighting rates of minke whale for the time periods 1990-94, 1995-99, 2000-04, and 2005-07

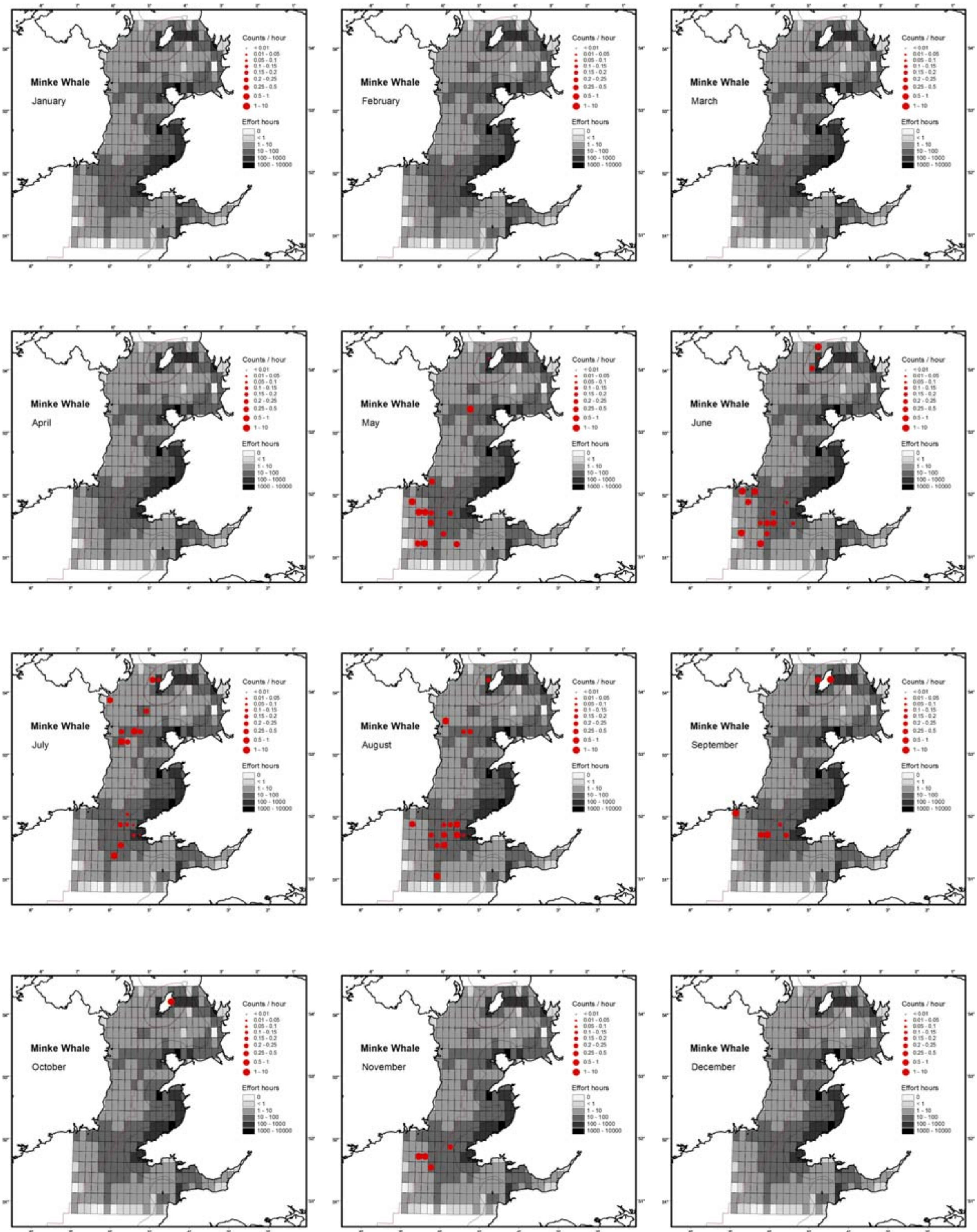


Figure 34 - Long term mean monthly sightings rates of minke whale

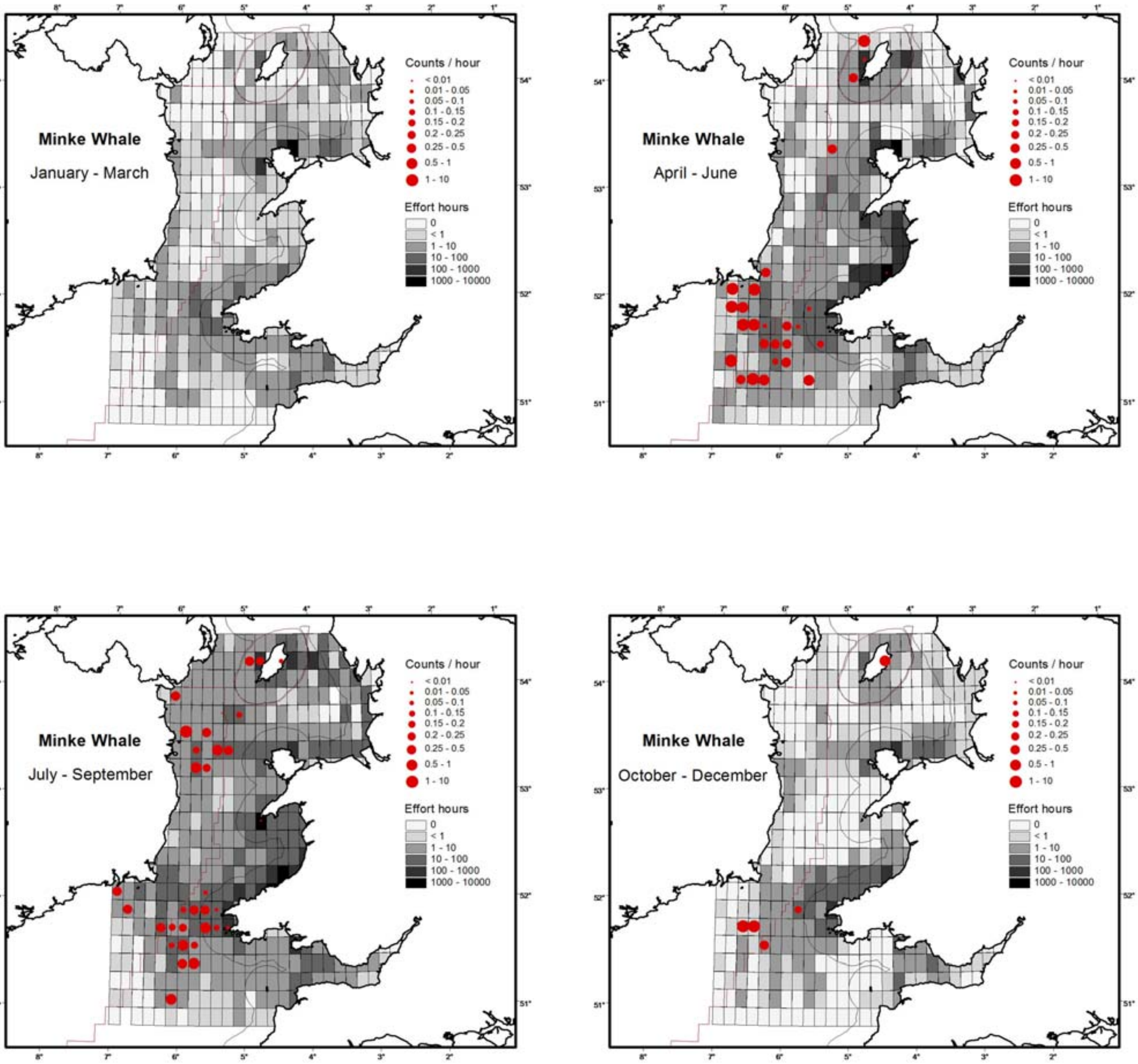


Figure 35 – Long term quarterly mean sightings rates of minke whale

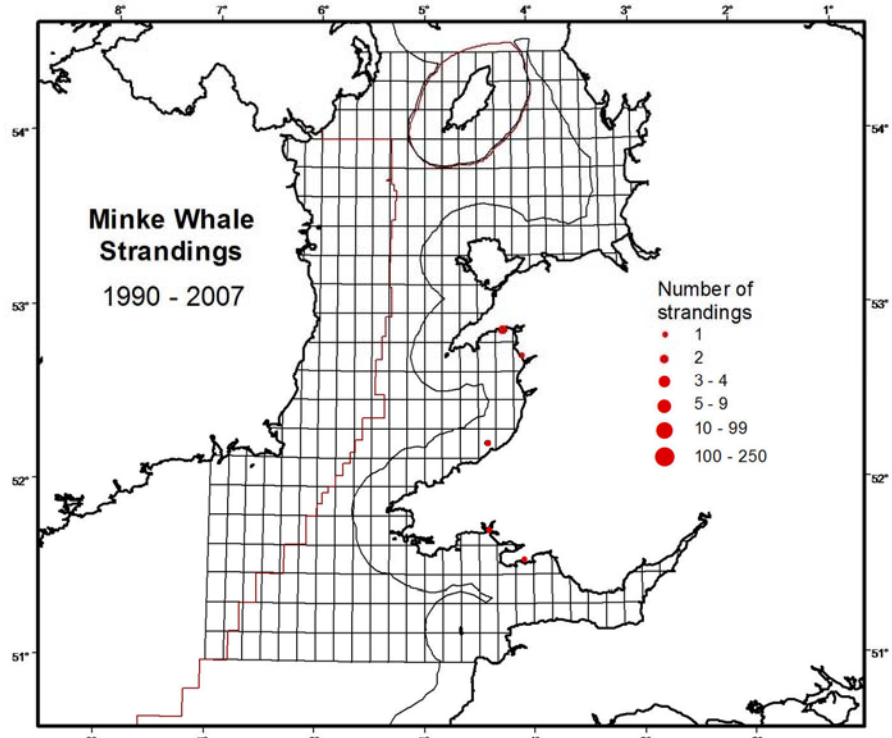


Figure 36 – Distribution of strandings of minke whale on the coasts of Wales

3.7 Other Cetacean Species

A further thirteen cetacean species have been recorded since 1990 in Welsh waters. These are: fin whale, sei whale, humpback whale, pygmy sperm whale, northern bottlenose whale, Cuvier's beaked whale, Sowerby's beaked whale, Blainville's beaked whale, long-finned pilot whale, killer whale, striped dolphin, white-beaked dolphin, and Atlantic white-sided dolphin Table 19 lists the number of sightings and individuals contained within the project database (from all the effort-based observations analysed here); Table 20 summarises the total numbers within the Sea Watch database (which includes both effort-related and casual observations) and Table 21 lists stranding from the Welsh coast. Maps of the distribution of strandings, and/or sightings of the rarer species from the project database, are included in the Appendix.

Table 19 - Summary of species in the project Database

Species	Sightings	Count of Individuals
Identified cetaceans		
Harbour porpoise	10,592	29,318
Bottlenose dolphin	10,006	31,876
Short-beaked common dolphin	1,104	15,028
Risso's dolphin	557	1,300
Minke whale	139	169
Fin whale	8	17
Killer whale	5	11
White-beaked dolphin	4	9
Atlantic white-sided dolphin	3	64
Long-finned pilot whale	2	3
Humpback whale	1	3
Northern bottlenose whale	1	1
Unidentified cetaceans		
Dolphin species	147	470
Cetacean species	137	286
Large whale	13	17
Unidentified small whale	13	17
Unidentified whale	6	6
Patterned dolphin species	2	8
Common / striped dolphin	2	53
Fin / sei whale	1	2
Seals		
Grey seal	2,586	3,424

Table 20 - Summary of all sightings data (effort + non-effort) in Sea Watch database for study area and time period under review

Species	Sightings	Counts of Individuals
Harbour porpoise	10,319	45,189
Bottlenose dolphin	5,489	28,151
Short-beaked common dolphin	1,643	22,769
Risso's dolphin	495	2,244
Minke whale	396	554
Killer whale	39	74
Fin whale	37	95
Long-finned pilot whale	19	115
Atlantic white-sided dolphin	5	65
Humpback whale	5	10
Striped dolphin	4	11
Northern bottlenose whale	3	4
White-beaked dolphin	2	9
Sei whale	1	1

Table 21 - Summary of stranding on the coasts of Wales

Species	Number
Identified cetaceans	
Harbour porpoise	1,312
Short-beaked common dolphin	126
Bottlenose dolphin	36
Striped dolphin	33
Long-finned pilot whale	18
Risso's dolphin	16
Minke whale	6
Atlantic white-sided dolphin	4
Fin whale	4
Sowerby's beaked whale	2
Blainville's beaked whale	1
Cuvier's beaked whale	1
Humpback whale	1
Northern bottlenose whale	1
Pygmy sperm whale	1
Unidentified cetaceans	
Cetacean species	122
Common / striped dolphin	29
Dolphin species	10
Beaked whale species	1

3.8 Cetacean Species Diversity

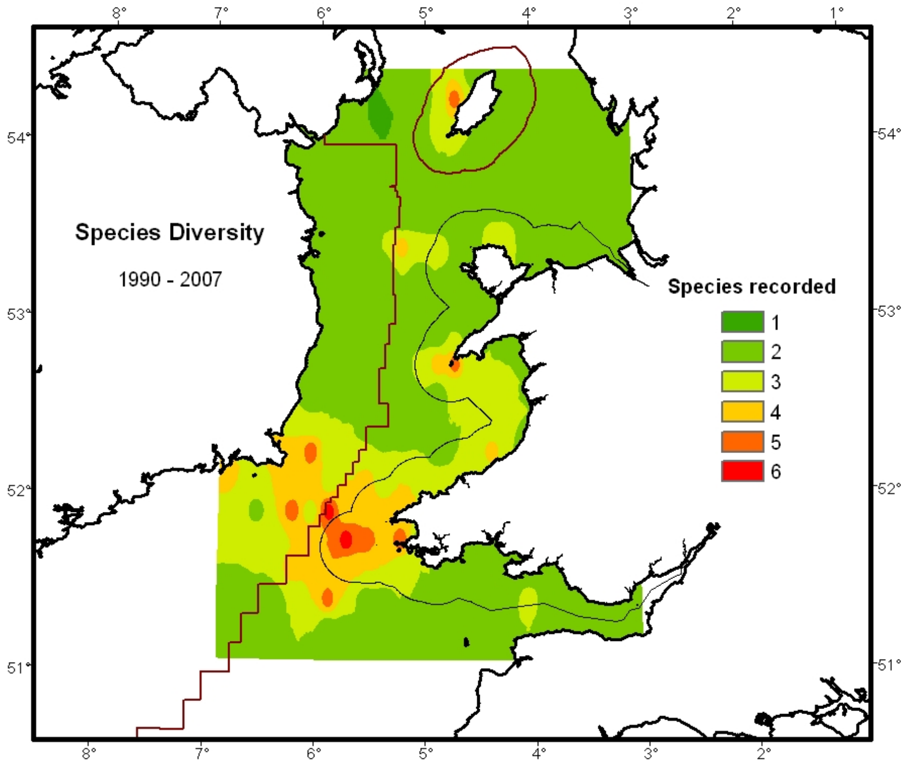


Figure 37 – Interpolated map of the number of cetacean species recorded per cell 1990 – 2007

The project database includes only effort related data and therefore some occasional sightings of rarer species, such as beaked whales are not included. Nevertheless, Figure 37 indicates those areas in which the highest diversity of cetacean species has been recorded. The main area of high diversity stretches in a band across St George's Channel, with the highest levels on the edge of the Celtic Deep. A smaller area of high diversity occurs off Bardsey Island at the western end of the Lleyn Peninsula, and further north, off the west coasts of Anglesey and the Isle of Man. All these areas represent the most central areas of the Irish Sea where land protrudes, and probably reflects the role played by the deeper parts of the Irish Sea through which the North Atlantic current flows, and the influence of the Celtic Sea and Irish Sea Fronts (Reid *et al*., 2003).

3.8 **Grey seal** *Halichoerus grypus*

The annual pup production data in Figure 38 are based on counts carried out in Ceredigion and Pembrokeshire in 1992-94 (Baines *et al.*, 1995) and in North Wales in 2002-03 (Westcott and Stringell, 2003, 2004). Although some counts of pup production have been carried out in Pembrokeshire since the 1992-94 census (Strong *et al.*, 2006), these have been at a relatively small number of selected sites, so the earlier data were used to ensure comprehensive spatial coverage. The highest concentration of pup production is centred on Ramsey Island and north-west Pembrokeshire, extending southwards to Skomer Island and northwards to southern Ceredigion. Smaller concentrations in north Wales are located around the Lleyn Peninsula and the coast of Anglesey (the Skerries).

The maps of grey seal sightings (Figure 39) should be interpreted with some caution, because the recording of seals during sightings surveys has been erratic, many observers simply not recording seals when their main target species have been cetaceans. Nevertheless, they show a wide distribution in Welsh seas. Although pup production in Wales is highest in Pembrokeshire, highest sightings rates occur in the north-east of Wales towards Hilbre Island, Cheshire, reflecting the distribution of haul-out sites during the non-breeding season (Figure 40). Note that the dots do not necessarily fall exactly on the locations of haul-outs. They are located in the centres of cells, as in all other maps. Hence the size of each dot is scaled to represent the sum total of all counted haul-outs in each cell. This ensures that precise locations of sensitive sites are not revealed.

The maps of monthly and quarterly mean sightings rates indicate that the species is present in coastal waters throughout the year (Figures 41 & 42). However, probably a better indication of the movements of grey seals comes from the results of radio tagging grey seals at three of the major haul-out sites. In June 2004, the Sea Mammal Research Unit attached Argos satellite (series 7000 SRDL) tags on 19 grey seals: four males and three females on Ramsey Island (Pembs), three males and two females on Bardsey Island (Gwynedd), and two males and five females on Hilbre Island (Cheshire) (B. McConnell, SMRU, *pers. comm.*). The seals were tracked for an average of 141 days (range 76-183 days). The results indicated foraging trips to often very localised areas (Figures 43 & 44). A relatively regional structure to foraging patterns was observed, although with occasional relocation between Wales and Ireland. However, most movement was contained within the Irish Sea (Hammond *et al.*, 2005).

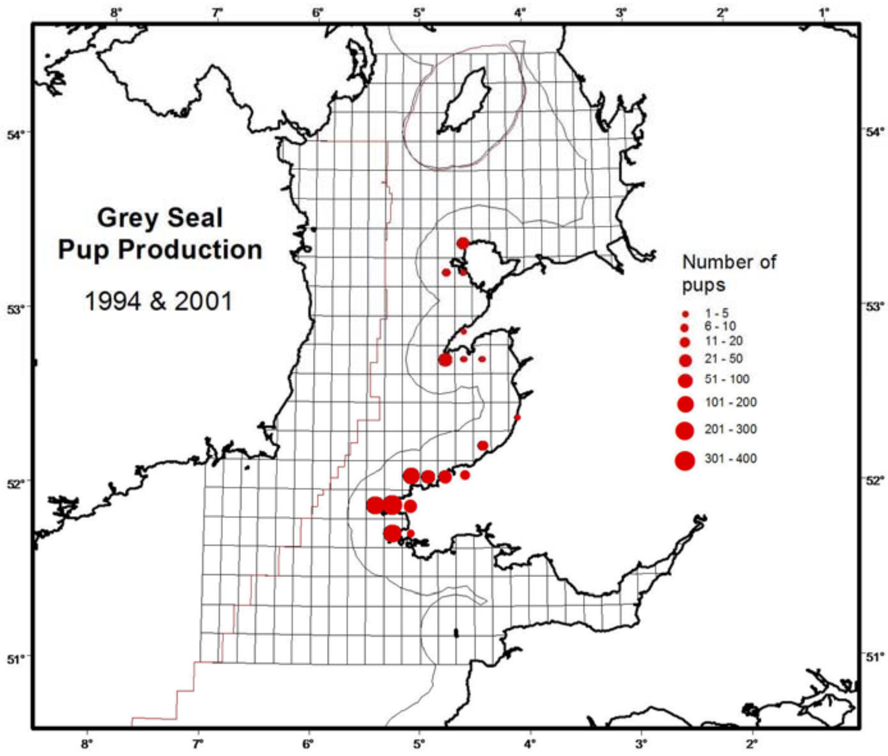


Figure 38 – Grey seal annual pup production in Wales

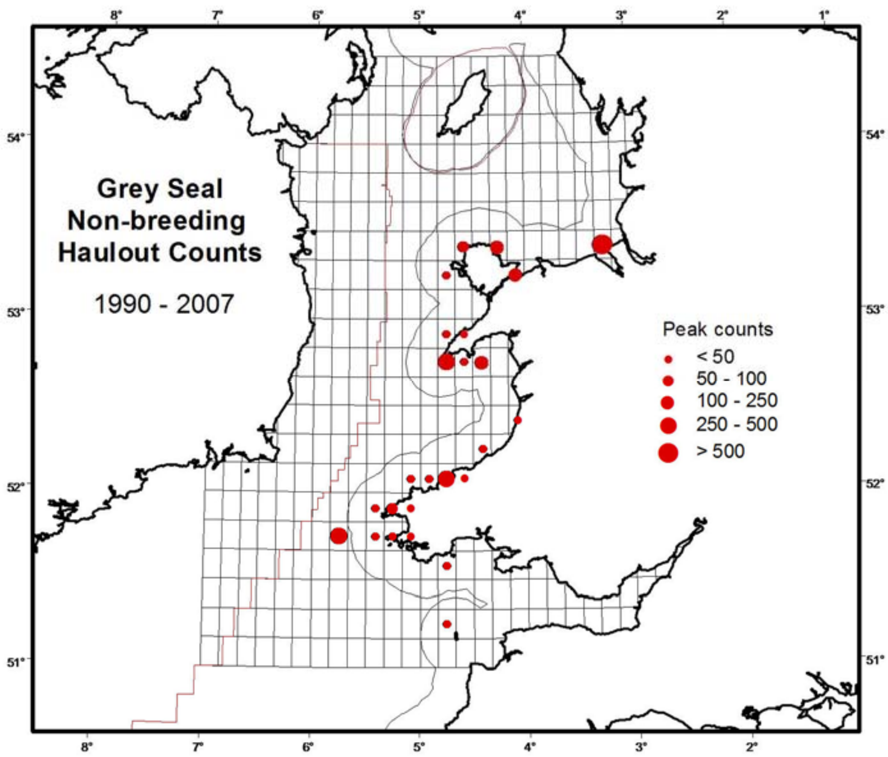
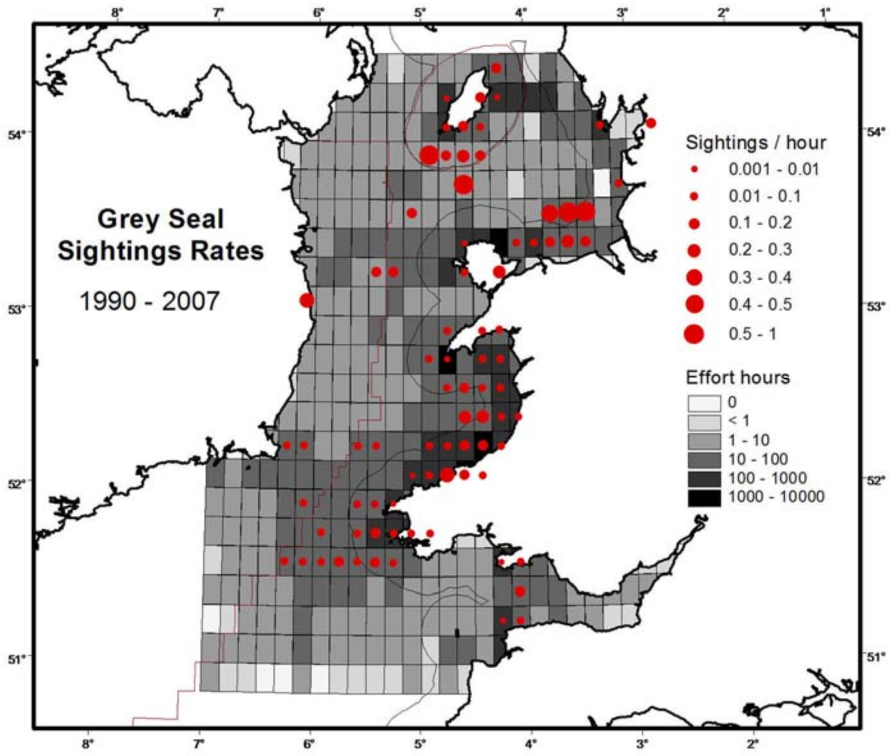


Figure 39 – Counts at grey seal haul-out sites in Wales during non-breeding season

a) Long-term mean sightings rates



b) Interpolated long-term mean sightings rates

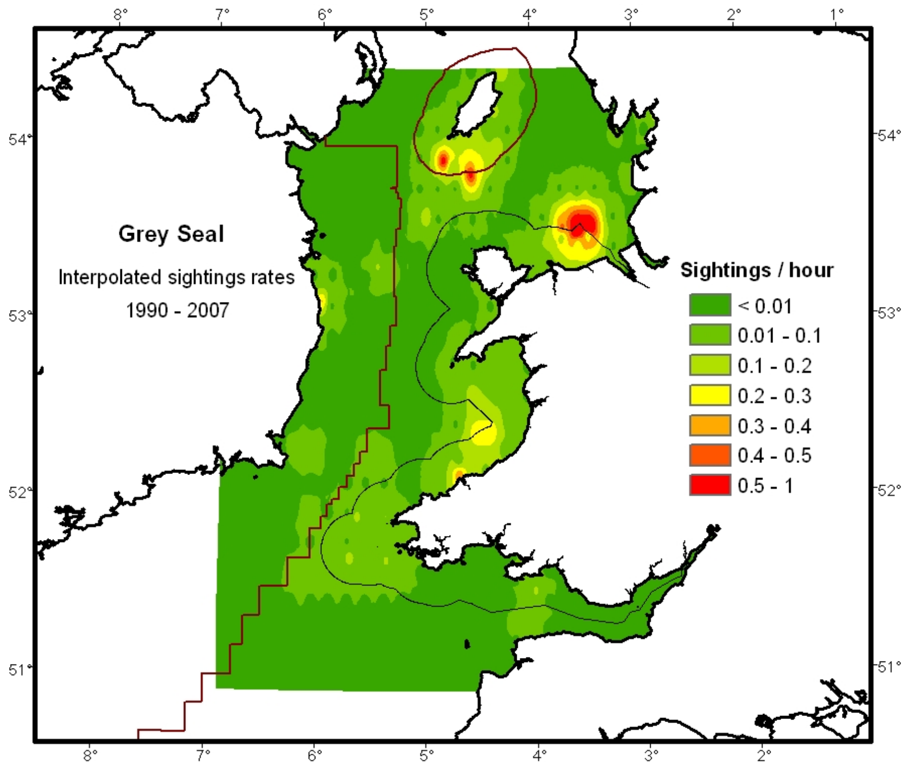


Figure 40 – Sightings rates of grey seals 1990 – 2007

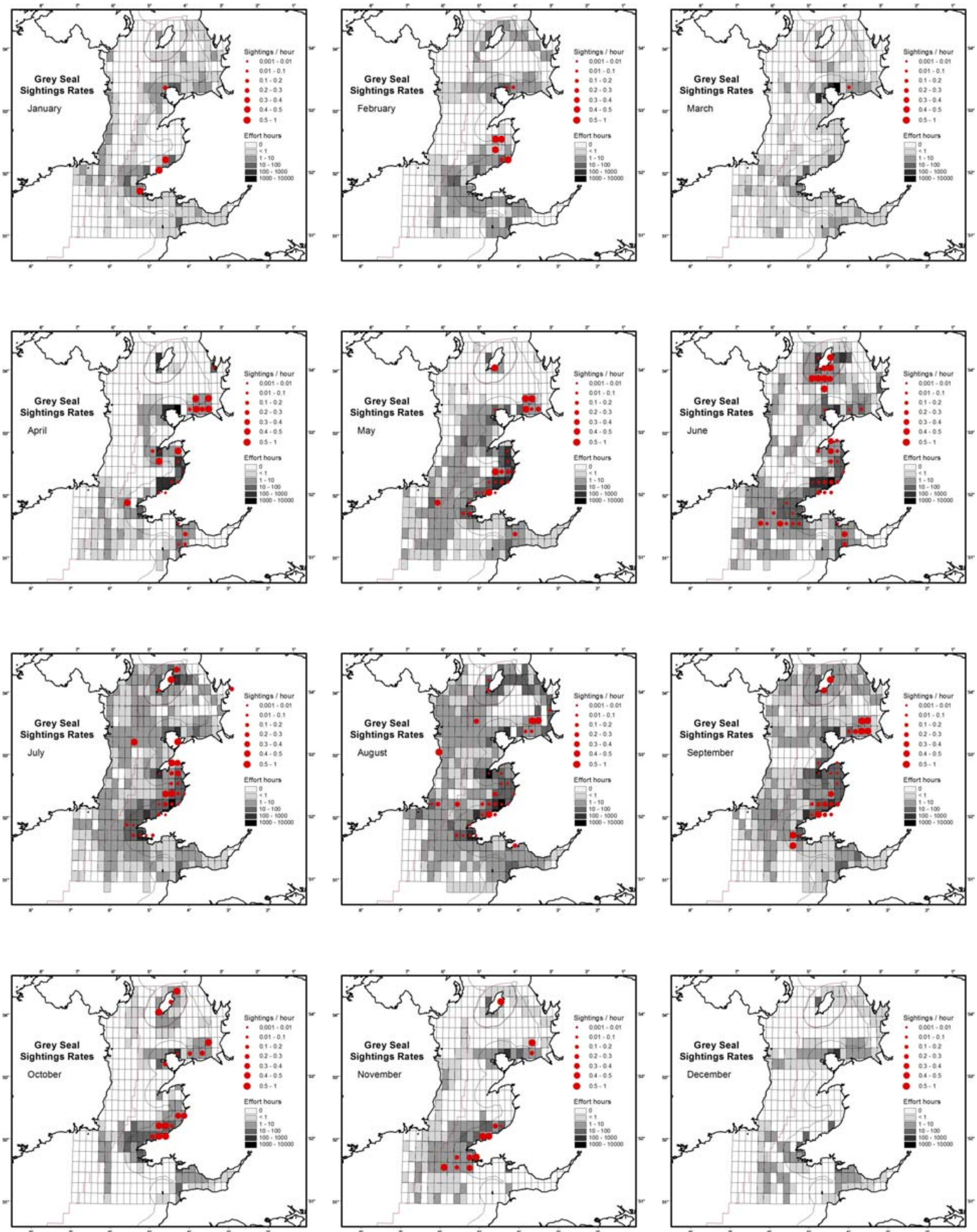


Figure 41 – Long term monthly mean sightings rates of grey seal

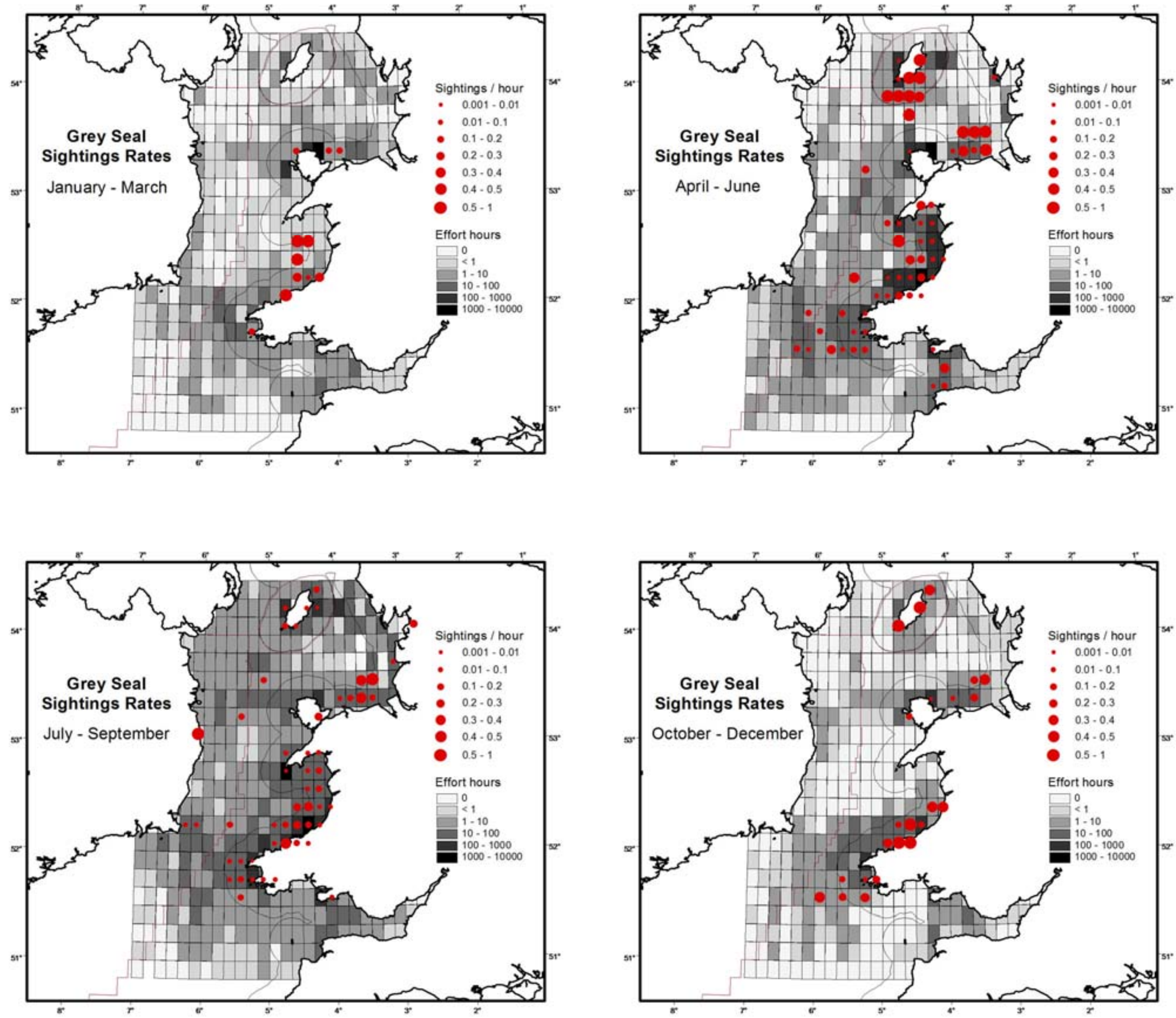


Figure 42 – Long term quarterly mean sightings rates of grey seal

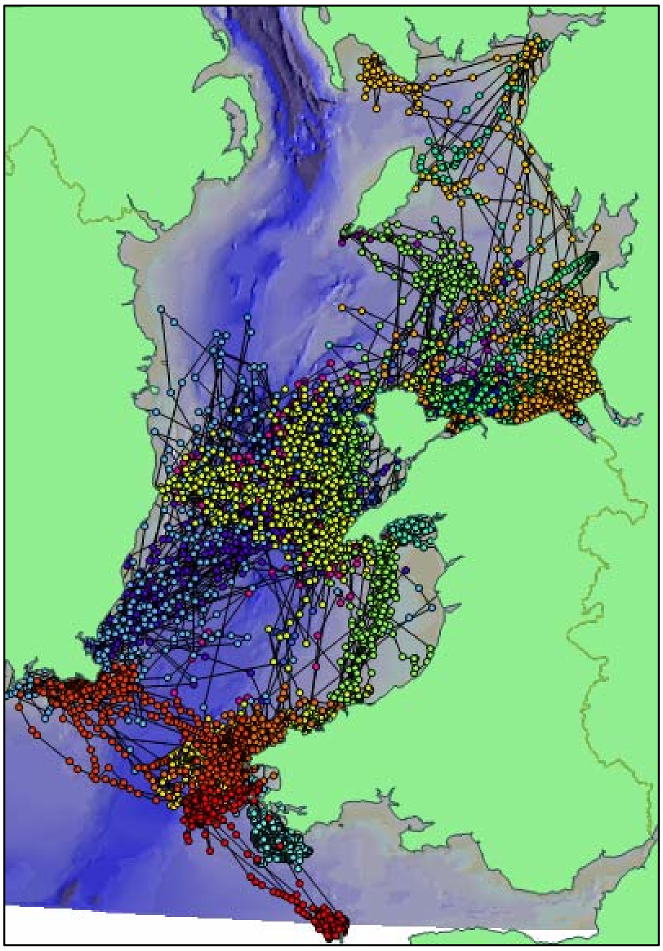


Figure 43 – Distribution of foraging grey seals tagged from Hilbre Island (Cheshire), Bardsey Island (Gwynedd), and Skomer Island (Pembrokeshire)

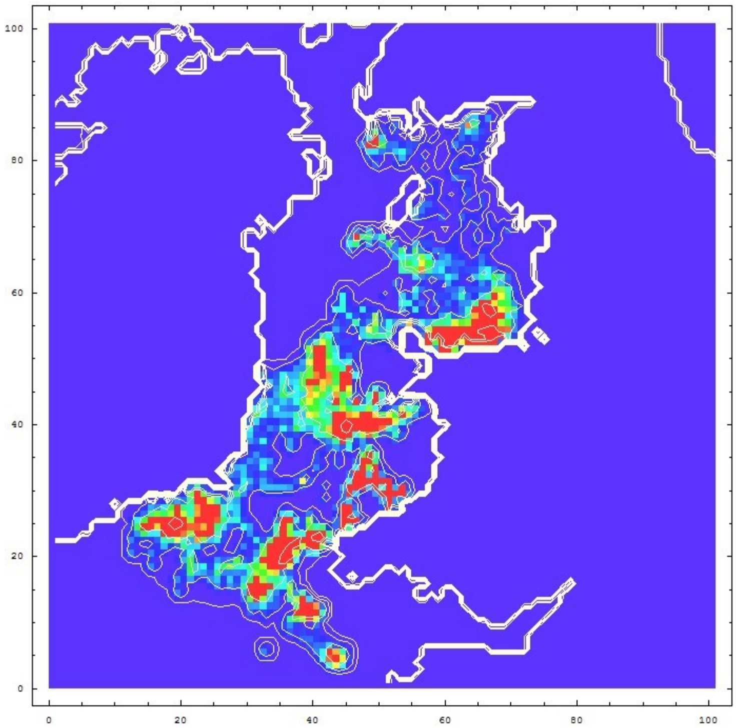


Figure 44 – Interpolated distribution of foraging tagged grey seals

4. DISCUSSION

Eighteen species of cetacean have been recorded in Welsh waters since 1990. Five of these are relatively common and it is possible to map their distributions and how they may vary in time. These are harbour porpoise, bottlenose dolphin, short-beaked common dolphin, Risso’s dolphin and minke whale. Rare species include fin whale, killer whale, and long-finned pilot whale, whereas other species are more or less casual visitors to the region: humpback whale, sei whale, pygmy sperm whale, northern bottlenose whale, Cuvier’s, Sowerby’s and Blainville’s beaked whales, striped dolphin, Atlantic white-sided dolphin, and white-beaked dolphin. The striped dolphin appears more frequently in the stranding record than indicated from sightings. Given that it may associate with groups of common dolphins and is relatively difficult to distinguish, the species may be more regular than the number of sightings records suggest. Humpback whale records have increased in recent years. Although still very rare, it is becoming a regular visitor to the Irish Sea.

The harbour porpoise is the commonest and most widespread species in Welsh waters. It is present year round, although probably under-recorded in winter. Static acoustic monitoring using T-PODs in Cardigan Bay SAC in fact indicate a higher occurrence of the species in winter than in summer, with higher activity in coastal waters at night-time, possibly to avoid bottlenose dolphin attacks (Pesante *et al*., 2008a). The species is not evenly distributed within the Irish Sea. Hot spots can be identified around Anglesey and off the Pembrokeshire coast, and to a lesser extent off the south coast of the Lleyn Peninsula, in southern Cardigan Bay, and in the Bristol Channel off the south coast of Wales (around the Gower Peninsula and in Newport Bay). These areas of relative high density largely persist across time periods. Outside Welsh waters, there is a clear hotspot east of Dublin Bay in Ireland. Porpoise calves occur throughout the region. Although juvenile:adult ratios are highest in southwest and south Wales, these findings should be viewed with some caution since they have not been recorded systematically by all observers.

The bottlenose dolphin has been the next most frequently recorded species. In the region it has a predominantly coastal distribution, although low densities have been recorded offshore, particularly in St George’s Channel and the southwest sector of the study area. The main concentrations of sightings appear to be southern Cardigan Bay and further north in Tremadog Bay. However, the species also occurs off the north coast of Wales, particularly north and east of Anglesey. There is some indication that bottlenose dolphins form small groups (generally <10 individuals) in summer centred upon Cardigan Bay, but then disperse more widely in winter, moving mainly northward to North Wales and beyond, where they often form very large groups (numbering 50-150 animals) (Pesante *et al*., 2008a, b). However, some bottlenose dolphin groups remain in coastal areas of Cardigan Bay through the winter, and conversely, the species can be seen at any time of the year at least occasionally in North Wales. The importance of Cardigan Bay for bottlenose dolphins has been maintained across the four 5-year time periods, but there is also evidence that the same applies to the species in winter along the North Welsh coast. Bottlenose dolphins have an extended breeding season, and calves have been observed in most months of the year, throughout Cardigan Bay and, to a lesser extent, east of Anglesey. Only small numbers of bottlenose dolphins have been recorded stranding.

The short-beaked common dolphin has a largely offshore distribution centred upon the Celtic Deep at the southern end of the Irish Sea, where water depths range from 50-150 metres. This high-density area extends eastwards towards the coast of west Pembrokeshire and the islands of Skomer, Skokholm, Grassholm and the Smalls. Elsewhere in the Irish Sea, common dolphins occur at low densities, mainly offshore northwards towards the Isle of Man. Similar patterns of distribution have persisted across the four time periods examined. The species appears to be mainly a summer visitor although it persists in the Celtic Deep at least to November. There is some indication of an influx of juvenile groups in late summer. Most strandings occur along the coasts of Southwest Wales.

Risso's dolphins have a rather localised distribution, forming a wide band running SW-NE that encompasses west Pembrokeshire, the western end of the Lleyn Peninsula and Anglesey in Wales, the south-east coast of Ireland in the west, and Manx waters in the north. There is no indication that this general distribution has changed over the long-term. The species is mainly a summer and autumn visitor to the Welsh coasts, with the highest sightings rates in the period July to September. At other times of the year, Risso's dolphins may range more widely offshore. In the Isle of Man, the species occurs particularly in late spring and early summer. The species breeds in the region, and young of the year have been seen frequently in groups sighted in Pembrokeshire, around Bardsey Island and Anglesey. There have been only a few strandings, across west Wales.

Like the short-beaked common dolphin, the minke whale has a predominantly offshore distribution, with highest densities of sightings in the area of the Celtic Deep, although the species also occurs in deeper areas (generally >50 m) northwards towards the Isle of Man. This distribution pattern is observed across the time periods under examination. Minke whales appear to be mainly summer visitors to the region, with few sightings in winter, although this may partly be due to low effort at that period. There is no evidence as yet that the species breeds in Welsh waters.

Overall, cetacean species diversity is highest around the Celtic Deep. The areas of coastal Wales with highest species diversity are west Pembrokeshire, the western end of the Lleyn Peninsula, and west of Anglesey – the regions that are closest to deeper waters and the possible influence of the two major frontal systems in the Irish Sea, the Celtic Sea and Irish Sea Fronts.

Of the two native pinniped species occurring in the British Isles, only the grey seal breeds in Wales. This species is widely distributed around the coasts of Wales, breeding in caves and small coves on offshore islands and less populated parts of the mainland coast. Pup production is greatest in Northwest Pembrokeshire, particularly on Ramsey Island, but extending southwards to Skomer Island and northwards to southern Ceredigion. Smaller concentrations occur around the Lleyn Peninsula and the coast of Anglesey. These same areas are used as haul-out sites during the non-breeding season. Many observers conducting surveys have not systematically recorded seals and so their distribution at sea is difficult to assess at this stage. However, the species clearly is widely distributed in Welsh coastal waters and throughout the year. Telemetry studies indicate foraging trips to often very localised areas, with animals from a particular area tending to remain in that region.

Much progress has been made in the last twenty years in terms of surveys for marine mammals in Welsh waters. In this atlas, a total of 37,266 hours of survey effort were devoted to systematically recording cetaceans in 376 (>90%) of the 414 cells within the study area, over a period of eighteen years. Nevertheless, coverage remains inadequate in all but a few small areas. For 38 cells (9%), there was no effort at all, and for 158 cells (38%), there was less than four hours of effort. Effort was highest in coastal areas, particularly in southern Cardigan Bay from New Quay to St David's Head, and around Bardsey Island. There has also been a temporal bias to the distribution of effort, with 85% of all effort in the six months, April to September. All areas would benefit from greater survey effort, but particular gaps occur in Caernarfon Bay, south Pembrokeshire, and the coast of Gwent in South-east Wales, as well as several offshore areas.

Other limitations to the maps produced here are that they are the result of compiling rather heterogeneous data sets, ranging from static observations from land-based sites through small boat surveys and platforms of opportunity such as whale-watch operations and ferry trips, to aerial surveys. Thus, large variations exist in terms of platform height, platform speed, and likely detection efficiency, not to mention differences in observer skills and experience. The effects of some of these variables have been examined here, but often there are confounding factors, for some of which, information is lacking. The majority of groups now collect data in a standardised format that is comparable to one another. However, it remains difficult to merge data sets from land based sites, offshore vessel surveys and aerial surveys. Furthermore, platforms of opportunity such as ferries that follow particular narrow band routes or are directed to finding concentrations of marine mammals for their customers, are not easily integrated with surveys that cover an area representatively and in a systematic manner.

Since only a limited number of groups estimated ranges of sightings to the platform, it was not possible to fit detection functions for the various species, and hence to derive absolute density estimates. In future, recording groups should be encouraged to do so on a routine basis, whilst ensuring that all their observers have appropriate training for accurate distance estimation.

Despite the limitations outlined above, the maps produced here show consistency across time periods, giving us some confidence at least at a gross level. With greater survey effort, and some refinement of recording techniques in certain cases, they would undoubtedly be improved still further.

5. REFERENCES

Anderwald, P. and Evans, P.G.H. (2008) Minke whale populations in the North-Atlantic – an overview with special reference to UK Waters. In: *An Integrated Approach to Non-lethal Research on Minke Whales in European Waters* (Editors K.P. Robinson, P.T. Stevick and C.D. MacLeod). *European Cetacean Society Special Publication Series*, 47, 8-13.

Baines, M.E., Earl, S.J., Pierpoint, C.J.L., and Poole, J. (1995) *The West Wales Grey Seals Census* CCW Contract Science Report No: 131.

Bravington, M.V., Northridge, S.P., and Webb, A. (2001) *An exploratory analysis of cetacean data collected from platforms of opportunity*. Unpublished report to MAFF.

Evans, P.G.H. (1980) Cetaceans in British waters. *Mammal Review*, 10: 1-52.

Evans, P.G.H. (1992) *Status Review of Cetaceans in British and Irish Waters*. Report to UK Department of Environment. Oxford, Sea Watch Foundation. 98pp.

Evans, P.G.H. and Wang, J. (2005) *Re-examination of distribution data for the harbour porpoise on the N.W.European Continental Shelf with a view to site selection for this species*. CCW Contract Science Report No. 634: 1-115.

Evans, P.G.H., Anderwald, P. and Baines, M.E. (2003) *UK Cetacean Status Review*. Report to English Nature and Countryside Council for Wales. Sea Watch Foundation, Oxford. 160pp.

Hammond, P.S., Northridge, S.P., Thompson, D., Gordon J.C.D., Hall, A.I., Aarts, G. and Matthiopoulos, J., (2005) *Background information on marine mammals for Strategic Environmental Assessment 6*. Sea Mammal Research Unit. http://www.offshore-sea.org.uk/consultations/SEA_6_Mammals_SMRU.pdf

Hiby, L. (2005) Effective strip width estimates for the SCANS2 aerial surveys. http://www.conservationresearch.co.uk/SCANS_2/scans_2.htm/documents.zip

Jepson, P.D. (editor) (2005) Cetacean Strandings Investigation and Co-ordination in the UK 2000-2004. Final report to the *Department for Environment, Food and Rural Affairs*. pp 1-79. <http://www.defra.gov.uk/wildlife-countryside/resprog/findings/index.htm>

Pesante, G., Evans, P.G.H., Baines, M.E., and McMath, M. (2008a) *Abundance and Life History Parameters of Bottlenose Dolphin in Cardigan Bay: Monitoring 2005-2007*. CCW Marine Monitoring Report No. 61, 1-75.

Pesante, G., Evans, P.G.H., Anderwald, P., Powell, D. and McMath, M. (2008b) *Connectivity of bottlenose dolphins in Wales: North Wales photo-monitoring*. CCW Marine Monitoring Report No. 62, 1-42.

Reid, J.B., Evans, P.G.H., and Northridge, S.P. (2003) *Atlas of Cetacean Distribution in North-west European Waters*. JNCC, Peterborough.

Robinson K., Ramsay K., Wilson J., Mackie A., Wheeler A., O'Beirn F., Lindenbaum C., Van Landeghem K., McBreen F., Mitchell N. 2007. HABMAP: Habitat Mapping for conservation and management of the southern Irish Sea. Report to the Welsh European Funding Office. CCW Science Report Number 810. Countryside Council for Wales, Bangor.

Strong P.G., Lerwill J., Morris S.R., and Stringell, T.B. (2006) *Pembrokeshire marine SAC grey seal monitoring 2005*. CCW Marine Monitoring Report No: 26; unabridged version (restricted under licence). 54pp.

Thomas, L. (2009) *Potential Use of Joint Cetacean Protocol Data for Determining Changes in Species' Range and Abundance: Exploratory Analysis of Southern Irish Sea Data*. Report to Joint Nature Conservation Committee, Irish National Parks and Wildlife Service, and Countryside Council for Wales. Centre for Research into Ecological and Environmental Modelling., University of St Andrews. JNCC Contract No. F90-01-1208. 35pp.

Webb, A., McSorley, C.A., Dean, B.J., Reid, J.B., Smith, L., and Cranswick, P.A. (2003) *Modelling the distribution and abundance of black scoter Melanitta nigra in Carmarthen Bay in winter 2001/02: a method for identifying potential boundaries for a marine Special Protection Area*. JNCC Report, No. 330.

Westcott, S.M. and Stringell, T.B. (2003) *Grey Seal Pup Production For North Wales, 200*2. CCW Marine Monitoring Report No: 5a. 1-57.

Westcott, S.M. and Stringell, T.B. (2004) *Grey Seal Distribution and Abundance in North Wales, 2002-2003*. CCW Marine Monitoring Report No: 13: 1-80.

6. ACKNOWLEDGEMENTS

A great many groups have contributed data to this project. We would specially like to thank the following: Cardigan Bay Marine Wildlife Centre (Steve Hartley and Sarah Perry), Ceredigion County Council (Liz Allan and Chris Pierpoint), Countryside Council for Wales (Mandy McMath, Tom Stringell and Stephen Westcott), E.ON UK (Eleri Owen), European Seabirds at Sea database (Andy Webb), Eurydice (Chris Pierpoint), Friends of Cardigan Bay (Munro Taylor, Megan Morgan-Jenks, Janene Ryan, Janet Baxter and Phil Hughes), Gower Marine Mammal Project (Rob Colley), Irish Whale & Dolphin Group (Dave Wall), Joint Nature Conservation Committee (John Goold, Tim Dunn), Manx Whale & Dolphin Watch (John Galpin, Tom Felce and Eleanor Stone), Marine Awareness North Wales (Dave Powell, Nia Haf Jones, and Richard Shucksmith), Marine Environmental Monitoring (Rod Penrose), RWE nPower (Carol Cooper, Kate Lewis), Sea Mammal Research Unit (Phil Hammond and Bernie McConnell), University of Swansea (John Houghton), Whale & Dolphin Conservation Society (Mark Simmonds and Marijke de Boer).

Over the years, data contributions directly to the Sea Watch database have come particularly from the following observers: Pia Anderwald, Martin Baxter, Mick Baines, Cliff Benson, Michel Betts, Rob Colley, Sarah Earl, Peter Evans, Tom Felce, John Galpin, Julie Gordge, Norman Hammond, Steve Hartley, Jim Heimlich-Boran, Graham and Jackie Hall, Ian Hotchin, Saana Isojunno, David Jenkins, Emily Lewis, Kate Lewis, Brian Maddrell, Dawn Murphy, Hanna Nuuttila, Giovanna Pesante, Chris Pierpoint, Dave Powell, Geoffrey Reading, Steve Rosser, Colin Speedie, Eleanor Stone, Dave Thomas, Fernando Ugarte, as well as members of staff & volunteers of Earthkind, Bardsey and Skokholm Bird Observatories.

Pia Anderwald organised data collection, processing and validation within the Sea Watch database, and Maren Reichelt helped with the layout of the maps.

The project was funded by the Countryside Council for Wales, and overseen by Mandy McMath and James Dargie.

7. DATA ARCHIVE