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Assessing harbour porpoise populations in south-west Wales, data issues and implications for conservation and management

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ABSTRACT

The UK Government was recently criticised for failing to fulfil its obligations under the Habitats Directive in respect of designating protected areas for Harbour Porpoise *Phocoena phocoena*. At the centre of the discussion lay the stringent nature of the qualifying criteria for site selection. Concurrently, there is a growing support for marine renewable energy technologies; however the planning process is often hampered by inadequate marine data to enable appropriate siting or mitigation against potential ecological impacts. The Bristol Channel region's physical environment is a suitable source for the generation of marine renewable energy, and the world's first tidal lagoon will be sited in Swansea Bay. A 10 year dataset was collected, analysed and compared against the qualifying criteria for a Special Area of Conservation (SAC). Results revealed that a resident population of porpoise existed and density values of 0.58 hp km^2 were comparable with other UK regions. While an insignificant calf adult ratio of 1:13 was recorded, breeding and nursery areas were identified. Analysis highlighted a number of hotspots of porpoise activity, suggesting that these areas are critical habitats, particularly for feeding and foraging. Such information will enable future marine renewable energy developers to select the most appropriate sites. It is argued that existing SAC qualifying criteria prevents recognition of critical habitats for the harbour porpoise and a case is made for an eastward extension of a proposed harbour SAC to include Swansea Bay and the south Gower coast. This paper demonstrates that cetacean data is sparse and even though this study has filled important knowledge gaps, there is still a need for further research. This research would enable both developers and planners to adequately and appropriately consider future marine renewable energy projects.

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1. Introduction

Harbour porpoise *Phocoena phocoena* are protected under the Habitats and Species Directive (92/43/EEC) and listed as a priority species in UK Biodiversity Action Plans (UKBAP; Jenkins, 2007). They are the smallest marine mammal found in UK waters and even though they occur offshore, are more typically sighted in coastal areas (Jenkins, 2007). Often associated with near-shore headlands and strong tidal currents, porpoise are commonly observed within shallow bays, estuaries and narrow tidal channels (Pierpoint, 2008; Baines and Earl, 1999). Their small size, shy nature, lack of clearly identifiable markings and highly mobile, wide ranging nature make harbour porpoise difficult to observe. These characteristics make data collection challenging, which in turn has contributed to a lack of protected areas being identified in the UK (Embling et al., 2009).

Dolman et al. (2013) identified 10 sites where sufficient evidence existed to undertake protective measures. In Wales, these sites included north Pembrokeshire, south Cardigan Bay, Lleyn Peninsula, Bardsey Island, and north and west Anglesey. However, there has been criticism that policy makers provide frameworks designed to support and conserve species, but make qualifying criteria too restrictive or inadequately defined, creating loopholes and inconsistencies (Pinn, 2010).

To ascertain whether harbour porpoise, currently a species of conservation priority, is at Favourable Conservation Status, it is necessary to monitor annual trends in numbers and distribution over a sufficient time scale, in order to test statistical significance. However, research data is limited, particularly in South Wales, and

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as a consequence, this has proved a barrier for harbour porpoise protection. This has been highlighted by the European Commission, who announced infringement action against the UK Government for failing to adequately fulfil its duty of care (July 2013). In October 2014 the UK Government was given two months to develop a porpoise protection programme or face penalties, for failing to comply with the Directive (Neslen, 2014).

Concurrently, there is increasing interest in marine renewable energy (wave, wind and tidal stream technologies) that is supported by the UK Government. However, developers and planners are often disadvantaged by a lack of accessible scientific data in order to make siting decisions. Strong baseline data is essential for compliance with legislation, planning processes and to provide an Environmental Impact Assessment (Environment Agency, 2002). Therefore, determination of potential conflict between marine mammals and marine renewable energy devices is fundamental to the industry's development in UK waters. Recent coastal and marine research has focused mainly on ecosystem management (Liquete et al., 2013) and building in resilience as a buffer against environmental and anthropogenic impacts (Brown et al., 2014) but worldwide research detailing harbour porpoise distribution is extremely sparse.

Therefore, this paper assesses harbour porpoise population distribution, both within Swansea Bay and the wider Gower coastal waters, filling an important research gap by bringing together an extensive dataset collected by multiple organisations. This represents one of the UK's largest datasets for cetaceans and enabled further understanding of regional porpoise distribution, highlighting the need for protection of its critical habitats. Results will inform both government and potential marine renewable energy developers.

1.1. Legislative overview

The harbour porpoise is legally protected under the EU Habitats Directive (92/43/EEC; EU, 1992). Under the Directive, all cetaceans are listed for protection and as such, governments have a duty to designate Special Areas of Conservation (SACs) to enable their survival (Evans and Prior, 2012). Harbour porpoise are also listed in the OSPAR Convention for the Protection of the Marine Environment of the North-east Atlantic as threatened and declining (OSPAR, 2008) and having unfavourable conservation status in Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS, 2015). Yet while *P. phocoena* is not under immediate threat of global extinction, there are a number of local impacts endangering both its distribution and abundance (Dolman et al., 2013). The EU Marine Strategy Framework Directive requires Member States to attain a Good Environmental Status (GES), using an ecosystem approach (EU, 2008) and the Natura 2000 network by implying that it is an essential tool for the attainment of GES (Dolman et al., 2013). Some of the highest concentrations of harbour porpoise are found in UK waters (Booth et al., 2012) and it is imperative that the UK designates some Natura 2000 sites as Marine Protected Areas (MPAs) in order that the network be representative. Where critical habitat (e.g. feeding and breeding areas) can be identified, then an MPA would provide some additional protection (Pinn, 2010).

The Marine and Coastal Access Act (2009) gave Welsh Ministers powers to designate a new genre of MPAs known as Marine Conservation Zones (MCZs; JNCC, 2014). MCZs provide protection to nationally important marine features that are not covered by existing designations, making the MPA network ecologically coherent. There is only one MCZ in Welsh waters around Skomer Island, Pembrokeshire (UK Grid reference 1726600,208900) and a further 10 sites that were consulted upon in 2012 but withdrawn in July 2013 (Davies, 2013). In order to comply with the Marine Strategy Framework Directive (MSFD) and the requirements of MaCAA (2009), the Welsh Government is obliged to contribute to a coherent and well-managed network of MPAs by 2016.

In response to difficulties experienced in identifying SACs for mobile marine species, an *ad hoc* working group of the EC Habitats Committee developed additional indicators in December 2000 (EC, 2001). These were published in the European Commission's marine guidelines (2007) creating a guiding principle designed to assist Member States in the identification of areas 'representing the physical and biological factors essential to their life and reproduction' (Aish and Johnson, 2009). These Additional Indicators are centred on four variables namely:

(1) Continuous or regular presence
(2) Good population density in relation to neighbouring areas
(3) High ratio of young to adult group members
(4) Other biological elements which are characteristic

It was anticipated that a coherent network of sites (Natura 2000) would span territorial waters of EU Member States by 2012 (EU, 2007). However, only Skerries and Causeway in Northern Ireland have been designated as a Grade C SAC (i.e. 5–9 months continuous presence) for harbour porpoise, recognised as a *Feature* but not a primary reason for SAC site selection (NIEA, 2010). Thirty three other identified sites were all graded 'D' (where populations were considered either too low or transient in nature and that no porpoise-specific management need be considered (Dolman et al., 2013). Many conservation groups and scientists believe that designation criteria are too stringent and not fit for purpose in the case of harbour porpoise (Green et al., 2012; Luk and Gregerson, 2013) and SAC designation processes have been criticised by a number of researchers (see for example, Dolman et al., 2013; Evans and Prior, 2012; Green et al., 2012; Clark et al., 2010). Work is currently being undertaken to analyse the most up-to-date and extensive porpoise datasets, to determine whether any further areas are suitable for designation within UK waters (Defra, 2015). The Swansea Bay and outer Bristol Channel region has been assessed based upon key criteria, in order to demonstrate that even if not specifically designated as a SAC for harbour porpoise, the habitat is critical for local populations seasonally.

1.2. Background to the study

The UK Government aimed to increase electricity produced from renewable sources to 15% by 2015 and coastal regions of South Wales are ideally located for the emergence of renewable energy technologies (DECC, 2013). Given the potential for conflict between marine renewable energy devices and marine mammals (Wilson et al., 2007), fine-scale surveys were needed to assess both distribution and habitat use of target species (Shucksmith et al., 2009). Swansea Bay has become the focus of a proposed tidal lagoon project, which was recently granted planning consent by the Secretary of State for Energy and Climate Change. The initial Environmental Impact Assessment (EIA) Scoping Report highlighted limited access to long-term monitoring data, a common problem facing many ecological consultancies (TLSB Ltd, 2012). Providing a clearer picture of habitat usage of marine mammals in coastal waters became essential not only for the proposed lagoon, but for future marine spatial planning. The European Regional Development Fund enabled the formation of the Low Carbon Research Institute (LCRI) a multidisciplinary collaboration of leading academic marine institutions in Wales, whose research projects inform, support and contribute to the marine energy sector. Under the project, porpoise distribution and abundance data was

systematically collected by UWTSD researchers using combined land and vessel based survey methodologies, for a period of 3 years, building upon other regional studies undertaken since 2002 (Jenkins, 2007; Jenkins et al., 2009).

1.3. Physical background

Swansea Bay and the Gower Peninsula are situated within the Bristol Channel on the southern coast of Wales (Fig. 1a). The Bristol Channel/Severn Estuary is an inlet from the Atlantic Ocean on the west coast of Great Britain, partially enclosed, and separating Wales from England (Phillips and Crisp, 2010; Uncles, 2010). The study is located towards the northwest end of the Bristol Channel, between Burry Holms (OSGB 274500; 192500) to the west and Port Talbot harbour (OSGB 274500; 187200) to the east. Experiencing one of the highest tidal ranges globally (*circa* 10 m on spring tides and 4 m at neap tides), waters are well mixed and sediment loading/organic content is high (Mackie et al., 2006). Tidal amplitude is large and tidal streams dominate patterns of water circulation in the area (Cefas, 2013). The bathymetry gradually slopes away to depths of over 20 m. Salinity levels consistently average around 32.5 ppt (Cefas, 2013). The Swansea Bay seabed sediment comprises mainly muddy sand and gravel with Carboniferous limestone headlands along the coastline such as at Oxwich Point and Pwll Du Head, punctuated by sandy bays. Along the south Gower coast, subtidal bedrock does not extend more than a couple of hundred metres offshore in most places, after which sandy sediments cover the seabed (Bunker and Hart, 2002). The survey area has some coastal SSSIs which may extend to mean low water mark (e.g. Blackpill SSSI, Swansea Bay) but in terms of offshore marine protection, only Carmarthen Bay and Estuaries Special Area of Conservation boundaries cover some of the survey area. However, eastern areas of Mumbles and Swansea Bay fall beyond this SAC (Fig. 1b) and it should be noted that while harbour porpoise occur within the SAC, they are not listed as a *feature* within that designation.

1.4. Methodology

Based on the methodologies described by Baines et al. (1997); Mann (1999); Bristow and Rees (2001); Pierpoint, 2001; Baines, 2002; Ribeiro et al. (2005) and Jenkins (2007), a variety of vessel-based transects, land-based observational surveys and behavioural studies combining *ad libitum*, scan and continuous sampling were undertaken to identify seasonal variation, porpoise hotspots and critical feeding habitats between February 2011 and May 2013. The survey area spanned coastal waters from Port Talbot deepwater harbour to Burry Holms (Fig. 1c). Sightings rates have been normalised for effort.

Other similar early regional project data (from 2002) was also considered in this research. This employed either constant-effort surveys, over a period of several years, or made use of incidental observations and aerial surveying techniques. As a result of the different methods employed, comparability is not possible. However, plotting all datasets does provide a more complete picture in terms of spatial distribution. Table 1 summarises sources, methods used and dataset coverage, which have been combined for the purpose of this paper.

1.5. Land-based surveys

Between 2002 and 2011 (Table 1), UWTSD researchers undertook two separate studies. Study 1 (2002–2005) totalling 260.5 h of constant effort at selected shorewatch sites, principally at Mumbles (n = 172 h; 65%) and Oxwich (n = 54 h; 21%). Further watches were carried out at Port Eynon and Burry Holms when opportunity allowed (Jenkins, 2007). Study 2 completed between 2011 and 2013 totalled 729 h of land-based surveying from 7 different sites (Port Talbot harbour (n = 104.85 h; 14%), Mumbles (Tutt Head) (n = 203.28 h; 28%), Pwll du Point (n = 48.03; 7%), Southgate (n = 173.13 h; 24%), Port Eynon Point (n = 61.25 h; 8%), Rhossili (n = 116.83 h; 16%) and Burry Holms (n = 8.73 h; 1%)). Oxwich Point (n = 13.07 h; 2%) was used as an initial survey site, but logistics meant that effort was concentrated at more accessible locations thereafter.

In all cases, selection of vantage points was based upon prior knowledge of harbour porpoise occurrence, and pilot studies. Timings of watches were randomly selected and conducted over 2–4 h periods with a minimum of two observers. Surveys were undertaken in Beaufort sea states 3 or lower. In accordance with standard protocol, continuous, focal scanning and *ad libitum* methods were used to record observations. Distance estimations were calculated using known landmarks/offshore buoys and a compass bearing to the animal (Bristow and Rees, 2001). Fig. 2 is representative of the arc of vision at such sites, in this case at Mumbles, and demonstrates total area covered during typical shore watch observations. As well as behaviour and group association, presence of calves was noted, along with relevant environmental data.

1.6. Vessel surveys

In Study 1, (Table 1) Jenkins (2007) conducted 12 surveys (n = 86 h) of observations between 2002 and 2005. In Study 2, 37 vessel-based surveys (n = 146.5 h) were undertaken across South Gower and Swansea throughout the 26 month survey period (March 2011–May 2013). Surveys were conducted using a 4.5 m Avon rigid inflatable boat (RIB) equipped with a 40 hp Yamaha outboard engine, at a steady speed of 5–12 knots. Continuous scanning was undertaken in Beaufort sea states 3 or lower, along standard routes, alternating between Port Eynon westwards to Broughton Bay, north Gower and Port Eynon eastwards to Port Talbot harbour (both return trips covering approximately 35 km; Fig. 3). Survey trips ran parallel to the coastline within approximately 2 km of the shore, out to approximately 5 km offshore, with some variation depending on prevailing weather conditions. Weather and resources often dictated trip frequency. Two observers were on a constant lookout, each scanning 180°, alternating between the naked eye and binoculars (10×50 magnification).

2. Results

Methodological differences make direct comparison with other datasets difficult, so porpoise observations are used principally to plot distribution (Fig. 4). However, where constant effort surveys were conducted for extended periods, principally the two studies undertaken at UWTSD, direct comparisons were made (Table 1). Given the criteria outlined by the EU Habitats Directive for SAC designation (where the qualifying species is the harbour porpoise), data for Swansea and Gower coastal waters are presented in accordance with the four additional indicators described earlier.

2.1. Continuous or regular presence (subject to seasonal variation)

When both vessel and land surveys between 2011 and 2013 (Table 1) were combined, the highest percentage of encounters occurred between November and December (*circa* 36%) and a secondary dataset spike also occurred between February and April (*circa* 25%); the remainder of the monthly sighting range being between 2.6% and 7.1% (Fig. 4a); showing a porpoise presence all year round, concurring with the findings of Jenkins et al. (2009).

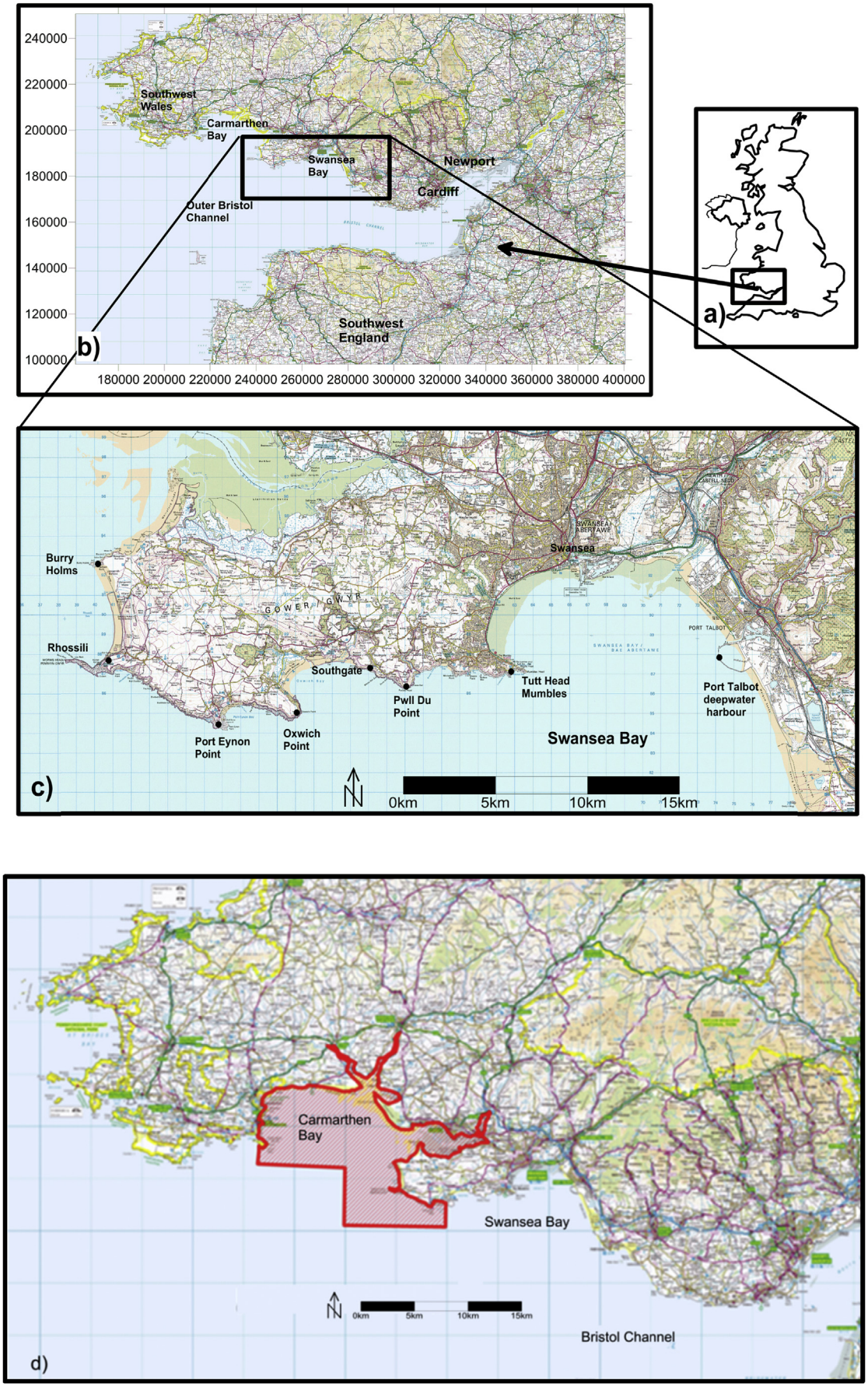


Fig. 1. a) UK, b) Study area location, c) land-based survey locations and d) Carmarthen Bay and Estuaries Special Area of Conservation.

Table 1
Sources and methods of data collection.

Source	Methods employed	Survey dates	Areas surveyed
Swansea Metropolitan University - UWTSD	*Ocean Eye* – data validation Shore and Vessel: *Ad Libitum*, Continuous and focal sampling	Study 1; August 2002–December 2005 (Jenkins, 2007)	Mumbles to Burry Holms
	Constant effort surveying	Study 2; February 2011–May 2013 (LCRI project)	Port Talbot docks to Burry Holms
Gower Coast Adventures (GCA)	Incidental encounters – ecotourism boat trips	August 2011–May 2013	Mumbles or Port Eynon to Worms Head
Wildfowl and Wetlands Trust Consulting	Aerial transects – primarily seabirds at sea surveys with incidental cetacean sightings recorded	February 2005–March 2008	Gower to Carmarthen Bay
MARINElife	Incidental encounters – Swansea-Cork ferry	July 2011	Swansea to Cork
Marine Conservation Society/ Environment Agency	Vessel line transects – mega fauna survey Bristol Channel	April–Sept 2007	Outer Bristol Channel
Chris Pierpoint/RPS	Vessel acoustic/line transects offshore windfarm baseline monitoring	May 2005–July 2007	Porthcawl to Swansea Bay
CCW	Aerial transects – common scoter counts primarily, with incidental cetacean sightings recorded	2005–2010	Carmarthen Bay

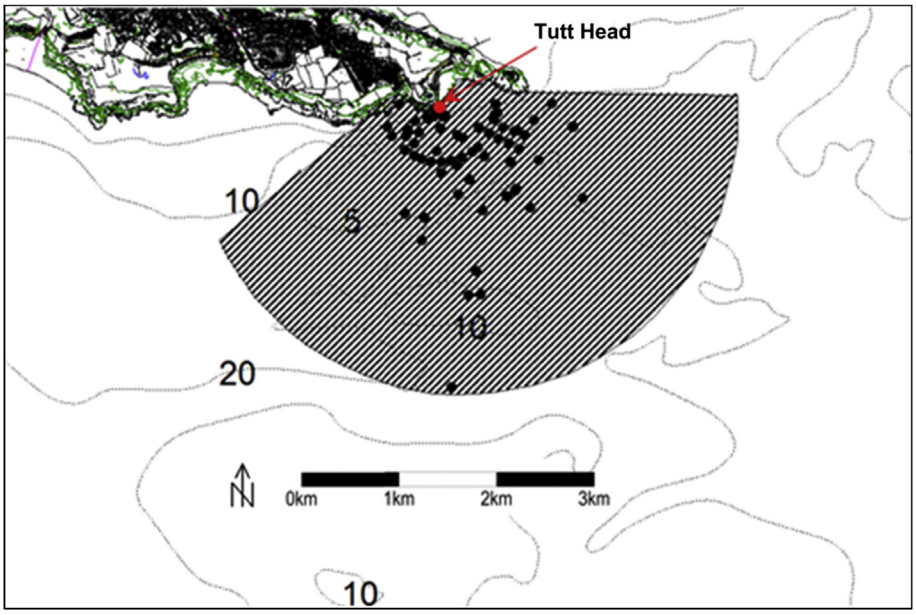


Fig. 2. Example of arc of view from land-based survey site: Tutt Head, Mumbles (porpoise sightings shown as black dots).

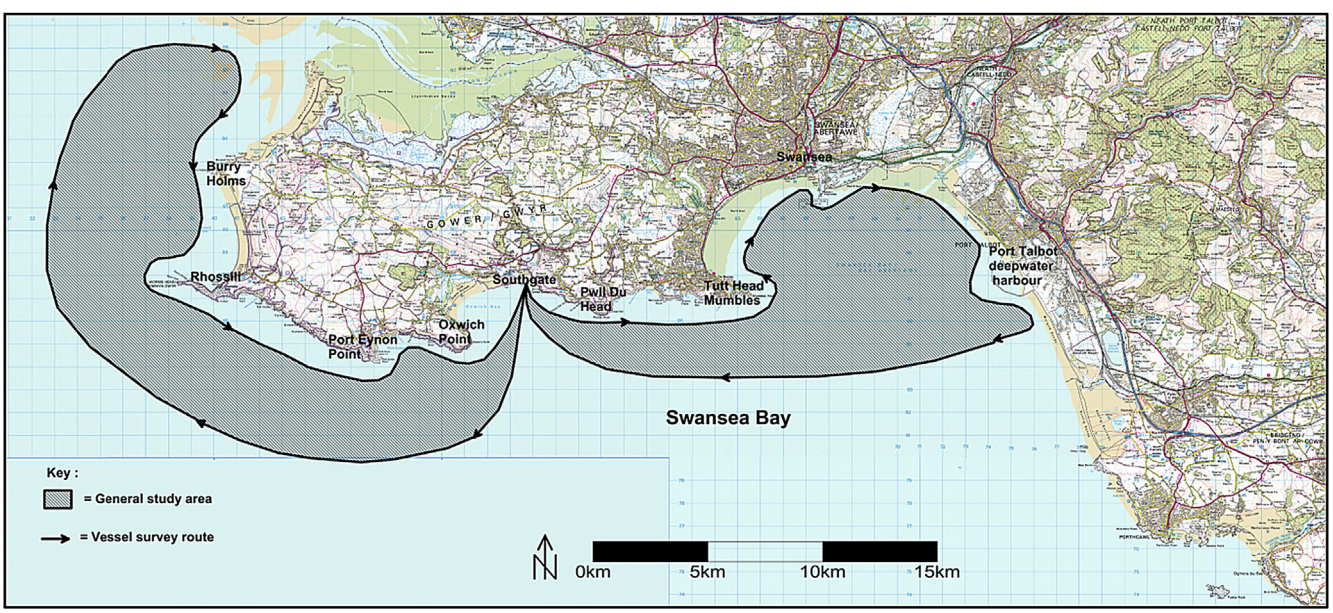


Fig. 3. General direction of vessel survey trips and general area covered. Note: observations were often made approximately 1 km beyond the vessel trackline shown.

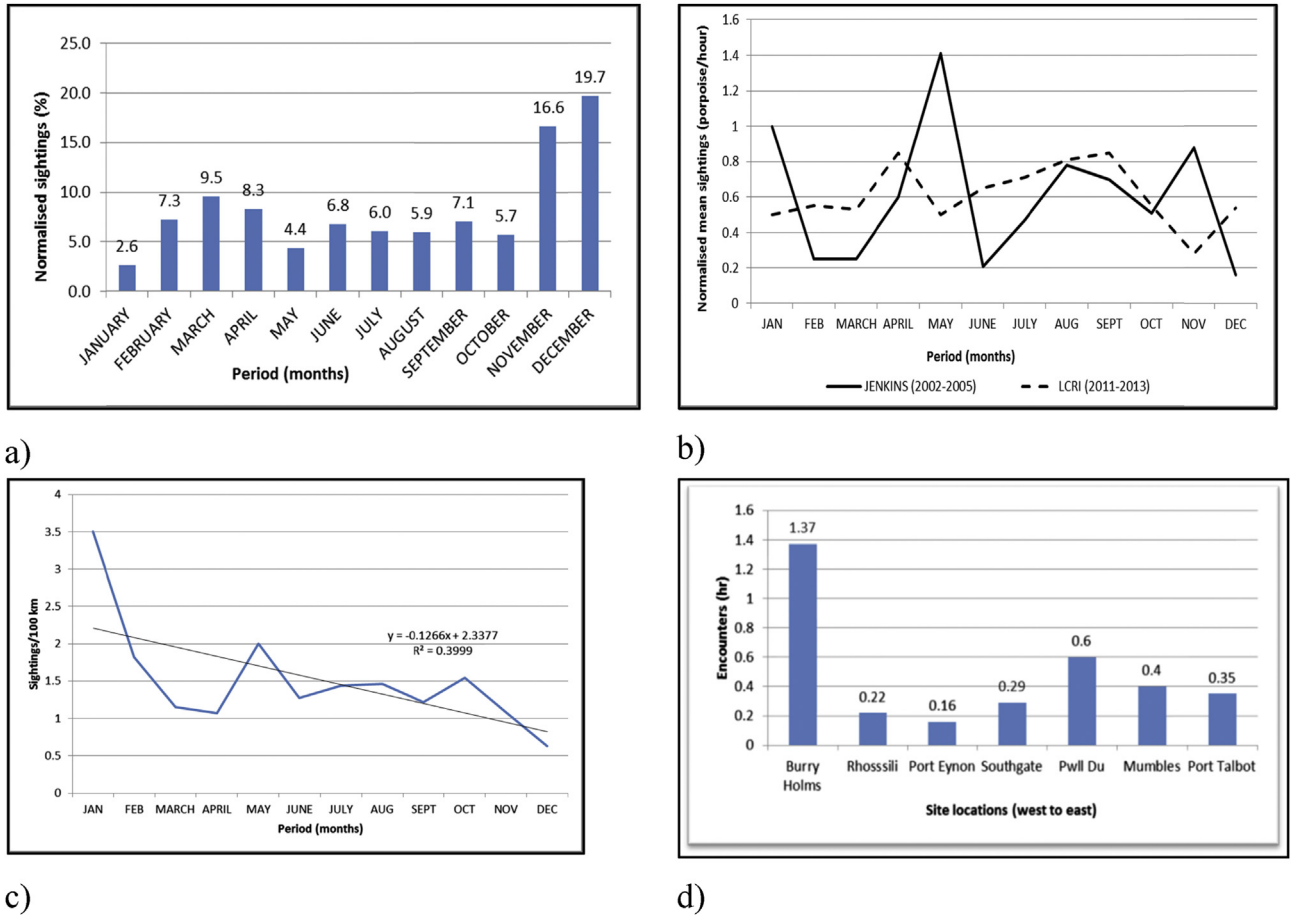


Fig. 4. a) monthly combined land and vessel based sightings 2011–2013, b) combined land and vessel based sightings/hour, c) Number of sightings/100 km from vessels and d) site specific land based sightings between 2011 and 2013.

However, Jenkins et al. (2009) showed that highest sightings rates occurred between August and September and importantly, the lowest rate occurred between November and December which contradicts the findings of this study. Results suggest that there is a small resident population of harbour porpoise in local waters, but their numbers vary; this may be dependent on weather conditions on the survey day and prey availability (Fig. 4b).

The number of porpoise sightings showed a temporal reduction from January to a minimum in December, shown by the equation $y = -011266x + 2.337$ and a coefficient of determination that explained almost 40% of data variation (Fig. 4c). Land based sightings varied alongshore with the highest encounters hr^{-1} occurring on west facing Burry Holms and southeast facing Pwll Du Point. Burry Holms is located within Carmarthen Bay and Estuaries Special Area of Conservation, but harbour porpoise do not feature in the designation, while Pwll Du Point is located adjacent to the SAC boundary (1.37 sightings hr^{-1} and 0.6 sightings hr^{-1} respectively; Fig. 4d). Sightings in the remaining locations range between 0.21 and 0.4 sightings hr^{-1}.

2.2. Good population density in relation to neighbouring areas

Jenkins (2002–2005) vessel study together with the Wildfowl and Wetlands Trust (2005–2008) and the CCW (2011) aerial surveys show that porpoise abundance was relatively low, ranging between 1.6 to 3.4 100 km^{-1}, when compared with more focused studies carried out by RWE (2009–2011), LCRI (2011–2013) and GCA (2011–2013) that ranged from 7.33 to 9.97 100 km^{-1} (Table 2). Goodwin and Speedie (2008) estimated relative abundance of harbour porpoise in North Pembrokeshire and the Lleyn Peninsula to be 2.5100 km^{-1} in 2002. Yet recently, the Wildlife Trusts stated that the Lleyn Peninsula should be regarded as a hotspot for megafauna and is notable for its population of harbour porpoise (Batey and Edwards, 2014). Even though differences exist, with vessel surveys within the same timeframe (i.e. GCA and LCRI) porpoise density in near-shore areas are comparable to those identified by both Goodwin and Speedie (2008) and Batey and Edwards (2014). Indeed many reflect a higher concentration within Swansea Bay and Gower.

Swansea Bay and Gower may not have similar megafauna populations, in terms of species diversity, compared to North Pembrokeshire or the Lleyn Peninsula, but when contrasted with other published sources (Table 3), harbour porpoise in local coastal waters appear to attract a higher relative density throughout the year.

This survey data covered an area of approximately 210 km^2. Therefore, using vessel data only, it was calculated that there were 0.58 hp km^{-2}. With the exception of Scarweather Sands that lies just 10 km south-southwest of Port Talbot and 7 km west of Porthcawl within Swansea Bay, only North Anglesey's data is higher (Table 3). As mentioned previously, an EU investigation has already identified 10 sites around Wales where there is sufficient evidence to take protective measures. Two of those sites were in the Lleyn Peninsula, and north Anglesey. As the density comparisons shown in Table 3 reveal, Swansea Bay and Gower compare favourably. Furthermore, the latter area has relatively high densities compared

Table 2
Density of Harbour Porpoise per 100 km (relative abundance).

Organisation	Harbour porpoise 100 km^{-1}	Survey type
Gower Coast Adventures (GCA) (2011–2013)	7.33	Vessel
UWTSD: Jenkins (2002–2005)	3.4	Vessel
LCRI (2011–2013)	8.8	Vessel
Wildfowl & Wetlands Trust (WWT) Consulting (2005–2008)	2.04	Aerial
RWE (Channel Energy Ltd) Atlantic Array (2009–2011)	9.97	Vessel
Countryside Council for Wales (2011)	1.6	Aerial

Table 3
Harbour porpoise density estimates around Wales, UK.

Area	Number of harbour porpoise km^{-2}	Survey type	Data source
Atlantic Array	0.12	V	Channel Energy Ltd., 2013
Scarweather Sands	1.55	V	Pierpoint, 2008
Swansea Bay	0.38	V	Pierpoint, 2008
N. Anglesey	0.63	V	Shucksmith et al., 2009; Jones et al., 2005
Cardigan Bay	0.23	V	Pesante et al., 2007
Bristol Channel	0.27 to 0.39	V	Hammond et al, 2013
Celtic Sea/Bristol Channel	0.41	V	Hammond and Mccleod, 2006
Irish Sea/Cardigan Bay	0.34	Ae	Hammond and Mccleod, 2006
LCRI Swansea Bay only	0.84	V and LB	UWTSD
LCRI whole survey area	0.58	V and LB	UWTSD

Key to survey: V = vessel, LB = land-based, Ae = aerial (Atlantic Array was a proposed windfarm development in the Outer Bristol Channel areas, south of Gower; Scarweather Sands lies east of Swansea Bay in the Bristol Channel and was also the site of a proposed wind farm).

with surrounding areas, with standardised sighting rates estimated to be 1.5 hr^{-1}. These have persisted over the long-term and compare well with the estimated 2 hr^{-1} for the Outer Bristol Channel proposed SAC for harbour porpoise (Evans and Prior, 2012).

2.3. Presence in the breeding season (relatively high ratio of young to adults)

Observing neonates (newly born c 70 cm long) and young calves (<110 cm long) is difficult, and it is highly probable that their presence is under-reported. Animals with a body length of 90 cm or less (calves and neonates) are still maternally dependent and therefore too young to survive alone (Penrose and Pierpoint, 1999). Mothers and calves typically remain in nearshore areas during the first few weeks after birth and need to surface frequently to breathe. That gives observers the opportunity to record them and identify potential breeding areas. During Study 2 (LCRI; Table 3) surveys, mean distance offshore for calf sightings (land and vessel combined) was 0.57 km ± 0.80 km. Combining all data within Swansea Bay between Mumbles and Port Talbot harbour, 39% of calves (n = 18) were sighted east of the survey area. However, marginally fewer (37%; n = 17) were sighted further west, within Rhossili Bay and off Worms Head and Burry Holms. The location with the highest frequency of calf sightings was Port Talbot harbour (22%). When shore and vessel data is combined, almost 10% of sightings were mother/calf pairings. Of these, *circa* 40% were 'escorted' by 1–3 other harbour porpoise. Pierpoint (2008) calculated that during surveys in 2005–7, 18% of all harbour porpoise pods in Swansea Bay included young calves.

There does not appear to be a very high ratio of young to adults (1:13) but Swansea Bay and surrounding waters do appear to have seasonal significance (Fig. 5a). Strandings data reveal that during the period of assessment, fresh calf strandings were only recorded in the eastern part of the study area around Swansea Bay, while neonates were only recorded in the western section (Fig. 5b). Fresh adult carcasses were also concentrated around Swansea Bay, between Mumbles and Port Talbot harbour (55% n = 6). This is indicative of a split in critical habitat requirements, with western sections being important for calving while eastern locations are used as a nursery area.

Combining data from Study 1 (2002–2005; Jenkins, 2007) and Study 2 (LCRI 2011–2013), females with calves were present in 9 out of 12 months of the year from January to March and July to December. Evans and Prior (2012) recommended that the most appropriate way to evaluate whether an area is important for breeding, is to examine areas of relatively high density during the period April–September, and particularly May to August. Sixty one per cent of all calves sighted were during the April to September calving period, with 26% during May to August. These predominantly summer observations of females with calves, combined with regional strandings records, support the previous assumption that breeding takes place within this study area.

Data show that neonates have only stranded locally during June and July, having likely been born in May or June, concurring with studies elsewhere in Northern Pembrokeshire, South West Wales (Clark et al., 2010). This also mirrors UK porpoise neonate strandings which show that 70% examined were found during June and July (Evans and Prior, 2012). Furthermore, seasonal increase in numbers in near-shore regions may indicate adults bringing young calves into shallower waters, so they can more easily learn to forage for themselves (Evans and Prior, 2012). These research findings appear to indicate a summer movement further offshore, with a migration closer inshore during autumn months. Additional scrutiny of transect data gives further indication of an offshore movement in early summer (May to June), suggesting a possible association with calving. This concurs with the findings of Evans (2003) who suggested that data analysis gave some indication of an offshore movement in early summer (May–June). Acoustic monitoring in West Wales (Pierpoint et al., 1999) revealing peak activity in December also appears to concur with observations within the Swansea Bay region. Therefore while Swansea Bay and surrounding areas do not necessarily fulfil the qualifying criteria of a high calf/adult ratio, it does appear to hold seasonal significance for the breeding population.

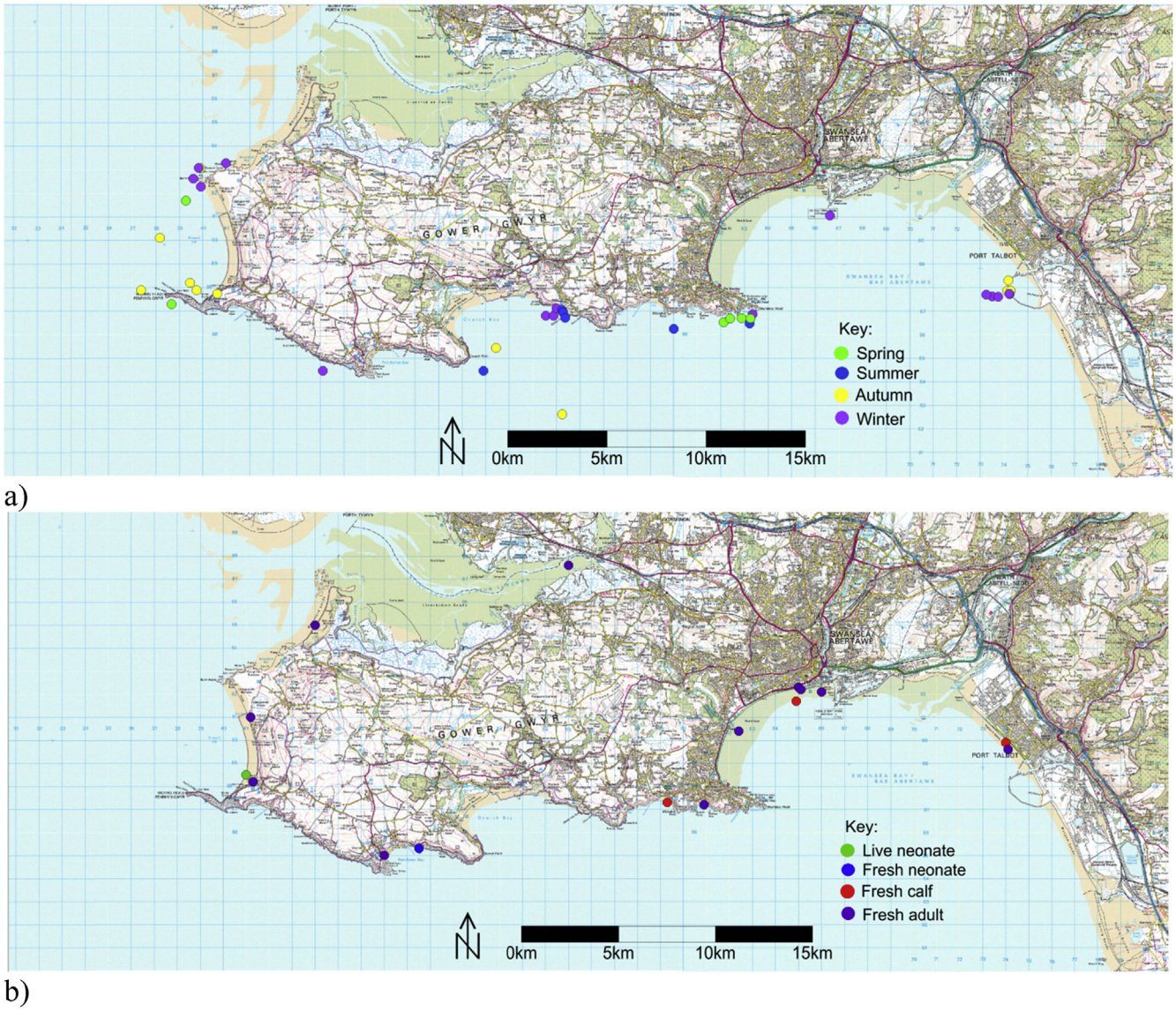


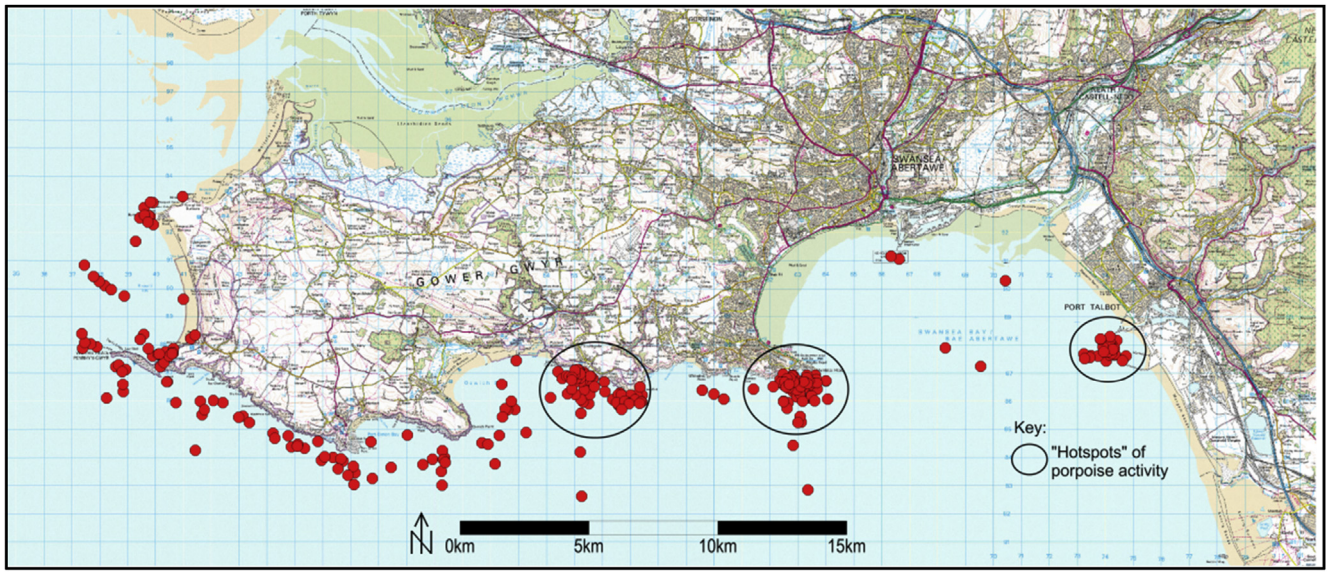
Fig. 5. a) Seasonal distribution of calf sightings (2011–2013) and b) Distribution of freshly stranded porpoise (2000–2013).

2.4. Other relevant biological factors

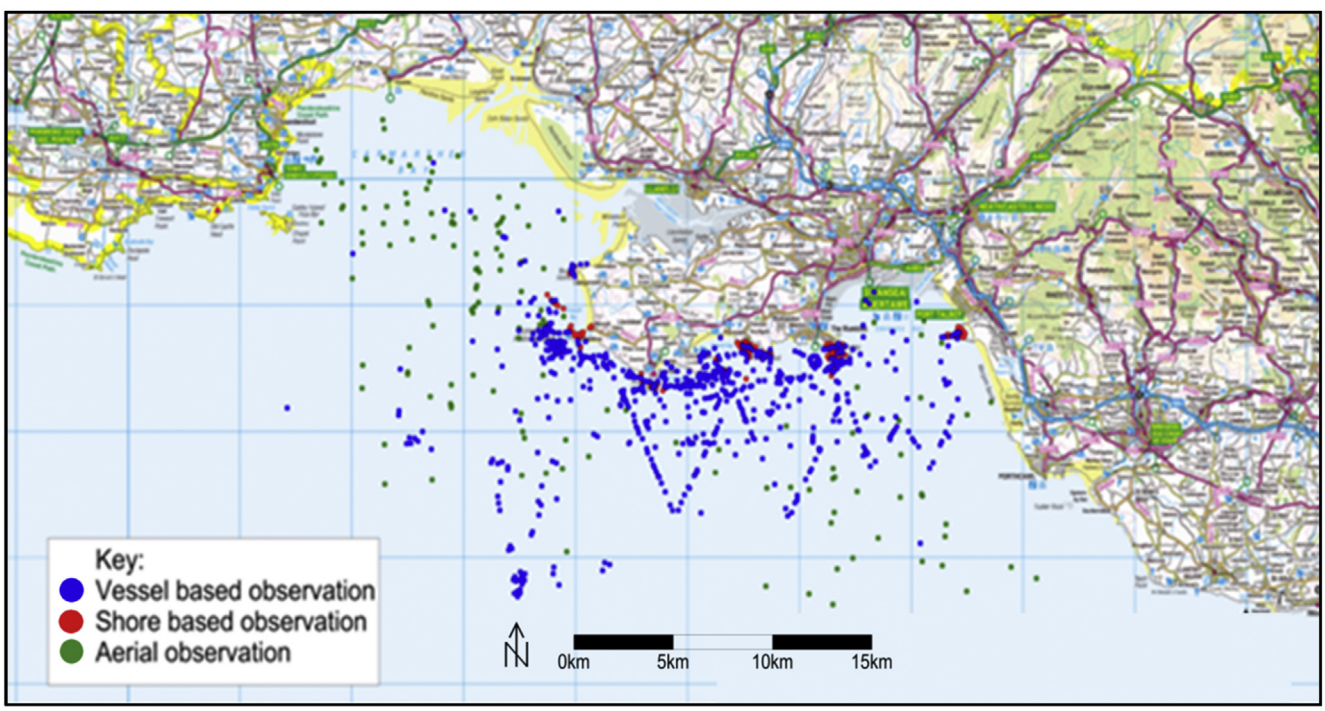
Additional features include seasonal aggregations and/or activity indicating site usage. Datasets were plotted to reveal any activity 'hotspots' within the region. Here hotspots are defined as areas with high concentrations of porpoise sightings. Data from this study was mapped, and revealed similar activity patterns to those produced by Jenkins (2007), particularly around Mumbles Head, Pwll Du Point and Rhossili to the west (Fig. 6a). These clusters are further highlighted when all available data is pooled to produce a more complete map (Fig. 6b). Baines and Evans (2012) noted that harbour porpoise hotspots have been identified in the Bristol Channel, including areas around Swansea Bay and Gower. While Fig. 6b combines data over a ten year period, and uses data collected through various methodologies, it does reveal that harbour porpoises predominantly utilise near-shore areas around Swansea Bay and Gower. These datasets, both individually and combined, reveal aggregations and site fidelity. Behavioural data collected during some of these studies indicates that the area is used for foraging/feeding, social (particularly during summer months) and breeding/calving purposes.

3. Discussion

It is important to contextualise the challenges surrounding species protection within the Swansea Bay and Gower coastal regions of South Wales, in light of proposed and future renewable energy developments. Global biodiversity decline is often attributed to habitat degradation caused by climate change impacts, and in some cases inappropriate development of coastal regions (UNEP, 2009). Predicted rises in sea surface temperature, turbidity levels and extreme weather will certainly impact marine and coastal species in terms of prey and habitat suitability (Harley et al., 2006). The UK Government and other European nations are striving to promote the use of renewable energy (European Union Committee, 2008) and provided planning decisions are based upon sound scientific protocols, vulnerable marine populations will be given adequate protection. However, the evidence-base for both positive and negative impacts of marine renewables remains poor, and there exists an urgent need for additional multi and inter-



a)



b)

Fig. 6. a) Activity 'hotspots' from land and vessel data from 2011 to 2013 and b) Harbour porpoise distribution, combining all available datasets 2002–2013.

disciplinary biodiversity orientated research, ranging from engineering to policy (Inger et al., 2009). Critically, success of conservation areas designated for cetaceans depends upon the quality of scientific information available (Clark et al., 2010). Recent experience in the UK suggests that decisions regarding major coastal developments are still being made based upon inadequate and often outdated information (MEA, 2005). The reason is lack of accessible data and the failure of planning consultants to engage with local stakeholder groups/individuals early enough in the process.

The multiplicity of environmental threats requires co-operation, conviction and legislation such as the Marine Strategy Framework Directive (MFSD) 2008/56/EC which adopts this very approach. As with the Habitats Directive, the MSFD strives to follow an ecosystem approach and achieve a *Good Environmental Status* (GES) by 2020 for all European waters. Four European Marine Regions have been identified, based upon geographical and environmental criteria, the UK lying within the Greater North Sea and Celtic Seas sub-regions. While every Member State is required to develop its own marine strategy, co-operation and coordination between

adjacent countries is managed through the Regional Seas Conventions, which for the UK is the OSPAR Convention (JNCC, 2014). Establishment of Marine Protected Areas (MPAs) is mandatory to all signatories and guidelines for achieving GES are laid down. Among those areas indicated as being vital, are maintenance of biodiversity, and ensuring that introduction of energy, including noise, into the marine environment should not adversely affect wildlife. Wales' existing MPA network (n = 125) covers approximately 5592 km^2; and 36.6% of Welsh territorial seas, but no sites are yet fully protected, and these continue to be intensively used.

Until December 2014, there was one Marine Nature Reserve (MNR) in Welsh waters, Skomer MNR, which was designated under the Wildlife and Countryside Act 1981. Upon commencement of Part V of the Marine Act in Wales, Marine Conservation Zone (MCZ) designation powers superseded the MNR powers and Skomer MNR was automatically converted to become Skomer MCZ. It remains the only MCZ in Wales. A draft Strategic Scoping Exercise for developing the Welsh National Marine Plan (undertaken in August 2014) defines Management Units (MUs) for different cetacean species (Welsh Government, 2014b). The Ices Working Group on Marine Mammal Ecology and Inter-Agency Marine Mammal Working Group (NRW, JNCC, NE and SNH) have classed the harbour porpoise as part of the Celtic and Irish Seas MU, based on current biological population data and ecological differentiation within these populations and management of this population is implied. Consequently, ensuring a more complete picture of their seasonal habits and distribution is vital. With the continued development of marine renewable technologies around the UK coastline, it will be impossible to assess likely short-term impacts and thereby suggest suitable mitigation, if baseline biological information is not robustly sought. Having that data reliably up-dated would certainly improve and potentially speed up the consultation period, making it a more rigorous and trustworthy approach.

In the case of the harbour porpoise, most regions throughout its range remain data deficient. However, as presented here, in respect of Swansea Bay and Gower areas, data has regularly been collected over a period of ten years, with opportunistic data contributing to the mix. Statistics reveal a continuous presence within the survey area for 12 months of the year and a density of 0.58 hp km^{-2} comparable with North Anglesey. A calf: adult ratio was recorded as 1:13, although given how challenging it is to observe calves, this is likely to be underestimated. Strandings data and visual observations reveal seasonal peaks in line with known breeding cycles, and spatial data would suggest that western areas are used for calving, while further east towards Swansea Bay and Port Talbot, the area is utilised as a nursery site (Fig. 5a). Further scrutiny of the data indicates spatial clusters of activity around headlands, but mapping other sources also revealed extensive use of Bristol Channel regions (Fig. 6a and b). Although not often considered in the literature as an important area for harbour porpoise, areas around South-west Wales appear to be significant for breeding populations (Pierpoint, 2006, 2008; Baines and Evans, 2012). There will inevitably be conflict between industrial development and marine biodiversity, for their ranges often overlap (Defra, 2011). However, far too many decisions are made despite data deficiencies, and this in itself calls for the Precautionary Principle to be invoked (Parsons et al., 2010). European Governments need to review their qualifying criteria for marine protection where there is clear evidence that processes are impossibly stringent, with demarcation of boundaries decided on the basis of information available to government agencies at the time (Evans and Pesante, 2008). Very little guidance was provided on the practical application of these criteria, resulting in each Member State interpreting and applying them differently (Pinn, 2010). Evans and Wang (2008) stated that if SACs are to be established within harbour porpoise hotspot areas, it is important to use long-term data sets to ensure that concentrations are not ephemeral, highlighting a challenge facing us when prescribing areas for special protection for mobile species such as cetaceans. In 2012, Northern Ireland designated the UK's first marine protected area for harbour porpoise - the Causeway Coast and Skerries SAC on the north coast, with a proposal for a new SAC in the Irish Sea announced in March 2015.

With respect to Swansea Bay and Gower, harbour porpoise data may not suggest further protection is needed by means of SAC designation, according to the criteria laid down. However it does compare well with other regions of Wales such as north Anglesey and the Lleyn Peninsula, with regard to density estimates and continual presence. Evans and Prior (2012) have suggested a draft porpoise SAC with a global grading of A/B which includes areas of South-west Lleyn, North & West Anglesey, Southern Cardigan Bay, Pembrokeshire Marine and the Outer Bristol Channel regions. We argue that areas studied around Gower and Swansea Bay should also be included as part of the Outer Bristol Channel SAC. The recent Natural Resources Wales (2015) document 'Possible new marine Special Areas of Conservation and Special Protection Areas in Wales' highlights potential sites around the Welsh coast which, according to scientific evidence, are considered to support internationally important populations of harbour porpoise. However, Swansea Bay/Gower areas were overlooked. The only sites under consideration (and based on visual sightings only) are north of Anglesey, the Lleyn Peninsula and Cardigan Bay and Carmarthen Bay extending across to North Devon and Cornwall. With the exception of the Outer Bristol Channel region, all other areas suggested within the Evans and Prior (2012) recommendations have been identified for consideration as harbour porpoise SACs. The evidence provided and analysed here suggests that the boundary of the suggested Carmarthen Bay/North Cornwall/Devon harbour porpoise SAC site be extended eastwards to incorporate the whole of the Gower Peninsula and Swansea Bay (Fig. 7). Decisions on whether to designate further SACs in Welsh waters will be made by the Welsh Minister for Natural Resources after full public consultation.

The presented data demonstrates a need to protect habitat integrity for the local resident population that exists so that breeding populations may continue to utilise these waters. Research is currently underway to develop a more cost effective, comprehensive biodiversity monitoring programme which will meet existing and future legal requirements, including those under the Habitats Directive and MSFD (DEFRA, 2014). In relation to cetaceans, this will assess effectiveness of all current approaches to monitoring (including dedicated and opportunistic survey data, strandings and bycatch monitoring) and, where necessary, indicate areas where monitoring could be better targeted. Improving the join-up between existing cetacean monitoring programmes and utilising novel methodologies that enhance cost-effectiveness will be germane to that commitment (DEFRA, 2014). Several organisations/academics may collect data but there is often an inherent failure to share or disseminate that information between interested parties. As a result, there can be many disparate sources of data but bringing that together in a coherent and effective manner is challenging.

This research has identified hotspots by wide-scale surveys and determined variations in abundance over an appropriate temporal scale. Data has been supplemented for better predictive assessments, and a variety of complementary survey and monitoring techniques to derive as much information as possible have been used. Key habitats such as nursery areas, where special protective measures need to be taken, have been identified, while adoption of a flexible management process has been suggested to allow boundary changes to be made at regular intervals. Consequently,

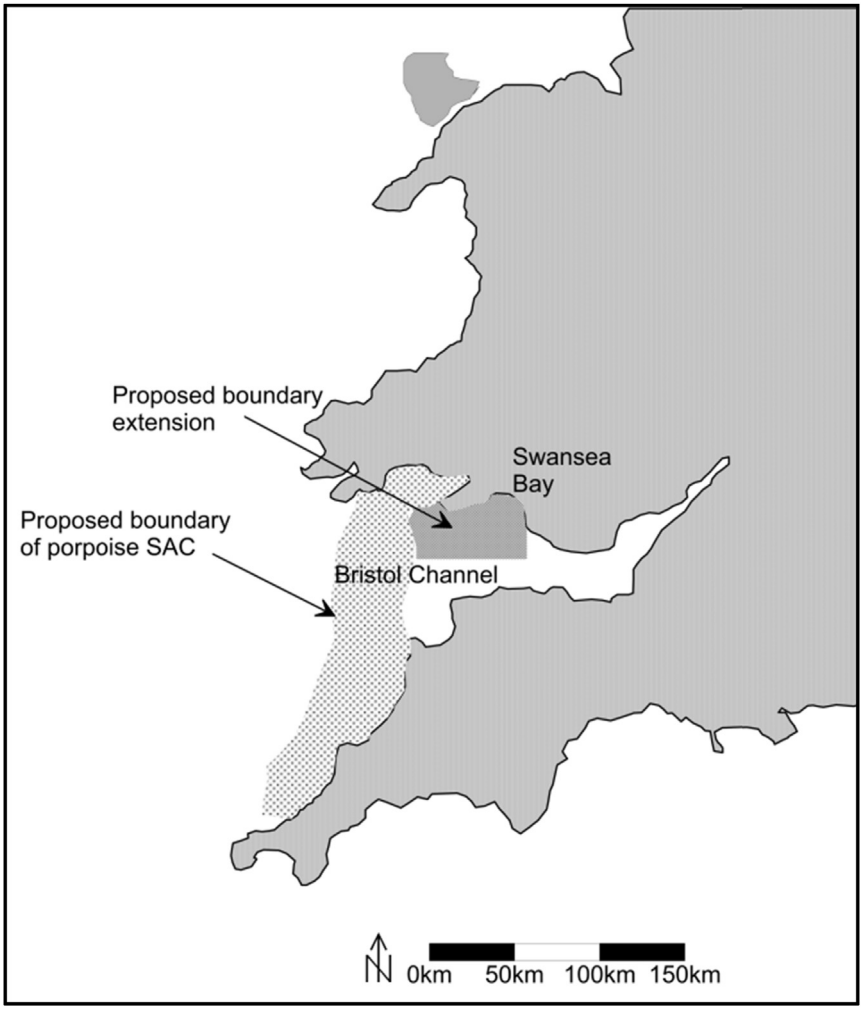


Fig. 7. Proposed Carmarthen Bay/North Cornwall/Devon harbour porpoise SAC site, with proposed eastward extension.

this work has followed Evans and Pesante (2008) five key recommendations with respect to applying criteria for marine protected areas.

4. Conclusion

This paper sought to produce a more complete assessment of harbour porpoise populations in the Swansea Bay and Gower region of South Wales. Using a number of different data sources, seasonal and temporal distribution patterns were established for the period 2002–2013. Several local sites have been identified by government/developers as suitable for emergent marine renewable technologies (wind farms and tidal lagoons principally) and while long-term benefits exist for all marine species, the siting of such developments will be critical to their immediate survival. All too often decisions are made based upon meagre available data, and lack of co-operation between organisations collecting ecological datasets compounds the challenge. This paper has collated observational data from disparate sources in order to provide a more complete picture of porpoise presence within local coastal waters. Continual data collection and this type of cooperation must be encouraged if science is to enable appropriate and adequate protection for marine mammals. Further, it will also provide a reservoir of current and long-term trend data which will undoubtedly speed up the protracted planning process for potential/future offshore marine renewable energy developments.

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References

Aish, A., Johnson, C., 2009. Selection Criteria and Guiding Principles for Selection of SACs for Marine. Annex I habitats and Annex II species in the UK. JNCC, p. 31.
Baines, M.E., 2002. Personal Communication. Surveying Methodologies Discussed during a Visit to Swansea. Institute of Higher Education in November 2002.
Baines, M.E., Earl, S., 1999. Analysis of Sightings Data for Indications of Harbour Porpoise Breeding off the Welsh Coast. CCW Report no. 379.
Baines, M.E., Evans, P.G.H., 2012. Atlas of the Marine Mammals of Wales. CCW Marine Monitoring Report No. 68, second ed., p. 139
Baines, M.E., Pierpoint, C., Earl, S., 1997. A Cetacean Sightings Database for Wales

and an Evaluation of Impacts on Cetaceans from the Sea Empress Oil Spill. Report to the Sea Empress Environmental Evaluation Committee. Countryside Council for Wales (CCW), p. 70.
Batey, L., Edwards, J., 2014. Megafauna Hotspots: the Missing Link in Our Network of Marine Protected Areas. Spatial protection for whales, dolphins, porpoises and basking sharks recommended by The Wildlife Trusts, p. 29.
Bristow, T., Rees, E.I., 2001. Site fidelity and behaviour of bottlenose dolphins (*Tursiops truncatus*) in Cardigan bay, Wales. Aquat. Mamm. 27 (1), 1–10.
Booth, C.G., Embling, C., Gordon, J., Calderan, S.V., Hammond, P.S., 2013. Habitat preferences and distribution of the harbour porpoise *Phocoena phocoena* west of Scotland. Mar. Ecol. Prog. Ser. 478, 273–285.
Brown, I., Harrison, P., Ashley, J., Berry, P., Everard, M., Firbank, L., Hull, S., Lundy, L., Quine, C., Rowan, J., Wade, R., Walmsley, S., Watts, K., Kass, G., 2014. UK National Ecosystem Assessment Follow-on. Work Package Report 8: Robust Response Options: what Response Options Might Be Used to Improve Policy and Practice for the Sustainable Delivery of Ecosystem Services? UNEP-WCMC, LWEC, UK, p. 177.
Bunker, F., Hart, S., 2002. Gower Seasearch 1995. A Report to the Countryside Council for Wales from MarineSeen, Estuary Cottage, Bentlass, Hundleton, Pembrokeshire. CCW Science Report No. 516.
Cefas, 2013. Sanitary Survey of Oxwich Bay. Cefas report on behalf of the Food Standards Agency, to demonstrate compliance with the classification of bivalve mollusc production areas in England and wales under EC Regulation Number 854/2004, p. 90.
Clark, J., Dolman, S.J., Hoyt, E., 2010. Towards Marine Protected Areas for Cetaceans in Scotland, England and Wales: a Scientific Review Identifying Critical Habitat with Key Recommendations. Whale and Dolphin Conservation Society, Chippenham, UK, p. 178.
CMS, 2015. Appendix II Convention on Conservation Migratory Species. Available from: http://www.cms.int/sites/default/files/basic_page_documents/Appendices_COP11_E.pdf. Appendices, Appendices I and II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS) (as amended by the Conference of the Parties in 1985 , 1988, 1991, 1994, 1997, 1999, 2002, 2005, 2008, 2011 and 2014) Effective: 8 February 2015.
Davies, A., 2013. Written Statement - Marine Conservation Zones and Marine Protected Areas in Wales. Available from: http://gov.wales/about/cabinet/cabinetstatements/2013/mcz/?lang=e (accessed (2.02.15.).
DECC., 2013. UK Energy Roadmap Update, Department of Energy and Climate Change. London, p. 76.
DEFRA., 2011. A Description of the Marine Planning System for England, p. 96. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/183195/110318-marine-planning-descript.pdf.
DEFRA, 2014. Marine Strategy Part Two: UK Marine Monitoring Programmes. DEFRA, pp. 22–28. July 2014.
DEFRA., 2015. Marine Strategy Framework Directive Consultation Programme of Measures, pp. 47–61. Available from: https://consult.defra.gov.uk/marine/msfd-programme-of-measures/supporting_documents/20141015%20POM%20complete%20consultation%20document%20FINAL.pdf.
Dolman, S.J., Champion, A., Clark, J., Eisfeld-Pierantonio, S., Green, M., Gregerson, S., Hodgkins, N., Ritter, F., Tetley, M., Hoyt, E., 2013. Making Space for Porpoises, Dolphins and Whales in UK Seas: Harbour Porpoise Special Areas of Conservation as Part of a Coherent Network of Marine Protected Areas for Cetaceans. A WDC report, p. 86.
EA (Environment Agency), 2002. Environmental Impact Assessment (EIA). A Handbook for Scoping Projects. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/296952/geho0411btrf-e-e.pdf (accessed Oct 12).
Embling, C.B., Gillibrand, P.A., Gordon, J., Shrimpton, J., Stevick, P.T., Hammond, P.S., 2009. Using habitat models to identify suitable sites for marine protected areas for harbour porpoises (*Phocoena phocoena*). Biol. Conserv. 143, 267–279.
European Commission, 1992. COUNCIL DIRECTIVE 92/43/EEC of 21 May 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31992L0043&from=EN (accessed Oct 2012).
European Commission, 2001. Interpretation Note: Selection of Sites for the Species of Annex II Phocoena Phocoena. Habitats Committee. Hab. 01/05.
European Union, 2007. Guidelines for the Establishment of the Natura 2000 Network in the Marine Environment. Application of the Habitats and Birds Directives. Available from: http://ec.europa.eu/environment/nature/natura2000/marine/docs/marine_guidelines.pdf.
European Union Committee, 2008. HOUSE of LORDS. European Union Committee 27th Report of Session 2007–08 The EU's Target for Renewable Energy: 20% by 2020 Volume I: Report. Published by the Authority of the House of Lords London : The Stationery Office Limited. Available from: http://www.publications.parliament.uk/pa/ld200708/ldselect/ldeucom/175/175.pdf.
Evans, P.G.H., 2003. Cetaceans in Swansea Bay and the Outer Bristol Channel. Sea Watch Foundation, Oxford, p. 14.
Evans, P.G.H., Pesante, G., 2008. Research for management: the Cardigan Bay experience. Ppp. 61–69. In: Selection Criteria for Marine Protected Areas for Cetaceans (Editor P.G.H. Evans). Proceedings of the ECS/ASCOBANS/ACCOBAMS Workshop Held in San Sebastían, Spain, 22 April 2007, European Cetacean Society Special Publication Series, 48, pp. 1–104. pages 61-69.
Evans, P.G.H., Prior, J.S., 2012. Protecting the Harbour Porpoise in UK Seas: Identifying a Network of Draft SACs for the Harbour Porpoise in the UK. A report to WWF UK, p. 66.
Evans, P.G.H., Wang, J., 2008. Harbour porpoise spatial modelling to identify possible hotspots for marine protected Areas. In: Selection Criteria for Marine Protected Areas for Cetaceans (Editor P.G.H. Evans). Proceedings of the ECS/ASCOBANS/ACCOBAMS Workshop Held in San Sebastían, Spain, 22 April 2007, European Cetacean Society Special Publication Series, 48, pp. 1–104 pages 44–51.
Goodwin, L., Speedie, C., 2008. Relative abundance, density and distribution of the harbour porpoise *Phocoena phocoena* along the west coast of the UK. J. Mar. Biol. Assoc. U. K. 88 (6), 1221–1228, 2008.
Green, M., Caddell, R., Eisfeld, S., Dolman, S.J., Simmonds, M.P., 2012. Looking Forward to 'strict Protection': a Critical Review of the Current Legal Regime for Cetaceans in UK Waters. A WDCS Science report, p. 54. Available online at: http://www.wdcs.org/submissions_bin/uk_legal_regime_report.pdf.
Harley, C.D.G., Hughes, A.R., Hultgren, K.M., Miner, B.G., Sorte, C.J.B., Thornber, C.S., Rodriguez, L.F., Tomanek, L., Williams, S.L., 2006. The impacts of climate change in coastal marine systems. Ecol. Lett. 9, 228–241 (2006).
Hammond, P.S., Macleod, K., 2006. Progress Report on the SCANS-II Project. University of St. Andrews, p. 6.
Hammond, P.S., Macleod, K., Berggren, P., Borchers, D.L., Burt, L., Cañadas, A., Desportes, G., Donovan, G.P., Gilles, A., Gillespie, D., Gordon, J., Hiby, L., Kuklik, I., Leaper, R., Lehnert, K., Leopold, M., Lovell, P., Øien, N., Paxton, C.G.M., Ridoux, V., Rogan, E., Samarra, F., Scheidat, M., Sequeira, M., Siebert, U., Skov, H., Swift, R., Tasker, M.L., Teilmann, J., Van Canneyt, O., Vázquez, J.A., 2013. Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management. Biol. Conserv. 164, 107–122.
Inger, R., Attrill, M.J., Bearhop, S., Broderick, A.C., Grecian, W.J., Hodgson, D.J., Mills, C., Sheehan, E., Votier, S.C., Witt, M.J., Godley, B.J., 2009. Marine renewable energy; potential benefits for biodiversity? an urgent call for research. J. Appl. Ecol. 46, 1145–1153.
Jenkins, R.E., 2007. Aspects of Harbour Porpoise Population Dynamics in the Bristol Channel and Strategies for Conservation Management. PhD thesis. School of Built & Natural Environment. Swansea Metropolitan University, Swansea, p. 398.
Jenkins, R.E., Brown, R.D., Phillips, M.R., 2009. Harbour porpoise (*Phocoena phocoena*) conservation management: a dimensional approach. Mar. Policy 33 (5), 744–749.
JNCC, 2014. EU Marine Strategy Framework Directive. http://jncc.defra.gov.uk/page-5193 (accessed 24.10.14.).
Jones, N., Shucksmith, R., Dicks, E.F., Stoyle, G.W., 2005. Abundance and Distribution of Harbour Porpoise in North Anglesey Waters Determined from 2002, 2003 & 2004 Boat Based Surveys. Species Challenge Report No. 04/01/02.
Liquete, C., Piroddi, C., Drakou, E.G., Gurney, L., Katsanevakis, S., Charef, A., Egoh, B., 2013. (2013). Current status and future prospects for the assessment of marine and coastal ecosystem services: a systematic review. Published online 2013 Jul 3 PLoS One 8 (7), e67737. http://dx.doi.org/10.1371/journal.pone.0067737. PMCID: PMC3701056.
Luk, S., Gregerson, S., 2013. Harbour Porpoise Special Areas of Conservation. Making a Case for Porpoises in UK Seas. Legal report prepared for Whale and Dolphin Conservation. ClientEarth, p. 102.
Mackie, A.S.Y., James, J.W.C., Rees, E.I.S., Darbyshire, T., Philpott, S.L., Mortimer, K., Jenkins, G.O., Morando, A., 2006. The Outer Bristol Channel Marine Habitat Study. — Studies in Marine Biodiversity and Systematics from the National Museum of Wales, p. 249. BIOMÔR Report 4.
Mann, J., 1999. Behavioural sampling methods for cetaceans: A review and critique. Mar. Mamm. Sci. 15, 102–122.
MCA., 2009. The Marine and Coastal Access Act 2009. The Stationery Office Ltd, London, p. 332.
MEA, 2005. Millennium Ecosystem Assessment: Ecosystems and Human Wellbeing: Synthesis. Island Press, Washington DC, p. 137.
Natura, 2000. (2007). Guidelines for the Establishment of the Natura 2000 Network in the Marine Environment. Application of the Habitats and Birds Directives. http://ec.europa.eu/environment/nature/natura2000/marine/docs/marine_guidelines.pdf (accessed Oct 2013).
Neslan, A., 2014. UK is breaking EU's conservation laws on porpoises. Published online 17 October 2014 The Guardian. Available from: http://www.theguardian.com/environment/2014/oct/17/uk-is-breaking-eus-conservation-laws-on-porpoise.
NRW (Natural Resources Wales), 2015. Possible New Marine Special Areas of Conservation and Special Protection Areas in Wales. NRW publication, p. 16.
NIEA., 2010. Inshore Special Areas of Conservation: Skerries and Causeway SAC Selection Assessment, p. 37. Northern Ireland Environment Agency. http://www.doeni.gov.uk/niea/skerries_and_causeway_sac__site_selection_assessment_v5_-_20_dec_2010.pdf.
OSPAR., 2008. Case Reports for the OSPAR List of Threatened And/or Declining Species and Habitats (2008/358), p. 261.
Parsons, E.C.M., Clark, J., Ross, A., Simmonds, M.P., 2010. The conservation of british cetaceans: a review of the threats and protection afforded to whales, dolphins and porpoises in UK waters, part 2. J. Int. Wildl. Law Policy 13 (2), 99–175, 2010.
Penrose, R., Pierpoint, C., 1999. Countryside Council for Wales (CCW) Contract Report. The Use of Welsh Coastal Habitats as Calving and Nursery Grounds for the Harbour Porpoise, 378, p. 22.
Pesante, G., Baines, M.E., Felce, T.H., Ugarte, F., Evans, P.G.H., 2007. Trends of abundance of bottlenose dolphins and harbour porpoises in the Cardigan Bay Special Area of Conservation, Wales (2001–2006). In: 21st Annual Conference of the European Cetacean Society, San Sebastian, Spain, 22–25 April 2007.

Phillips, M.R., Crisp, S., 2010. Sea level trends and NAO influences: the bristol channel/severn estuary. Glob. Planet. Change 73 (3), 211–218.
Pierpoint, C., 2001. Harbour Porpoise Distribution in the Coastal Waters of SW Wales. A report to the International Fund for Animal Welfare, p. 41.
Pierpoint, C., 2006. Pre-construction Monitoring of Harbour Porpoise at Scarweather Sands Offshore Wind Farm. SW Wales: Annual Report 2005-06. First Interim Report. Report to E.ON Renewables and DONG Energy by RPS Group Plc, p. 59.
Pierpoint, C., 2008. A Two-year Pre-construction Baseline of Harbour Porpoise Activity at Scarweather Sands Offshore Wind Farm. Report to E.ON Renewables and DONG Energy by RPS Group Plc, p. 102.
Pierpoint, C., Baines, M.E., Earl, S.J., Harris, R., Tregenza, N., 1999. Night life of harbour porpoises. In: Evans, P.G.H. (Ed.), European Research on Cetaceans – 13. European Cetacean Society, Cambridge, pp. 70–71.
Pinn, E., 2010. Charting progress 2: healthy and biological diverse seas feeder report: section 3.7: cetaceans. Published by department for environment food and rural affairs on behalf of UKMMAS. In: Frost, M., Hawkridge, J. (Eds.), UKMMAS (2010) Charting Progress 2 Healthy and Biological Diverse Seas Feeder Report, pp. 550–591.
Ribeiro, S., Viddi, F.A., Freitas, T.R.O., 2005. Behavioural responses of chilean dolphins (*Cephalorhynchus eutropia*) to boats in yaldad bay, southern Chile. Aquat. Mamm. 31 (2), 234–242.
Shucksmith, R., Jones, N.H., Stoyle, G.W., Davies, A., Dicks, E.F., 2009. Abundance and Distribution of the Harbour Porpoise (Phocoena Phocoena) on the North Coast of Anglesey, 89. JMBA, Wales, UK, 2009, 89(5), 1051–1058.
TLSB., 2012. Proposed Tidal Lagoon Development in Swansea Bay, South Wales - Environmental Impact Assessment Scoping Report. http://infrastructure.planningportal.gov.uk/wp-content/ipc/uploads/projects/%20EN010049/1.%20PreSubmission/EIA/Scoping/Scoping%20Request/EN010049_Tidal%20Power%20Swansea%20Bay%20Scoping%20Document%20Final%20reduced%20size.pdf (accessed Oct 2012).
Uncles, R.J., 2010. Physical properties and processes in the bristol channel and severn estuary. Mar. Pollut. Bull. 61 (2010), 5–20.
UNEP., 2009. Council for the Pan-European Biological and Landscape Diversity Strategy Fifth Intergovernmental Conference Biodiversity in Europe 22-24 September 2009 Liege, Belgium. Connecting Biodiversity and Climate Change Mitigation and Adaptation 1-Key Messages of the Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change, p. 10.
Welsh Government, 2014b. Developing the Welsh National Marine Plan: A Draft Scope, Draft Vision and related Objectives including questions on the Draft Scope for the Sustainability Appraisal. Consultation Document Number: WG22047.
Wilson, B., Batty, R.S., Daunt, F., Carter, C., 2007. Collision Risks between Marine Renewable Energy Devices and Mammals, Fish and Diving Birds. Report to the Scottish Executive. Scottish Association for Marine Science, Oban, Scotland., p. 110