Bryony Manley

Risso's dolphins (*Grampus griseus*) and harbour porpoise (*Phocoena phocoena*) around the Isle of Man:

Passive Acoustic Monitoring and visual observations to determine seasonal presence and habitat use

Executive Summary

There is relatively little known about how cetaceans use Manx waters, which are visited regularly by five species including the more unusual Risso's dolphin. Risso's dolphins are generally thought to prefer the deeper waters of shelf edge habitats, making their presence in shallow Manx waters interesting.

Many cetacean studies rely on visual observations to gather information, yet these methods are not ideal. Cetaceans spend little of their time at the surface, making visual observations difficult. Furthermore, visual surveys rely on favourable light and weather conditions, generally biasing data collection to daytime in the summer months. Odontocetes, such as the Risso's dolphin, use echolocation for navigation, hunting, and socialization. By using equipment such as the C-POD, an acoustic device which detects echolocation clicks of dolphins and porpoises, surveys can be conducted in conditions when visual observations would not be possible. This allows a greater insight into the lives of these species, and adds to our limited knowledge of cetacean use of Manx waters.

This study makes use of two C-PODs to study odontocete presence in Manx waters from July to November, particularly looking into the efficacy of using this type of equipment to aid in the study of Risso's dolphins, but also examining porpoise presence, as this is the most commonly seen cetacean species. The devices were deployed in similar depths of water, at two inshore sites in the south west of the Isle of Man.

Over 5000 hours of acoustic data were collected. There were a greater number of detections of both porpoises and dolphins at Calf West compared to Port St Mary. Porpoise detections were lowest in September, when dolphin detections were highest. Porpoises were more active around sunset and at night, whilst dolphins were more active in the day. Porpoises and dolphins appeared to prefer Calf West on the ebb tide and Port St Mary on the flood tide. Due to unfavourable weather conditions, only 51 hours of visual surveying were conducted, with more sightings of both porpoises and dolphins at Port St Mary over Calf West. This indicates the difficulties in relying only on visual methods as small data sets and daylight biased data collection can give misleading results.

The study highlights the power of using acoustic methods to supplement visual ones, and shows the advantages of having a method of surveying which can operate continuously. This opens up areas for future investigation, and contributes to the knowledge of cetacean use of Manx waters.

Introduction

The Isle of Man is a small island in the Irish Sea (Figure 1) covering around 580km^2 and sits approximately 50km from the UK and Ireland. The territorial waters stretch to 12nmi and are generally shallow, with the greatest depths reaching just over 100m. The waters out to 3nmi cover an area of approximately 783km^2, whilst the waters out to 12nmi cover an area of approximately 3926km^2. Within the territorial seas there are fisheries for king scallop, queen scallop, crab, lobster, nephrops, and whelk (Hanley *et al*., 2012a).

Figure 1: Showing the small Isle of Man, and its location in the middle of the Irish Sea (Google Maps)

The Isle of Man hosts a number of marine 'megafauna' species. The island is well known for basking sharks (*Cetorhinus maximus*) with the tourism website mentioning that "between May and August Manx waters are infiltrated by high numbers of basking sharks" (Visit Isle of Man, 2015). Also seen are the grey seal (*Halichoerus grypus*) and the common seal (*Phoca vitulina*). A number of cetacean species including harbour porpoise (*Phocoena phocoena*), short-beaked common dolphin (*Delphinus delphis*), bottlenose dolphin (*Tursiops truncatus*), Risso's dolphin (*Grampus griseus*), and minke whale (*Balaenoptera acutorostrata*) also use Manx waters, at least seasonally (Hanley *et al.,* 2012b). However, with very few published papers mentioning them, little is understood about exactly how cetaceans use Manx waters.

One of the more interesting frequenters of Manx waters is the Risso's dolphin (Figure 2). Risso's are the fifth largest of the delphinid species, exhibiting a worldwide distribution through temperate and tropical oceans, often preferring deeper, shelf edge habitats (Baird, 2002), and are considered to have a teuthophagous (cephalopod) diet (Neves, 2013). Though the Risso's dolphin has been listed as Least Concern on the IUCN Red List (Taylor *et al.*, 2012), there are no worldwide, and few regional, estimates of population size or trends. Around the UK they are often seen off the west coast of Scotland, and around Ireland and Wales, and the UK population is genetically differentiated from Mediterranean animals (Gaspari *et al.*, 2007). A recent paper suggests that the waters around Bardsey Island, Wales, may host a population in the region of 90-151 individuals (de Boer *et al.*, 2013). However, this is likely to be seasonal and was based on a small amount of data. Furthermore, there have been confirmed photo-identification matches between Wales and the Isle of Man suggesting a larger area is used by the population (Baines & Evans, 2012).

There have been numerous sightings of Risso's dolphins around the Isle of Man, including sightings of calves and juveniles (pers. obs., Hanley *et al.*, 2012b). They are most often seen in the summer months and generally around the south of the island and, through photo-identification, the same individuals have been known to return year after year (Manx Whale and Dolphin Watch, unpub. data). With relatively little known about the species, the Isle of Man could potentially be an important region for them.

The most frequently seen species in Manx waters is the harbour porpoise, which is seen all around the island and often seen with calves or juveniles in the summer (pers. obs., MWDW unpub. data). Harbour porpoises generally inhabit shallow (<200m) coastal waters in the Northern hemisphere, with the North Sea being a particularly important region potentially hosting around half of the world population. Harbour porpoises usually feed on fish near the sea bed (Bjørge & Tolley, 2002).

Figure 2: A Risso's dolphin leaping in Manx waters (Bryony Manley)

In light of the position of cetaceans as higher trophic level predators, a full understanding of their spatial and temporal habitat use is important as this can often give indications of the health of the underlying marine ecosystem, and contributes to conservation knowledge. This information becomes particularly relevant with regards to marine development projects such as offshore wind farms and tidal energy turbines, both of which have recently been proposed for Manx waters (BBC News, 2014). In order to mitigate risks to marine life during the installation and operation of such developments, detailed spatio-temporal information is needed for species using the area (Thompson *et al.*, 2013).

Studying cetaceans is inherently problematic as they spend almost all of their time underwater. Visual observations have often been the first port of call in cetacean studies, despite their limitations. To collect sufficient visual data requires man power and a great deal of time, and is limited to daylight hours and calm sea conditions, and hence is predominantly collected in the summer season. However, baseline studies, particularly in relation to marine development projects, require sufficient year round data to detect temporal trends, often making visual studies alone inappropriate (Bailey *et al.*, 2010). An alternative approach is acoustic surveys, which have become increasingly popular in cetacean studies in recent years, due to the opportunity for continuous operation at night and in poor weather when visual observations would not be possible (Mellinger *et al.* 2007).

Like most animals, cetaceans make noise and this fact can be utilised to provide information on the location and behaviour of animals when they are out of sight underwater. In particular, odontocetes, or toothed whales including dolphins and porpoises, produce echolocation clicks to communicate, navigate, and hunt. These distinctive sounds can be detected by static passive acoustic loggers such as the C-POD (Manufactured by Chelonia, Figure 3), which continuously logs clicks within the frequency range 20-160khz (Chelonia, 2015). There have been no acoustic studies conducted in Manx waters, so any information gathered will contribute to the knowledge of cetaceans in this region. Whilst C-PODs have been used regularly in the study of harbour porpoises, worldwide there is little acoustic data on Risso's dolphins.

Figure 3: A C-POD static passive acoustic logger (Chelonia, 2015)

This study will take a preliminary look into the efficacy of C-PODs in Manx waters, with a particular interest in their use relating to the study of the poorly understood Risso's dolphins. Any acoustic data successfully collected will be compared to any visual observations that can be made to examine the usefulness of the different methods and provide some insight into how odontocete species use Manx waters. This study has only two C-PODs available; more than two C-POD's would normally be used to provide sufficient data for an accurate interpretation of site use by a species. Additionally, acoustic loggers should be placed without any bias to particular areas (Mellinger *et al.*, 2007) but as this is a preliminary study into the usefulness of C-PODs to study Risso's dolphins, sites will be chosen based on previous Risso's sightings data obtained by Manx Whale and Dolphin Watch. There are various factors which can affect acoustic studies, and preliminary research and pilot studies such as this are therefore important in determining suitable survey design and interpretation of results (Alonso & Nuutila, 2014; Nuutila *et al.*, 2013).

Methods

Determining C-POD locations

Manx Whale and Dolphin Watch have collected data on the locations of cetaceans in Manx waters since 2007. Data have been collected from various platforms, including sightings reported by members of the public and dedicated surveys from land and boat.

Information from these sources was compiled and ArcMap10.2 was used to determine suitable areas with sightings of Risso's dolphins (Figure 4). It was considered suitable to choose one site on each side of the island, to maximise chances that one area would be sheltered from wind, allowing visual surveys to take place. Additionally, sites were required to not be too strongly tidal, or too close to Douglas due to the frequency of the passenger ferries and other boat traffic operating from here which would significantly contribute to background noise and may reduce detection chances. Finally, the sites needed to be clearly visible from land to allow visual surveys of the waters immediately surrounding the C-PODs.

Based on this information the two sites chosen were 54.061°, -4.741° in Bay Ny Carrickey, hereafter referred to as Port St Mary (PSM), and 54.061°, -4.816°, on the northwest side of the Calf of Man, hereafter referred to as Calf West (CW) (Figure 5).

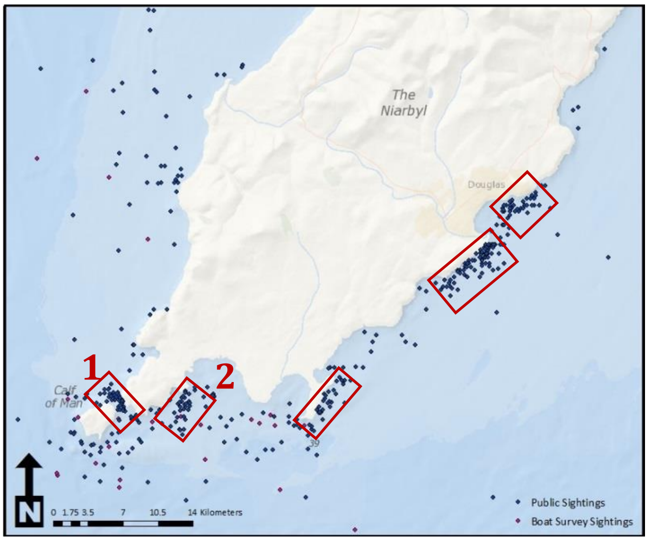

Figure 4: Risso's dolphin sightings from boat and public data from Manx Whale and Dolphin Watch between 2007 and 2013. Red boxes indicate small areas with lots of sightings, boxes 1 & 2 were chosen

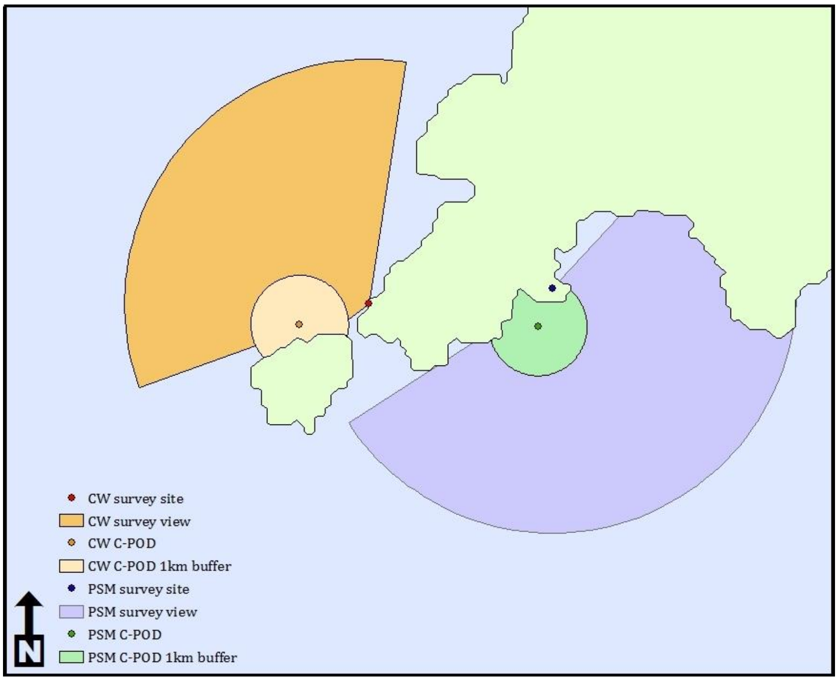

Figure 5: Showing the locations of the C-PODs and the visual survey sites, as well as the approximate areas covered by each (1km around the C-PODs and 5km out from the survey site)

Acoustic monitoring

Two C-POD acoustic loggers were used in this study, each one powered by eight D cell batteries, recording data on to a 4GB SD card, and attached to approximately 50kg of weight to sit 3.5-5m above the sea bed. The C-PODs were deployed in two separate locations as stated above, one at Port St Mary in approximately 25m of water, and the other at the Calf West in approximately 22m of water.

The two C-PODs were initially deployed on 22/07/2014. CW C-POD was retrieved on 24/08/2014, the batteries were changed and the data downloaded from the SD card, before the C-POD was re-deployed in the same location. PSM C-POD was retrieved on 02/09/2014, and again batteries and SD card were changed, before re-deployment in the same location. The C-PODs were then left in place for the remainder of the study period, to be hauled approximately 12 weeks later, depending on weather conditions. CW C-POD was retrieved on 25/11/2014, and PSM C-POD on 31/11/2014.

Visual monitoring

Whilst the C-PODs were operational, visual monitoring was conducted at the two sites whenever conditions allowed, i.e. suitable daylight, more than 1km visibility, and Beaufort sea state <3 (no white-capped waves). Surveys were always conducted from the same locations: 54.068°, -4.737° at Port St Mary, and 54.065°, -4.794° at Calf West. Survey areas were scanned with the naked eye and Nikon 7x50 binoculars to spot cetacean species. Animal locations were determined, wherever possible, using a Nikon NE-20S digital theodolite to record vertical and horizontal angles to the animal. When the theodolite was used, height above the water was determined using a vertical angle from the theodolite and a distance to the waterline through a laser range finder. The theodolite could not be used in the rain, therefore if conditions were not suitable locations were collected using a compass to determine bearing, and millimetres below the horizon to determine distance. Data were recorded in the field on paper forms and transferred to an Excel spreadsheet where formulae were used to convert angles from the theodolite, or bearing and distance from the compass, into latitude-longitude positions.

Manx Whale and Dolphin Watch also regularly receive information about cetacean sightings from members of the public. These were collated for the duration of the C-POD deployments.

Acoustic analyses

Analyses of C-POD data were carried out using the software, CPOD.exe, provided by the C-POD manufacturing company and freely downloadable from their website (Chelonia, 2015). This software allows all details of the files to be examined and chosen features to be exported to spreadsheets for further analysis. Files were imported to CPOD.exe from the SD cards, and run through the classifier to determine the number of cetacean clicks detected in each of two categories: 'NBHF' – narrow band high frequency, which in this case will be harbour porpoises, and 'other cetaceans' – most likely here to be Risso's dolphins, though also potentially from common or bottlenose dolphins.

The metadata warnings generated for each file indicated whether the likelihood of false positive train identification was low, or whether a sample of trains should be visually validated. If no warnings were present false positives were likely to be below 15%. Where visual validation was recommended, the method of sampling 100 trains as suggested in the CPOD.exe manual was used, and false positives where ignored where they constituted less than 15%, which was the case for all files.

For porpoises and dolphins only High and Moderate quality trains were used to examine features such as detection positive minutes (DPM) per hour and detection positive hours (DPH) per day. Detection positive intervals are specified periods of time in which a detection was made. Therefore a detection positive hour could contain one click train, or many, but it indicates that an animal was present within that interval. For each species at each site data were summarized as mean detection positive intervals in different categories.

Times of high water and low water (Tide Times, 2015), as well as the times of nautical sunrise and sunset (Time and Date, 2015) were compiled for each site. Survey days were separated into hour intervals and marked as **day** or **night** based on nautical sunrise and sunset times. Periods were then further separated into **SR-1** (hour preceding sunrise), **SR Hr** (hour of sunrise), **SR+1** (hour following sunrise), **SS-1** (hour preceding sunset), **SS Hr** (hour of sunset), **SS+1** (hour following sunset), **day** (hours between SR+1 and SS-1), and **night** (hours between SS+1 and SR-1). Mean detection positive intervals were calculated for each of these periods to indicate any diel patterns in presence.

Days were also separated into periods based on the tidal cycle, with the period between low water and high water deemed **Flood**, and the period between high water and low water deemed **Ebb**. The day with the highest tidal range, and the day either side were deemed **Spring**, and the lowest ranges and the day either side deemed **Neap**. Therefore the days could also be separated into **Flood Spring**, **Flood Neap**, **Ebb Spring**, and **Ebb Neap**. Mean detection positive intervals were calculated for each of these periods to indicate any patterns in presence.

Visual analyses

Date, time, latitude-longitude location, and species of each sighting was compiled for each of the two survey sites from both dedicated visual surveys, and publicly reported sightings. These data could then be compared to the acoustic data to confirm species on any concurrent detections, and determine closest and furthest detection distances on the C-PODs using ArcMap10.2.

Results

Acoustic monitoring

Acoustic monitoring took place on a total of 233 days, with 5641 hours of data collected across the two survey sites (Table 1). The C-POD at Calf West operated for the entire time it was in the water, whilst the C-POD at Port St Mary stopped on 08/11/2014, hence completing fewer days.

Table 1: Showing deployment details for the two C-PODs

<table>
<tr><th>C-POD</th><th>Location</th><th>Latitude</th><th>Longitude</th><th>Deployment date/time</th><th>Retrieval date/time</th><th>Complete Days</th><th>Complete Hours</th></tr>
<tr><td rowspan="2">38</td><td rowspan="2">Calf West</td><td rowspan="2">54.061</td><td rowspan="2">-4.816</td><td>22/07/2014 10:18</td><td>24/08/2014 11:40</td><td rowspan="2">125</td><td rowspan="2">3025</td></tr>
<tr><td>24/08/2014 11:48</td><td>25/11/2014 13:55</td></tr>
<tr><td rowspan="2">39</td><td rowspan="2">Port St Mary</td><td rowspan="2">54.061</td><td rowspan="2">-4.741</td><td>22/07/2014 10:20</td><td>02/09/2014 11:31</td><td rowspan="2">108</td><td rowspan="2">2616</td></tr>
<tr><td>02/09/2014 11:36</td><td>30/11/2014 10:40</td></tr>
</table>

Porpoises

The first porpoise detected at Calf West was on 23/07/2014, and the first at Port St Mary on 22/07/2014. The last porpoise detected at Calf West was on 24/11/2014, and the last at Port St Mary was on 08/11/2014 the last operating day for that C-POD.

A total of 27750 porpoise click trains were detected, 78.32% (21735) at Calf West, and 21.68% (6015) at Port St Mary. Porpoises were detected on 98.40% of days and in 38.51% of hours at Calf West, and on 95.37% of days and in 19.53% of hours at Port St Mary (Table 2). Detection positive hours (DPH) per day at Calf West (mean=9.32, s.d=4.92) were significantly higher than at Port St Mary (mean=4.63, s.d=3.34) (t-test, $p<0.001$). Detection positive minutes (DPM) per hour at Calf West (mean=2.20, s.d=4.75) were also significantly higher than at Port St Mary (mean=0.76, s.d=2.59) (t-test, $p<0.001$). Mean DPM/hour were highest in August and October at Calf West, and in August and November at Port St Mary, and at both sites mean DPM/hour were lowest in September (Figure 6).

At Calf West mean DPM/hour were greater at night (mean=3.55, s.d=6.45) than during the day (mean=1.39, s.d=3.08) (t-test, $p<0.001$), but there was no difference between day (mean=0.76, s.d=2.49) and night (mean=0.75, s.d=2.75) (t-test, $p=0.98$) detections at Port St Mary. When data were further separated into periods before, during, and after sunrise and sunset, differences in detections could be seen (Table 3). The period with highest mean DPM/hour was SS+1 at both Calf West (4.24) and Port St Mary (1.13). The lowest detections at Calf West came in SS-1 (0.81), and in SR+1 (0.33) at Port St Mary (Figure 8).

At Calf West mean DPM/hour were higher during Ebb tides (mean=2.34, s.d=4.71) than Flood tides (mean=2.05, s.d=4.78), though this was not significant (t-test, $p=0.09$). At Port St Mary, the opposite was the case, with higher DPM/hour in Flood tides (mean=0.95, s.d=3.09) than Ebb tides (mean=0.56, s.d=1.91), and this was a significant difference (t-test, $p<0.001$). At Calf West DPM/hour were highest in Spring tides (mean=2.67, s.d=5.78), though this was not significantly higher than Neap tides (mean=2.39, s.d=4.85) (t-test, $p=0.37$), but was significantly higher than when the tide was neither spring nor neap (mean=1.96, s.d=4.25) (t-test, $p<0.005$). At Port St Mary DPM/hour were also highest in Spring tides (mean=1.05, s.d=2.96), which was significantly higher than Neap tides (mean=0.46, s.d=1.58) tides (t-test, $p<0.001$) and when the tide was neither spring nor neap (mean=0.75, s.d=2.69) (t-test, $p<0.05$). When further separated Calf West showed the highest DPM/hour during Ebb Spring (3.08), followed by Ebb Neap (2.56), whereas Port St Mary was highest during Flood Spring (1.25) followed by Flood (0.96) (Table 4, Figure 10).

Table 2: C-POD detection summaries for porpoises and dolphins at each of the two survey sites. (DPD/DPH/DPM = detection positive day/hour/minute)

Species	Site	Total clicks	Total trains	DPD	DPH	%DPD	% DPH	Mean DPH/day	Mean DPM/hour
Porpoises	CW	340337	21735	123	1165	98.4	38.51	9.32	2.20
	PSM	95596	6015	103	511	95.37	19.53	4.63	0.76
Dolphins	CW	34091	1661	24	49	19.20	1.62	0.39	0.11
	PSM	7336	412	13	17	12.04	0.65	0.15	0.03

Table 3: Mean detection positive minutes per hour for different periods of day and night, at each site and for each species. SR=Sunrise, SS=Sunset, Hr=hour containing SR or SS, -1=hour before, +1=hour after.

Species	Site	Day	Night	SR-1	SR Hr	SR+1	Day	SS-1	SS Hr	SS+1	Night
Porpoises	CW	1.39	3.55	2.26	1.95	1.41	1.33	0.81	3.33	4.24	3.79
	PSM	0.76	0.75	0.68	0.45	0.33	0.80	0.75	1.10	1.13	0.68
Dolphins	CW	0.16	0.03	0.02	0.05	0.07	0.19	0.06	0.02	0.00	0.03
	PSM	0.05	0.003	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.005

Table 4: Mean detection positive minutes per hour for different tidal states. Neap and Spring are defined as the day of the lowest and highest tidal ranges, respectively, and the day either side.

Species	Site	Flood	Ebb	Flood	Ebb	Flood Neap	Ebb Neap	Flood Spring	Ebb Spring	Neap	Spring	Neither
Porpoises	CW	2.05	2.34	1.92	2.00	2.24	2.56	2.23	3.08	2.39	2.67	1.96
	PSM	0.95	0.56	0.96	0.54	0.65	0.26	1.25	0.85	0.46	1.05	0.75
Dolphins	CW	0.07	0.15	0.10	0.12	0.07	0.42	0.00	0.01	0.24	0.01	0.11
	PSM	0.05	0.01	0.07	0.02	0.00	0.00	0.05	0.00	0.00	0.03	0.04

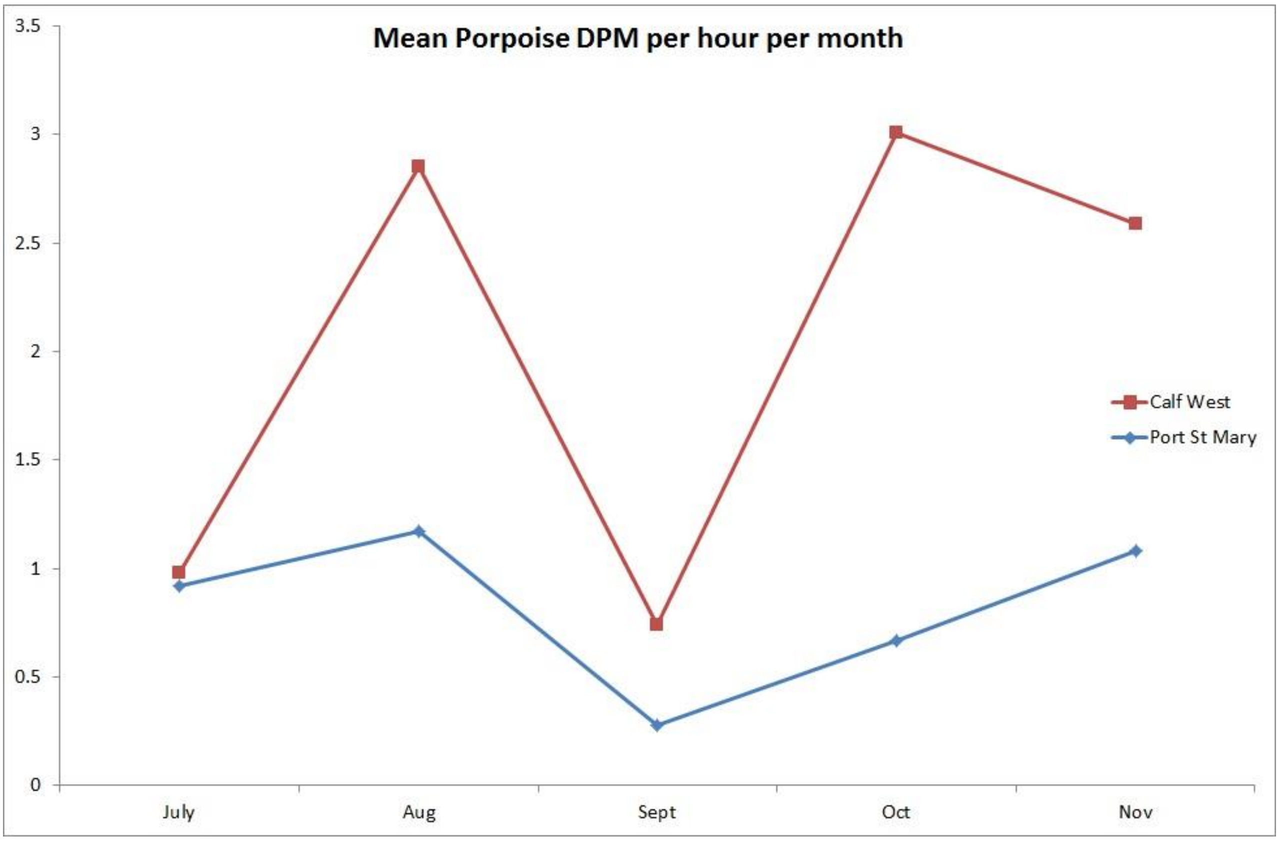

Figure 6: Mean porpoise detection positive minutes per hour in each month, for each of the C-POD sites

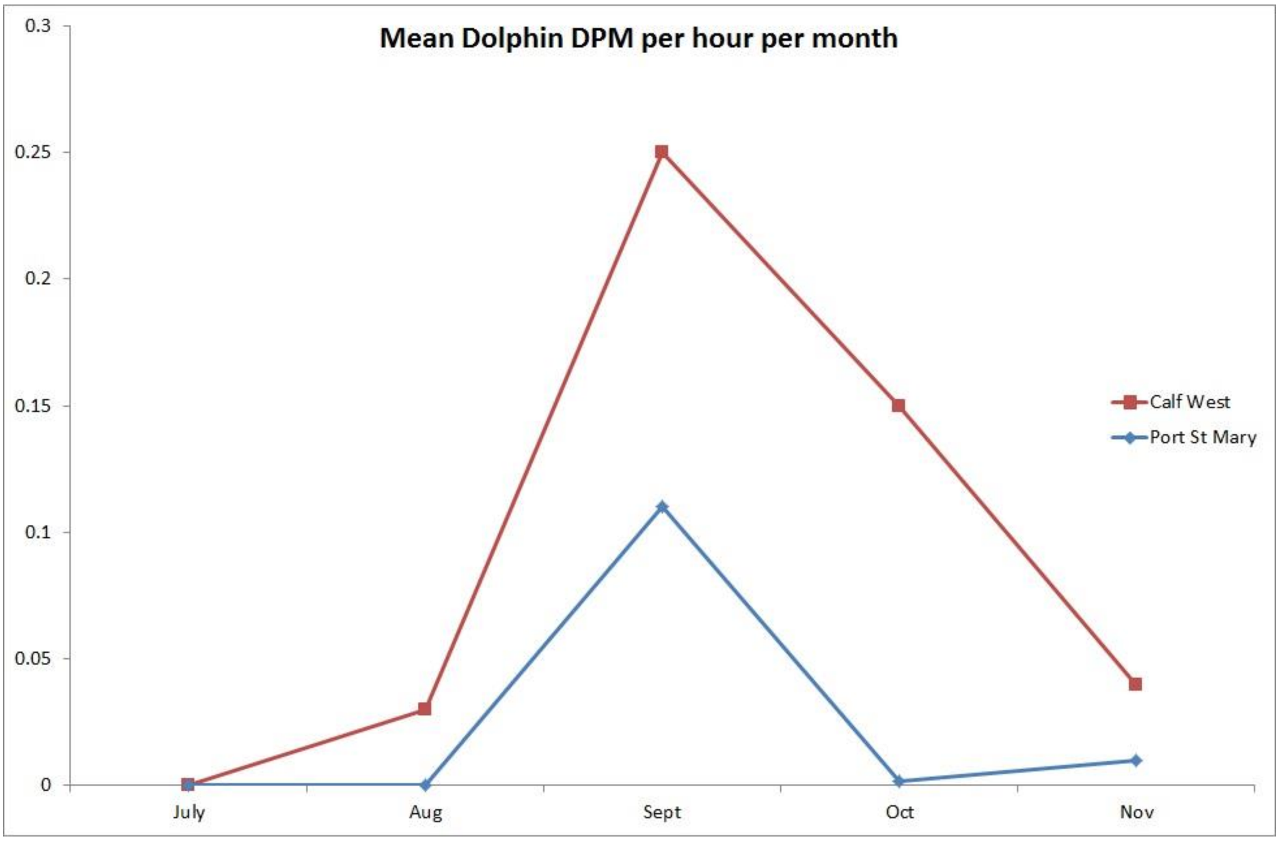

Figure 7: Mean dolphin detection positive minutes per hour in each month, for each of the C-POD sites

Dolphins

The first dolphin detected at Calf West was on 02/08/2014, and the first at Port St Mary on 01/09/2014. The last dolphin detected at Calf West was on 19/11/2014, and the last at Port St Mary was on 08/11/2014 the last operating day for that C-POD.

A total of 2073 dolphin click trains were detected, 80.13% (1661) at Calf West, and 19.87% (412) at Port St Mary. Dolphins were detected on 19.20% of days and in 1.62% of hours at Calf West. Detections were made on 12.04% of days and in 0.65% of hours at Port St Mary (Table 2). Detection positive hours (DPH) per day at Calf West (mean=0.39, s.d=1.08) were significantly higher than at Port St Mary (mean=0.15, s.d=0.47) (t-test, $p<0.05$). Detection positive minutes (DPM) per hour at Calf West (mean=0.11, s.d=1.31) were also significantly higher than at Port St Mary (mean=0.03, s.d=0.52) (t-test, $p<0.01$). Mean DPM/hour were highest in September at both Calf West and Port St Mary, followed by October at Calf West, with low detections in other months at both sites (Figure 7).

At Calf West mean DPM/hour were greater during the day (mean=0.16, s.d=1.62) than at night (mean=0.03, s.d=0.39) (t-test, $p<0.001$), and at Port St Mary DPM/hour were also greater during the day (mean=0.05, s.d=0.65) than at night (mean=0.003, s.d=0.07) (t-test, $p<0.01$). When data were further separated into periods before, during, and after sunrise and sunset, differences in detections could be seen (Table 3). The period with highest mean DPM/hour was day at both Calf West (0.19) and Port St Mary (0.06). The lowest detections at Calf West came in SS+1 (0.00), and at Port St Mary there were no detections in any period except day and night (0.005) (Figure 9).

At Calf West mean DPM/hour were higher during Ebb tides (mean=0.15, s.d=1.47) than Flood tides (mean=0.07, s.d=1.11), though this was not significant (t-test, $p=0.09$). At Port St Mary, the opposite was the case, with higher DPM/hour in Flood tides (mean=0.05, s.d=0.69) than Ebb tides (mean=0.01, s.d=0.26), though this was not significant (t-test, $p=0.06$). At Calf West DPM/hour were highest in Neap tides (mean=0.24, s.d=2.03), which was significantly higher than Spring tides (mean=0.01, s.d=0.17) (t-test, $p<0.01$), though not significantly higher than neither tides (mean=0.11, s.d=1.23) (t-test, $p=0.14$). At Port St Mary DPM/hour were highest in neither tide (mean=0.04, s.d=0.64), which was significantly higher than Neap tides (mean=0.002, s.d=0.04) (t-test, $p<0.05$), though not significantly higher that Spring tides (mean=0.03, s.d=0.41) (t-test, $p=0.46$). When further separated Calf West showed the highest DPM/hour during Ebb Neap (0.42), followed by Ebb (0.12), whereas Port St Mary was highest during Flood (0.07) followed by Flood Spring (0.05) (Table 4, Figure 11).

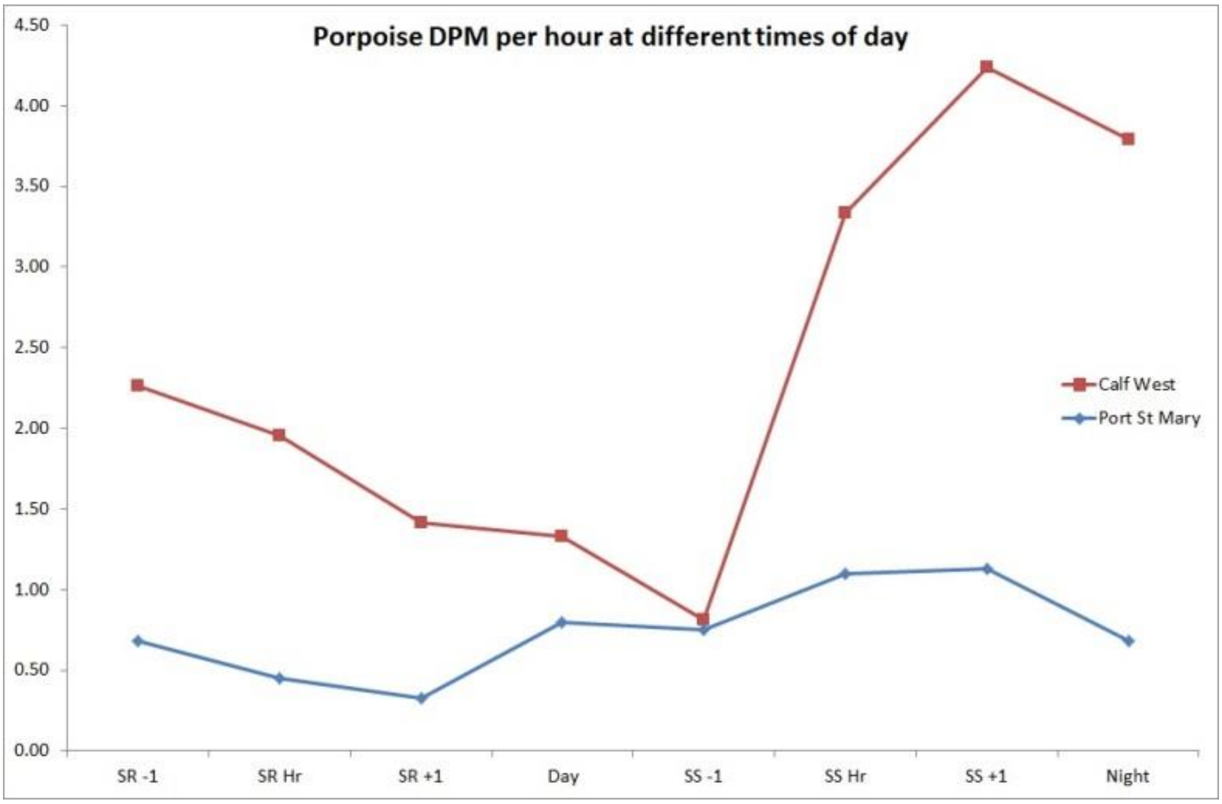

Figure 8: Mean porpoise detection positive minutes per hour at different times of day. SR Hr is the hour in which nautical sunrise occurs, SS Hr is the hour nautical sunset occurs, -1/+1 the hours preceding and succeeding this, and day and night the periods in between.

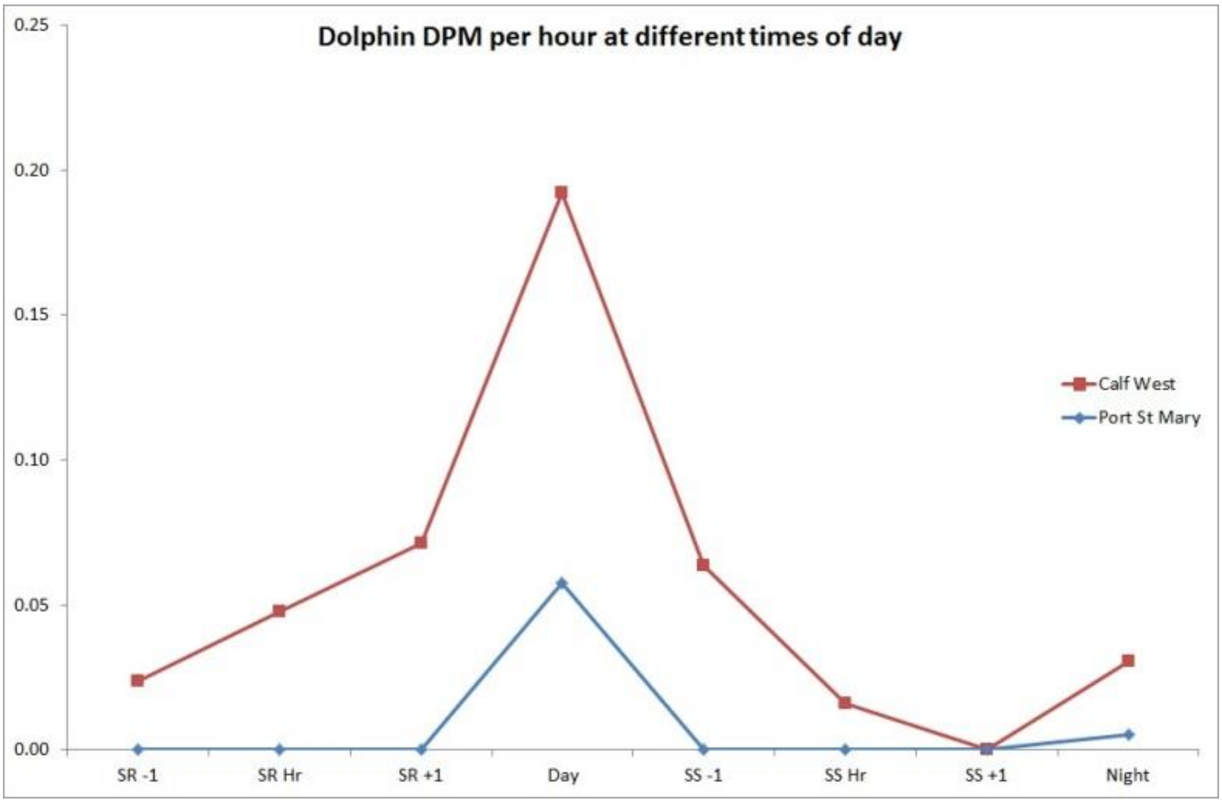

Figure 9: Mean dolphin detection positive minutes per hour at different times of day. SR Hr is the hour in which nautical sunrise occurs, SS Hr is the hour nautical sunset occurs, -1/+1 the hours preceding and succeeding this, and day and night the periods in between.

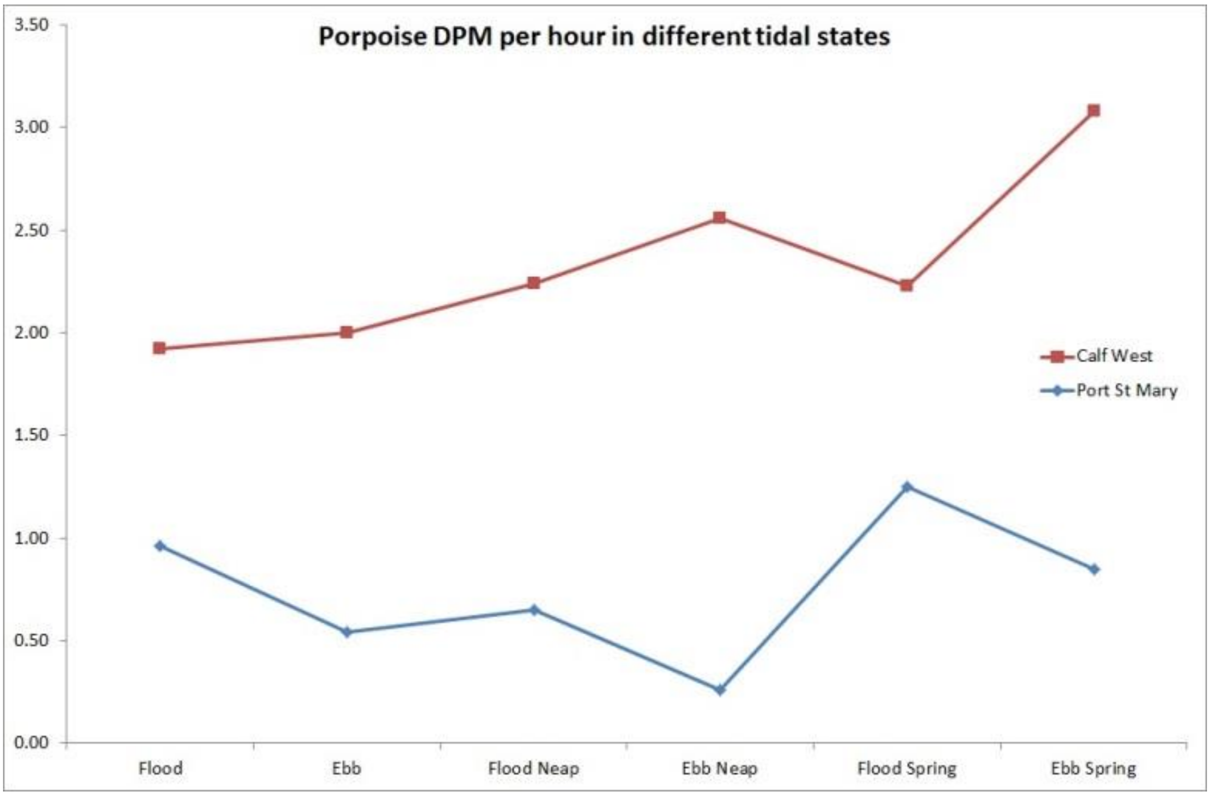

Figure 10: Mean porpoise detection positive minutes per hour in different tidal states. The days with lowest and highest tidal ranges are termed Neap and Spring, respectively, along with the day either side. Flood is the period moving from low water to high water, and Ebb from high water to low water.

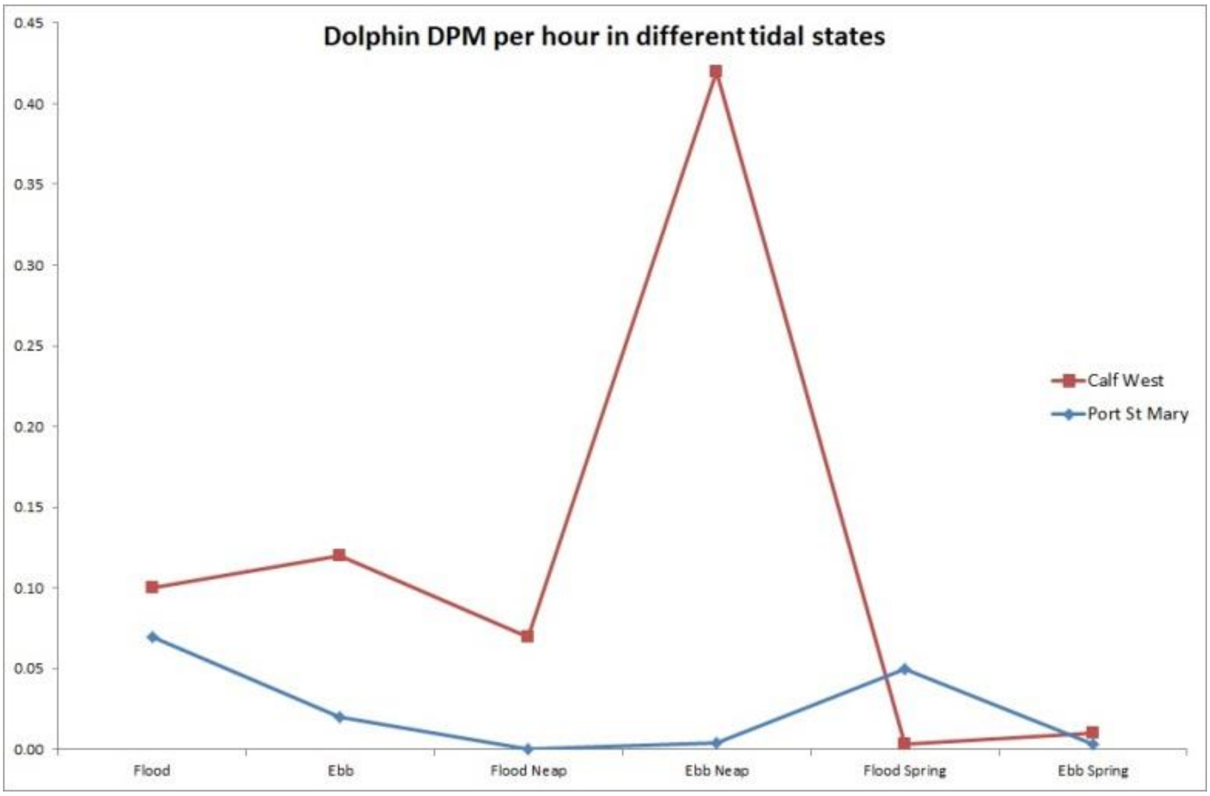

Figure 11: Mean dolphin detection positive minutes per hour in different tidal states. The days with lowest and highest tidal ranges are termed Neap and Spring, respectively, along with the day either side. Flood is the period moving from low water to high water, and Ebb from high water to low water.

Visual

Dedicated

Visual monitoring took place on a total of 29 days, with 51 hours of data collected across the two sites (Table 5). 14 days (11.20%) had visual surveys at Calf West, compared to 125 acoustically, and 25.5 hours (0.84%) were visually surveyed compared to 3025 acoustically. 15 days (13.89%) had visual surveys at Port St Mary compared to 109 acoustic days, and 25.5 hours (0.97%) were visually surveyed compared to 2616 acoustically.

Table 5: Summarising the dedicated visual surveys conducted at the two sites whilst C-PODs were deployed

Location	Latitude	Longitude	Days on site	Hours effort	Porpoise Sightings	Dolphin Sightings
Calf West	54.065	-4.794	14	25.5	4	3
Port St Mary	54.068	-4.737	15	25.5	12	4

A total of 23 odontocete sightings were made during visual surveys. There were 16 sightings of harbour porpoises, with 3 (21.43%) detection positive days (DPD) at Calf West and 6 (40.00%) DPD at Port St Mary. There were 7 sightings of Risso's dolphins, with 2 (14.29%) DPD at Calf West and 4 (26.67%) DPD at Port St Mary. At Calf West all but one of the harbour porpoise sightings had associated acoustic detections (occurring up to 15mins before or after the sighting period), whilst none of the Risso's dolphin sightings did. At Port St Mary 7 of the 12 porpoise sightings had associated acoustic detections. One Risso's dolphin sighting had no acoustic detections, and one had detections an hour before the sighting was made.

The closest distances of sightings to the C-PODs were determined using ArcMap. At Calf West one porpoise sighting had no associated acoustics, and this occurred at 1497m. Of the other three porpoise sightings, which had associated acoustics, the closest recorded distance was 1378m, and the greatest was 2353m. There were three Risso's dolphin sightings, none of which had associated acoustics, with closest recorded distances ranging from 296m to 3058m. At Port St Mary there were 12 porpoise sightings, five of which had no associated acoustics, with closest recorded distance ranging from 779m to 1952m. The closest recorded distances for the other seven sightings ranged from 247m to 1842m. The two Risso's sightings with no acoustics were at distances of 621m and 1832m, and the two sightings with acoustics were at 515m and 812m.

Table 6: Details of each sighting made during visual surveys at each of the two sites. 'Closest' refers to the closest distance between a sighted animal and the C-POD. 'Acoustic' refers to the minutes in which acoustic detections were made on the C-PODs.

Site	Date	Time	Duration (min)	Closest (m)	Species	Acoustic
Calf West	08/08/2014	15:52	15	1775	Harbour porpoise	15:40
	08/08/2014	16:25	90	1378	Harbour porpoise	16:20, 16:21, 16:45, 17:55
	02/09/2014	16:10	75	296	Risso's dolphin	0
	02/09/2014	16:10	30	1497	Harbour porpoise	0
	09/09/2014	16:10	60	3058	Risso's dolphin	0
	09/09/2014	17:21	60	635	Risso's dolphin	0
	11/09/2014	14:27	15	2353	Harbour porpoise	14:30
Port St Mary	14/08/2014	12:28	45	621	Risso's dolphin	0
	14/08/2014	10:50	15	934	Harbour porpoise	10:54
	14/08/2014	11:52	15	934	Harbour porpoise	11:37, 11:38, 11:40, 11:42, 11:43, 11:44, 11:52
	14/08/2014	13:15	15	1952	Harbour porpoise	0
	20/08/2014	16:01	15	615	Harbour porpoise	15:57
	08/09/2014	14:40	15	779	Harbour porpoise	0
	09/09/2014	11:35	15	1832	Risso's dolphin	(08:29-10:35)
	15/09/2014	14:00	15	1381	Harbour porpoise	0
	15/09/2014	15:07	15	834	Harbour porpoise	0
	15/09/2014	15:25	15	1473	Harbour porpoise	0
	28/09/2014	12:29	180	812	Risso's dolphin	12:35, 12:38-12:44
	28/09/2014	12:51	15	904	Harbour porpoise	12:51, 12:52
	29/09/2014	13:54	60	515	Risso's dolphin	13:39, 13:43
	05/11/2014	14:34	60	247	Harbour porpoise	14:23, 14:27, 14:32, 14:39, 15:03, 15:05, 15:08, 15:22, 15:25
	05/11/2014	15:09	15	1842	Harbour porpoise	15:03, 15:05, 15:08, 15:22
	05/11/2014	15:19	15	1348	Harbour porpoise	15:05, 15:08, 15:22, 15:25

Public

Whilst the C-PODs were active a total of 63 sightings of odontocetes were reported by members of the public, these included 24 harbour porpoise, 17 Risso's dolphins, 17 bottlenose dolphins, and 5 common dolphins. Extracting just the sightings which fell within the visual survey area at each of the sites, there were 3 sightings of harbour porpoise, and 2 of common dolphin at Calf West, and 1 sighting of harbour porpoise, and 3 of Risso's dolphins at Port St Mary (Table 7). At Calf West all three of the porpoise sightings had associated acoustics, whilst the two common dolphin sightings did not. At Port St Mary the one porpoise sighting had no acoustics, and two of the three Risso's dolphin sightings had no acoustics but one sighting did.

Table 7: Details of each sighting reported by members of the public at each of the two sites. 'Acoustic' refers to the minutes in which acoustic detections were made on the C-PODs.

Site	Date	Time	Species	Acoustic
Calf West	24/08/2014	12:05	Harbour porpoise	12:18, 12:19, 12:20, 12:22
	24/08/2014	12:05	Harbour porpoise	12:18, 12:19, 12:20, 12:22
	26/08/2014	19:25	Common dolphin	0
	31/08/2014	17:20	Common dolphin	0
	31/08/2014	18:30	Harbour porpoise	18:42, 18:43, 18:50
Port St Mary	22/08/2014	12:15	Risso's dolphin	0
	28/09/2014	10:40	Risso's dolphin	0
	29/09/2014	13:00	Risso's dolphin	13:39, 13:43
	29/09/2014	15:00	Harbour porpoise	0

Discussion

Acoustic

Despite the C-POD at Port St Mary ceasing to operate earlier than expected, a good number of acoustic hours were collected for each of the two sites. Both C-PODs remained in the position of deployment despite some very rough weather with strong winds, and both C-PODs made detections of porpoises and dolphins, indicating that the in water set-up and deployment locations were satisfactory for this preliminary study.

Mean detection positive hours (DPH) per day, and mean detection positive minutes (DPM) per hour were greater at Calf West than at Port St Mary for both porpoises and dolphins, suggesting the Calf West site is used more than the Port St Mary site. The peak in dolphin detections in September interestingly coincides with the lowest detections of porpoises. This could perhaps indicate a broad temporal avoidance between the two species, with porpoises avoiding an area when the likelihood of dolphin presence increases. Risso's dolphins are large, robust animals, two to three times the size of a harbour porpoise which they could easily chase off. There are known cases of aggression and fatal attacks by bottlenose dolphins on harbour porpoises (Ross & Wilson, 1996), so porpoises could also be intimidated by the similarly sized Risso's dolphin.

Porpoise detections at Calf West showed more activity at night, with peak periods being the hour of sunset, the hour after sunset and night. These differences were not as strong at Port St Mary, but this may have been due to the significantly lower number of detections on this C-POD. Risso's dolphins were most active during the day at both sites, with fewer detections during other periods. This interestingly contradicts the idea that Risso's would be more active at night due to feeding on cephalopods which exhibit nightly vertical migrations (Baird, 2002). There were relatively few dolphin detections made, so this could be a product of small sample size, but perhaps indicates that feeding in Manx waters during the summer months, differs from otherwise expected Risso's dolphin behaviour. The results could be an indication of diel temporal avoidance between porpoises and Risso's dolphins, which follows from the broad monthly temporal avoidance.

The tidal activity of porpoises and dolphins differed across the two sites, perhaps indicating a preference for one site over the other depending on tidal state. Both species appear to show some preference for Ebb tide at Calf West and Flood tide at Port St Mary. Porpoises appeared to show a preference for Spring tides at both sites. There were no clear patterns with dolphins but this could be due to not having enough dolphin detections to determine any patterns. Tidal movement is a complex issue to understand, and it may be that the water flow in the different tidal states at the sites improves feeding conditions. If this were the case, it would perhaps be understandable that porpoises showed a preference for Spring tides, when tidal ranges are greatest.

<u>Visual</u>

There was a relatively small amount of visual data collected, compared to acoustic data. This immediately highlights the problem of reliance on visual survey techniques in restricting opportunities for data collection. Not only is the potential number of survey hours essentially immediately halved due to the restrictions of daylight hours, there is also the need for favourable weather conditions, which were lacking during the summer of 2014. Unfortunately, there were many periods over the course of the C-POD deployment when high winds and poor visibility prevented visual surveys from taking place. It is important not to conduct surveys in poor sea states as this can decrease the chances of sightings, particularly of small species such as the harbour porpoise.

Interestingly, more sightings of both porpoises and dolphins were made at Port St Mary than Calf West, despite the acoustic data suggesting the opposite trend. This highlights the problem of limited visual surveys, in that reliance only on visual data here would have resulted in concluding that Port St Mary was the more frequented site. Additionally, the highest acoustic detections of porpoises were at night, and of Risso's dolphins during the day. As visual surveying can only take place during the day, this adds further potential bias to sole reliance on visual data. Furthermore, the apparent preference of different tidal states at different sites could bias visual surveys if they were not representative across the full tidal cycle.

During dedicated visual surveys only harbour porpoise and Risso's dolphins were observed. However, publicly reported sightings included reports of common dolphins and bottlenose dolphins. None of the bottlenose dolphin sightings fell within the viewing areas of Calf West or Port St Mary, so it seems unlikely that they would have been detected on the C-PODs. Whilst two common dolphin sightings fell within the Calf West viewing area, neither of these sightings had any acoustic data associated with them. Whilst it is of course possible that the animals could have travelled to within detection range of the C-PODs and not been reported by the public, it nevertheless seems very likely that all dolphin detections on the C-PODs were in fact of Risso's dolphins.

The distances of observed animals to the C-PODs can sometimes give an idea of detection range for these animals. However, this will only be as accurate as the method of locating the animals, which in some cases was done using a compass which is far less accurate than the theodolite, which would bias results. Additionally the animals are moving, and theodolite readings were only taken every 15mins, meaning the animals could well have moved closer to the C-POD than the distance otherwise suggests. It seems likely that the distances here are not representative of the detection ranges, as they are much greater than would be expected, particularly for porpoises which would not generally be detected at greater than 400m (Chelonia).

Overall

This preliminary study into the use of C-PODs in Manx waters highlights the potential power of using acoustics in studying cetaceans. This data is from only two small areas, yet detections of both porpoises and dolphins indicate that this method has great potential for further research, and shows that surveying from land needs to cover as many times and tidal states as possible to minimise bias in the results.

There are still difficulties in acoustic surveys, and in using equipment such as the C-PODs. C-PODs only detect odontocetes, excluding mysticetes of which the minke whale is a common visitor to Manx waters. Therefore, additional survey methods such as visual or alternative acoustic methods would still be required to detect this species. Species differentiation in C-PODs still requires some work. Determining the difference between 'NBHF', or porpoises, and 'other cetaceans', i.e. dolphins, is straight-forward. As the only species of porpoise to use Manx waters is the harbour porpoise it is extremely likely that any 'NBHF' clicks originate from this species. 'Other cetaceans' will cover the dolphin species, which is essentially only going to be one of three species in the case of the Isle of Man, the Risso's dolphin, the bottlenose dolphin, and the common dolphin. Distinguishing between these species with the C-POD data could be possible, but would be difficult, which is where confirmation from visual surveys and public sighting reports will add weight to these data.

The deployment of the C-PODs in late July missed the 'arrival' time of the Risso's dolphins in Manx waters, when first sightings are generally reported around April time. In future studies it would be interesting to examine this further, with C-PODs active earlier in the year to mark the date of first detection. A full calendar year of data would allow greater insight into these species temporal use of Manx waters. Additionally, a greater number of C-PODs to detect across a larger area would be required to really investigate dolphin and porpoise spatial use of Manx waters.

Conclusion

There is still much to learn about how cetaceans make use of Manx waters, and in the coming years, with the potential for marine energy developments, this information will be important to understand. There appear to be monthly, diel, and tidal patterns in the usage of the two study sites by harbour porpoises and Risso's dolphins. This preliminary information opens up potential for future study areas to gather more information. By using such acoustic equipment as C-PODs to inform and supplement the already used visual survey techniques, data can be better collected and interpreted. By combining the powers of each method greater insight into the lives of these fascinating species will be granted.

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References

Alonso, M.S., Nuutila, H.K., 2014. Detection rates of wild harbour porpoises and bottlenose dolphins using static acoustic click loggers vary with depth. *Bioacoustics*. DOI: 10.1080/09524622.2014.980319

Bailey, H., Clay, G., Coates, E.A., Lusseau, D., Senior, B., Thompson, P.M., 2010. Using T-PODs to assess variations in the occurrence of coastal bottlenose dolphins and harbour porpoises. *Aquatic Conserv: Mar. Freshw. Ecosyst.* 20:150-158

Baines, M.E., Evans, P.G.H., 2012. Atlas of the Marine Mammals of Wales. CCW Monitoring Report No. 68. 2nd

Edition. 139pp

Baird, R.W., 2002. Risso's dolphin in Encyclopaedia of Marine Mammals. *Academic Press, San Diego, CA.* 1037-1039

BBC News, 2014. Isle of Man wind and tidal power schemes 'worth £5m a year'. http://www.bbc.co.uk/news/world-europe-isle-of-man-26018367

Bjørge, A., Tolley, K. A., 2002. Harbour porpoise in Encyclopaedia of Marine Mammals. *Academic Press, San Diego, CA.* 530-533

Chelonia, 2015. Chelonia Limited, Cetacean Monitoring Systems. www.chelonia.co.uk

de Boer, M.N., Clark, J., Leopold, M.F., Simmonds, M.P., Reijnders, P.J.H., 2013. Photo-identification methods reveal seasonal and long-term site-fidelity of Risso's dolphins (*Grampus griseus*) in shallow waters (Cardigan Bay, Wales). *Open J. of Mar. Sci.* 3:66-75

Gaspari, S., Airoldi, S., Rus Hoelzel, A., 2007. Risso's dolphins (Grampus griseus) in UK waters are differentiated from a population in the Mediterranean Sea and genetically less diverse. *Conserv. Genet* 8:727-732

Hanley, L.J., Gell, F.G., Kennington, K., Stone, E., Rowan, E., McEvoy, P., Brew, M., Milne, K., Charter, L., Gallagher, M., Hemsley, K., eds., 2012a. Manx Marine Environmental Assessment – Commercial Fisheries and Sea Angling. Isle of Man Marine Plan. Isle of Man Government. 71pp

Hanley, L.J., Gell, F.G., Kennington, K., Stone, E., Rowan, E., McEvoy, P., Brew, M., Milne, K., Charter, L., Gallagher, M., Hemsley, K., eds., 2012b. Manx Marine Environmental Assessment – Marine Mammals-Cetaceans. Isle of Man Marine Plan. Isle of Man Government. 52pp

Mellinger, D.K., Stafford, K.M., Moore, S.E., Dziak, R.P., Matsumoto, H., 2007. An overview of fixed passive acoustic observation methods for cetaceans. *Oceanography*. 20(4):36-45

Neves, S., 2013. Acoustic behaviour of Risso's dolphins, *Grampus griseus*, in the Canary Islands, Spain. *PhD Thesis, University of St Andrews*. 177pp

Nuutila, H.K., Thomas, L., Hiddink, J.G., Meier, R., Turner, J.R., Bennell, J.D., Tregenza, N.J.C., Evans, P.G.H., 2013. Acoustic detection probability of bottlenose dolphins, *Tursiops truncatus*, with static acoustic data loggers in Cardigan Bay, Wales. *J. Acoust. Soc. Am.* 134(3)Pt2:2596-2609

Ross, H.M., Wilson, B., 1996. Violent interactions between bottlenose dolphins and harbour porpoises. *Proc. R. Soc. Lond. B.* 263:283-286

Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J.K.B., Mead, J.G., Notobartolo di Sciara, G., Wade, P., Pitman, R.L., 2012. *Grampus griseus*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. www.iucnredlist.org

Thompson, P., Brookes, K., Cordes, L., Barton, T., Cheney, B., Graham, I., 2013. Assessing the potential impact of oil and gas exploration operations on cetaceans in the Moray Firth. *Final Report for DECC, Scottish Government, COWRIE, and Oil & Gas UK.* 144pp

Tide Times, 2015. UK tide times. www.tidetimes.org.uk

Time and Date, 2015. Sunrise, sunset, and day length. www.timeanddate.com

Visit Isle of Man, 2015. Wildlife Watching – Basking Sharks. www.visitisleofman.com