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Land-based observations of ocean megafauna off Cape Clear Island (South-West Ireland) in the summer of 2008

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We report results from 51 days of land-based observations of marine megafauna from Cape Clear Island performed in summer 2008. Altogether, 124 megafauna sightings (five taxa of cetaceans, Basking Shark, and Sunfish) were recorded. Observed species richness increased with time, with higher numbers of both taxa and individuals recorded in August. None of assessed weather characteristics (sea state, visibility, cloud cover, glare) had significant effects on observed megafauna abundance or daily species richness. The study confirms that waters off Cape Clear are important for large marine species, and continue to represent a valuable resource for both ecotourism and field studies.

Keywords: Cape Clear Island, land-based observations, marine megafauna, cetaceans

Introduction

In contrast to terrestrial environments, marine habitats are much less accessible for humans and thus direct observations of marine megafauna, such as cetaceans, large fish, or marine turtles, are more complicated. Members of these animal groups often swim rapidly, may range over long distances on a daily basis, and often have seasonal migrations of thousands of kilometres. They are especially difficult to observe because they disappear during dives and do not leave long-lasting traces of their activities, such as tracks, scats, or dens (Mann 1999), although many cetaceans can be efficiently monitored by recording their acoustic communication (O´Brien *et al.* 2009).

Although air-breathing marine vertebrates (marine mammals and turtles) spend a substantial part of their time underwater, they have to surface regularly to get air. Other marine megafauna, such as Sunfish (*Mola mola* Linnaeus, 1758) and Basking Sharks (*Cetorhinus maximus* Gunnerus, 1765), also occasionally occur at the surface. For example, the Basking Shark often feeds on plankton concentrations near the surface (Sims *et al.* 2009, Berrow and Heardman 1994, Leeney *et al.* 2012), and Sunfish are often seen basking on the surface waters, perhaps to elicit the assistance of birds to remove parasites, or as a method of 'thermal recharging' after dives (Dewar *et al.* 2010). Under such circumstances, all these large animals can be sighted (Ó Cadhla *et al.* 2003). Thus, surface observations can bring valuable data on changes in their distribution, abundance and behaviour. Visual surveys are particularly important source of information on species that would not be picked up acoustically, *e.g.* turtles, Sunfish and Basking Sharks.

Observation of marine megafauna from fixed stations (Denardo *et al.* 2001) is cost-effective and a non-intrusive method. The data collected are easy to standardize, surveys are generally cheaper to undertake than boat-based or aircraft-based studies, and so can be made at greater frequencies. A major disadvantage is that the area of coverage is limited; generally to marine areas immediately adjacent to land. Regular land-based watching for defined periods of time has frequently been used to identify coastal areas important for particular species and to determine variation in numbers both seasonally and over the longer term (Barlow and Taylor 2005, Perryman *et al.* 2002). When using fixed stations to monitor status changes, however, it is important to keep in mind that one is monitoring the occurrence of animals in a particular restricted area and not the population at large. Despite these limitations, land-based studies also provide sufficiently robust data for statistical analyses (Taylor *et al.* 2007).

Irish waters are among most important regions for observing cetaceans in Europe (Berrow 2001).

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In particular, the southernmost inhabited Irish island, Cape Clear, is considered one of the best places in the region to watch these marine mammals. This is mainly due to prey availability as a result of strong currents offshore promoting mixing of coastal and oceanic water and nutrient upwelling (Berrow 2001). Moreover, the island is positioned close to whale migration routes and lies near the edge of the continental shelf, so oceanic cetacean species, Sunfish and Basking Shark may also come within sight (Sharrock 1973). Cape Clear has also the highest frequency of Leatherback Turtle (*Dermochelys coriacea* Vandelli, 1761) sightings in Ireland and the UK (Doyle 2007, King and Berrow 2009), and there is only one more European location, La Rochelle at the Atlantic coast of France, where similar or greater numbers of this species are sighted (Duron 1978, Duguy *et al.* 1980). Both sites are at the extreme northern limit of this species (McMahon and Hays 2006) but it seems likely that due to climate change more Leatherback Turtles as well as other thermophilic marine fauna will be observed in these areas in the near future. Cape Clear Island also provides good opportunities for birdwatching, which has been regularly conducted on the island for more than five decades. Sightings of prominent marine megafauna have been occasionally recorded during seabird surveys and also during weekend Whale Watching courses organised on the island by the Irish Whale and Dolphin Group.

Despite the long history of casual land-based observations, no dedicated systematic survey of local marine megafauna has been conducted at Cape Clear. The aim of our study was to obtain information about species diversity and temporal variation in observed numbers of individuals and species at this island during the summer 2008 season. We also focused on factors which may influence data collection, and hoped to obtain some observational data on Sunfish and Leatherback Turtles, such as foraging behaviour or swimming direction.

Methods

Cape Clear Island (Oileán Cléire, South-West Ireland; Fig. 1) is the most southerly inhabited location in Ireland and Blananarragaun Point (51°25'15" N, 9°30'44" W) is the most southerly tip of this island (see Fig. 1). Rocks above the point *c.*50 m above the sea level are regularly used by birdwatchers and provide good conditions for megafauna surveys. Sea watches (*i.e.* land-based sea observations), were conducted entirely by the first author of the study (HS) during the period between 30 June 2008 and 26 August 2008. In all, sea watches were conducted on 51 days of the 58-day study period (Fig. 2). The time spent varied between one and eight hours per day depending on the weather, with an average 4.4 hours per day mostly between 9:00 and 15:00 GMT (10:00 and 16:00 BST).

Observations were conducted when sea conditions were suitable (Beaufort Sea State <3), however, higher sea states were sometimes recorded when conditions deteriorated during the observation day. Sea watches consisted of continuous 10-minute scans of the immediate seascape (up to *c.*3 km from the shore) using a combination of naked eye scans and binoculars (8×40). For some observations, a spotting scope (30× magnification) was necessary. A 5-minute break followed each scan to minimise observer fatigue as continuous use of binoculars or telescope causes eye-strain and may result in loss of efficiency (Sharrock 1973). Observations were terminated either when the weather substantially deteriorated, or early in the evening (between 18:00 and 19:30 h).

Basic weather variables that may influence observation quality or animal behaviour (sea state, glare, cloud cover and visibility) were recorded every hour during the sea watches. Sea state was recorded in the Beaufort scale. Glare was evaluated using a system of octares (Houghton *et al.* 2006a) whereby the seascape was visually divided into 8 sections, and the number of sections obscured by glare was subsequently noted. Cloud cover was estimated similarly: by dividing the sky field into 8 sections, and subsequent estimating the proportion of sky obscured by clouds. We also recognised five categories of visibility, based on how well the Fastnet Rock (an uninhabited island located ca 6 km further southwest) and surrounding sea surface could be observed. Average sea surface temperature data was obtained for each observation day for Databuoy M5 (51°41'21" N, 6°42'04" W), located 50 km offshore in the Celtic sea and 197 km eastwards from the observation point (Marine Institute 2012).

The following parameters were recorded whenever one or more megafauna specimens were sighted: time of sighting, number of individuals and their behaviour, animal size (estimated from comparison with nearby seabirds, Houghton *et al.* 2006b) and additional noteworthy observations such as the presence and behaviour of abundant birds. Sightings were identified to species level where possible, based on the following characteristics: estimated body length, shape of dorsal fin and its position on the back, body colour and pattern, head-shape, surfacing sequence and presence/absence of tail and blow (see Wilson and Berrow 2007). Certain dolphins with distinct black and white colouration could

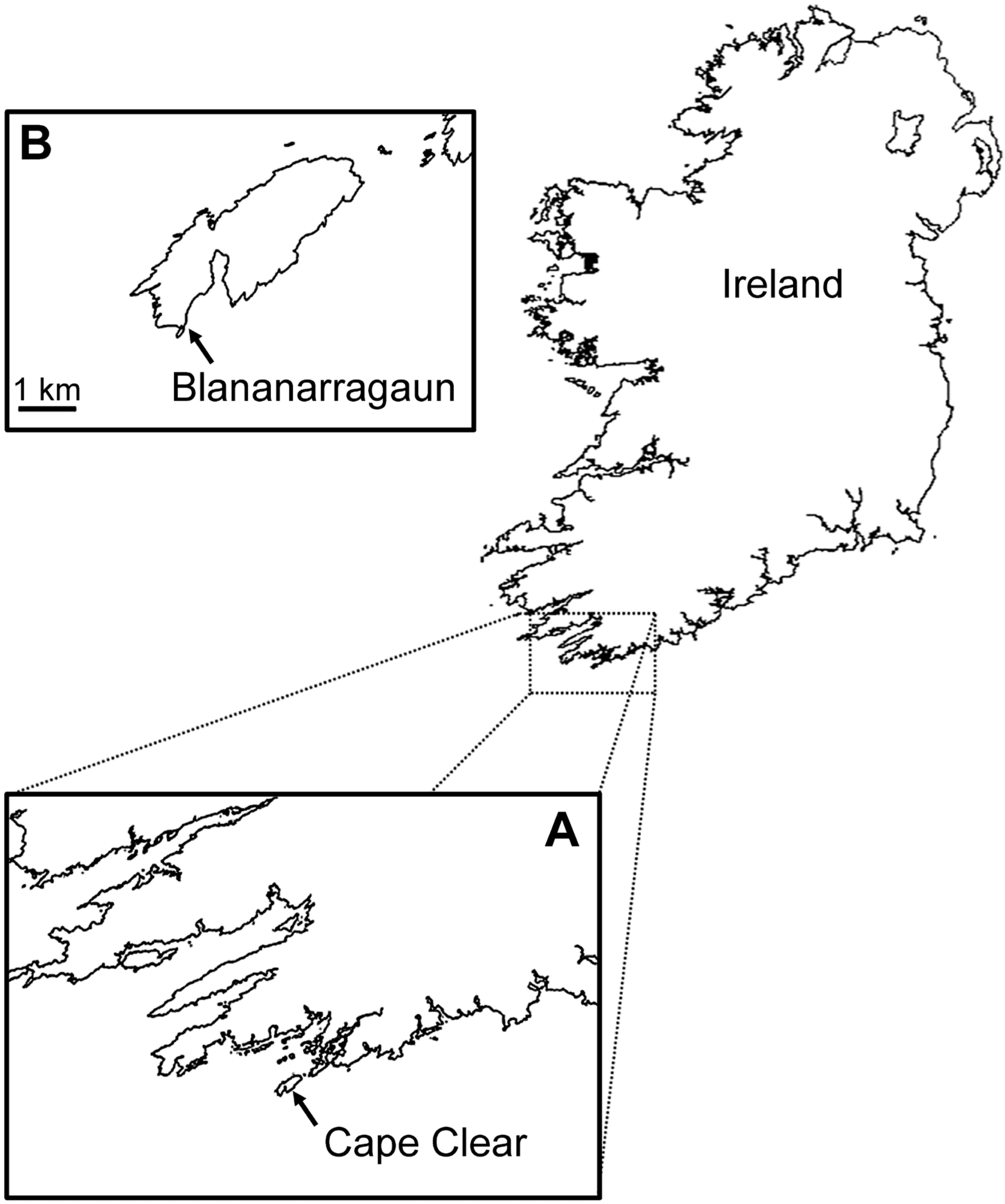

Figure 1. Position of Cape Clear (A) and Blananarragaun Point observation station within it (B) in Irish coastal waters.

not be reliably identified to species level so were pooled into a category of unidentified 'black-and-white' dolphin spp. In all likelihood these were mostly the Common Dolphin (*Delphinus delphis* Linnaeus, 1758), however, the presence of the Atlantic White-sided Dolphin (*Lagenorhynchus acutus* Gray, 1828) or the White-beaked Dolphin (*L. albirostris* Gray, 1846) could not be ruled out (for more details, see Discussion).

Cetacean behaviour was divided into two main categories: a) swimming (travelling steadily in one direction with regular surfacing intervals), b) feeding (individuals moving in a variety of directions relative to each other; repeated dives and surface rushes). Feeding animals were often associated with diving birds.

Data analysis

The potential influence of the recorded weather characteristics on the observed numbers and species richness of megafauna was estimated. Because the data originated from serial observations, numbers of different species

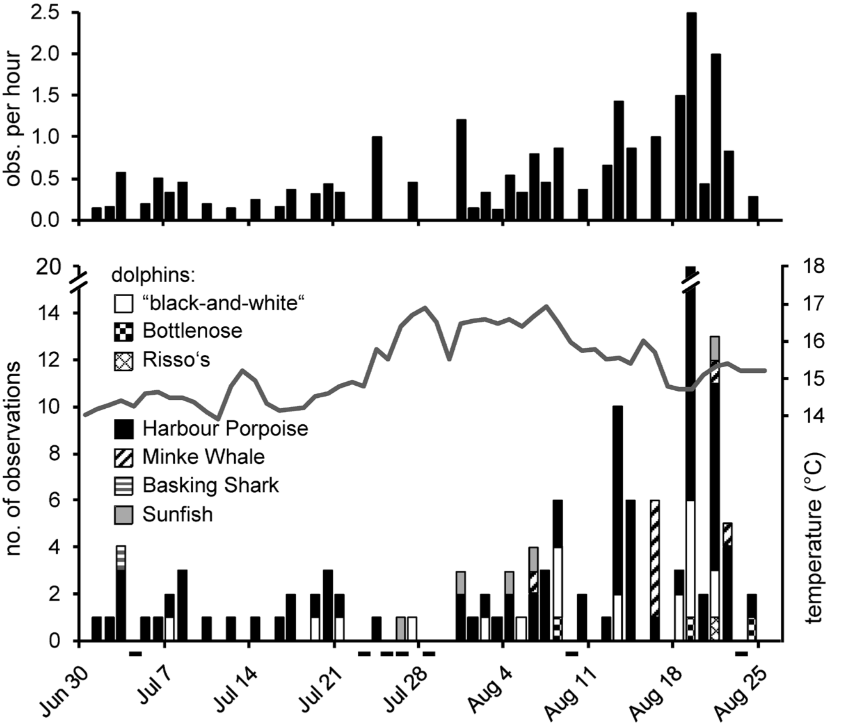

Figure 2. Temporal distribution of recorded megafauna species, and the hourly frequency of megafauna observation, during the study period (30 June – 26 August 2008). Number of sightings of all megafauna species per hour of observation are shown in the top chart, numbers of sightings of all individual megafauna species in each day in the lower chart. The grey line indicates the mean daily sea surface temperature at the databuoy M5. Short horizontal lines under the x axis show dates when no land-based sea observations were conducted.

observed per day as well as their abundances were at first investigated for the partial temporal autocorrelation using the acf function in the R software (R Development Core Team 2008). As the autocorrelation was insignificant, we used four separate generalized linear models with Poisson distribution (GLM-p) to estimate the relationships between recorded weather variables (sea state, visibility, cloud cover, glare) and observed daily species richness (*i.e.* the number of species observed per day; model 1); abundance of all megafauna species pooled (model 2); and separately the abundance of the two most common taxa which were the unidentified 'black-and-white' dolphins (probably Common Dolphins) (model 3); and the Harbour Porpoise (*Phocoena phocoena* Linnaeus, 1758) (model 4).

Furthermore, we tested the significance of temporal trends and the influence of surface sea water temperature in four additional models (GLM-p). The independent variables were therefore the day of observation and surface sea water temperature, and the dependent variables were those already described in the previous paragraph. To compensate for the observation effort, logarithms of observation hours for each day were added to all models as an offset parameter. All analyses were performed in R.

Results

Sea and weather conditions

In total, data are available from 233 hours of observation, with 221 hours (92 per cent) at Beaufort sea-state 3 or lower. The prevailing conditions during the observation periods were good visibility (during 80 per cent of the time, the Fastnet Rock was clearly visible but not the sea behind it), cloudy sky (at least 50 per cent of sky obscured by cloud during 53 per cent of observation hours), little or no glare (no octare of sea surface obscured by glare during 54 per cent of observation hours), and little wave action (Beaufort scale 2 or less during 68 per cent of observation hours).

Megafauna observations

Altogether, 123 megafauna observations were recorded (Fig. 2), totalling approximately 301 individuals. Seven megafauna taxa were identified (Table 1, Fig. 2) during the study period, six of them to species level. One taxon

Table 1. Summary of megafauna sightings during the study period (51 observation days, 233 hours). 'No. obs.' indicates number of observations, 'No. inds' indicates the best estimate of total number of individuals. For group size, the range and median (in parentheses) are provided. Two categories of behaviour were distinguished: travelling / feeding. Swimming direction (west / east) is indicated for individuals or groups observed travelling.

Species	No. obs.	No. inds	Group size	Behaviour	Swimming direction (west / east)	Association with seabirds
Harbour Porpoise (*Phocoena phocoena*)	83	151	1–8 (1)	61% / 39%	26 / 5	No
unidentified 'black-and-white' dolphin spp.	21	88	1–11 (3)	52% / 48%	10 / 0	19%
Bottlenose Dolphin (*Tursiops truncatus*)	3	43	8–23 (12)	100% / 0%	2 / 0	No
Risso's Dolphin (*Grampus griseus*)	1	4	4	100% / 0%	1 / 0	No
Minke Whale (*Balaenoptera acutorostrata*)	8	8	1	88% / 12%	4 / 3	75%
Basking Shark (*Cetorhinus maximus*)	1	1	1	100% / 0%	1 / 0	No
Sunfish (*Mola mola*)	6	6	1	100% / 0%	5 / 1	No

(unidentified 'black-and-white' dolphin spp.) was reliably assigned to family (*i.e.* Delphinidae) and these were most likely Common Dolphins (see Discussion).

Most of the species observed were cetaceans (at least five taxa, 116 sightings). The Harbour Porpoise, was the most regularly sighted animal (observed 83 times: Table 1, Fig. 2). Unidentified 'black-and-white' dolphins with 21 observations were second most frequently observed cetaceans. These two taxa occurred during the whole observation period in July and August; the remaining observed cetaceans (two dolphin and one whale species) were seen in August only (Fig. 2). Three groups of Bottlenose Dolphins (*Tursiops truncatus* Montagu, 1821) were seen during the study. The least commonly observed cetacean, with only a single observation, was the Risso's Dolphin (*Grampus griseus* Cuvier, 1812).

Eight individual sightings of Minke Whales (*Balaenoptera acutorostrata* Lacépède, 1804), were recorded, five of them on a single day, 16 August 2008. However, in this case it is not clear whether four of those five observations represented different individuals or whether a single individual was foraging in the area and repeatedly passed by the observation point (swimming direction in different observations varied). The fifth Minke Whale observation of the day was certainly of a different animal, as it was approximately one third bigger than others seen during the day. In all cases on this date, the whales were associated with seabirds (that could be used to assess the animal size); such association was also occasionally observed with unidentified 'black-and-white' dolphin spp. (Table 1).

Apart from cetaceans, a single Basking Shark seen on 3 July 2008, and six individuals of Sunfish were observed. All Sunfish were small, with body lengths approximately 1 m. Most were seen actively swimming with dorsal fin flapping from side to side as they moved through the water; one animal was swimming without fin flapping. No 'basking' behaviour (when the animal lays horizontally on the sea surface) was observed. We did not record any Leatherback Turtle during the study.

None of the weather characteristics (sea state, visibility, cloud cover, glare) recorded during the observation hours had significant effects on the observed daily species richness (GLM-p, $p > 0.26$), abundance of all observed species (GLM-p, $p > 0.31$), or on the abundance of any of two most common taxa, Harbour Porpoise or 'black-and-white' dolphins (GLM-p, $p > 0.11$). The daily numbers of observed megafauna significantly increased during the study period, as reflected in a strong positive correlation between the date (expressed as number of days since the beginning of the study) and the number of observations, for all species merged together (GLM-p, $F_{1,47}=24.4$, $p < 0.001$) as well as for the two most common taxa, unidentified 'black-and-white' dolphin spp. (GLM-p, $F_{1,47}=5.8$, $p = 0.02$) and Harbour Porpoise (GLM-p, $F_{1,47}=17.4$, $p = 0.001$), respectively. A positive correlation with the date was significant also for the daily species richness (GLM-p, $F_{1,47}=5.4$, $p = 0.025$). The temperature was significantly, but only very slightly negatively correlated with number of Harbour Porpoise observations (GLM-p, $F_{1,46}=5.2$, $P=0.027$) but not with abundances of other taxa or species richness.

Discussion

The total of 123 sightings of seven megafauna taxa identified during the study is of course only a fraction of large animals present in the area. To be counted, the animals must have been near the coast, on the surface and present during observation hours. Negative bias could arise because the sea-observer was alone, which may result in well-presented animals being missed (Dawson *et al.* 2008, Sharrock 1973). One person is not able to cover the whole visible sea surface at the same time, especially as screening the nearshore areas requires observation by naked eye, more distant areas require binoculars, and the most distant places need a telescope. Additionally, even the active period of observation is not spent fully in screening the sea surface but also by other activities, such as taking notes.

We expected that weather and sea state conditions could also influence the results of observations. More animals should be detectable if visibility is excellent or good because an observer can cover a bigger area. The probability of animal detection should be lower with greater number of seascape octares obscured by glare and also in sea-states greater than Beaufort 3 (Hammond *et al.* 2002, Leeney *et al.* 2012, Ó Cadhla *et al.* 2003). However, we did not detect any significant effect of these variables on number of megafauna observations or number of observed species in this study. It is likely that this was due to generally favourable weather during the observation hours because the observations were cancelled when the conditions substantially deteriorated and the probability of missing the animals would increase.

The only strong statistically significant trends in the observations were increases in the number of both individuals and species towards the second month of the study. This might reflect the seasonality in behaviour of the respective species (Rogan and Berrow 1996). Such a trend agrees with other studies from the same area (*e.g.* Robinson *et al.* 2007). Another potential source of bias which cannot be fully ruled out is the increasing experience of the observer. Although care was taken from the beginning to meticulously screen the study area, it is possible that with the increased time spent on the observation point, the observer may have inadvertently focused on sections of seascape more likely to reveal additional sightings.

Megafauna observations

The overall trends in relative abundance and species composition of megafauna observed in summer 2008 at Cape Clear was concordant with recent studies on megafauna distribution in Irish coastal waters and the Celtic Sea. The species composition agrees with a cliff-based visual monitoring exercise conducted in the waters of Broadhaven Bay and northwest Mayo (ca 280 km further north) during 57 days between October 2001 and October 2002 by Ó Cadhla *et al.* (2003). This research team recorded 223 distinct sightings of marine mammals during a total of 317 hours of full monitoring. They reported seven cetacean species, which included White-sided and White-beaked Dolphins that were pooled in our study under the unidentified "black and white" dolphin category. The number of sightings reported by Ó Cadhla *et al.* (2003) is higher than in our study (123 sightings per 233 hours); however, their methodology involved parallel observations from two stations by several observers. Other results from land-based observations conducted at Broadhaven Bay during 2002, 2005 and 2008–2011 were reported by Anderwald *et al.* (2012). From the whole period, they reported only two more cetacean species, Sei Whale (*Balaenoptera borealis* Lesson, 1828: 1 observation), and Killer Whale (*Orcinus orca* Linnaeus, 1758: 9 observations).

Other surveys from the Celtic Sea, the results of which were published recently (Leeney *et al.* 2012, Pikesley *et al.* 2012), were conducted in the area between Cornwall and the Isles of Scilly. The former study was based on aerial and boat-based observations from January 2006 to November 2007, the latter study analysed incidental sightings data from the period 1991–2008. Both studies reported higher number of species, including Long-finned Pilot Whale (*Globicephala melas* Traill, 1809) and Killer Whale, and eight more rarely observed cetacean taxa (with less than 25 observations over 17 years). The reported higher species richness is easy to explain, given the long time frame covered by Pikesley *et al.* (2012) and higher likelihood of observing pelagic species during off-shore cruises.

The Harbour Porpoise was the most often observed species at Cape Clear, consistent with previous studies made in the Celtic Sea (Sharrock 1973, Berrow 2001, Rogan and Berrow 1996, Evans 1990, Hammond *et al.* 2002, Leeney *et al.* 2012). It was seen travelling alone or in groups of up to three individuals, which seems to be characteristic for this species (Rogan and Berrow 1996, Leeney *et al.* 2012, O´Cadhla *et al.* 2003).

We recoded twenty one sightings of unidentified 'black-and-white' dolphin spp. These were probably Common Dolphins, the most abundant dolphin species along the west coast of Ireland (Wall *et al.* 2006, Berrow 2001). However, in some cases dolphins of such appearance could have been the Atlantic White-sided Dolphin or the White-beaked Dolphin, which are relatively frequent offshore (Hammond *et al.* 2002, Wall *et al.* 2006) but rarely observed in inshore waters (Sharrock 1973, Wall *et al.* 2006, Ó Cadhla *et al.* 2003). The former species would be the less likely of the two as it is less abundant in coastal waters (Evans 1990, Wall *et al.* 2006) and prefers surface water temperatures between 9° and 13° C (Skov *et al.* 1995). These temperature values were exceeded in the study area in summer 2008, when the daily mean of the sea surface temperature measured at Databuoy M5 ranged from 13.9° to 16.9° C (Fig. 2).

Minke Whales, Bottlenose Dolphins and Risso's Dolphins were only seen in August during our study. Although we did not detect a statistically significant relationship between the species richness and temperature, this might have been related to increase in sea water temperature, which was higher in August than in July. Minke Whale sightings seem to be positively correlated with temperatures. For example, in a 4-year study from Scotland (Tetley 2004) they were seen in greater frequencies during September 2002 and July 2003, the months of highest sea surface temperatures. Other important factors that can determine the megafauna distribution include abundance and distribution of their prey (Lindstrøm *et al.* 2009) which may be also temperature-related (Perry *et al.* 2005). Although Minke Whales and Bottlenose Dolphins are opportunistic species adapting their diet according to local prey availability (Robinson and Tetley 2007, Tetley *et al.* 2008, Evans 1990) the overall food supply may influence their distribution.

Bottlenose Dolphins in the waters off Ireland and the UK occur mostly in groups (ranging from 2 to more than 40) or rarely as solitary individuals (Evans 1990, Culloch and Robinson 2008, Ó Cadhla *et al.* 2003). In our study period, only three groups of Bottlenose Dolphins were observed, the largest of them comprising 23 individuals. Risso's Dolphins were observed only once in our study. This species is rare in the area (Evans 1990) as it prefers deep-water habitats and thus is more frequent in offshore waters (Weir *et al.* 2012, Leeney *et al.* 2012).

Six out of eight Minke Whale observations were associated with birds, as well as four out of 21 observations of unidentified 'black-and-white' dolphins. This phenomenon has been reported in numerous studies (*e.g.* Anderwald and Evans 2007, Robinson and Tetley 2007, Tetley 2004). In particular, Minke Whale associations with birds are very common. For example birds recorded during Minke Whale observations accounted for 27 per cent (Hodges and Woeher 1993), 76 per cent (Robinson and Tetley (2007) and 34 per cent (Gill *et al.* 2000) of all observations. For some bird species, association with cetaceans is a characteristic, and apparently beneficial, foraging method (Pitman and Ballance 1992). Whales exploit concentrations of small fish such as herring, sprat and sand eels, by driving and concentrating them close to the surface. This makes the fish prey available to surface-feeding and shallow-diving birds (Hebshi *et al.* 2008, Gill *et al.* 2000) which were observed feeding (diving) close to cetaceans several times during our study.

Six Sunfish were observed, but only from the end of July to August. This may have been related to higher sea surface temperatures in this period. The Sunfish were relatively small (no more than 1 m long) which is the size most often reported from the Irish and Celtic Seas (Houghton *et al.* 2006b). Based on the characteristics of the dorsal fin, we are confident that these six Sunfish sightings were of *Mola mola* and not of the Slender Sunfish (*Ranzania laevis* Pennant, 1776). Furthermore, very few records of the Slender Sunfish have been recorded in Irish and UK waters (Houghton *et al.* 2006b). In most cases (5 out of 6 observations), the animals were swimming west (Table 1). This seems to be the typical swimming direction of megafauna in Cape Clear waters, as was already noted in historical records (Sharrock 1973). In our study the Basking Shark, Risso's Dolphins, most of the recorded Harbour Porpoises, unidentified 'black-and-white' dolphins, Bottlenose Dolphins and Minke Whales that were observed while travelling, were swimming west (Table 1). This prevalence of westward swimming of megafauna observed from Cape Clear is possibly related to direction of ocean current in the area (Fernand *et al.* 2006, Hill *et al.* 2008).

Sighting of one individual Basking Shark with a length around 4-6 m at the beginning of July corresponds with the normal temporal and size distribution of sightings of this species at Cape Clear and in Ireland in general (Ó Cadhla *et al.* 2003). Most Basking Sharks are generally seen between April and November, with two seasonal peaks in June and September (Berrow and Heardman 1994) and decrease in July and August. As in our case, Basking Sharks are mostly observed during sunny days with excellent visibility and nearly calm sea surface. In most cases only a single individual is observed, although occasionally groups up to twenty animals have been recorded (Berrow and Heardman 1994, Ó Cadhla *et al.* 2003).

No Leatherback Turtles were recorded at Cape Clear during our study or in the whole 2008 season. This is not unusual, as relatively few observations of Leatherback Turtles have been recorded since 2000 (range between 0 and 20, Steve Wing, pers. comm.). Generally low numbers of Leatherback Turtles in the north-eastern Atlantic Ocean in 2008 were confirmed by records from La Rochelle, France. Only three individuals were observed at that site (a single one in summer), although there have been usually over 10 records per year since 1995, except 2006 with a single leatherback sighting (Dell´amico and Morinière 2010).

In summary, our study is the first systematic land-based observation of marine megafauna over an extended period of the summer season at Cape Clear. It confirms that Cape Clear waters are important area for cetaceans as well as other large marine species, making it not only a great resource for local ecotourism industry but also valuable site for field studies.

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References

Anderwald, P. and Evans, G.H. (2007) Minke Whale populations in the North Atlantic: an overview with special reference to the UK. In Robinson, K.P., Stevick, P.T. and MacLeod C.D. (eds) *Proceedings of the Workshop on An Integrated Approach to Non-Lethal Research on Minke Whales in European Waters*: 8-13. ECS Special Publication Series No. 47. European Cetacean Society. San Sebastian, Spain.

Anderwald, P., Haberlin, M.D., Coleman, M., Ó Cadhla, O., Englund, A., Visser, F. and Cronin, M. (2012) Seasonal trends and spatial differences in marine mammal occurrence in Broadhaven Bay, northwest Ireland. *Journal of the Marine Biological Association of the United Kingdom* **92**: 1757-1766.

Barlow, J. and Taylor, B.L. (2005) Estimates of sperm whale abundance in the northeastern temperate Pacific from a combined acoustic and visual survey. *Marine Mammal Science* **21**: 429-445.

Berrow, S. (2001) Biological diversity of cetaceans (whales, dolphins and porpoises) in Irish waters. In Nunn, J. (ed.) *Marine Biodiversity in Ireland and adjacent waters*: 115-119. Ulster Museum, Belfast.

Berrow, S.D. and Heardman, C. (1994) The Basking Shark *Cetorhinus maximus* (Gunnerus) in Irish waters – patterns of distribution and abundance. *Biology and Environment: Proceedings of the Royal Irish Academy* **94B**: 101-107.

Culloch, R.M. and Robinson, K.P. (2008) Bottlenose Dolphins using coastal regions adjacent to a Special Area of Conservation in north-east Scotland. *Journal of the Marine Biological Association of the United Kingdom* **88**: 1237-1243.

Dawson, S., Wade, P., Slooten, E. and Barlow, J. (2008) Design and field methods for sighting surveys of cetaceans in coastal and riverine habitats. *Mammal Review* **38**: 19-49.

Dell´amico, F. and Morinière, P. (2010) Observations des tortues marines en 2008 et 2009 (Côtes atlantiques françaises). *Annales de la Société des Sciences Naturelles de la Charente-Maritime* **10**: 69-76.

Denardo, C., Dougherty, M., Hastie, G., Leaper, R., Wilson, B. and Thompson, P.M. (2001) A new technique to measure spatial relationships within groups of free-raging coastal cetaceans. *Journal of Applied Ecology* **38**: 888-895.

Dewar, H., Thys, T., Teo, S.L.H., Farwell, C., O'Sullivan, J., Tobayama, T., Soichi, M., Nakatsubo, T., Kondo, Y., Okada, Y., Lindsay, D.J., Hays, G.C., Walli, A., Weng, K., Streelman, J.T. and Karl, S.A. (2010) Satellite tracking the world's largest jelly predator, the ocean sunfish, *Mola mola*, in the Western Pacific. *Journal of Experimental Marine Biology and Ecology* **393**: 32–42.

Doyle, T.K. (2007) Leatherback Sea Turtles (*Dermochelys coriacea*) in Irish waters. *Irish Wildlife Manuals*, No. **32**. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin, Ireland.

Duguy, R., Duron, M. and Alzieu, C. (1980) Observations de tortues luth (*Dermochelys coriacea*) dans les Pertuis Charentais en 1979. *Annales de la Société des Sciences Naturelles de la Charente-Maritime* **6**: 681-691.

Duron, M. (1978) *Contribution à l'étude de la biologie de* Dermochelys coriacea *(Linné) dans les Pertuis Charentais*. Unpublished PhD thesis, University of Bordeaux, Talence.

Evans, P.G.H. (1990) *Marine mammals in the English Channel in relation to proposed dredging scheme*. Sea Watch Foundation, Oxford.

Fernand, L., Nolan, G.D., Raine, R., Chambers, C.E., Dye, S.R., White, M. and Brown, J. (2006) The Irish coastal current: A seasonal jet-like circulation. *Continental Shelf Research* **26**: 1775-1793.

Gill, A., Fairbairns, B.R. and Fairbairns, R.S. (2000) Some observations of Minke Whale (*Balaenoptera acutorostrata*) feeding behaviour and associations with seabirds in coastal waters of Isle of Mull, Scotland. *European Research on Cetaceans* **13**: 61- 64.

Hammond, P.S., Berggren, P., Benke, H., Borchers, D.L., Collett, A., Heide-Jøorgensen, M.P., Heimlich, S., Hiby, A.R., Leopold, M.F. and Øien, N. (2002) Abundance of Harbour Porpoise and other cetaceans in the North Sea and adjacent waters. *Journal of Applied Ecology* **39**: 361-376.

Hebshi, A.J., Duffy, D.C. and Hyrenbach, K.D. (2008) Associations between seabirds and subsurface predators around Oahu, Hawaii. *Aquatic Biology* **4**: 89-98.

Hill, A.E., Brown, J., Fernand, L., Holt, J., Horsburgh, K.J., Proctor, R., Raine, R. and Turrell, W.R. (2008) Thermohaline circulation of shallow tidal seas. *Geophysical Research Letters* **35**: L11605.

Hodges, C.L. and Woeher, E.J. (1993) Associations between seabirds and cetaceans in the Australian sector of the southern Indian Ocean. *Marine Ornithology* **22**: 205-212.

Houghton, J.D.R., Doyle, T.K., Wilson, M.W., Davenport, J. and Hays, G.C. (2006a) Jellyfish aggregations and Leatherback Turtle foraging patterns in temperate coastal environment. *Ecology* **87**: 1967-1972.

Houghton, J.D.R., Doyle, T.K., Davenport, J. and Hays, G.C. (2006b) The ocean Sunfish *Mola mola*: insights into distribution, abundance and behaviour in the Irish and Celtic Seas. *Journal of the Marine Biological Association of the United Kingdom* **86**:1-7.

King, G.L. and Berrow, S.D. (2009) *Marine turtles in Irish waters*. Irish Naturalists' Journal, Belfast.

Leeney, R.H., Witt, M.J., Broderick, A.C., Buchanan, J., Jarvis, D.S., Richardson, P.B. and Godley, B.J. (2012) Marine megavertebrates of Cornwall and the Isles of Scilly: relative abundance and distribution. *Journal of the Marine Biological Association of the United Kingdom* **92**: 1-11.

Lindstrom, U., Smout, S., Howell, D. and Bogstad, B. (2009) Modelling multi-species interactions in the Barents Sea ecosystem with special emphasis on Minke Whales and their interactions with cod, herring and capelin. *Deep-Sea Research II* **56**: 2068-2079

Mann, J. (1999) Behavioural sampling methods for cetaceans: a review and critique. *Marine Mammal Science* **15**: 102-122.

McMahon, C.R. and Hays, G.C. (2006) Thermal niche, large-scale movements and implications of climate change for a critically endangered marine vertebrate. *Global Change Biology* **12**: 1330-1338.

Marine Institute (2012) *Irish Marine Weather Buoy Network*. Online at: http://www.marine.ie/home/publicationsdata/data/buoys

O'Brien, J., Berrow, S., McGrath, D. and Evans, P. (2009) Cetaceans in Irish waters: a review of recent research. *Biology and Environment: Proceedings of the Royal Irish Academy* **109B (2)**: 63-88.

Ó Cadhla, O., Englund, A., Philpott, E., Mackey, M. and Ingram, S. (2003) *Marine mammal monitoring in the waters of Broadhaven Bay and northwest Mayo: 2001-2002.* Report to Enterprise Energy Ireland, Ltd. Coastal and Marine Resources Centre, University College, Cork. 74pp.

Perry, A.L., Low, P.J., Ellis, J.R. and Reynolds, J.D. (2005) Climate change and distribution shifts in marine fishes. *Science* **308**: 1912-1915.

Perryman, W.L., Donahue, M.A., Perkins, P.C. and Reilly, S.B. (2002) Gray whale calf production 1994-2000 are observed fluctuations related to changes in seasonal ice cover? *Marine Mammal Science* **18**: 121-144.

Pikesley, S.K., Witt, M.J., Hardy, T., Loveridge, J., Williams, R. and Godley, B.J. (2012) Cetacean sightings and strandings: evidence for spatial and temporal trends? *Journal of the Marine Biological Association of the United Kingdom* **92**: 1809-1820

Pitman, R.L. and Balance, L.T. (1992) Parkinson's Petrel distribution and foraging ecology in the Eastern Pacific: aspect of an exclusive feeding relationship with dolphins. *Condor* **94**: 825-835.

R Development Core Team (2008) *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria.

Robinson, K.P., Baumgartner, N., Eisfeld, S.M., Clark, N.M., Culloch, R.M., Haskins, G.N., Zapponi, L., Whaley, A.R., Weare, J.S. and Tetley, M. J. (2007) The summer distribution and occurrence of cetaceans in the coastal waters of the outer southern Moray Firth in northeast Scotland (UK). *Lutra* **50**: 19-30.

Robinson, K.P. and Tetley, M.J. (2007) Behavioural observations of foraging Minke Whales (*Balaenoptera acutorostrata*) in the outer Moray Firth, north-east Scotland. *Journal of the Marine Biological Association of the United Kingdom* **87**: 85-86.

Rogan, E. and Berrow, S.D. (1996) A review of Harbour Porpoises, *Phocoena phocoena*, in Irish waters. *Reports of International Whaling*

Commission **46**: 595-605.

Sharrock, J.T.R. (1973) *The Natural History of Cape Clear Island*. T and AD Poyser, Berkhampstead.

Sims, D.W., Queiroz, N., Doyle, T.K., Houghton, J.D.R. and Hays, G.C. (2009) Satellite tracking of the World's largest bony fish, the ocean Sunfish (*Mola mola* L.) in the North East Atlantic. *Journal of Experimental Marine Biology and Ecology* **370**: 127-133.

Skov, H., Durinck, J., Danielsen, F. and Bloch, D. (1995) Co-occurrence of cetaceans and seabirds in the Northeast Atlantic. *Journal of Biogeography* **22**: 71-88.

Taylor, B.L., Martinez, M., Gerrodette, T. and Barlow, J. (2007) Lessons from monitoring trends in abundance of marine mammals. *Marine Mammal Science* **23**: 157-175.

Tetley, M.J. (2004) *The distribution and habitat preference of the North Atlantic Minke Whale (*Balaenoptera acutorostrata acutorostrata*) in the Southern Outer Moray Firth, NE Scotland*. Unpublished MSc. Thesis, University of Wales, Bangor.

Tetley, M.J., Mitchelson-Jacob, E.G. and Robinson, K.P. (2008) The summer distribution of coastal Minke Whales (*Balaenoptera acutorostrata*) in the southern outer Moray Firth, NE Scotland, in relation to co-occurring mesoscale oceanographic features. *Remote Sensing of Environment* **112**: 3449-3454.

Wall, D., O'Brien, J., Meade, J. and Allen B.M. (2006) Summer distribution and relative abundance of cetaceans off the west coast of Ireland. *Biology and Environment: Proceedings of the Royal Irish Academy* **106B**: 135-142.

Weir, C.R., Macleod, C.D. and Pierce G.J. (2012) Habitat preferences and evidence for niche partitioning amongst cetaceans in the waters between Gabon and Angola, eastern tropical Atlantic. *Journal of the Marine Biological Association of the United Kingdom* **92:** 1735–1749.

Wilson, J. and Berrow, S. (2007) *A guide to the identification of the whales and dolphins of Ireland*. The Irish Whale and Dolphin Group. Merchants Quay, Kilrush, Co.Clare, Ireland.