North Atlantic Killer Whale Workshop

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Abstracts

Killer whale strandings in the UK 1913-2010

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Between 1990 and 2010, 9894 UK stranded cetaceans were reported to the Cetacean Strandings Investigation Programme. During this period, only 22 killer whales (*Orcinus orca*) were reported stranded. Five of these stranded animals were investigated at post-mortem, the rest being live stranded animals that were refloated or were too decomposed or inaccessible to allow examination. The causes of death of these five individuals were starvation (n=2), old age/tooth root infections (n=2) and live stranding (n=1). Contaminant analyses were conducted in all five individuals and markedly elevated levels were noted, including some of the highest levels of polychlorinated biphenyls (PCBs) ever recorded in marine mammals (mean sum25CBs levels 100mg/kg lipid, range 23.6-819.0). Examination of the stranding dataset collated by the Natural History Museum in the UK between 1913 and 1989 reveals that killer whale strandings were recorded across most parts of the UK, including along the coastline of the southern North Sea where its distribution is currently classified as rare. This suggests that a contraction in range in coastal populations of killer whales has occurred in the UK over the last 100 years, which may at least in part have been driven by exposure to marine contaminants.

Population identity of Shetland killer whales – results of the analysis of pulsed call repertoires

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Killer whales, *Orcinus orca*, are sighted regularly off Shetland, UK, but information about their numbers, diet and population identity is currently limited. Like most other odontocetes, killer whales produce three types of vocalizations: echolocation clicks, whistles and pulsed calls. Killer whale pulsed calls typically shows dialect variation with different populations or even social groups within the same population having different repertoires of structurally distinct call types. Because call types are transmitted through vocal learning and therefore reflect ancestry and social affiliation, analysis of call repertoires provides a quick and comparatively easy way to delineate killer whale populations. We compared the vocal repertoires of seal-eating and herring-eating groups of killer whales off Shetland to call types recorded off Iceland, Norway and the west coast of Scotland. We did not find any call type matches between Shetland seal-eaters and any other North Atlantic killer whale population analyzed. Two call types recorded from herring-feeding groups of Shetland clearly matched call types recorded from killer whales off southern Iceland who also specialize on herring. These results show that the herring-eating killer whales off Shetland are either part of, or recently diverged from, the Icelandic herring-eating sub-population.

Killer whale (*Orcinus orca)* occurrence and predation in the Bahamas

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Killer whales (*Orcinus orca*) are commonly observed in cold temperate waters of the world, however little is known about populations that inhabit tropical waters. In the Bahamas we have recorded 30 sightings of killer whales from 1913 – 2011. Group sizes were generally small (median = 3.5, range = 1 – 12). Thirteen sightings were documented with photographs and/or video of sufficient quality to allow photo-identification analysis. Of the 27 whales photographed, there were 15 individual identifications, nine of which have been resighted (60%). An adult female (Oo6) and her presumed offspring, now an adult male (Oo4), were first seen together in 1995, and have been resighted together 8 times over a 16-year period. Killer whales were observed predating on Atlantic spotted dolphin (*Stenella frontalis*), Fraser's dolphin (*Lagenodelphis hosei*), and dwarf sperm whale (*Kogia sima*), all new records of prey for the species. Observations during these encounters suggest that killer whales in the Bahamas specialise in feeding on marine mammals, and that individuals may return to the islands for foraging purposes. Future focus will be on collecting genetic samples and acoustic recordings to help with assessment of population structuring of Bahamian killer whales.

Killer whales in the Strait of Gibraltar

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Killer whales have been described in the Strait of Gibraltar for centuries. A long-term study has been conducted based on photo-identification catalogue, remote biopsy sampling and behavioural data since 1999. A total of 47 individuals were identified, grouped in 5 different pods. Two feeding strategies were described: one, exhausting the tunas, chasing them during about 30 minutes, which implicates high energetic investment, and another one, interacting with the long-line fishery, which is suspected to have a lower energetic investment. From 1999 to 2005, all 5 newborn calves had survived through their first year of life. However, a significant change was observed from 2005, where none of the 3 newborn calves survived through their first year of life. A two-year delay was observed between the decrease in the Bluefin tuna captures and the decrease of the orcas first-year survival rate. Analysis with 17 polymorphic microsatellite loci indicated that these groups formed a single population, which was significantly differentiated from two populations sampled in waters further North around the UK, Iceland and Norway. This study contributed to catalogue as "vulnerable" in the Spanish Catalogue of Endangered Species, and also to propose a Site of Community Importance (SCI) in the Strait of Gibraltar.

Current knowledge of killer whales of the Canadian Arctic and northwest Atlantic

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To better understand Canadian Arctic and northwest Atlantic killer whales (*Orcinus orca*) we initially compiled a database of sightings from 1700s to present to document the historical occurrence, distribution, feeding ecology, and seasonality of killer whales in the region. For the Arctic, sighting reports (n=450) per decade increased substantially since 1850 and were most frequent in the eastern Canadian Arctic. The mean reported group size was 8.3 (median = 4, range 1–100), but size varied significantly among ecoregions and observed prey types. No sightings occurred during winter, with sightings gradually increasing from early spring to a peak in summer, after which sightings gradually decreased. Anecdotal evidence, sighting reports, Inuit traditional knowledge, and photographic identification indicate that killer whale occurrence in Hudson Bay is increasing. Killer whales were not known to be present in the region prior to the mid-1900s but have since shown an exponential increase in sightings. More sightings appear to be related to a decrease in summer sea ice in Hudson Strait.

Observations of predation events indicate that Canadian Arctic killer whales prey upon other marine mammals and not fish. Monodontids were the most frequently observed prey items, followed by bowhead whales (*Balaena mysticetus*) and phocids. A survey of Inuit Traditional Ecological Knowledge provided considerable information on killer whale feeding ecology. We conducted 105 semi-directed interviews in 11 eastern Nunavut communities from 2007-2010. Results detailed local knowledge of killer whale prey items, hunting behaviour, prey responses, distribution of predation events, and prey capture techniques. Using stochastic models with Monte-Carlo simulations, we studied predator selection within the Hudson Bay region and found that killer whales seasonally concentrate feeding activities on the large-bodied bowhead whale. Model results indicated that killer whales do not show strong prey specialization and instead alternatively feed on monodontid whales early and late in the ice-free season.

Individual killer whales were identified using recent (2004-09) photographs to obtain a minimum count of whales that use eastern Canadian Arctic waters. Fifty-three individuals were

identified from nine different sightings with only one whale resighted suggesting that the number of individuals using this area is likely much larger. No photographic re-sightings occurred between Arctic killer whales and Newfoundland. During August 2009, satellite transmitters were deployed onto two killer whales in Admiralty Inlet, Baffin Island, Nunavut. A whale tracked for 90 days remained in Admiralty and Prince Regent Inlets from mid-August until early October, when increasing ice cover in late September and early October resulted in the whale leaving the region prior to heavy ice formation. The whale traveled an average of 159 km/day out into the open North Atlantic by mid-November, covering over 5,400 km in approximately one month.

For the northwest Atlantic, sightings data (n=744) and a multi-year photographic catalogue of killer whales suggested more sightings in the last ten years and most commonly during the June-September period in the Newfoundland and Labrador area. While most sightings have been made relatively close to shore, there have also been sightings in offshore areas. Killer whales have been sighted both alone and in groups, with group sizes ranging from 2-100 whales (most 3-7). Based on the photographics analyzed to date, there are at least 65 individual killer whales in the northwest Atlantic, although this is likely to be an underestimate. Relatively fewer killer whale sightings have been recorded on the Scotian Shelf, in the Gulf of St. Lawrence, or the northeastern USA despite appreciable effort.

Ecological and evolutionary differentiation among Northeast Atlantic killer whales

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Sequencing of complete mitochondrial genomes indicates that Northeast Atlantic killer whale haplotypes fall into three distinct clades, one of which shares a more recent common ancestor with the Antarctic type A killer whales than the other two Northeast Atlantic killer whales. Measurement of phenotypic traits and stable isotope values of hard tissues from museum specimens found differences correlated with these phylogenetic differences. Individuals in the sister clade to Antarctic type A had invariant isotope values, had a larger maximum length and had unworn teeth. Individuals sampled from around the UK and adjacent waters that were phylogenetically placed within the other two clades had more variable isotopic ratios and adult specimens had some degree of apical tooth wear.

A population genetic investigation was carried out over a wider geographic area using skin samples collected by biopsy from free-ranging animals or stranded individuals. Using 17 polymorphic microsatellite loci we identified at least three populations within our sampleset. There was some correlation with prey choice with one population consisting of individuals sampled from the Icelandic and Norwegian herring grounds, one population containing individuals known to feed on tuna in the Strait of Gibraltar and individuals distributed along the migration route of the Northeast mackerel stock. Isotopes, mtDNA and photo-id data suggest matrilineal differentiation between the Icelandic and Norwegian samples assigned to population A.

Orca conservation in the Strait of Gibraltar

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According to the 2006 ACCOBAMS/IUCN joint workshop, the orca population of the Strait of Gibraltar and Gulf of Cadiz should be classified as "Critically Endangered" following IUCN criteria C2a(i,ii) and D. In 2008, the Small Cetaceans' sub-committee of the IWC recommended that "the relevant local and national agencies in Spain and Morocco cooperate to monitor killer whale status and assess the need for conservation action in the Strait of Gibraltar". A long-term study carried out by CIRCE contributed to include the orca population of the Strait of Gibraltar and Gulf of Cadiz as "vulnerable" in the Spanish Catalogue of Endangered Species (CEEA in Spanish,) in 2011 (Real Decree 139/2011), due to the small size of this isolated population (Spanish criterion: C1 and/or C2), its decreasing food resource (A2), and the decreasing calf survival rate (A2 and C1).

The inclusion in the CEEA requires by law the creation and implementation of a conservation plan, in a period of 5 years. CIRCE leaded a project aiming at writing the draft conservation measures to be presented to the Spanish Ministry of Environment for approval.

Main actions included the implementation of a recovery plan for its main prey the Bluefin tuna (*Thunnus thynnus*), the creation of a Site of Community Importance (SCI) in the Strait of Gibraltar, a better control of WW activities and the limitation of contamination (including acoustical) below sustainable level for the population.

Killer Whales (*Orcinus orca*) in the Caribbean Sea and adjacent waters of the central-western Atlantic

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The killer whale (*Orcinus orca*) is found in all oceans of the world but most of our knowledge on the species comes from studies conducted at higher latitudes. Records of killer whales in the Caribbean have been scarce. Historical (pre-1900) records from whaling ships indicated the presence of killer whales in this region between the months of March and July. In 2009, an international cooperative effort was initiated in Latin America and the Caribbean aiming at centralizing information and photographs of recent sightings of killer whales. We present data on 47 new sightings of killer whales, for Barbados (n=1), Cayman Islands (n=2), Costa Rica (n=2), Dominica (n=1), French Antilles (n=14), Honduras (n=1), Jamaica (n=2), Leeward Dutch Antilles (n=12), Panama (n=1), Puerto Rico (n=4), St. Lucia (n=1), St. Vincent (n=5) and Venezuela (n=1). An additional 54 records were recovered from the literature. Sightings were recorded for every month of the year with a peak in April to June (37%). Group size ranged from 1 to 25 individuals (4.5 ± 4.4, n=86 sightings). These results confirm the presence of killer whales in the region year-round and provide insight into the distribution of this species in the Caribbean Sea. This is an ongoing study in which the new sighting records will be analyzed on zoo-geographical aspects, behavior and morphological characteristics. A better understanding of the distribution, morphology and ecology of killer whales in the Caribbean will shed further light on their evolutionary ecology, taxonomy and conservation status, and will help to set research and conservation priorities.

Using opportunistic data to study a critically small community of killer whales in Scottish waters

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Photo-identification data identified 10 individuals that were linked by association and which were photographed in multiple years on the west coast of Scotland. Recently these individuals have also been photographed off the coast of Ireland and Wales, but not in the Northeast of Scotland despite increased photo-identification effort in that area. Pigmentation patterns are shared by all individuals and are distinctive from groups seen in neighbouring waters, further suggesting a degree of isolation. Typical group size was small, 2-3 individuals and association indices indicate there are long-term preferred associates. A discovery curve suggests that all individuals belonging to this community have been identified. One adult male individual has not been photographed since 2001. Despite photographic records spanning 20 years, no calves have been photographed in association with any of these individuals, suggesting a skewed demography. The small size and apparent isolation of this community is cause for concern for it's long-term viability. It also highlights how opportunistic data can contribute towards conservation-orientated research on wide-ranging species that occur at low density.

Population dynamics of Northern Norwegian killer whales

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Long-term photo-identification study of killer whales (*Orcinus orca*) in northern Norway initiated in 1986, once their prey the Norwegian spring-spawning herring (*Clupea harengus*) started to winter in a fjord system above the Arctic Circle. The aim of this work was to estimate population size, survival rates and temporary emigration rates of identifiable individuals in this killer whale population using photo-identification and mark-recapture techniques with data collected during October-January 1986-2003. Mark-recapture analysis was done with program MARK. Total population size was estimated to be highest in year 2003: 731 individuals (SE = 136, 95% CI = 509-1051) by M(th)Chao model. Apparent constant survival (CJS) for adult males and adult females were estimated as 0.967 (SE = 0.0062) and 0.968 (SE = 0.0081), respectively. Estimate of survival with blocks of time show an increase in mortality through the 18 years. Pollock´s robust design results confirmed temporary emigration occurring from the main wintertime area and this movement to be random. A large-scale distribution change of wintering NSS herring was first recorded in 2002. The major part of the herring stock was no longer concentrating inside the fjord system but was found in the offshore areas of the Northeast Atlantic. The impacts of this significant change in prey distribution on killer whale distribution and adaptation is under evaluation.

Assessing diet of Eastern Canadian Arctic/Northwest Atlantic killer whales using stable nitrogen isotope ratios (δ15N) in teeth

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Killer whales in the Eastern Canadian Arctic (ECA) have been documented feeding on narwhal, beluga, and bowhead whales, and seals. In adjacent regions of the Northwest Atlantic (NWA), killer whale diet includes both marine mammals and fish. However, whether ECA and NWA killer whales are specialist or generalist foragers is not known. To learn more about ECA and NWA killer whale diet, we measured stable nitrogen (δ15N) isotope ratios in teeth from ECA (n=6) and NWA (n=7) killer whales. Dentin was sampled from within annual growth layer groups (GLGs) to construct δ15N profiles for individual whales spanning 4 to 19 yrs. Significant differences in mean GLG δ15N among individuals from each region correspond to trophic-level variation in diet, and suggest prey specialization may exist in ECA/NWA killer whales. Comparison with δ15N values of potential prey species indicates one ECA and one NWA individual may have fed predominantly on baleen whales, while diets of the remaining ECA and NWA individuals may have comprised other marine mammals at higher trophic levels. Temporal effects on tooth δ15N, such as a change in diet or basal foodweb δ15N, are also possible explanations for inter-individual differences in δ15N. Variable δ15N among older GLGs indicates trophic-level changes in diet between years, or reflects feeding in regions with different basal foodweb δ15N.

Orca (*Orcinus orca*) occurrence off the Portuguese continental coast: Data compilation from distinct historical and recent sources

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The orca (*Orcinus orca*) is the most cosmopolitan cetacean species and it is believed to be the most widely distributed marine mammal. In the Atlantic Ocean, distribution and population studies have been made in several areas of the North Atlantic, but there is a lack of information in some regions such as the Western Iberian coast. This study aims to contribute towards the compilation of available data of orca occurrence off the Portuguese continental coast from distinct sources, such as historical records, sightings and strandings. We collected through an extensive review a total of 31 records: 2 captures, 2 reports, 5 strandings and 22 sightings. The first orca record corresponds to a stranding prior to 1895, of which the skeleton is in Coimbra's Natural History Museum. Since then records have been rare and irregular throughout the years. However for the last decade, records have been more frequent due to the increasing scientific interest and public awareness for the cetacean diversity that occurs on the Portuguese continental coast. The largest number of sightings occurred within the continental slope and during summer, which may reflect species-specific traits such as spatial preferences and seasonal movements related to their prey species. Considering the seasonal specializations on prey resources that occur in the North Atlantic, these sightings may also be related to the movements of orcas to the strait of Gibraltar where they feed on Atlantic bluefin tunna (*Thunnus thynnus)*. This is an aspect that should be considered in future European, transnational research projects.

Cross-cultural and cross-ecotype production of a killer whale excitement call suggests universality

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Facial and vocal expressions of emotion have been found in a number of social mammal species and are thought to have evolved to aid social communication. There has been much debate about whether such signals are culturally inherited or are truly biologically innate. Evidence for the innateness of such signals can come from cross-cultural studies. Previous studies have identified a vocalisation (the V4 or 'excitement' call) associated with high arousal behaviours in a population of killer whales in British Columbia, Canada. In this study, we compared recordings from three different socially and reproductively isolated ecotypes of killer whales, including five vocal clans of one ecotype, each clan having discrete culturally transmitted vocal traditions. The V4 call was found in recordings of each ecotype and each vocal clan. Nine independent observers reproduced our classification of the V4 call from each population with high inter-observer agreement. Our results suggest the V4 call may be universal in Pacific killer whale populations and that transmission of this call is independent of cultural tradition or ecotype. We argue that such universality is more consistent with an innate vocalisation than one acquired through social learning and may be linked to its apparent function of motivational expression.

Behaviour of Icelandic killer whales (*Orcinus orca*)

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Studies on Icelandic killer whales started in the 1980s in the herring overwintering grounds of Eastern Iceland by the Marine Research Institute and were followed by efforts in 2000-2002 in the herring spawning grounds of Vestmannaeyjar (SW Iceland), by the Ocean Futures Society. In 2008 we started a project in Vestmananeyjar with a focus on studying the behaviour of Icelandic killer whales by identifying the animals that were encountered in this area and studying their acoustic and underwater behaviour.

To date we have identified a total of 121 individuals in this area, 56 of which have been sighted in more than one year suggesting some site fidelity. Of all the identified individuals 42 were males, 63 were adult females/juvenile males and 16 were juveniles. We identified marks on the skin of some individual killer whales that resembled the dentition patterns of a sea lamprey (*Petromyzon marinus*). Although previously a rare species in these waters, sea lampreys have occurred more frequently in southern Iceland since 2006 and our observations of sea lampreys attached to two killer whales in 2009 suggested this association was a recent phenomenon.

We found that Icelandic killer whales, like herring-eating killer whales recorded off Norway and Shetland, produce high frequency whistles, i.e., whistles with fundamental frequency contours entirely above 17 kHz, although most have entirely ultrasonic (>20 kHz) frequency contours. Unlike the previously reported low frequency whistles from other locations, high frequency whistles were short and had simple contours. Additionally, the frequency characteristics of the ultrasonic whistles produced in these three locations are very similar suggesting a similar function. However, there is little indication of call type sharing between locations, although call type sharing occurs between groups within each population. This suggested the existence of different levels of similarity in acoustic repertoires of presumably separate populations across the Northeast Atlantic.

We also used Dtags and a 4-element vertical hydrophone array to investigate the underwater behaviour and sound production. Similar to findings of previous tag studies, killer whales spent the majority of their time (average ± stdv: 71 ± 13%; 4 Dtags) in the top 10 m of the water

column. However, feeding-related sounds (tailslaps and herding calls) were only localized to depths >10m, while calls and high frequency whistles were also produced at higher rates at these depths than at the surface. In addition, feeding behaviour was characterised by non-directional movement and increased production of biphonic calls. These results suggested that killer whales do not use near-surface carousel feeding when feeding upon spawning herring. Instead, feeding takes place deeper while still involving some acoustic coordination between group members.

Do salmon feeding North Atlantic Killer Whales use context specific calls?

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The Norwegian population of North Atlantic Killer Whales mostly feed on herring. This year we made the first observation that Norwegian killer whales also feed on salmon. During salmon feeding these whales produced different calls as whales feeding on herring. In this talk we will address the question, whether the whales used context-specific calls during salmon feeding or whether the differences were due to group-specific differences in call usage. The study is based on 43 hrs of sound recordings of herring feeding North Atlantic Killer Whales from 2004-2011 and 16 hrs of recordings of a salmon feeding killer whale group in 2011. Both datasets were recorded in the Vestfjord in Northern Norway.

Experimental insights and observational evidence of prey switching by killer whales, *Orcinus orca*, in the northeast Atlantic

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Studies in the Pacific have identified distinct killer whale ecotypes that are either specialized mammal- or fish-eaters. The different types have developed specialized hunting strategies that would suggest specialization could be more advantageous than generalism. However, it has been suggested based on long-term dietary markers of tooth wear and stable isotope values that lineages in the north Atlantic are generalist, but with individual variation in the proportion of prey consumed. Here, we present the results of ten years of observational and photo-identification data of a population of killer whales that follows the Norwegian spring-spawning stock of Atlantic herring. The observations were predominantly of feeding upon herring, but included three observations of one pod interacting with seals. This pod was also observed feeding on herring in association with other known herring-eating killer whale pods. This supports the hypothesis based on the long-term markers of a degree of specialization, with small number of groups persistently feeding upon mammals, but switching between herring and seals. We further investigated this prey switching using an experimental approach by conducting playbacks of Norwegian herring-eating killer whale sounds to Norwegian harbor seals at haul-out sites on the herring spawning grounds. The responsiveness of the Pacific harbor seals to familiar fish-eating has been shown to be optimized to reduce losing foraging opportunities by not responding to cues that do not illicit a threat. Conversely, we recorded changes in behavior consistent with an anti-predator response, suggesting the seals perceived the herring-eating killer whales as a potential predatory threat and had not habituated to their calls. This could be due to the risk of herring-eating killer whales switching to mammalian prey, or the difficulty of discriminating between killer whale pods due to the large population size and number of killer whale call dialects in this population, or a combination of both.

Killer whale recording in Irish waters by IWDG

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The Irish Whale and Dolphin Group (IWDG) have run the Irish cetacean sighting and stranding schemes on an All-Ireland basis since the group was established in 1990. These cetacean recording schemes are widely regarded as being among the most effective in the British Isles. Between 2008-2011 there has been an increase in the number of killer whale sightings in Irish waters reported to and validated by the IWDG. Photographic evidence shows that an increasing proportion of these are individuals belonging to the Scottish West Coast Community group. Whether this increase reflects a change in their distribution or developments in digital photography is uncertain. This presentation seeks to show how national biological recording schemes, that engage the general public, as well as researchers and dedicated observer teams, can improve our understanding of this highly mobile, apex predator and how they use local and adjacent waters.