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SPERM WHALES IN DOMINICA: A CASE STUDY

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Introduction

Sperm whales, the largest odontocetes, have been described as 'cosmopolitan' within the wider Caribbean region (Ward *et al.* 2001). Ecologically, they are an extremely successful species; feeding mainly on mesopelagic squid (Kawakami 1980) at depths generally greater than 1,000m (Whitehead and Weilgart 2000). They are thought to be responsible for the removal of around 100 million tons of biomass annually, a similar amount to that removed by all human fisheries combined (Kanwisher and Ridgway 1983). Sperm whales are clearly both a significant element in the pelagic ecosystem, particularly given recent insight into top-down ecological effects in marine food webs (Worm and Myers 2003), and very successfully adapted to exploit the highly variable resources in that system (Whitehead 1996b). Below, we briefly review current knowledge on sperm whale social and population structure; as well as, vocal behaviour where it pertains to potentially useful management information. It should be noted that virtually all our current knowledge is based on longitudinal studies in the Pacific Ocean, and that part of the motivation for the work presented here is to understand how valid these conclusions are globally.

Among sperm whales, the factors driving the two sexes to form groups differ. Females, calves and immature animals of both sexes, found in sub-tropical and tropical waters, live in relatively stable social 'units' containing on average 11-12 animals that persist for decades. However, these units typically form groups with one or more other units for periods of several days, and so at sea one generally encounters groups that are temporary associations of stable units (Christal *et al.* 1998;Whitehead *et al.* 1991;Whitehead and Weilgart 2000). These social units appear from genetic and photo-identification studies to be long-term associations, typically between maternally related kin, but that often include more than one unrelated matriline (Christal *et al.* 1998;Mesnick 2001;Mesnick *et al.* 2003;Richard *et al.* 1996). The benefits of group living for females include, but may not be limited to, communal care of young and defence against predation (Pitman *et al.* 2001;Whitehead 1996a). In contrast to females, males disperse from their natal units at a mean estimated age of 6 years, whence they migrate slowly into higher latitudes prior to attaining sexual maturity at 18-21 years, and subsequently attain social maturity at around 27 years, at which time they are generally very large (16 m, 45 metric tons) and solitary; at this point, they return to the tropics to mate (Whitehead and Weilgart 2000).

Population or stock structure is likewise largely unknown, due in part to the complexity of the underlying social structure (Donovan 1991). The South Pacific population is the best studied; in it females appear to have ranges of at least 1,000 km (Dufault and Whitehead 1995;Whitehead 2001), perhaps averaging 1,500 km (Whitehead 2003). However, recent work has pointed to a lack of geographically based structure, promoting instead the matrilineal unit as the primary structural determinant (Whitehead *et al.* 1998). This is in contrast to the broad and often arbitrary geographical stock divisions of recent management models (Donovan 1991).

The sperm whale vocal repertoire is dominated by clicks (Whitehead and Weilgart 2000). Codas are repeated stereotyped sequences of 3-40 broadband (0-16kHz) clicks generally

heard during periods of socialising at or near the surface (Watkins and Schevill 1977), behaviour that contrasts sharply with the prolonged dives and wide spacing of foraging groups (Whitehead and Weilgart 1991). For this reason, codas are presumed to have a social function such as re-affirming bonds after foraging bouts (Whitehead and Weilgart 2000). Codas can be classified into types according to the number and temporal pattern of the clicks they contain. For example, "2+3" is a coda containing two regularly spaced clicks followed by a longer gap before three more clicks while "5R" is a coda with five regularly spaced clicks (eg Rendell and Whitehead 2003a). It has been shown that all known social units from the Pacific can be assigned to vocal "clans" based on the usage frequency of certain coda types (Rendell and Whitehead 2003b). For example, one clan uses primarily codas containing regularly spaced clicks, and is termed the 'Regular' clan, while another uses codas that have a pause before the final click, and is termed the '+1' clan. We have suggested that these clans form a further, higher, level of social structure (Rendell and Whitehead 2003b) and there is some genetic evidence they may represent an important element in population structure (Rendell *et al.* unpublished data). Clans also vary in other, non-vocal, aspects of behaviour, most notably movement, habitat use and foraging success (Whitehead and Rendell 2004). In considering management plans for this species, the potential behavioural variation and population structure represented in vocal clans may need to be taken into account (Whitehead *et al.* 2004).

In the Caribbean, sperm whale research has concentrated on two areas – the Gulf of Mexico and the Windward Isles. In the Gulf of Mexico there is an ongoing study overseen by the U.S. Minerals Management Service that was prompted by an expansion of oil extraction activities into the deep water habitat of sperm whales; however, the results of this work have yet to be published. In the Windward Isles, research opportunities are provided by tall islands, notably Guadeloupe and especially Dominica, with deep water close to shore resulting in sperm whales reliably occurring in calm waters close to shore. Over the past 20 years many groups have studied sperm whales in this area, most notably a group led by W. Watkins of the Wood Hole Oceanographic Institute in the 1980's (Watkins *et al.* 2002;Watkins *et al.* 1993;Watkins and Moore 1982;Watkins *et al.* 1985) and a longitudinal study conducted by the International Fund for Animal Welfare in the 1990's (Gordon *et al.* 1998). This latter study collected photo-identification data and showed that the population in the area is likely fairly small given the high between-year resighting rate observed. Here we present results from combining data collected in January-April 2005 during a collaborative research project conducted by ourselves in Dominican waters with this existing data, and results from an analysis of coda recordings made across the north Atlantic.

Methods

The data presented here was collected from small (10-12m) sailing vessels using cameras and hydrophones to photograph and record groups of sperm whales. Animals were tracked for extended periods by using directional hydrophones to follow the echolocation clicks that are made almost continually by foraging groups. Individual whales were approached while at the surface and photographs taken of their tails ('flukes') when raised into the air at the start of foraging dives. When coda vocalisations were detected,

they were recorded using various hydrophone array systems all of which recorded in the 0-20kHz range that contains most of the energy of sperm whale clicks.

Photographs not taken with a digital camera were scanned and all subsequent analysis performed on a PC. Pictures were graded for quality based on the following five attributes of the photograph: focus, exposure, orientation of the fluke to the frame, percent cover of the frame by the fluke, and tilt of the fluke with the surface of the water (Arnbom 1987). Only high quality photos (>Q3) were used in social analyses.

Recordings of codas were analysed using the software 'Rainbow Click' (Gillespie 1997) to extract the timing of coda clicks, and repertoire similarities were calculated (Rendell and Whitehead 2003a). These similarities were then used to construct dendrograms illustrating the relationships between repertoires and bootstrap resampling used to estimate the robustness of branches in the dendrograms.

Results

The most striking aspect of our fieldwork was that our encounters with sperm whales were dominated by the continuous presence of one particular social unit consisting of five adults, one juvenile and one calf (Figure 4), which we dubbed the 'Group of Seven'. This group was first encountered on Jan. 16th, 2005 and remained within the lee of Dominica until they were last seen on the 26th of Mar. 2005. The 'Group of Seven' was the only group of sperm whales in the lee and was observed 100% of days at sea between Jan 16th and Feb. 22nd. This contrasts completely with what had previously been considered 'normal' sperm whale ranging behaviour; instead of ranging over an area many hundreds of miles across, this group was essentially resident in Dominican waters (Figure 1). Subsequent comparison of photo-identification images of this group with those recorded by IFAW in 1995 showed that four of the seven members of this group had been seen in Dominican waters previously and have persisted in using this area for at least10 years. This is a striking long term residency pattern, with management implications.

The vast majority (78%) of identified individuals were sighted in the second half of the field season, after the 'Groups of Seven' had begun to depart (Figure 5). Eight other groups of female and immature sperm whales were encountered in the lee of Dominica between Feb. 22nd and Apr. 12 2005; as well as, four large males. Groups ranged in size from 8 to 11 individuals (mean=9.3). All but one group contained at least one calf. Excluding the 'Group of Seven', only 17% of identified individuals were sighted on two or more different days. With the exception of one group, all groups were sighted on only one day (Figure 5). Members of the former were sighted on multiple days in early March, then again almost a month later. This group remained in the lee for the final days of the field season and was still present on the last day. Members of this group were sighted on nine different days that were up to 49 days apart.

The 'Group of Seven' had a distinctive coda repertoire dominated by a 2+3 coda type (Figure 2). This distinctive coda type is commonly heard from sperm whales in this area (L.R. pers obs) and may be one reason why coda repertoires recorded in the Caribbean

Sea are distinctive from those heard in any other area of the North Atlantic (Figure 3).

Conclusions

The data presented here should be regarded as preliminary. They were collected this year and have yet to be statistically analysed. We can say though that there is a pattern of residency for at least one group that we have not seen elsewhere. The high residency time of the Group of Seven means they are vulnerable to degradation of a relatively small area of habitat; this habitat is likely critical given the residency, the presence of calves and observed interactions with males also suggesting this is a breeding ground. Furthermore, this residency exposes to them to repeated whale-watch approaches and makes them vulnerable should the current whale-watching activities in Dominica grow out of control. Currently there is cause for optimism as the operations are clearly not preventing this group from using preferred habitat over many years. However, this could easily change with the addition of only one or two more significant operators. There is no doubt that effective management of tourism operations where they occur will be vital in securing a long-term future for these sperm whale populations. We were particularly concerned to observe and hear of future plans for 'swim-with' tourism based around these animals. This activity should be curtailed, as it places inexperienced tourists in an extremely vulnerable position close to wild animals massing many tons. If allowed to continue we believe it is only a matter of time before the serious injury or death of a participant does major harm to the local whale-watch industry, with concomitant adverse effects on sperm whale conservation efforts.

There appear in our study to be two distinct population segments – the Group of Seven that was essentially resident off Dominica for the first part of the study, and then other groups that began moving into the area in the latter half of the study. Management plans should consider the possibility that there may be numerous, behaviourally distinct, sub-populations inhabiting the Caribbean, as we have shown is the case in the Pacific (Whitehead and Rendell 2004;Whitehead *et al.* 2004). Similarly, the acoustic study shows that in terms of acoustic behaviour the Caribbean population is quite distinct from others in the North Atlantic, and so a conservative approach to management, in the absence of data on genetic population structure, would not assume that this population can be replaced from Atlantic stocks should it be extirpated.

The fact that animals came and went from the study area shows that their habitat must be larger than the lee of a single island. It is very likely that these whales regularly cross national boundaries, especially given the small distances between the Windward Islands (Watkins *et al.* 2002). Therefore, individual states will not be able to effectively manage the population alone, as they will effectively be only managing a part of the population's range and events elsewhere could impact populations over a large area. We have extremely poor knowledge of sperm whales in the wider Caribbean. This case study shows how small scale research projects can begin to show us how sperm whales use these waters and how their populations may be divided.

Recommendations for the MMAP

(1) Our first and most immediate recommendation is the establishment of a multi-national pooled photo-identification database with which animal movements, ranges and social associations can be tracked. Ideally all research projects in the wider Caribbean would contribute to it and analyses would be regularly performed. There is a model for this in the NAMSC North Atlantic catalogue curated by IFAW, but this is only a collection of images and there is no regular analysis of the results. The establishment of such a database under the auspices of a body like UNEP would be a major step in improving our knowledge of sperm whales in the Caribbean
(2) Future research should also concentrate on establishing the extent of linkage between the Caribbean population and that of the wider Atlantic. Genetic analysis combined with acoustic repertoire analysis is the best way to do this.
(3) Some wider surveys should be planned to assess sperm whale distribution over the wider Caribbean. Using acoustic equipment from platforms of opportunity would be a good and relatively economical way to start this process.
(4) UNEP / SPAW should work towards drafting international agreements governing sperm whales as a cross-border resource. For example, if participant states could agree common rules for regulating tourism interactions with sperm whales then we could ensure a maximum protection standard.

Acknowledgements

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Figures

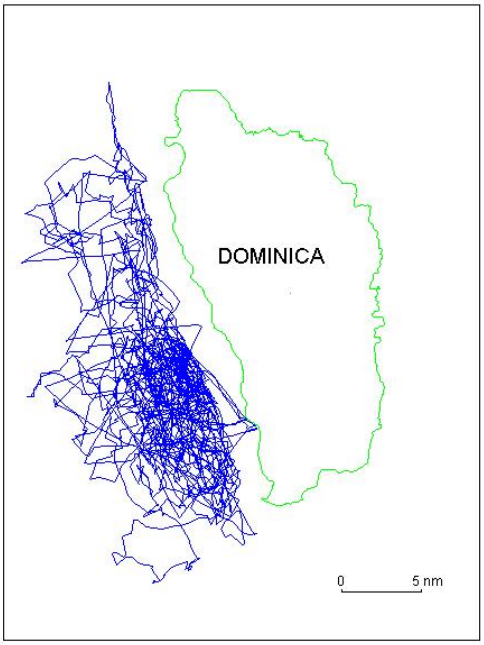

Figure 1: Track of research vessel while following the 'Group of Seven' 14th Jan – 15th Feb 2005

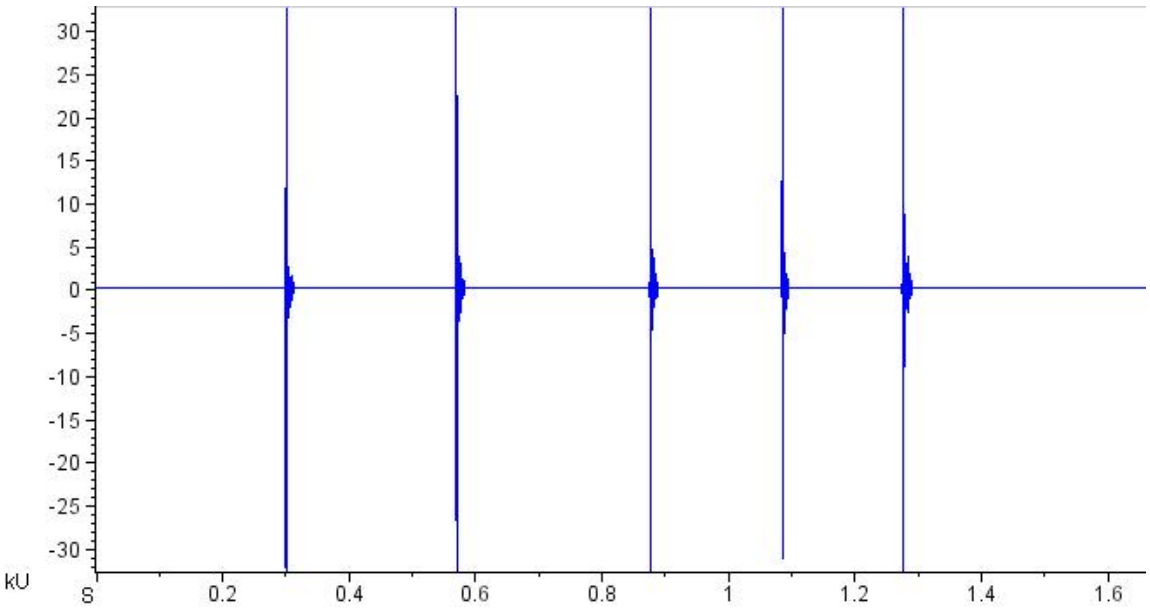

Figure 2: Waveform of typical '2+3' coda type

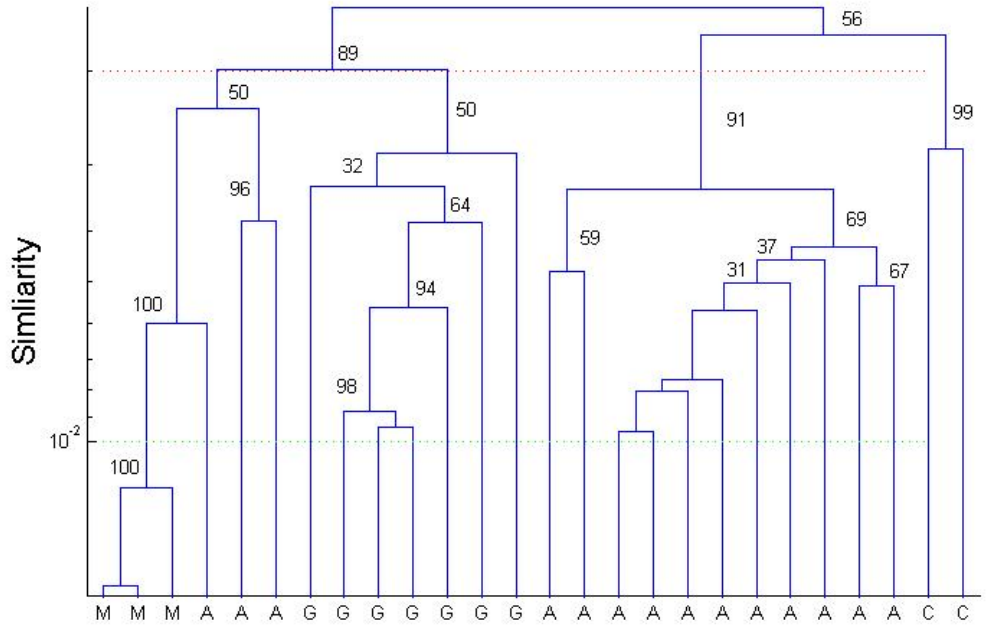

Figure 3: Coda repertoires from the North Atlantic. Each node represents 50 or more codas from a sperm whale group. Location codes are: M – Mediterranean, A – Azores, G – Gulf of Mexico, C – Caribbean Sea. Note that the Caribbean repertoires are NOT from the 'Group of Seven'. Numbers next to branches indicate percent boostrap support for that branch.

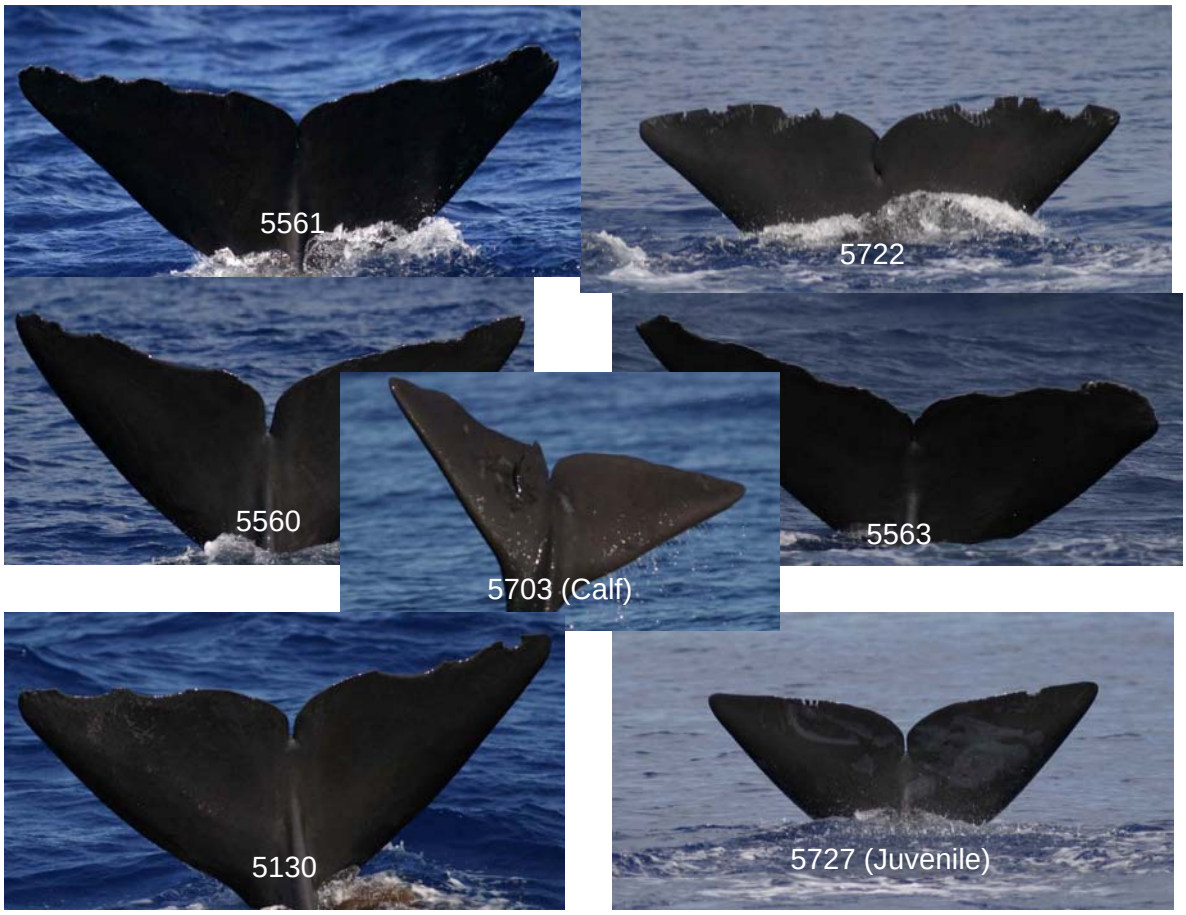

Figure 4: Identification photos of the 'Group of Seven'

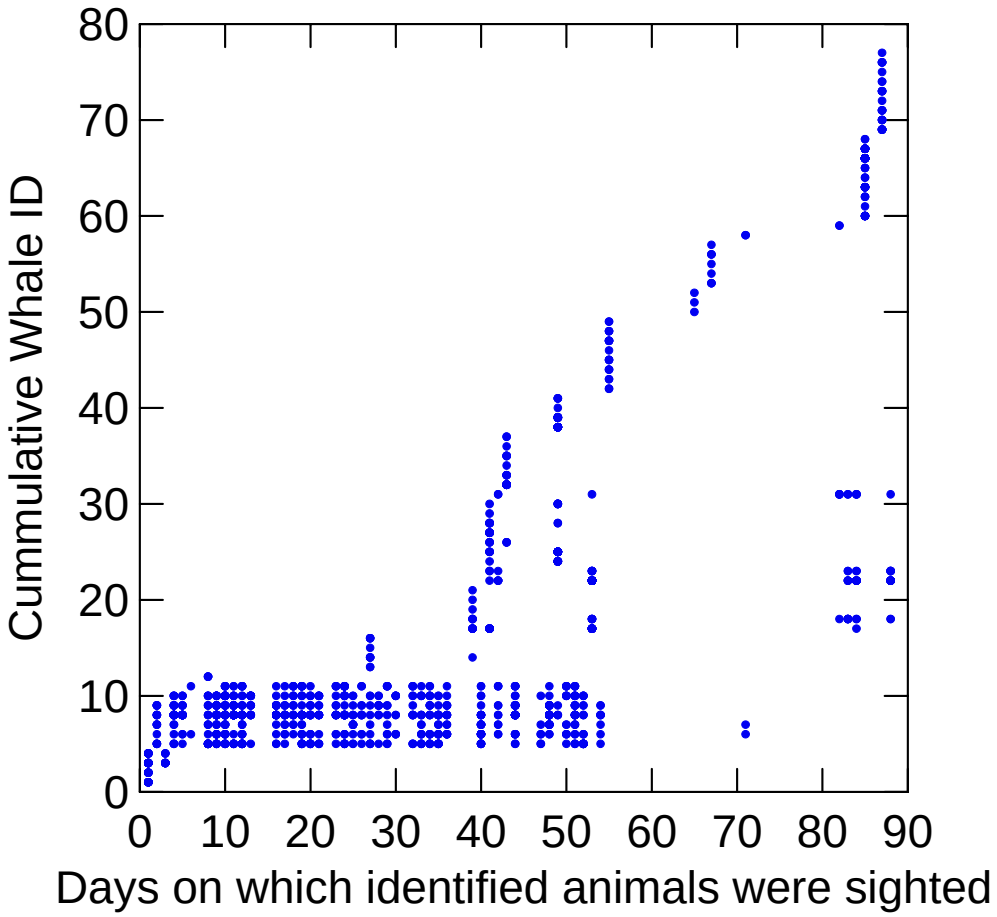

Figure 5: Days on which individual whales were sighted off Dominica during the 2005 field season. This plot also serves as a discovery curve, indicating that the vast majority of individuals were only encountered in the last half of the season.