THE SOCIALITY OF BOTTLENOSE DOLPHINS IN THE OUTER SOUTHERN MORAY FIRTH, NE SCOTLAND: IMPLICATIONS FOR CURRENT MANAGEMENT PROPOSALS?

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INTRODUCTION. Ascertaining group composition and the affiliation of individual animals within a dolphin population are prerequisites fundamental to our understanding of the social structure and behaviour of these long-lived mammals. The general procedure to convert long-term photographic identification databases into models of social structure is to define and calculate association indices between all pairs of identified animals that together make up an association matrix (Cairns & Schwager, 1987; Ginsberg & Young, 1992). Utilising methodologies such as cluster analyses or sociograms, the association matrices for a particular dataset can be displayed. In order to test for preferred companionships, permutations of association measures can further be used (Whitehead, 1999a).

Since 1989, studies of individually identifiable bottlenose dolphins (*Tursiops truncatus* Montagu) using the inner Moray Firth in NE Scotland (57º40´N, 3º30´W) have examined the size, distribution and health of this population (Hammond & Thompson, 1991; Wilson, 1995; Wilson & Thompson, 1996; Wilson *et al.*, 1997) and the environmental threats it faces (Curran *et al.*, 1995). As one of just two known populations of bottlenoses in British waters and the only population in the North Sea, the Moray Firth animals have both national and international importance. Currently estimated at 129 individuals (Wilson *et al*., 1999), the small size and isolated position of this population makes it undoubtedly vulnerable to extinction. In this respect, a greater understanding of the social formation and ecology of the bottlenoses known to use the coastline of the outer southern Moray Firth is considered particularly relevant to the development of conservation policies for their protection.

Using original data collection and an established bottlenose dolphin identification database, the principle objectives of this study aimed: (i) to determine the group size and composition of bottlenose dolphins frequenting the coastline of the southern outer Moray Firth; (ii) to calculate and define the association indices between pairs of identified animals; (iii) to evaluate and interpret patterns of affiliation between individual dolphins; and (iv) to estimate the probabilities of association between individuals over time.

METHODS. Data were collected from dedicated boat-based surveys conducted between July 1997 and August 2003 along an 83km stretch of coastline of the southern outer Moray Firth in NE Scotland, between Lossiemouth and Fraserburgh (Fig. 1), using photo-identification methodologies as a central methodology. Half Weight Indices (HWI) of association (Equation 1) were used to calculate coefficients of association (CoA's) between individual dolphins from the study area with the application of SOCPROG v1.3 developed by Whitehead (1999a, b) for MATLAB v5.1.

$$\text{HWI} = \frac{X}{X + \frac{1}{2}(Ya + Yb)} \qquad \textbf{(1)}$$

After Cairns & Schwager (1987) where:

X = the number of times both individual a and b were seen together in the same group,
Ya = the number of times individual a was seen, and
Yb = the number of times individual b was seen.

The SOCPROG software was used to test observed association patterns of individual dolphins against those expected from random associations. The social organisation of the population for the entire study period could then be graphically presented using a hierarchical cluster analysis (average linkage method) of the HWI matrix. This technique clustered individuals not only by preferred partnerships, but also using least preferred partners (Whitehead, 1999a). The significance of the association indices of all possible pairs (or dyads) of animals in the sample used, and therefore the significance of the groups discriminated by the cluster analyses, was assessed using a Monte Carlo randomisation approach (Manly, 1995; Bejder *et al.*, 1998; Whitehead, 1999b). In this test, individuals within groups were randomly permuted keeping group size, and the number of times each individual was seen, the same as in the original dataset. The number of permutations performed was increased until the *P*

value obtained from the Monte Carlo simulation became stabilised and the confidence intervals decreased. If more than 95% of the expected HWI were found to be smaller than the observed HWI, a pair of dolphins was defined as a preferred companionship, i.e. the pair was more likely to be seen together than by chance. A Mantel test, using 1,000 permutations, was applied to examine the dataset for differences in association depending on sex. Variations in lagged association rates were calculated for all associations to determine the stability of associations amongst individuals.

RESULTS. Group sizes were found to range from 1 to 44 animals with a mean of 11.07 ± 7.93 animals (n = 132). From a sample of 40 known individuals identified 5 or more times (19 females, 17 males and 4 of unknown sex), calculated half-weight CoA's ranged from 0.00 to 0.73 (mean = 0.11 ± 0.04) (Fig. 2). The dolphins were typically found in mixed-sex groups, but associations between and within sex classes were not found to be significantly different from one another (Mantel test, t = 0.024, p = 0.51) (Fig. 3). Inter-sexual associations were seen to be as strong as intra-sexual associations (Table 1). Both sex classes were found to show a tight network of associations with 24% of the males and 21% of the females displaying HWI of ≥ 0.50. Permutation tests for non-random associations indicated that dolphins in this population did not associate preferentially with or avoid other individuals (random, permuted mean = 0.10819, observed mean = 0.10836, p = 0.87520). No clear divisions were found in the community, the echelon pattern of the resulting dendrogram (Fig. 2) expressing no clear architecture, as defined by Lusseau *et al*. (2003), except for dyads, triads and their multiple networks. Analyses of lagged association rates suggested short-term associations of individuals over periods of days, with rapid disassociations, except for a smaller number of constant companions, by the end of a few weeks.

CONCLUSIONS. Group sizes of bottlenose dolphins in the southern outer Moray Firth were found to be significantly larger than those occupying the more estuarine-like conditions of the inner Moray Firth. Whilst this might be attributed to environmental differences between the two areas, group size and formation in this dolphin community are likely to be affected also by the feeding ecology in this area of the firth, the availability of prey items, and the potential risk of predation.

The composition of this bottlenose dolphin community was found to be dissimilar to other bottlenose populations, in that the animals were found to live in large mixed-sex groups, where strong associations occurred within and between both sexes. Perhaps unusually, no clear sub-units were found to exist in this community, yet some males and females did tend to spend more time together than others. The changeability of units and sub-units recorded was found to be directly related to the differences in occurrence patterns observed, and this was considered to reflect the extensive home range and migratory/seasonal movements identified in this North Sea bottlenose population.

The preferred associations were typically mixed, with relationships lasting just several days to a few weeks. A small number of individuals, however, were predicted to form longer-term associations. Females of the same reproductive status were seen to group together, as in other bottlenose dolphin populations. In addition, a small sample of mature male individuals showed strong male-male associations indicating the possibility of alliance formation between mature males within this bottlenose community, which certainly warrants further investigation.

Associations between males and females were primarily attributed to the reproductive state of the female in the present study, but other factors such as relatedness, dispersal and anthropogenic impacts are all considered to shape the sociality of this species in this North Sea coastal location. The implications of this preliminary study may be particularly significant to management proposals currently aimed at this internationally important bottlenose population.

ACKNOWLEDGEMENTS. We would like to thank Drs. Jonathan Wright and John Goold from the University of Wales, Bangor, for providing sound advice when needed, Prof. Hal Whitehead for much appreciated assistance with the SOCPROG programme, and numerous friends, colleagues and volunteers at the Cetacean Research & Rescue Unit for their invaluable assistance and support with boat work and data collection.

REFERENCES

Bejder, L., Fletcher, D. and Bräger, S. 1998. A method for testing association patterns of social animals. *Animal Behaviour,* 56: 719 – 725.

Cairns, S. J. and Schwager, S. J. 1987. A comparison of association indices. *Animal Behaviour*, 35: 1454 – 1469.

Ginsberg, J. R. and Young, T. P. 1992. Measuring association between individuals or groups in behavioural studies. *Animal Behaviour,* 44: 377-379.

Lusseau, D., Schneider, C., Boisseau, O. J., Haase, P., Slooten, E. and Dawson, S. M. 2003. The bottlenose dolphin community of Doubtful Sound features a large proportion of long-lasting associations. Can geographic isolation explain this unique trait? *Behavioral Ecology and Sociobiolgy*, 54: 396 – 405.

Manly, B. F. J. 1995. A note on the analysis of species co-occurrences. *Ecology,* 76 (4): 1109 – 1115.

Whitehead, H. 1999a. Testing association patterns of social animals. *Animal Behaviour*, 57: F26-F29.

Whitehead, H. 1999b. Programs for analysing social structure. Website handbook.

Wilson, B., Hammond, P.S. and Thompson, P.M. 1999. Estimating size and assessing status of a coastal bottlenose dolphin population: seasonal distribution and stratified movement patterns in the Moray Firth, Scotland. *Ecological Applications,* 9: 288-300.

Table 1. Mean and maximum half-weight indices (HWI) between and within sex classes. SD = Standard Deviation.

	Mean HWI (SD)	Maximum HWI (SD)
All individuals	0.11 (0.04)	0.48 (0.13)
Female – Female	0.10 (0.03)	0.40 (0.11)
Male – Male	0.12 (0.05)	0.39 (0.17)
Female – Male	0.12 (0.05)	0.40 (0.13)

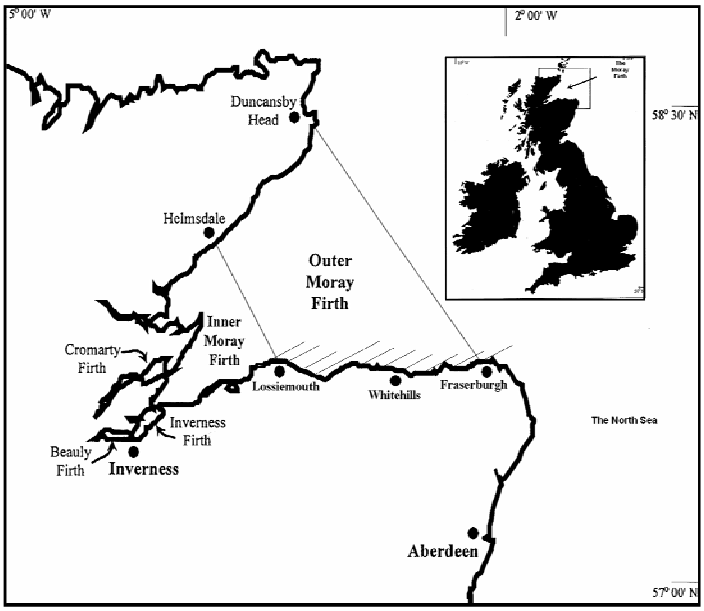

Figure 1. Map of Northeast Scotland showing the location of the Moray Firth and the area in which the present study was carried out (shaded area).

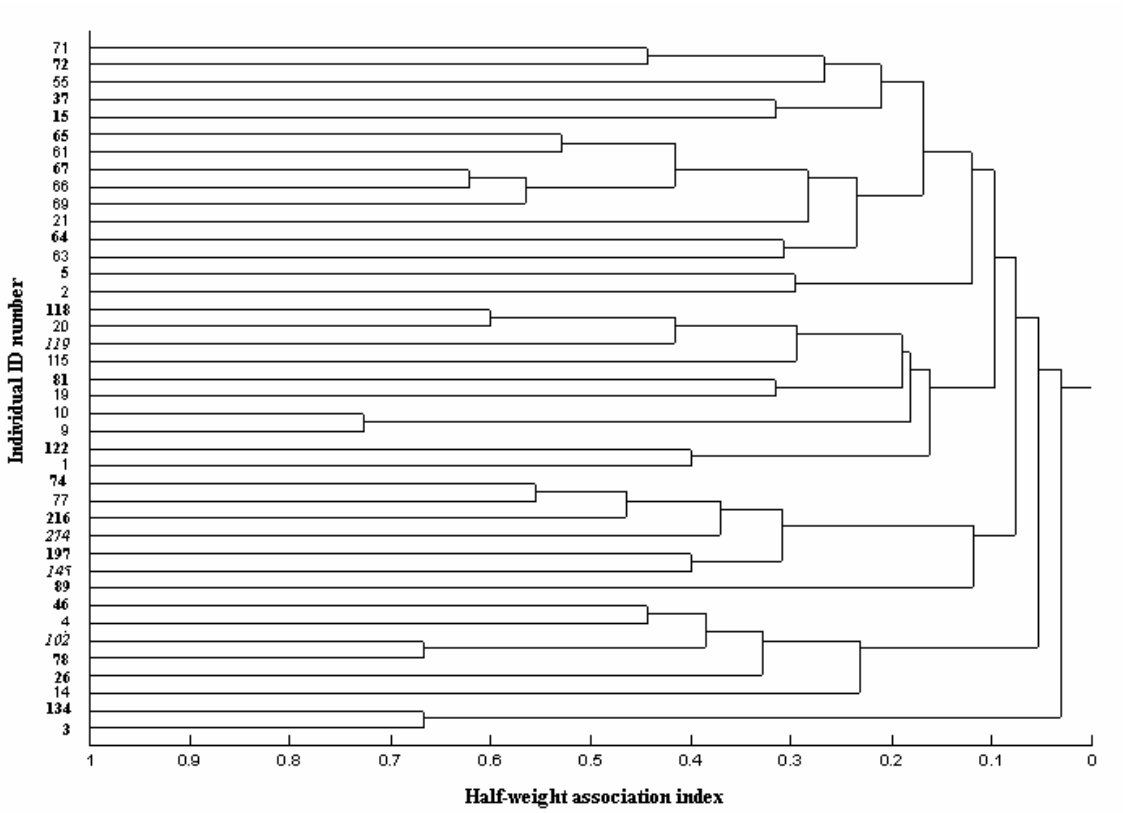

Figure 2. Dendrogram showing the average-linkage cluster analysis of associations between 40 selected bottlenoses seen ≥ 5 times in the study area between 1997 and 2003. Ordinary type ID numbers represent known males, bold type known females, and italics individuals of unknown sex.

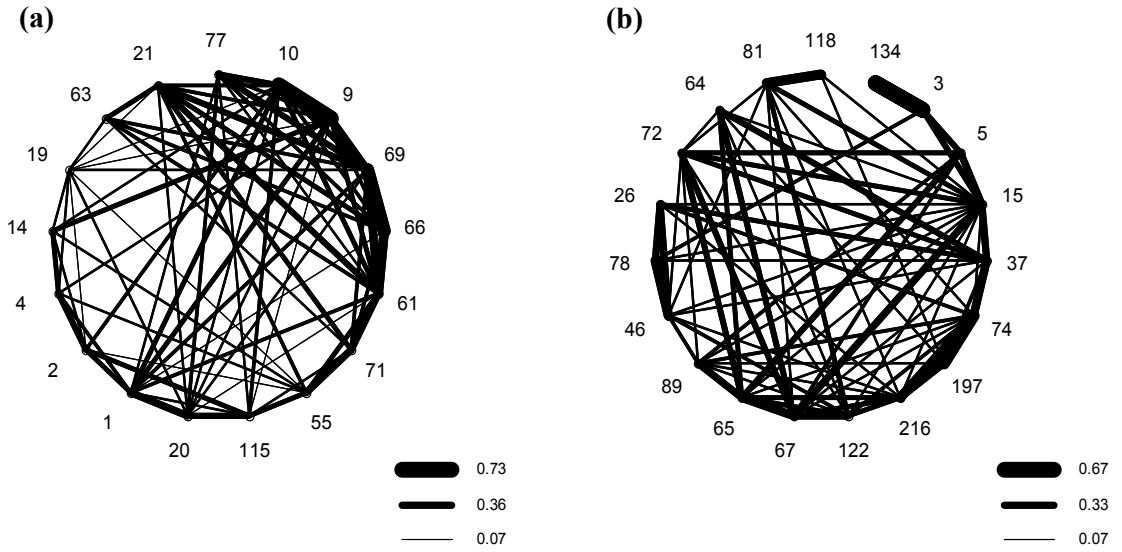

Figure 3. Sociogram representations of (a) male-male and (b) female-female half-weight coefficients of association. Dolphin identities are indicated by their ID number. Lines of increasing thickness correspond to the increasing strength of pairwise associations (see legend).