Whistle production by bottlenose dolphins *Tursiops truncatus* in the Shannon Estuary

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The Shannon Estuary has been designated a 'candidate Special Area of Conservation' (cSAC) for bottlenose dolphins *Tursiops truncatus* (Montagu) under the EU Habitats Directive (Berrow 2003). In order to maintain the dolphins in a "favourable conservation status" it is essential that their behaviour and use of the estuary are better understood. Bottlenose dolphins, like all marine mammals, live in a largely acoustic environment and have evolved highly specialized vocal anatomy in order to communicate and navigate underwater (Richardson *et al.* 1995). They produce a wide range of sound signals, including broad-band echolocation clicks, which are used to navigate, and burst pulsed sounds, often described as squawks, yelps and barks (Schultz 1995) as well as a frequency-modulated narrow-band sound, which is known as a whistle. Despite the large amount of work carried out on dolphin whistles, the function of whistles to bottlenose dolphins is still unclear. Although the complexity of whistle types for captive animals is well documented, the difficulties of observing and recording individual dolphins in the wild has mitigated against field studies designed to explore how they use these calls (Janik 2000).

Here we present preliminary data obtained from a new system deployed in the Shannon Estuary to record dolphin vocalizations from a land station.

Methods

Data Collection

A standard underwater hydrophone (MAGREC HP30), which operates between 200Hz and 20KHz, was fixed to a metal frame, 1m above the seabed, at a depth of 10-12m and *c*100m off Kilcredaun Point, Co Clare (52° 34.7'N 9° 41.3'W). The signal from the hydrophone passed through a 400Hz (High Pass) filter to remove some low frequency ambient noise. This filter box also enabled headphones and a DAT recorder to be attached. The detection range of the hydrophone is not known but distance trials have suggested a maximum of 1.5km (Berrow and Holmes, unpublished data).

Two-hour samples were recorded onto a Sony TCD8 DAT, using an acquisition rate of 44.1kHz, on nine different days between 9 August and 8 September 2004. Each sample was taken during daylight hours between 10.00 and 21.00 and at different states of the tidal cycle on both an ebb and flood tide. Pro-luxe PX-921 stereo digital headphones were used to listen to the signal as it was recorded. Each time dolphins were detected acoustically a note was made of the type (whistle, click, groan, bark) and time, and marked on the DAT recording.

During each sampling period the area was scanned visually for the presence of dolphins with the aid of binoculars (8x56), while simultaneously listening through the headphones. If dolphins were observed, the time, number of dolphins present, estimated distance from the hydrophone and behaviour (travelling, travel/feeding, foraging or milling) was recorded using those definitions described by Shane (1990).

Two recordings (of 45 and 60 minute duration) were made from a 5.4m rigid inflatable boat (RIB). One group of 12-15 dolphins, including two calves, was recorded south of Scattery Island (51° 35.5'N 9° 30.0'W) on 3 August 2004. Another recording was made on 4

Figure 1. Spectrograms of main whistle types recorded in the Shannon Estuary.

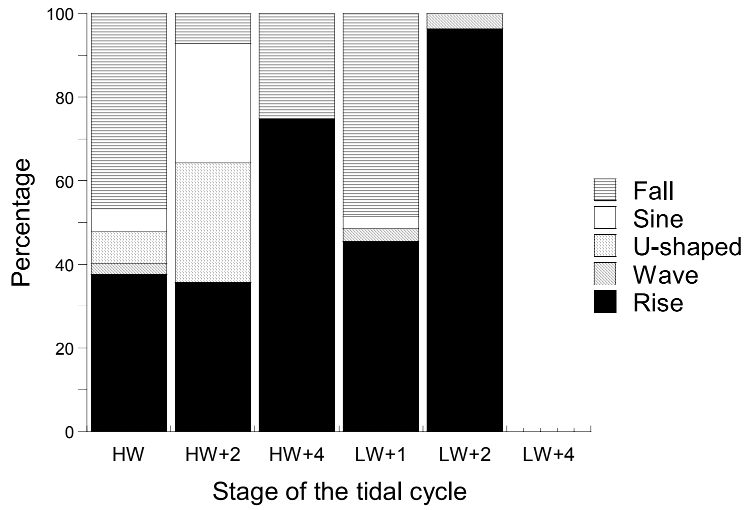

Figure 2. Whistle types recorded at different stages of the tidal cycle at Kilcredaun Point (HW=High Water, LW=Low Water, HW+2=High Water + 2 hours).

August in Glendoosagh Bay (51° 34.3'N 9° 24.7'W) of 15-20 dolphins, including three calves. Towards the end of the second sample, group size had declined to eight dolphins, but the remainder of the group were still within 200m. Behaviour was recorded using those definitions described by Shane (1990).

Data Analysis

On return to the research centre, each sample was played through signal processing software (Adobe Audition, Version 1.0), which can display a spectrograph of each vocalization. Individual spectrographs were generated for each whistle, which were described and classified as one of five different types, depending on its frequency contour, following the categories presented in Janik and Slater (1998). Many whistles were recorded during the same bout (defined as whistles recorded within 2 minutes of the previous whistle) and thus were not independent of each other, *i.e.* the type of whistle produced may have been influenced by the preceding whistle type.

Results

Between 9 August and 8 September 2004, a total of 18 hours (1080 minutes) of acoustic data was collected from Kilcredaun Point. Dolphin vocalizations were recorded on

Table 1. Acoustic sampling periods collected from Kilcredaun Point, Co Clare.

Sample	Date	Time of sample	Time of HW	State of tide	Group size	Behaviour	Distance from hydrophone	No. of whistles
1	9 Aug.	15.00-17.00	12.57	LW - 2	-	-	-	-
2	10 Aug.	19.00-21.00	14.12	LW ± 1	8-10	Foraging	50m	35
3	13 Aug.	13.11-15.11	17.11	LW + 4		-	-	-
4	16 Aug.	14.08-16.08	19.08	LW + 2	6-8	Foraging	500-800m	28
5	23 Aug.	15.14-17.14	11.14	LW - 2	4-6	Milling	1000m	3
6	24 Aug.	12.20-14.20	12.20	LW - 4	-	-	-	4
7	1 Sept.	09.58-10.58	07.58	LW - 2	-	-	-	3
8	3 Sept.	09.15-11.15	09.07	LW - 4	-	-	-	1
9	8 Sept.	11.21-13.21	13.21	LW + 6	6+	Travelling	100m	88

HW = High water, LW = Low Water, LW-2 = Two hours before Low Water, LW ± 1 = One hour either side of Low Water

Table 2. Whistle types recorded during different periods of behaviour.

Behaviour	Number	%	Rise	Wave	U-shaped	Sine	Fall
Foraging	63	25	42	2	2	1	16
Travelling	88	35	29	5	6	8	40
Travel/Feed	89	35	45	7	10	9	18
Not known	11	5	7	1	2	1	0
Total	**251**		**123**	**15**	**20**	**19**	**74**

seven of the nine samples with a total of 162 different whistles recorded. Most whistles (n=88, 54%) were recorded on 9 September, two hours before high water and on the 10 August (n=34, 21%) one hour either side of low water. Although dolphins were detected acoustically during seven samples they were observed visually only on four (Table 1). Each time only bottlenose dolphins were observed. A total of 89 whistles was recorded on 3 (n=59) and 4 August (n=30) from a RIB when the dolphin's behaviour was classified as travel/feeding.

Whistle classification

Whistles were allocated into one of five main categories: A. Rise B. Wave C. U-shape D. Sine E. Fall (see Fig. 1 for examples of each contour). Of the five whistle categories identified, type A (rise) was the most frequently recorded accounting for 49 per cent of total number with this and type E (fall) accounting for 82 per cent of the total whistles recorded. Type A (rise) was recorded most frequently at slack water and just before mid-flood tide and whistle type E (fall) at slack water (Fig. 2).

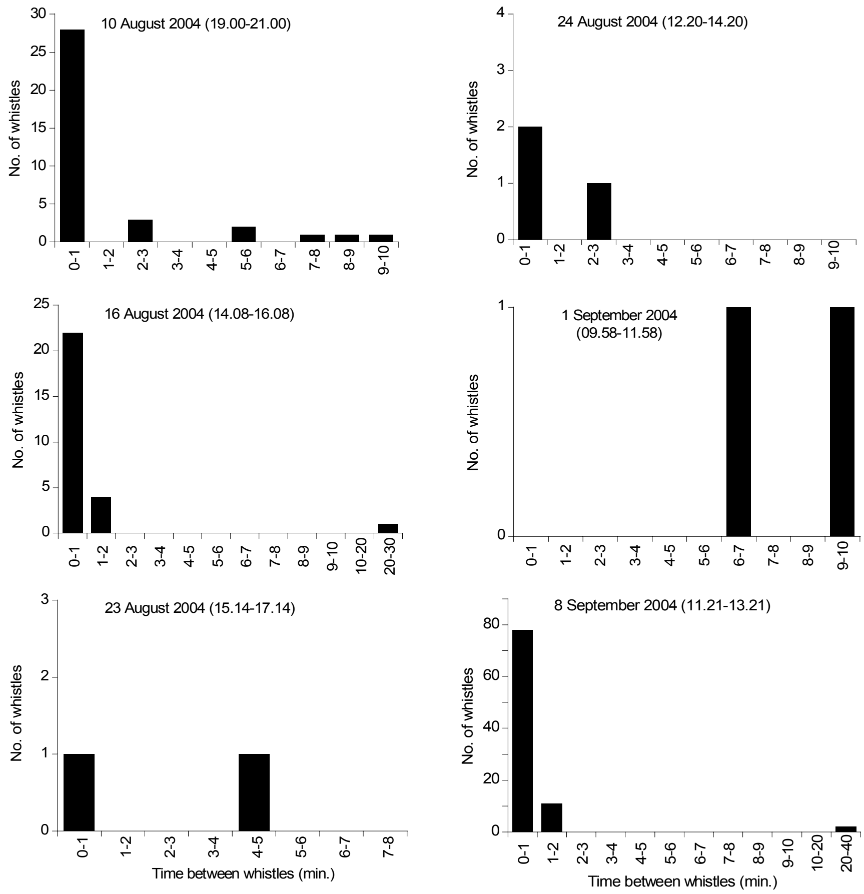

Figure 3. Distribution of whistles over a two-hour period (time of production of each whistle is relative to the one previous).

Whistle distribution

Whistles recorded during each sample were plotted to assess the time of production relative to the previous whistle (Fig. 3). It was found that on five of the seven samples (71%) that once one whistle was detected, then subsequent whistles were heard within 1 minute. During the two samples where the time elapsed between whistles was greater than 1 minute, the number of whistles recorded was small (a total of 1-5 whistles during each sample). Thus whistles tended to be produced in bouts. A bout was defined as all those whistles produced within 2 minutes of the previous whistle.

Whistle type and behaviour

It was not possible to assess which individual dolphin was producing each whistle, therefore the behaviour of the group was used to relate whistle type to behaviour. Overall, type A (Rise) was the most frequently recorded whistle and it was the most abundant whistle during foraging and travel/feeding. During travelling, type E (Fall) was the most abundant whistle type (45%). With the exception of type C (U-shaped) during travel/feed, all other whistle types were only rarely recorded and did not show any relationship with behaviour (Table 2).

Discussion

The function of whistles to bottlenose dolphins is still unclear. One hypothesis is that these whistles are individually distinct (Caldwell *et al.* 1990) and broadcast to identify the whistler. The 'signature whistle hypothesis' predicts that each dolphin produces, and is individually identified by, a categorically different stereotypic whistle contour type, and not by individual acoustic variations of a shared contact whistle or call type like in other species. The signature whistle hypothesis has been challenged, as few studies have been able to show a clear context use for these whistles (McCowan and Reiss 2001). Although the complexity of whistle types for captive animals is well documented, the difficulties of observing and recording individual dolphins in the wild has mitigated against field studies designed to explore how they use these calls (Janik 2000).

This short study shows that although a range of whistles types are produced by bottlenose dolphins in the Estuary, distinct whistle types predominate. Whistles are produced in bouts rather than singularly and thus when a whistle is detected it is likely that more will be detected within one minute. Whistle type A (Rise) was most frequent and preliminary data suggest this whistle type might be associated with foraging or travel/feeding. Type E (Fall) was the second most frequently recorded whistle type and detected when dolphins were observed travelling. However there are too few data recorded to stratify whistle production by variables such as behaviour/state of tide/group size, thus it is not possible to draw any conclusions at this early stage. We have demonstrated that we can successfully and regularly receive dolphin whistles, and other vocalizations, via a fixed hydrophone to the shore to provide access to this little understood aspect of bottlenose dolphin ecology. This system offers considerable advantages over conventional boat-based systems as the presence of a boat may influence dolphin behaviour and it can acquire data in all weather conditions and sea-states, and throughout the day and night.

As part of the management of the Lower Shannon cSAC, the National Parks and Wildlife Service are required to develop monitoring programmes. Traditionally, monitoring of bottlenose dolphins has tended to use visual techniques. A possible alternative approach might be to develop acoustic surveillance techniques to monitor relative abundance and habitat use. However, before acoustic techniques can be developed a better understanding of the acoustic behaviour and repertoire of bottlenose dolphins is required.

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