

NEW SPERM WHALE VOCALISATIONS RECORDED IN THE MEDITERRANEAN SEA

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INTRODUCTION Sperm whales are vocal animals primarily known for their clicks vocalisations (Backus and Schevill, 1966; Watkins, 1980). Diverse categories of sound have been recognised to date according to the pattern and number of the clicks emitted: namely 'usual clicks', 'creaks', 'rapid clicks', 'chirrup' and 'codas' (Gordon, 1987) and they seem to be related to the activity of the whales. 'Codas' are distinctive and repetitive pattern of clicks (Watkins and Schevill, 1977), and 'chirrup' are brief rapid trills of clicks (Gordon, 1987). Both are generally heard from whales forming large and tight group at the surface and are believed to be « social sounds » (Gordon, 1987). To date only one coda pattern has been described in the Mediterranean Sea (Borsani and Pavan, 1994), although some variation within this pattern have been evidenced (Pavan *et al*, 1996). During a dedicated sperm whale survey in the Tyrrhenian and Ionian Seas (Gannier and Drouot, 1999) numerous codas were recorded from nursery schools. The diverse coda patterns recognised are presented below.

MATERIAL AND METHODS The platform was a 12 metre motor-sailer with a 80HP diesel engine. A mono hydrophone was used, towed behind the boat by a 60m cable. Its sensitivity was about 89.10^6 mV per Pa and its frequency response was linear from 200Hz to 25kHz. A multiple setting high-pass analog filter was added to reduce the ambient noise and thus improve the recording. The recording equipment consisted of a Sony WMD6 analog recorder (used in the Tyrrhenian Sea) and a TCD-7 DAT recorder (used in the Ionian Sea). Recording were performed during the observation of two nursery schools: one in the Tyrrhenian Sea including 5 individuals (one calf, one juvenile and 3 females) and one in the Ionian Sea including 7 individuals (one calf, 2 juveniles and 4 females). The distance of the animals from the boat was less than 100m, when recordings were undertaken. The best quality recordings were copied on to Digital Audio Tape (DAT), resulting in 17 min recordings from the Tyrrhenian Sea group and 45 min recordings from the Ionian Sea group. Recordings of the different vocalisations were sampled onto a computer hard disk using a Cambridge Electronic Design (CED) 1410 laboratory interface. The sampling frequency was 45.5kHz and a high-pass filter of 2kHz was used. The analysis of the vocalisation was performed using CED Spike 2 software V.4.70. The Codas were distinguished in the recording sequence from their specific and repetitive pattern of clicks. They were categorised according to the number and timing of the clicks they included. The click pattern of each coda type was described by measuring the Inter-Click Interval (ICI), defined by the time interval (in ms) between consecutive clicks. The Chirrup were distinguished aurally by the characteristic burst of clicks. They were numerous in the recording of both groups. A representative sample of 38 « chirrup » were randomly selected and analysed. The analysis consisted in measuring the ICI, the total length, the click number and the click rate of each 'chirrup' retained for analysis.

RESULTS Three coda types were identified in the recordings from the Ionian sea: 4-click codas, 4-click codas and 7-click codas. They all started with 3 regular clicks, at approximately equal intervals and were followed by 1, 2 or 4 clicks, for the 4-click, 5-click and 7-click coda respectively. The 4-click coda (Table 1) consisted of 3 rapid and evenly spaced clicks followed by a 4th click after a long interval 4time the first ICI, i.e: [/// /]. The 5-click coda (Table 2) included 3 rapid and evenly spaced clicks followed by a 4th and 5th clicks with doubling ICI, i.e: [/// / /]. The 7-click coda (Table 3) consisted of 3 rapid and evenly spaced clicks followed by 4 evenly spaced clicks (at about 4 time the first ICI), i.e: [/// / / / /].

Three other coda types were identified in the Tyrrhenian sea recordings (July 1998): A [/// /] 4-click coda type (Table 4) (3 rapid and evenly spaced clicks followed by a 4th click after an interval of twice the first ICI); a [/ // /] 4-click coda type (Table 5), with a central pair of rapid clicks; and a [/ / /] 3-click coda type (Table 6), with the final interval twice the first ICI.

DISCUSSION During our study, codas were heard only from nursery schools at the surface, which is consistent with the results of Weilgart and Whitehead (1992). Six distinct coda patterns were recognised, 3 in the Ionian Sea and 3 in the Tyrrhenian Sea. Sperm whales in the Mediterranean produce more than one coda pattern, like in other studied populations. Only the (3+1) pattern was recognised to date. A (3+1) type coda was found in the recordings from both the Ionian and the Tyrrhenian seas. This (3+1) pattern was similar to the codas already described in the Mediterranean Sea (Borsani and Pavan, 1994). However, considerable variations in both the total duration and the click timing within this (3+1) pattern are evident between the two regions. In the Tyrrhenian sea, the (3+1) coda is similar to the « short codas » previously recorded there by Pavan *et al* (1996) in the same region. In contrast, the (3+1) pattern from the Ionian Sea had considerably shorter duration and shorter ICI between the initial 3 clicks. Thus our recordings provide further evidence of variations in the (3+1) pattern within the Mediterranean basin. These variations could represent regional differences, since it has been suggested by several authors that codas could vary geographically (Gordon, 1987). Some new coda patterns were found in our recordings. The 3 coda patterns described in the Ionian Sea all started with 3 rapid clicks. This observation is consistent with the finding of Weilgart and Whitehead (1992), who observed that sperm whales off the Galapagos Islands produced different codas by the addition of clicks to a « root » pattern.

CONCLUSION This study resulted in new findings concerning the acoustic activity of sperm whales in the Mediterranean. This included the identification and description of several new coda types, not only in a region never subjected to acoustic survey such as the Ionian Sea, but also in the Tyrrhenian Sea, previously investigated.

REFERENCES

- BACKUS R.H. and SCHEVILL W. E. 1966. *Physeter* clicks. In Norris, K.S.(ed.) *Whales, dolphins and porpoises*. University of California press, Berkeley, CA.
- BORSANI J.F. and PAVAN G., 1994. Acoustics and aspects of Sperm whale behaviour and ecology in the Mediterranean Sea. *Boll. Zool. Suppl.*, 79.
- GANNIER A. and DROUOT V., 1999 (submitted).Relative abundance and distribution of the sperm whale in the western and central mediterranean Sea. *European research on Cetaceans*, 13.
- GOOLD J.C., In press. Behaviour and Acoustic observations of sperm whales in Scapa Flow, Orkney Islands. *J. Mar. Biol. Ass. U. K.*
- GORDON J.C., 1987. *The behaviour and ecology of sperm whales off Sri Lanka*. PhD thesis, Darwin College, University of Cambridge.
- PAVAN G., NASCETTI D., MANGHI M.,PRIANO M., FOSSATI C. and BORSANI J.F., 1996. Bioacoustic research on sperm whales in cooperation with the Italian Navy. *European Research on Cetaceans*, 10: 82-85.
- WATKINS, W. A. 1980. Acoustics and the behaviour of sperm whales. In *Animal sonar systems* . Plenum, New York and London : 283-290.
- WATKINS W. A. AND SCHEVILL, W.E. 1977. Sperm whale codas. *J. Acoust. Soc.Am.*, 62: 1485-1490.
- WEILGART L.,AND WHITEHEAD H. 1992. Coda communication by sperm whales (*Physeter macrocephalus*) off hte Galapagos islands. *Can. J. Zool.* 71: 744-752.

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Table 1 Interclick Interval (ICI) and total duration of the 4-click [/// /]codas (N=54) recorded in the Ionian Sea.

ICI (in ms)	Mean	SE	Min	Max
t2-t1	28.7	0.4	24.4	37.4
t3-t2	32.6	0.7	25.1	51.4
t4-t3	181.3	8.9	58.3	300.5
Total duration	242.7	9.0	117.2	375.9

Table 2 Interclick Interval (ICI) and total duration of the 5-click [/// / /]codas (N=12) recorded in the Ionian Sea.

ICI (in ms)	Mean	SE	Min	Max
t2-t1	32.2	0.6	28.7	35.7
t3-t2	35.9	1.0	31.6	43.1
t4-t3	61.4	2.8	43.4	82.4
t5-t4	120.1	11.1	66.2	188
Total duration	249.7	9.6	181.6	330.7

Table 3 Interclick Interval (ICI) and total duration of the [/// / / / /]7-click codas (N=5) recorded in the Ionian Sea.

ICI (in ms)	Mean	SE	Min	Max
t2-t1	28.7	2.6	22.1	37.9
t3-t2	55.2	4.5	42.2	66.2
t4-t3	152	25.5	91.2	243.1
t5-t4	176.1	7.27	151.4	193.0
t6-t5	165.9	28.3	62.9	216.6
t7-t6	190.3	20.9	152.3	245.9
Total duration	768.2	36.6	704.1	897.7

Table 4 Interclick Interval (ICI) and total duration of the [/// /]4-click codas (N=5) recorded in the Tyrrhenian Sea.

ICI (in ms)	Mean	SE	Min	Max
t2-t1	153.8	5.5	137.1	171.7
t3-t2	109.7	3.1	100	117.6
t4-t3	285.6	6.6	268.5	308.4
Total duration	549.2	12.2	523.2	594.3

Table 5 Interclick Interval (ICI) and total duration of the [/ // /]4-click codas (N=4) recorded in the Tyrrhenian Sea.

ICI (in ms)	Mean	SE	Min	Max
t2-t1	150.1	9.1	137.6	176.9
t3-t2	25.5	2.4	19.8	31.0
t4-t3	241.3	4.7	229.2	251.5
Total duration	416.9	7.73	397.1	433.9

Table 6 Interclick Interval (ICI) and total duration of the [/ / /]3-click codas (N=6) recorded in the Tyrrhenian Sea.

ICI (in ms)	Mean	SE	Min	Max
t2-t1	144.1	3.4	136.1	154.3
t3-t2	253.8	3.5	240.8	264.8
Total duration	397.8	5.5	376.8	414.3