UNDERWATER VOCALISATIONS FOR ASSESSING SPERM WHALE HABITAT

(1). Drouot V., (2) Gannier A and (3) Goold J.

(1) GREC, 741 chemin des Moyennes Bréguières, villa 13, 06600 Antibes, France.
(2) Centre de Recherche sur les Cétacés, Marineland, 306 avenue Mozart, Antibes.
(3) Institute of Environmental Science, University of Wales, Bangor, LL57 2UW,U.K.

INTRODUCTION Sperm whales are known to feed mainly on mesopelagic squids. However, since methods of sampling deep-living squids have not yet been developed, efforts have been made to relate sperm whale distribution to major oceanographic features as underwater topography, productivity, temperature, or current, rather than to the distribution of its main prey item (Jaquet and Whitehead, 1996). Acoustic methods might give a new opportunity to define sperm whale habitat according to their food ressources. It is generally assumed that sperm whales use echolocation to scan the environment and detect preys. During a prolonged dive, sperm whales produce clicks at a fairly regular rate, typically between one and two clicks per second, in long sequences (Gordon, 1995; Goold and Jones, 1995). Within these long sequences of clicks, the click production rate do sometime increases, to create distinct sequences of rapid and increasing clicks termed ‘creaks’. Creaks are thought to be produced when sperm whales are investigating prey, and could thus be indicative of feeding attempts (Goold 1999; Gordon, 1995). In this study, we focus on creak detection to determine indices of sperm whale feeding activity, in an attempt to define sperm whale habitat use.

MATERIAL AND METHODS The survey was conducted during summer 1997 (from 7th July to 8th August), 1998 (from 18th June to 13th August), and 1999 (from 23rd June to 14th August).

EQUIPMENT The platform was a 12 metre motor-sailer with a 80HPdiesel engine. For the acoustic sampling, a dual channel hydrophone was used in 1997 and 1999 (IFAW type) and a mono hydrophone in 1998 (MAGREC HP30/MT). A high-pass filter (MAGREC) was added to remove excessive noise. Either a Sony WMD 6 analog recorder or a Sony TCD 7 DAT were used for the recordings.

STUDY AREA Four distinct regions of the Mediterranean were investigated: the North-western basin, the South-western basin, the Tyrrhenian Sea and the Ionian Sea. Each region was divided into sampling boxes (Figure1) where zig-zag cruise tracks were defined.

SAMPLING SURVEY The acoustic sampling consisted of 1 minute listening every 2 milles along the transect to detect the characteristic sperm whale clicks. A scale was used to quantify the background noise (from 1 to 5, for increasing noise), and the signal intensity (1 to 5, from low to high). Recordings were performed systematically when sperm whales were detected, and the station prolonged for longer recording when click intensity was high (greater than 4).

DATA ANALYSIS Only recording from diving sperm whale were taken into account. The recordings were analysed aurally, by playing the tape in real time, to identify and count the creaks. Consecutive positive acoustic samples were grouped together into acoustic sequence. The creak rate (i.e. the number of creaks per minute per whale) was calculated for each acoustic sequence for which sufficiently high quality recording (i.e. good signal intensity/background noise ratio) was available. Recording where either the signal intensity level was low (lower than 3), or the background noise level was load (greater than2) were not included in the analysis. In recording in which more than 2 individulas were heard, creak counting was still undertaken, although it became difficult to determine individual creaks due to click overlapping. Recording performed over the continental slope (between 200m and 2000m contour) were discreminated from those performed in the open-sea (>2000m contour).

RESULTS Among the recordings performed over the 3 surveys, 5 hours 30 were used to count creaks, with an average recording duration of 18 minutes per acoustic sequence.

The creaks heard were always included in long click sequences emitted from diving sperm whales, while they were never heard from animals at the surface. The variation of the click rate during a prolonged dive is shown in Figure2. The creaks appear as sudden increase of the click rate followed by a gap of 3 seconds or more.

From our recordings, it was calculated that on average a sperm whale produced creaks at a rate of 0.27 (st dev= 0.295) per minute. The creaks were produced sporadically. In some recording session, no creak was heard, while in other ones the creaks were relatively clustered, with up to 1.24 creaks produced per minute per whale in one of the recording from the Lion Gulf.

Off –shore/ Continental slope

Over the continental slope, the creak rate fitted a normal distribution (Anderson Darling Test, p=0.059), with a mean of 0.31creak/min/whale (Table 1). In the open-sea recordings, the mean creak rate was slighly lower, and in 50% of the case, no creak was detected (Figure3). Thus, it appears that creaks were more frequent in recordings performed over the continental slope than in the open-sea, although this difference was not significant statistically.

Comparison between different basin

Although the relationship was not significant statistically (Pearson correlation), from Figure 4, we notice a trend for creak production rate (per whale) to increase in regions of enhanced sperm whale abundance. Particularly the Provence coast, the Lion Gulf and the Balearic Sea, regions of highest sperm whale relative abundance, showed high feeding indices. This could means that sperm whales tend to gather in areas where they find good foraging conditions.

DISCUSSION The fact that creaks were not heard from whales at the suface and were always included in regular click sequences from diving whales is consistent with the hypothesis that they are produced during feeding dives, while investigating prey (Gordon, 1987). Assuming a creak equal to one squid eaten, the average rate of 0.27 creak/min corresponds to 389 squids eaten in one day (24h). These results are credible, since Clarke's calculations (1987) suggested that a sperm whale eat an average of 2000 cephalopods within 1 and 2.5days.

The trend for the creak production rate to be higher over the continental slope is consistent with the fact that many species of squids are found in dense concentrations over the continental slope, at depth between 200 and 3000 meters (Clarke, 1979). Unfortunately, no stomach content are available from the Mediterranean so that sperm whale foraging activity cannot be direclty related to the ecology of a particular cephalopod species. Nevertheless, many other studies in other part of the world have suggested an habitat preference of the sperm whale to continental slope waters (Gannier,1998; Hooker et al, 1999; Christensen *et al*. 1992, Jaquet and Whitehead, 1996).

It should be noted that the comparison between the continental slope and the open-sea strata might be biased by the wide range of the hydrophone (5 to 8km). However, in this study, only the recordings with high signal intensity where taken into account for creak counting, thus reducing the detection range to 3 to 4 km each side of the boat.

The enhance feeding activity in regions of high abundance of sperm whale, such as off Provence coast, the Lion Gulf and the Balearic Sea, suggests that these regions meet the feeding requirements to sustain relatively high abundance of sperm whales. This is consistent with previous studies that showed that these regions undergo a relatively high primary productivity compared to other areas of the Mediterranean (Jacques and Treguer, 1986).

CONCLUSION The results give further support to the hypothesis that sperm whale preference to continental slope waters is linked to the food ressources. The positive relationship between sperm whale abundance and the creak rate strongly suggests that feeding success might be an important factor influencing sperm whale distribution.

Further effort should be put on improving the methodology for creak counting as this study shows that creak rate could provide a good indicator of sperm whale habitat use.

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Table 1. Creak rate (nb creak/min/whale) calculated over the continental slope and off shore (>2000m contour).

Creak rate	N	Mean	SD	SE	Min	Max
Off shore	14	0,2258	0,3348	0,0895	0	1,2353
Continental slope	20	0,3091	0,2674	0,0598	0	1.0

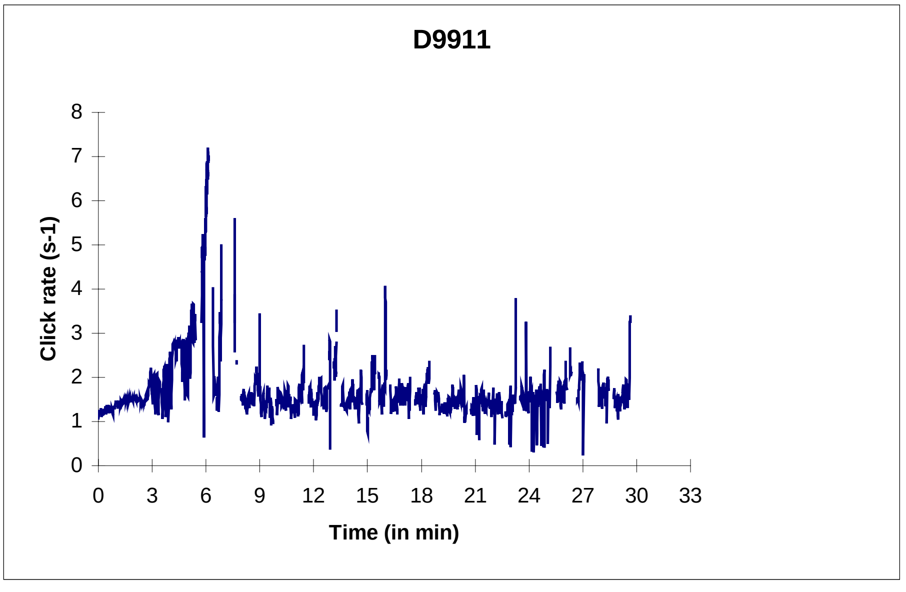
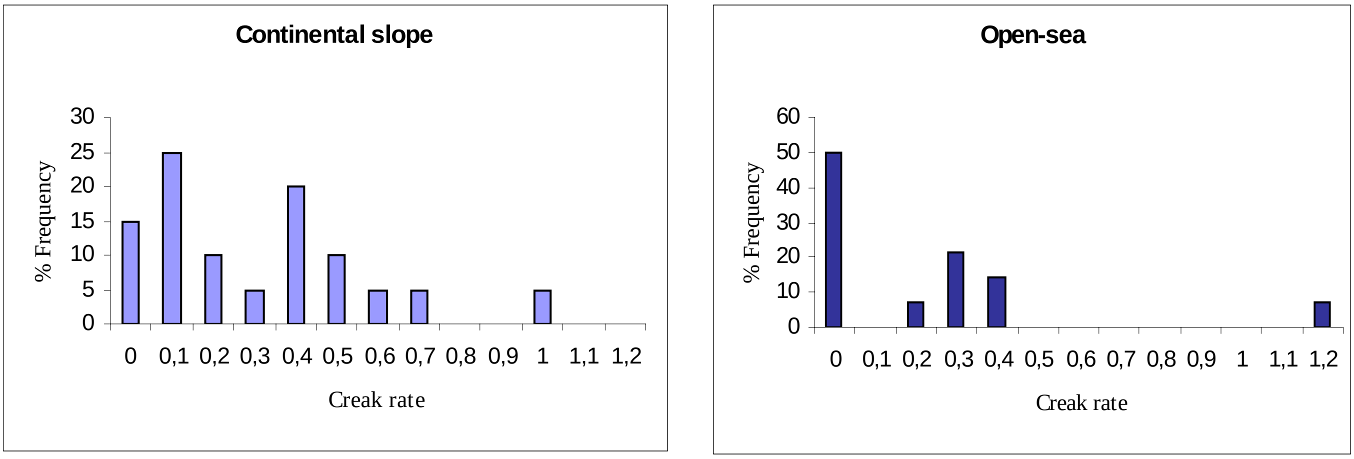


Figure 2. Variation of the click rate during the first 30min of a sperm whale dive.



A **B**

Figure 3 . Frequency of the creak rate from (**A**) continental slope recording sessions (N=20) and (**B**) from the open-sea recording sessions (N=14).

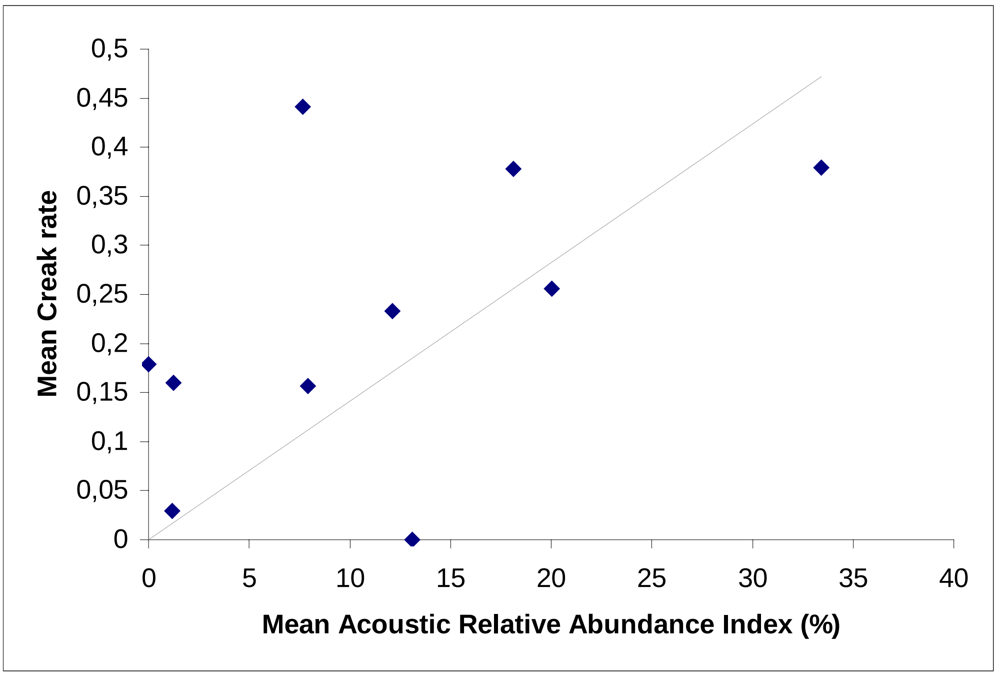


Figure 4. Relationship between the mean creak rate (creaks/min/whale) and the mean acoustic relative abundance index (% of positive acoustic sampling stations), calculated for each region investigated.