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Examination of the stomach contents from a Mediterranean sperm whale found south of Crete, Greece

Stephen M. Roberts

Natural History Museum, University of Crete, PO Box 2208, 71409 Irakleio, Crete, Greece.
Present address: Department of Biology, University of Crete, PO Box 2208, 71409 Irakleio, Crete, Greece.
E-mail: stephen@imbc.gr

The stomach contents from a male sperm whale, *Physeter macrocephalus*, first located floating a short distance off the south coast of Crete were examined. The remains within the stomach consisted almost exclusively of cephalopod mandibles, or beaks, though other material was found including a piece of rigid plastic mesh. Of the beaks found, 1714 were upper beaks and 2178 were lower beaks, that were used to identify the species. A total of seven species was identified, all of which have been previously recorded in the eastern Mediterranean though are rarely caught by man. Of these *Histioteuthis bonnellii* was found to be the most important species in terms of both weight and numbers. Although it must be borne in mind that the whale may not have followed its normal feeding habits prior to its premature death, an important insight into its prey items can be revealed. This is the first documented account of the stomach contents of a sperm whale from the Mediterranean, and helps to complete a global record of sperm whale diets.

INTRODUCTION

The analysis of remains found inside the stomachs of cetaceans is an established procedure that has been used as a tool to assess their dietary habits worldwide (Santos et al., 2001). In particular, since Clarke's publication of 1986, the identification of cephalopods, which are the primary prey items of sperm whales, has been greatly facilitated. Although this is the first instance of the stomach contents of a sperm whale being examined from within the Mediterranean, several other studies have taken place in the Atlantic Ocean, of which, the closest are: off Vigo (north-west Spain), the Azores and Madeira (Portugal) (Clarke, 1962; Clarke & MacLeod, 1974; Clarke et al., 1993). All of these studies have identified the species present by using the lower beaks and any partially digested body parts and all have shown *Histioteuthis bonnellii* (Férussac, 1834) to be the most important species in terms of numbers.

The cephalopod fauna of the eastern Mediterranean has been studied by several authors and is generally accepted to be poorer than that of the western Mediterranean basin. The number of Teuthidae reported from the eastern Mediterranean (Salman et al., 2002) includes at least 22 species of which 15 have been reported from the stomach contents of cetaceans (Bello, 1992; Wurtz & Marrale, 1993; Blanco et al., 1995). Of the 15 species found in cetaceans eight of those have been reported from the stomach contents of sperm whales from adjacent Atlantic waters (Clarke, 1962; Clarke & MacLeod, 1974; Clarke et al., 1993). To date there have been no comprehensive studies of the cephalopod fauna off the south-west coast of Crete. The main prey item for sperm whales from outside the Mediterranean, in terms of numbers, *H. bonnelii*, has been reported from Greek waters by various authors (Salman et al., 1997; Koutsoubas & Boyle, 1999) and is considered by Bello (2000) to be one of the most abundant pelagic cephalopods in the area.

Due to the nature of the Mediterranean as a semi-enclosed, oligotrophic sea, it might be considered as unlikely to support large populations of sperm whales, and as far east as Crete there were, until recently, only a few documented sightings or strandings in the literature (Goffman et al., 2000). However, in recent years a more concerted effort has been made towards rectifying this situation and Frantzis et al. (1999) have reported the presence of more than 25 individuals off south-west Crete and have to date photo-identified 54 individuals with sightings almost all year round (A. Frantzis, personal communication). At present there is still a lack of information regarding the current population status, feeding habits or ecology of the sperm whale population in the Mediterranean.

MATERIALS AND METHODS

On 21 March 2001 the corpse of a 12.9 m male sperm whale, weighing approximately 22 tn, was reported floating off Loutro, near Sfakia, south-west Crete, Greece. It was transported to a landfill site near Irakleio, Crete, where, over a period of four days it was dissected and the stomach contents removed. The contents were emptied into a large barrel containing 75% ethanol alcohol then after four days were sieved and the sorting took place in the Mollusc Department of the Natural History Museum of Crete, separating beaks, flesh remains and other debris, at all times storing them in 75% ethanol alcohol. Firstly, the beaks were counted and sorted into upper and lower beaks. Only when it was possible to identify clearly its main characteristics was the beak included in both the count and the results below. All other fragments of beaks were nevertheless kept. Clarke's guidebook (1986) and other publications (Bello, 1992) along with beaks removed from identified

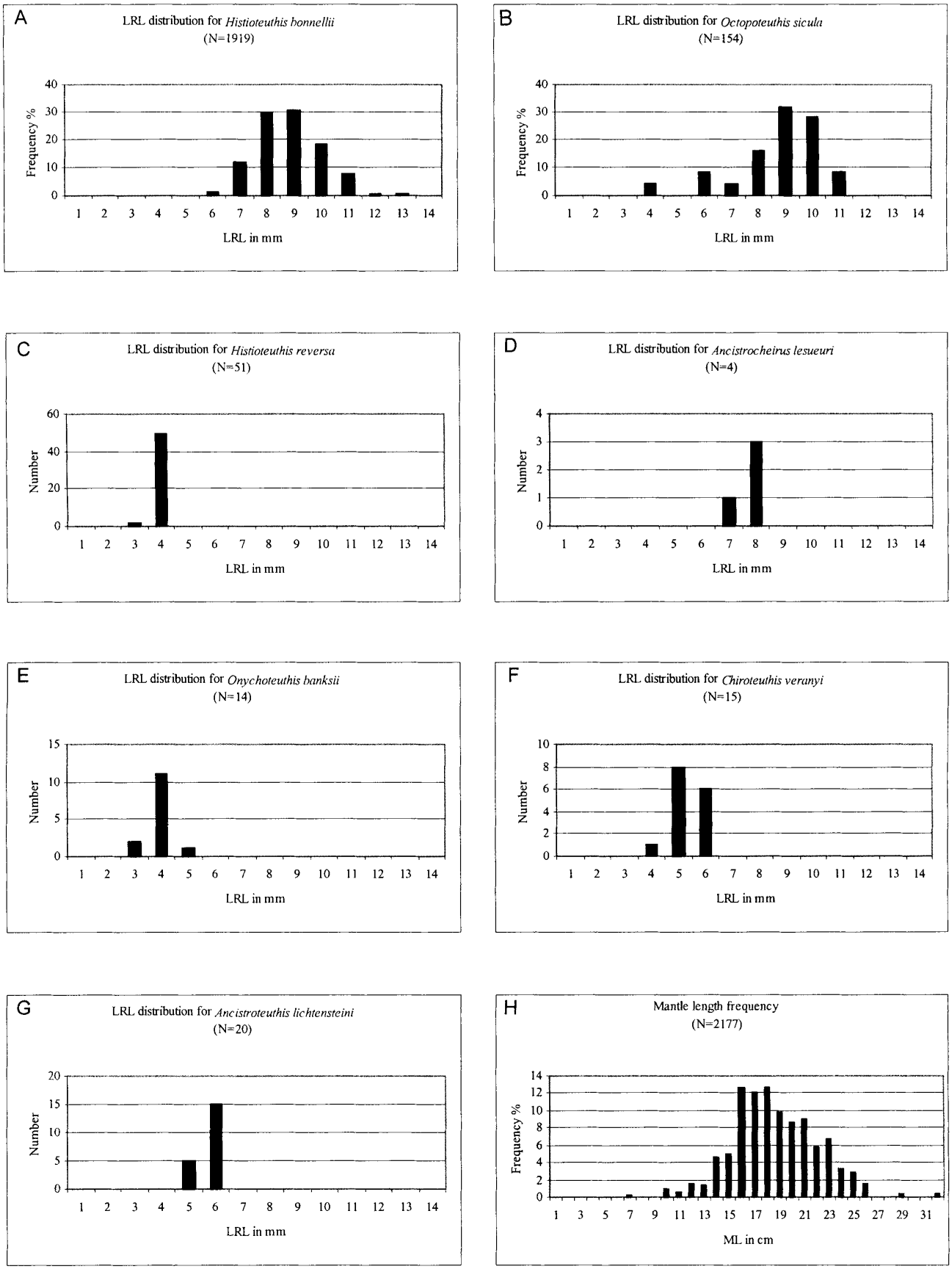

Figure 1. (A–H) Distributions of Lower Rostral Lengths (LRL) in mm for all seven species and 2 H, distribution of estimated Mantle Lengths (ML) from all species, shown as frequencies for each length from 2177 lower beaks. N, number; LRL, lower rostral length; ML, mantle length.

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Table 1. *The numbers of beaks representing each species and their importance as a percentage of the total (T) in terms of number and wet weight (WW) in grams. Additionally the estimated mean mantle lengths (ML) in millimetres for each species are shown.*

Species	T No.	% T No.	Mean WW	Total WW	% total WW	Mean ML
Histioteuthis bonnellii (Férussac, 1834)	1919	88.15	486.52	933,632	95.05	192.45
Histioteuthis reversa (Verrill, 1880)	51	2.34	258.05	13,161	1.34	118.93
Onychoteuthis banksii (Leach, 1817)	14	0.64	296.76	4155	0.42	211.82
Ancistroteuthis lichtensteini (Férussac, 1835)	20	0.92	107.21	2144	0.22	182.25
Octopoteuthis sicula (Rüppell, 1844)	154	7.07	149.04	22,952	2.34	121.25
Ancistrocheirus lesueuri (Orbigny, 1842)	4	0.18	1229.6	4918	0.5	275.33
Chiroteuthis veranyi veranyi (Férussac, 1835)	15	0.69	71.51	1073	0.11	140.71
Totals	2177	99.99		982,035	99.98	

museum specimens were used to identify the species. In addition techniques to measure the beaks were also carried out according to Clarke in order to utilize his identification key. Once the species had been identified the Lower Rostral Lengths (LRL) were measured using electronic vernier calipers. In the case of *Histioteuthis bonnellii* and of *Octopoteuthis sicula* where there were large numbers of beaks, a random sample of 250 out of 1919 and 50 out of 154 beaks respectively was measured. All the beaks, flesh remains and other stomach contents have been recorded and are deposited at the Natural History Museum of Crete, University of Crete.

Following the measurement of the beaks, the LRLs were used in formulae to calculate both the approximate mantle length (ML) and wet weight (WW) of the individual concerned (Table 1). This is a common technique and the formulae applicable for species or genera, or at worst family, were taken from the literature (Clarke, 1986; Bello, 1992).

RESULTS

Possibly as a result of the whale not having fed for some time prior to its death there were no buccal masses, nor any other recognizable cephalopod body parts often found in sperm whales (Clarke et al., 1993). Furthermore no parasites were extracted from the stomachs, possibly suggesting that feeding had not taken place for some days (R. Sabin, personal communication). There were 3633 beaks that on the whole were in good condition. On the other hand, thousands of pieces of chitin from beaks, and unidentified parts of beaks, that were in the latter stages of digestion, were not included in counts. The respective numbers of each species and their percentages of the total number and weight are shown on Table 1.

The frequencies of the lower rostral lengths (LRLs) for *Histioteuthis bonnellii* and *Octopoteuthis sicula* are shown in Figure 1A & B, while the rest of the LRLs are shown in numbers for the other species (Figure 1C–F). Finally, the mantle length frequencies for all species are shown combined in Figure 1H, each species being given weight appropriate to its respective percentage of the total number of beaks.

A small square piece of rigid plastic mesh 10×10 cm was also found inside the stomach of the whale, this is most likely to be litter disposed of at sea rather than part of fishing gear as has been reported by others (Clarke et al., 1993).

DISCUSSION

When examining stomach contents great care should be taken to avoid drawing too many conclusions from an isolated sample, in particular when exact time and cause of death are unknown, as is often the case for stranded animals (Santos et al., 2001). This is all the more appropriate for this study as it is the first of its kind within the relative confines of the Mediterranean Sea. However, for the same reason some valuable insights and conclusions can be made based on the data available.

Histioteuthis bonnellii is a neutrally buoyant, ammoniacal cephalopod with extensive photopores that inhabits waters from the upper 100 m to depths of up to 2200 m (Voss et al., 1998). It would seem that generally juveniles inhabit upper waters (100–200 m) while more mature specimens are found at greater depths. Large adult specimens have been found both at depth and at surface upwellings (Voss et al., 1998). *Histioteuthis bonnellii* may reach a size of up to 330 mm mantle length though its head is large and the total length including arms is considerably longer than this, reaching up to 1190 mm (Voss, 1998).

On first appearance it may seem that the number of prey species found is rather small. However, it is not out of line with other studies, in particular when the time of year, status of the individual whale and cephalopod species present in the area are considered. Off Vigo *H. bonnellii* represents 67.2% of the beaks collected from a 12.4 m whale (sex not listed) caught in June (Clarke & MacLeod, 1974). A study from the Azores (Clarke et al., 1993) examined the stomach contents of 17 sperm whales and *H. bonnellii* made up 63.3% of the total number of beaks present. Of particular interest from the data of this study is one adult male, 13.4 m in length, caught in January, that is quite similar both in size and time of year examined to the individual in the present study. This male and another caught 19 days earlier, 15.8 m in length, showed *H. bonnellii* to represent 86.4% and 93.3%, of all lower beaks respectively (Clarke et al., 1993). From Madeira *H. bonnellii* also made up a large part of the total number of beaks, representing 88.3% (Clarke, 1962).

All of the other species identified in the stomach contents reported here have also been reported from other stomach content analyses (Bello, 1992; Blanco et al., 1995). The Histioteuthidae are the most commonly reported, being found in the stomachs of most of the predators in the literature with the exception of the bottlenose dolphin (*Tursiops truncatus*).

It is perhaps unusual that there were no representatives of some of the larger cephalopod species such as *Todarodes sagittatus* (Lamarck, 1789), which is found in the wider area, or *Architeuthis* sp., that have both been reported from the stomach contents of sperm whales from the Atlantic (Clarke et al., 1993). These large cephalopods are notable exceptions, although normally only relatively few beaks are found they often represent an important part of the diet by weight. Of course it cannot be excluded that Mediterranean sperm whales also prey upon these cephalopods, perhaps at other times of year, or infrequently so as to have no remains left inside the stomach contents.

There are important implications from the results presented above. It may well be the case that cephalopods, and in fact *H. bonnellii*, play a much more significant role in the Mediterranean deep-sea food webs than was previously thought. The assessment of abundance of cephalopod species in the Libyan Sea and the Mediterranean as a whole should be considered with a great deal of care. Although the subject of total annual consumption is one that requires a cautious approach, (Santos et al., 2001) it is nevertheless possible to provide a conservative estimate of consumption for the individual described above. Lockyer (1981) estimated the daily feeding rate of sperm whales consuming cephalopods at 3% of the body weight, though this may vary, possibly up to 4.7%, depending on prey items (Clarke et al., 1988, in: Santos et al., 2001). If this estimate is accurate it is expected that this individual normally consumes some 660 to 1030 kg per day and from 240 to 377 tn per year. If we assume that more than 50 sperm whales are resident off south-west Crete, as has been suggested (A. Frantzis, personal communication), bearing in mind their combined energy budget, and if, as is quite likely, most individuals have similar diets to the one described above, then the quantity of cephalopods consumed must be considerable. A conservative estimate, assuming the presence of 50 individuals with an average size similar to that of the studied animal, present for just six months a year would be from 6000 to 9400 tn annually. Following publication of a detailed quantification of the population of sperm whales off the south coast of Crete it should be possible to make several important assessments of the role of these large predators in the Mediterranean and the food-webs of which they form part.

The role of *H. bonnellii* in the diet of the sperm whale in the present study confirms the importance of the species on a global scale, the other six species combined making up approximately five per cent by weight of the total. These results, as the first indications for the diet of the sperm whale in the Mediterranean, though in no way conclusive, are a starting point for a more complete understanding of the animal's ecological role in the Mediterranean. In light of these findings, further investigation into the status of the Mediterranean sperm whale populations should be pursued with increased vigour in order to ascertain if any steps could be taken to implement their effective protection and management. Furthermore, investigations into the dynamics of the food webs in the deep-sea in the eastern Mediterranean and any influences man may be having on them should be promoted.

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