

Fishing in the Adriatic at the Mesolithic–Neolithic transition: Evidence from Vela Spila, Croatia

Clare Rainsford¹, Terry O'Connor², Preston Miracle³

¹Department of Archaeological Sciences, University of Bradford, UK, ²Department of Archaeology, University of York, UK, ³Division of Archaeology, University of Cambridge, UK

Recent excavations at the site of Vela Spila, Korčula, on the Adriatic coast of Croatia have yielded a substantial assemblage of fish bone dating to the Mesolithic and Neolithic period. Few similar assemblages have been recovered to date, and zooarchaeological analysis of the material from Vela Spila provides an insight into the choices and practices associated with fishing across the crucial Mesolithic–Neolithic transition, and across a period of coastal change due to rising sea levels, in this area. Specialised capture and processing of mackerel (*Scomber japonicus*) in the Mesolithic period was indicated, with estimates indicating nearly half a tonne of mackerel processed at the site. A decrease in quantity of fish bone recovered from the Mesolithic to Neolithic phases is matched by a change in fishing strategy to opportunistic coastal fishing in the Neolithic periods. Fishing is discussed in relation to the broader lived context of the Mesolithic and Neolithic in the Adriatic, particularly its place within dietary practices and maritime activity.

Keywords: Vela Spila, Croatia, Fishing, Mesolithic, Mackerel, Adriatic

Introduction

Excavations at the prehistoric cave site of Vela Spila in Adriatic Croatia in 2004 and 2006 have recovered a substantial assemblage of fish bone, numbering nearly 60,000 specimens, from layers spanning the Late Upper Palaeolithic to Neolithic periods. This is the first substantial prehistoric assemblage of fish remains to be recovered from the Adriatic region. Because of the important role that the sea and marine resources must have played in this island landscape in prehistory, analysis of the assemblage holds great potential for illuminating the role of fishing in prehistory in the region.

The role of fish in early prehistory has been the subject of much discussion but little direct investigation. Fish were a known resource and are likely to have played a significant role in subsistence from the Upper Palaeolithic onwards (Cleyet-Merle and Madelaine 1995; Lotze *et al.* 2011), but evidence is sporadic compared to later periods, owing to problems of preservation and recovery. Furthermore, the presence of relatively small numbers of fish bones at some Upper Palaeolithic sites yields little information about fishing techniques or the wider

place of fish in that economy. The scale of the assemblage that we report here is quite exceptional, particularly for the Mediterranean region. Sea-level rise at the end of the Pleistocene and continuing into the early Holocene has meant that many Palaeolithic and Mesolithic coastlines have been lost. Exceptions to this include the coastlines of Western Scotland and Scandinavia, where glacioisostatic recovery has exceeded eustatic sea-level change, leaving Mesolithic coastlines above present-day sea level. The evidence of marine resource exploitation in these areas, in the form of shell middens such as those on Oronsay, is striking, and has helped to contribute to the perception of fish as a key resource in the Mesolithic.

The development of dietary stable isotope analysis has provided a means of understanding the place of fish in prehistoric diet, as analysis of stable carbon and nitrogen isotope ratios taken from human bone collagen can provide a basic characterisation of the contribution of marine protein in overall diet (e.g. Choy and Richards 2009; Schwarcz *et al.* 2010). A significant number of studies have been carried out on samples from either side of the transition to agriculture. These have largely focused around Northern and Atlantic Europe, and have been taken to indicate an abrupt and complete abandonment of marine

Correspondence to: Clare Rainsford, Department of Archaeological Sciences, Phoenix Building, University of Bradford, Richmond Road, Bradford, BD7 1DP. Email: clare.rainsford@cantab.net

resources at the beginning of the Neolithic (e.g. Richards 2003; Richards *et al.* 2003; Schulting and Richards 2002; Thomas 2003; see also Milner *et al.* 2004). Some studies have also been carried out in the Mediterranean region (e.g. Guixé *et al.* 2006; Lightfoot *et al.* 2011; Lubell *et al.* 1994; Papathanasiou 2003), and these have tended to show a more gradual pattern of decline in use of marine resources into the Neolithic, with a small amount continuing to be consumed after the beginning of agriculture. However, practical constraints such as the tendency of isotopic studies to be based on small, time-averaged samples, and their inability to distinguish between different types of marine protein mean that these studies have by and large raised more questions than they have answered. Further investigation of the role of fish over the Mesolithic–Neolithic transition requires investigation at macroscopic as well as molecular scales of resolution.

This paper presents the results of a zooarchaeological analysis of the Vela Spila fish bones. Its principal aims are to investigate evidence for changes in fish exploitation and fishing strategies across the Mesolithic–Neolithic boundary, and to test whether any such changes exceed in scale or direction any variation seen within the Mesolithic sequence.

Site, materials and methods

Vela Spila is located at the western end of the island of Korčula, directly above the bay town of Vela Luka and overlooking the Kale Cove arm of Vela Luka bay (Fig. 1). Excavation at the site has been intermittent since the 1950s. Dinko Radić directed the excavations in 2004 and 2006 that produced the analysed fish assemblage. Since 2007 the postexcavation analyses of materials excavated in 2004 and 2006 have been co-directed by Miracle and Radić, and new excavations were initiated at the site by Miracle, Radić and Forenbaher in 2010. The cave comprises a single hall, with a depth of archaeological stratigraphy greater than 10 m in some areas. The stratigraphy of the site is complex, and both cultural and absolute (C14) dates are available from many phases (see Table 1). It is worth noting that the dates for the Mesolithic phases at Vela Spila are relatively late compared to other sites in the Mediterranean region (e.g. Franchthi Cave (Perlès 2003); Grotta dell'Uzzo (Tagliacozzo 1996), see discussion below). The landscape within which Vela Spila is situated has been profoundly affected by sea-level change over the Pleistocene–Holocene transition, with the Adriatic doubling in extent between 16,000 and 6000 BC (Miracle 1995; Shackleton *et al.* 1984). However, approximation of the position of coastlines around the Adriatic based

on estimations of sea level in prehistory and bathymetric data appear to indicate that the configuration of Vela Luka bay has not changed substantially since 9000 BC, prior to the beginning of the Mesolithic at Vela Spila (Forenbaher 2002; Lambeck *et al.* 2004). None the less, the possibility of changes in marine conditions through the Mesolithic should be recognised (Lane-Serff *et al.* 1997; Mylona 2003).

The fish bones discussed here were recovered from deposits attributed to the Late Palaeolithic (Horizons LUP-H and LUP-I), Mesolithic (Horizons Meso A to Meso D) and Neolithic (Horizons Neo A–C) (for dating, see Table 1). Material was recovered from both the 2004 and 2006 excavations, which focused on different areas of the cave (Fig. 2). In 2004 (quadrant H5–7), recovery was primarily by dry sieving on a 5 mm mesh, with the exception of one sample from the Mesolithic layers (context 339B), which was subjected to flotation on a 1 mm mesh due to the presence in the same layer of a human burial. All sediments from the 2006 excavations (quadrants B-D5–7 and E6) was wet sieved on a 3 mm mesh. This yielded substantial assemblages representing the Mesolithic phases, in particular the two earliest Mesolithic horizons, and smaller amounts of material from the Late Upper Palaeolithic and the Neolithic. There is a clear and predictable bias against the recovery of fish remains and of bones of smaller-sized fish in the 2004 excavations compared to the 2006 excavations. It is not expected that this will have significantly affected interpretation, as both excavation seasons covered the same stratigraphic sequence, although the recovery decisions taken make it difficult to explicitly test for spatial variation on the basis of this sample.

Owing to time constraints and the large quantity of material represented, it was neither possible nor necessary to analyse the full quantity of material recovered. Sampling was carried out with a view to optimising representation of spatial, temporal and taxonomic variation without over-recording redundant data. A full discussion of the sampling strategy is included in Rainsford (2010), and the key details are noted here. The full fish assemblage recovered to the end of the 2006 season totalled an estimated 58,000 fragments. The present analysis is based around an approximately 15% sample of this assemblage (ca. 7500 fragments). This sample included three contexts, all from Meso A or B, which were sufficiently large that sub-sampling each of them was justified. Context 339B (flotation sample, mentioned above) comprised over 1000 fragments, of which a 50% sample was analysed. Contexts 31 and 37 (Meso B and Meso A, respectively) each comprised well over 1000 fragments, the majority of which were

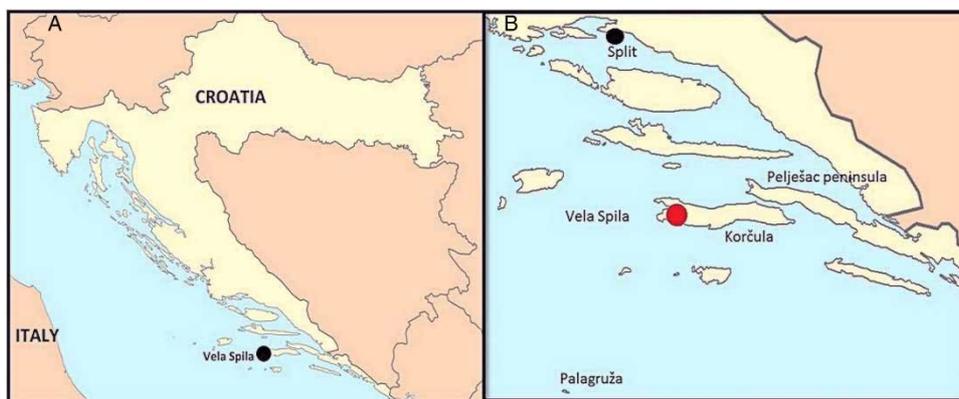


Figure 1 Location map showing the position of Vela Spila within (A) Croatia and (B) the Dalmatian archipelago. Map adapted by C. Rainsford from source (Minestrone/Wikimedia Commons/CC BY 2-5; http://commons.wikimedia.org/wiki/File:Croatia_map_blank.png, accessed 1 November 2013).

Table 1 Radiocarbon dates of stratigraphic sequence at Vela Spila. Dates calibrated using CalPal 8/2009

Phase	Dates BC	14 C sample
LUP A	17,530–17,190	Z-3987
LUP I	12,950–12,250	Wk-27370
Meso B	7310–7038	OxA-18171; Z-3986; Z-3995
Meso D	6360–6070	Wk-24216; Z-3994
Neo C	5660–5530	Wk-24218

vertebrae from *Scomber japonicus* (see Results, below). For each of these, the small proportion of non-vertebral material was fully analysed, along with a 25% sample of the vertebral material. The totals from this 25% sample were then multiplied by 4 to give estimated totals for the full context for discussion of mackerel processing and calculation of minimum number of individuals (MNI) values, as the cranial:vertebral element ratios are significant here (Results:

Tables 3 and 4). Table 2 shows only the values for the identified sample, not the estimated ‘full context’ values.

Identification focused on the more taxon-specific elements of the cranium, and secondarily on the vertebrae. Reference specimens in collections at the University of York and in the collections of Dr. Sheila Hamilton-Dyer were used to confirm identifications. Specimens were recorded to the level of element of taxon. The data are stored as Excel spreadsheets.

Number of identified specimens (NISP) has been used as a simple, descriptive quantification method throughout. Limited use was made of MNI estimation, based on the most abundant non-reproducible element per taxon in order to estimate quantity of one particularly abundant taxon (see below). Semi-quantitative categorisation was also used in order to clarify patterns within the data.

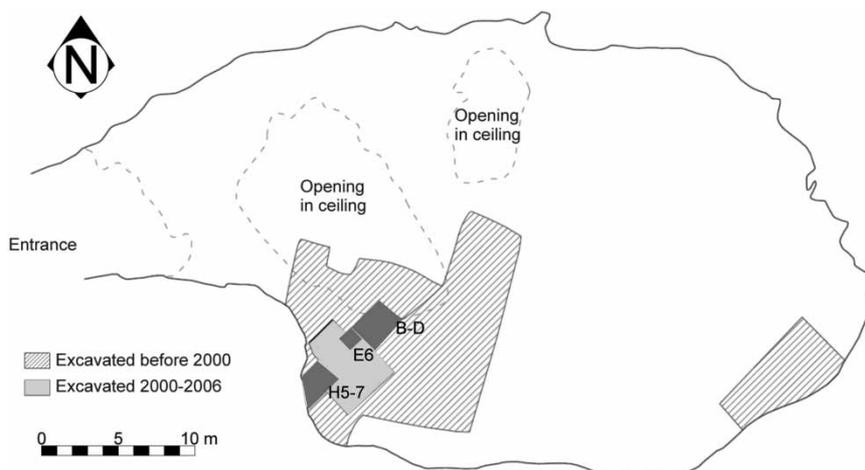


Figure 2 Plan of Vela Spila cave, showing location of trenches discussed in the text (original image courtesy of P. Miracle and D. Radić, adapted with permission by C. Rainsford). Quadrants H5–7 were excavated 2004; quadrants E6 and B-D5–7 were excavated 2006.

Table 2 The analysed sample of the Vela Spila fishbone assemblage (NISP by chronological period). As reference material was limited for initial identification, vertebrae were divided into categories based on morphological features. Owing to similarities between several taxa, several categories were preserved. 'Taxon 1' = largely caudal vertebrae of *S. japonicus*, but may contain caudal vertebrae of Mullidae and Sparidae. 'Taxon 4' = both caudal and pre-caudal vertebrae which are relatively short in anterior-posterior length, including *B. belone*, Labridae and Sparidae. 'Taxon 7' = vertebrae which probably come from fish under 25 cm in length, comparable to Clupeid, but potentially also containing vertebrae of juvenile *B. belone*

Family	Species	Common name	Croatian name	LUP H	LUP I	Meso A	Meso B	Meso C	Meso D	Neo A	Neo B	Neo C	Total
Anguilliforme							7	3	5		1		16
Congridae	<i>C. conger</i>	Conger eel	Gruj			2	2	4	30	3	5		46
cf. Congridae									1				1
Muraenidae	<i>M. helena</i>	Moray eel	Murina			4	48	24	133	25	6		240
Sparidae	<i>Dentex</i> sp.	Dentex	Zubac			1			1		1		3
	<i>Pagellus erythrinus</i>	Common pandora	Arbul				2		2				4
	<i>Sarpa salpa</i>	Salema	Salpa				2						2
	<i>Spondyliosoma cantharus</i>	Black sea bream	Kantar						1				1
	<i>Sparus aurata</i>	Gilt-head sea bream	Orada, Lovrata				2	1		1			4
	cf. <i>S. aurata</i>								2				2
Sparidae	unknown					8	9	8	18	3			46
Scombridae	<i>T. thynnus</i>	Atlantic bluefin tuna	Tuna			1	6						7
	<i>Euthynnus alletteratus</i>	Little tunny	Lić			4			4				8
	cf. <i>Thunnus</i>				1				1		1		3
	<i>S. japonicus</i>	Chub mackerel	Lokardo		11	228	348	52	24	1			664
	cf. <i>S. japonicus</i>					5	1						6
Scombridae	unknown				1	2	6	2	1				12
Taxon 1					18	336	575	94	97	2			1122
Mugilidae	<i>Lisa</i> sp.	Grey mullet	Cipal				6	3	6	1			16
Mullidae	<i>Mullus</i> sp.	Red mullet	Barbun				2		4				6
Labridae	<i>Labrus</i> sp.	Wrasse	Vrana			3	10	3			1		17
Belonidae	<i>B. belone</i>	Garfish	Iglića			12	5	4	2				23
	cf. <i>Belone</i>									2			2
Taxon 4						6	12	17	58	3			96
Scorpaenidae	<i>Scorpaena scrofa</i>	Red scorpionfish	Škrpina				11	4	11				26
	cf. <i>Scorpaena</i>					1				1			2
Taxon 7						27	20	31	116				194
Perciforme (Small)							26	9					35
UNID				1	25	110	481	143	206	25	11	1	1003
Total				1	56	750	1581	402	723	67	26	1	3607

Results

Table 2 gives NISP data by phase. Very little of the assemblage derives from Late Upper Palaeolithic contexts. Material from these phases was of very poor quality: 45% was unidentified, and the species distribution of the identified material bears a strong resemblance to the succeeding Early Mesolithic (Meso A). We cannot be confident that the material attributed to the Late Upper Palaeolithic is not intrusive from the Mesolithic phases of the site, as the assemblage size, composition and taphonomy are consistent with the material having moved down-profile. There is therefore no unambiguous evidence to date of fish exploitation prior to the beginning of the Mesolithic at Vela Spila.

The majority of the fish assemblage derives from the Mesolithic phases of the site, most notably the two earliest Mesolithic phases (Meso A and B) (Fig. 3).

Fish bones account for about 90% of the total vertebrate NISP in Meso A and B (Miracle and Radović in press), declining to 50–60% by the later Mesolithic (Meso C and D). Chub mackerel (*S. japonicus*) accounts for over 75% of the identified fish assemblage in Meso A, and almost 60% in Meso B. Note that figures for garfish *Belone belone* should be regarded as a minimum, as this species presented particular identification difficulties and was only confirmed on a small number of skeletal elements.

In the later phases of the Mesolithic, the quantity of fish and particularly of mackerel drops, and species diversity within the fish assemblage rises. The contribution of chub mackerel declines to 36% in Meso C and further to <17% in Meso D. The species that increase in abundance and contribution to the assemblage in the later Mesolithic – eels (*Conger conger*, *Muraena helena*), sea breams (Sparidae), mullets



Figure 3 Fish vertebrae from Early Mesolithic levels at Vela Spila. Photograph courtesy of V. Pia Spry-Marqués.

(Mugilidae) and wrasse (Labridae) – tend to be solitary rather than schooling, and dwell for the most part around rocky shorelines. The beginning of the Neolithic sees a significant further drop in overall quantity of fish to less than a tenth of the NISP of the preceding period. Mackerel are almost absent from the assemblage, and eel are the most abundant species in an assemblage composed primarily of coastal-dwelling species.

Discussion

Vela Spila in the Mesolithic

The predominance of chub mackerel in the Early Mesolithic horizons (Meso A and B) is the most striking feature of the assemblage. Chub mackerel are a migratory species, which form large shoals mostly in open water, although they may also migrate inshore at certain points in the year or in the lifecycle (Hernández and Ortega 2000). Until recent times, mackerel were caught in the Adriatic during the summer months, and could be captured using drift nets close to Vela Luka bay, typically at night and in combination with some source of light to attract the fish (T. Vučetić pers. comm., September 2010). Although it is difficult to be certain that migratory patterns would have been similar in the Mesolithic, it is likely that mackerel would have been available close to the bay for a limited time, and the possibility of

Table 4 Ratios of vertebrae to cranial elements for *S. japonicus* (including Taxon 1) by phase and quadrant/recovery method. The analytical categories are not exactly congruent with those used previously in Table 3. All values given are NISP

<i>S. japonicus</i>	Cranial	Vertebra	Ratio vertebrae/cranial
Meso A + B (quad E6) (3 mm)	12	3516	293.00
Meso A + B (quad H/I) (5 mm)	9	101	11.22
Meso B (flotation sample, quad H/I) (1 mm)	39	288	7.38

Continued

exploiting these shoals may have drawn the inhabitants of Vela Spila to this particular area in the summer months. The presence of garfish (*B. belone*) and tuna (*Thunnus thynnus*) in the assemblage in these phases may be associated with mackerel catches. Garfish are a predatory species with similar diet and migratory patterns to mackerel (Muus and Nielsen 1999), and thus may have been caught incidentally along with mackerel catches. However, garfish are currently fished later in the season than mackerel from Vela Luka (T. Vučetić pers. comm., September 2010), so this interpretation is provisional. Atlantic bluefin tuna (*T. thynnus*) is also present in very small quantities (NISP = 7) in the Early Mesolithic at Vela Spila, probably caught incidentally in association with the mackerel shoals that tuna predate. The presence of tuna at Mesolithic sites has often been taken as an indication of deliberate deep-sea or offshore fishing (e.g. at Franchthi Cave, but see Pickard and Bonsall 2004) – however, the modest quantities found at Vela Spila would appear to rule out deliberate targeting of this kind. The scarcity or absence of non-migratory, coastal species such as eel and sea-bream, particularly in Meso A, serves as a further indication of the overwhelming importance of mackerel fishing. Either other modes of fishing practice were largely neglected, or the debris from coastal fishing was selectively deposited elsewhere. In the absence of any such evidence, we propose that the capture of non-

Table 3 Comparison of NISP and MNI values for *S. japonicus* (including Taxon 1) for the identified sample of fish remains from Vela Spila. MNI estimates for vertebrae are based on an average of 31 vertebrae per mackerel (Hernández and Ortega 2000)

Context	NISP	MNI (cranial)	MNI (vertebrae)	MNI (overall)
Meso B (flotation sample, quad H/I)	327	12	9	12 (hyomandibular)
Meso A + B (quad E6; B–D)	3652	4	117	117 (verts)
Meso A + B (quad H/I)	110	1	3	3 (verts)
Meso C + D (quad E6; B–D)	270	1	8	8 (verts)
Meso C + D (quad H/I)	9	0	1	1 (verts)
Neo (quad B–D)	3	0	1	1 (verts)
Neo (quad H/I)	0	0	0	0
Total	4395	18	139	142
Total MNI (15%): 142				

migratory coastal fish was a low priority in the Early Mesolithic.

In the later phases of the Mesolithic, the quantity of fish and particularly of mackerel drops, and species diversity within the fish assemblage rises. The most notable feature of the assemblage in these phases is the reduction in both the absolute quantity of mackerel, and in their relative abundance. There is a corresponding decrease in overall assemblage size, and a relative increase in inshore taxa such as eels, sea breams, mullets and wrasse. Eel species are caught throughout the year around the Adriatic islands by either net or long-line fishing (T. Vučetić pers. comm., September 2010). Although conger eel often inhabit deep water rather than coastal environments, the specimens in the assemblage appear to represent young conger which are more commonly found along coastlines and may have been stranded in rockpools.

The reduction in size of mackerel catches and increase in species diversity and coastal exploitation is consistent with a situation where the target species (mackerel) were no longer being caught with such success as in the earlier Mesolithic, and targeting of coastal species was increased to make up the short fall. The size of populations of pelagic fish such as mackerel, and hence the success or failure of fishing for them, is known to fluctuate dependent on a complex web of environmental factors which affect spawning and survival of juvenile fish (e.g. Mann 1993; Yatsu *et al.* 2005). It is likely therefore that the inferred reduction of mackerel in the late Mesolithic at Vela Spila was due to a reduction in overall mackerel population caused by what may only have been slight changes in environmental conditions either globally or in the Adriatic, necessitating an increase in more opportunistic coastal-based fishing. However, other factors such as a slight change in seasonality of occupation of the site, or a change in other activities at the site which made targeted mackerel fishing less feasible for the occupants, cannot be ruled out at present.

Mackerel quantity and processing

Converting numbers of excavated bones to quantities of meat is always a hazardous and approximate business. However, it was considered worthwhile to provide an estimation of MNI for the most abundant species at Vela Spila, chub mackerel (*S. japonicus*), as this taxon dominates the assemblage throughout the Mesolithic period. MNI was calculated with respect to phase and to recovery method (see Table 3), and was also calculated separately for cranial elements and for vertebrae, due to an apparent bias in the data against Scombrid cranial elements. The estimated MNI given for the identified sample is

142 mackerel, with the highest single value being a minimum of 117 individuals from the Early Mesolithic contexts recovered by 3 mm wet sieving. As the identified sample accounts for approximately 15% of the entire fish assemblage (see Methods, above), this gives a total of 946 mackerel from the material recovered thus far from the site. Assuming a weight of approximately 0.5 kg per fish, based on a ball-park estimate of modern mackerel size (Hernández and Ortega 2000), this equates to almost half a ton of mackerel. It should be emphasised that these numbers are broad estimates only, and we use 0.5 kg rather than 500 g, as the latter would suggest an inappropriate degree of precision. However, it can be said that the quantity of mackerel brought to the cave would have numbered many hundreds of fish, especially in the earliest phases of the Mesolithic at the site.

In addition to the evidence for large-scale targeting of mackerel in the Early Mesolithic, there is evidence regarding their processing and preparation. The low ratio of cranial elements to vertebrae for mackerel has already been mentioned. While studies have shown that fish vertebrae are more likely to survive in the archaeological record than cranial elements (e.g. Lubinski (1996) for salmonid fish), this cannot be taken as a general rule as the structure, number and density of bones varies a great deal between different fish taxa (Lubinski 1996, 179). Table 4 shows a breakdown of mackerel cranial elements:vertebrae ratios by phase and quadrant/recovery method. While recovery method has clearly affected the relative quantities of vertebrae and cranial elements recovered, the most notable result is the large number of mackerel vertebrae per cranial element in the Early Mesolithic in quadrant E6, which is more than seven times greater than the ratio in the later Mesolithic and Neolithic in quadrant B–D/5–6. As these assemblages are comparable in terms of preservation and recovery method, the data show a lack of mackerel heads, which can be attributed to deliberate butchery in the Early Mesolithic. A similar bias against cranial elements in the Mesolithic has been noted at the Cave of Cyclope, Youra, Greece (Mylona 2003), and the heads of oily fish such as mackerel are often removed in modern fishing shortly after they are caught, as they are thought to spoil faster otherwise (Mylona 2003, 186). Mackerel heads may have been used as bait, both for attracting more mackerel and for larger predatory fish (Hernández and Ortega 2000). Removal and discard of mackerel heads either on a boat or at the shoreline would have also reduced the weight of fish to carry back to the site. However, there is less evidence of this practice continuing in the later Mesolithic, although taphonomic factors

make the data difficult to interpret. This would be consistent with a change in fishing location, for example from boat-based to shore-based fishing, which allowed the catches to be carried back to the cave before processing. The inferred change of location would also be consistent with the changes in relative abundance of taxa already noted. Alternatively, the reduction of catch sizes in this period may have removed the necessity for weight reduction before returning to the cave.

Changes at the Mesolithic–Neolithic Transition

The most notable change in the faunal record at Vela Spila at the beginning of the Neolithic is the introduction of domestic animals – in particular, sheep (*Ovis aries*) and goat (*Capra hircus*) – to the site. The reduction in quantity of fish corresponds to a probable change in the function of the site, to a temporary shepherd camp (Miracle and Radović in press). The small quantities of fish present and lack of any pelagic species suggests small-scale, opportunistic fishing to supplement a diet based largely around terrestrial animals. The lack of mackerel may indicate a lack of interest in catching them, a change in site seasonality, or lack of knowledge and resources to exploit migratory species. However, moray and conger eel, as well as sparids, are present in all phases at Vela Spila, indicating both the easy availability of these resources, and their usefulness in supplementing a diet based for the main part around other species. Fishing at the site changed from one of the primary activities in the Mesolithic, contributing significantly to subsistence, to a small-scale and opportunistic activity in the Neolithic, taking up little time and providing a modest source of protein.

Change and continuity at the Mesolithic–Neolithic Transition

Changes in fishing practices at Vela Spila appear to be most marked across the cultural transition between the Mesolithic and the Neolithic at the site. The overall quantity of fish brought to site drops sharply across this transition, consistent with the general pattern noted across Europe for a decline in reliance on fish as a resource at this time. At Vela Spila, this generalisation masks a change in fishing practice, from targeting seasonal mackerel shoals to opportunistic capture of year-round species, and a change in the dietary role of fish from a major seasonal resource in the Mesolithic to a small-scale resource supplementing a lifestyle and diet based largely around domesticates. These are primarily alterations to previous strategies in response to the availability of mackerel, which we suggest may have been environmentally driven. The abandonment of mackerel fishing in the Neolithic

indicates a more substantial change in fishing practice than those which preceded it.

That said, there is also continuity which it is important to recognise. Coastal fishing had become increasingly important at Vela Spila throughout the Mesolithic, mitigating a decline in mackerel catches that was already apparent in the later Mesolithic phases, and thus the more coastal fishing in the Neolithic record shows continuity with the Mesolithic. Species diversity is arguably more restricted in the Neolithic, perhaps because of smaller catches, and there may be a focus towards certain key species such as moray eel. Thus, the transition in fishing practices seen at the Mesolithic/Neolithic boundary can be seen to have had its roots in the preceding Mesolithic phases. This continuity should be considered in terms of arguments for significant population change at the beginning of the Neolithic (Forenbaher and Miracle 2005; Turney and Brown 2007), and may reflect the importance of the local environment of the site in determining which fishing practices are most effective. When considering change at the site, it is important to recognise that by the time domesticates were introduced, the zenith of mackerel fishing was already long past.

Diversity of fishing practice in the Mediterranean region

Few assemblages of fish remains have been recovered and analysed from the Mesolithic period in the eastern Mediterranean region, and none from around the Adriatic. However, comparison of the data from Vela Spila to other sites in the region indicates a considerable diversity in fishing strategies and the role of fish which has yet to be fully explored, both in the Mesolithic and across the Mesolithic–Neolithic transition. Vela Spila, particularly in the Early Mesolithic phases, appears to have been a site which was occupied seasonally. Occupation was restricted in function and of short duration, possibly as the site functioned as a base from which to fish, and at which to process and preserve the catch, which would then be taken by the inhabitants when they moved on. This is a slightly unusual instance of fishing practice in the Mesolithic of the eastern Mediterranean. Targeted exploitation of specific marine resources is known from two other sites in the area: the Cave of Cyclope (Mylona 2003; Powell 2003) and Franchthi Cave (Payne 1975; Perlès 2003; Rose 1995). Seasonally migratory species such as mackerel were exploited in the Mesolithic and Neolithic at the Cave of Cyclope, Youra, and a similar pattern of mackerel processing to that found at Vela Spila has been found from the site (Mylona 2003, 186). Fish remains predominate in the assemblage, and fishing is thus argued to be one of the

principal reasons behind occupation of the site (Trantalidou 2003, 170). However, migratory species at the Cave of Cyclope always make up only a minority of the assemblage, with the majority of species (Sparidae, Serranidae, etc.) caught from inshore or coastal waters. Tuna dominate the fish assemblage from the Upper Mesolithic levels at Franchthi Cave (ca. 8000–7500 BC, most probable dates 7850–7700 BC; Perlès 2003), evidence for targeting of seasonally available migratory fish similar to Vela Spila. Other taxa at Franchthi, such as sea bream, groupers (*Epinephelus* sp.), barracuda (*Sphyræna sphyraena*) and grey mullet, would have been available year-round (Rose 1995). However, unlike Vela Spila and the Cave of Cyclope, terrestrial fauna make up the greater part of the faunal assemblage in all phases at the site (Payne 1975; Perlès 2003), and it is suggested that fish were a supplement rather than a mainstay of the diet (Rose 1995).

The Grotta dell'Uzzo, Sicily (Tagliacozzo 1996) provides the greatest contrast in fishing patterns to Vela Spila, despite being closest in terms of location. Fish began to be exploited at a similar date to the earliest Mesolithic levels at Vela Spila, and only became important in the transitional (Meso–Neo) phase (6998–6605 BC). The assemblage is dominated by coastal taxa such as sea breams (Sparidae) and groupers (*Epinephelus* sp.), a genus that is not found as far north as Korčula, but which have similar habits to the sea breams. Red deer (*Cervus elaphus*) or domesticates dominate the faunal assemblage, and fish remains never outnumber the remains of terrestrial mammals. Fish in this instance appear to have been used to supplement diet at a site focused on largely terrestrial resources, with little effort put into their exploitation – a strategy similar to that used in the Neolithic phases at Vela Spila, but commencing at the Grotta dell'Uzzo before the introduction of domesticates.

With the Neolithic introduction of domesticates in the Eastern Mediterranean region, there appears to have been a move away from the intensive exploitation of marine resources. This is marked by the abandonment of specialised fishing for migratory species, as at Vela Spila, Franchthi and the Cave of Cyclope, in favour of small-scale exploitation of species which could be fished relatively readily from coastal waters, and eventually by complete abandonment. However, the timing and the specific character of these transitions varies. At Franchthi Cave, the specialised exploitation of tuna was confined to a brief period in the Later Mesolithic, and by the Final Mesolithic (ca. 6000 BC), exploitation of marine resources was mostly focused on shellfish (Perlès 2003). At the Cave of Cyclope, a marked drop in quantity and abandonment of migratory fish did not occur until the Late Neolithic (ca. 4800 BC). For the Grotta dell'Uzzo, the

drop in quantity and in species diversity to focus more closely on the groupers (*Epinephelus* sp.) was again delayed until the later Neolithic (Neolithic II, after 5600 BC). Both the timing of the transition and the fishing practices underlying these changes appear to have depended on the context and history of the site, and how fishing was carried out at the site in previous generations. This serves to further emphasise the complexity and diversity of processes of change from the Mesolithic to the Neolithic with the introduction of agriculture and domestic animals in the Eastern Mediterranean.

Fishing practice and social context

These changes in fishing and fishing practice through the Mesolithic and Neolithic did not occur in isolation. Fishing in prehistory is inextricably linked into a broader social context, as one in a suite of inter-linked activities. Changes in fishing practice, therefore, will affect and be affected by this broader context.

Fishing can usefully be viewed as a developing engagement with the marine environment. It has typically been considered as an exclusively coastal activity (e.g. Broodbank 2006), with little connection to longer-distance sea travel; however, use of the sea for fishing, in developing seafaring skills, may have formed an important step towards the use of the sea as a medium for travel (Powell 2003, 82). Both activities would have shaped perceptions of the sea, and of how venturing onto the sea linked into day-to-day life. The Mesolithic at Vela Spila is characterised by a great deal of fishing activity, and modest evidence for occasional longer-distance sea travel. Occasional crossings of the Adriatic in the Mesolithic have been argued primarily on the basis of a lithic artefact found at the site, which has been sourced to Palagruža, an island midway between the Italian and Croatian coasts (see Radić 2009). There is no evidence for systematic exploitation of deep-sea resources at Vela Spila, and it is likely that mackerel would have been fished close to the bay, most likely using small boats and organic nets to trap shoals moving near the coast. However, a significant level of knowledge and of skill in exploiting the marine environment can be argued for the Mesolithic inhabitants of Vela Spila, as the site was consistently returned to at a time when mackerel were available in the surrounding area. In the Neolithic, the situation is reversed, with evidence for maritime activity in the area becoming more plentiful at the same time as fishing declines and is restricted to coastal areas. Evidence for the spread of the Neolithic strongly suggests that maritime travel played an important role (Broodbank 2006; see also the argument of Forenbaher and Miracle 2005), obsidian from Lipari and Melos became a major traded commodity (Renfrew *et al.* 1965), and the

extensive distribution of Impressed Wares indicates the existence of good connections across the sea (Radić 2009). It should be emphasised that the concurrent decline of fishing noted at Vela Spila is not the case at all sites in the surrounding area – the Cave of Cyclope and the Grotta dell’Uzzo do not show a shift away from fishing until the later Neolithic. However, at Vela Spila there is a distinct move away from the use of the sea as a resource, most likely linked to the introduction of new dietary resources, at a time when evidence for seafaring increases. The evidence from Vela Spila demonstrates the extent to which fishing and maritime travel are, in fact, separable activities. Connection with the sea as a medium for travel did not necessarily lead to an increase in fishing; nor vice versa. While the skills involved may have overlapped, the motivation and social context for each activity would have differed. As this social context changed between the Mesolithic and Neolithic at Vela Spila, so did the role of the sea, and the practices and perceptions associated with it.

Consideration of fishing practices and their context must be linked back into consideration of fish as a dietary resource, and how changes in procurement practice may have influenced how fish was perceived in terms of consumption. Production and consumption of food can be argued to exist in a dialectic where production influences the food that is consumed and how it is perceived, both through the specific producer and through intrinsic properties such as availability and location (Meigs 1997; Moore *et al.* 2000); and consumption choices influence what food is procured through culturally defined concepts of edibility, appropriateness and desirability (e.g. Caplan 1997; Parker Pearson 2003). When considering fishing practices in prehistory, therefore, the importance of consumption in informing the choice of resources cannot be ignored, and it is important to take into account the complex cultural values attached to food and the various roles it may play when considering any changes in fishing and consumption practices over the period.

Stable isotope studies have been used to argue for a sharp reduction in the consumption of fish at the Meso/Neolithic boundary. Isotopic evidence from Vela Spila is consistent with this trend, although Lightfoot *et al.* (2011) suggest that the consumption of fish in the Mesolithic may have been restricted to certain seasons, a pattern which the zooarchaeological data would appear to corroborate. If the procurement of fish was temporally and spatially restricted, requiring return visits to particular sites at specific times of year, it is likely that consumption of fish would have also been particularly associated with certain seasons and certain locations. Fish may have been dried and preserved for consumption later on in the year,

although this would have altered the taste and potentially the way in which they were consumed. Mackerel were likely to have been a valued part of diet, as their procurement involved skill and effort, as well as a detailed knowledge of seasonal movements and a willingness to return to locations where they could be caught. However, the occasional catch of larger eel or tuna perhaps afforded social status for the person responsible for catching them, particularly as the decline in size of catches in the later Mesolithic and increased emphasis on coastal fish underscored the extent to which the mackerel were an unpredictable and risky resource.

Diet at Vela Spila in the Neolithic changed substantially from the Mesolithic, with the introduction of domesticates and the declining role of fish, now a critical resource rather than a staple. A focus on opportunistic coastal fishing, probably year-round, may have led to fish being regarded as a reliable but minor source of food, no longer associated with any particular location or season, unless fish were only caught when visiting Vela Spila with the flocks at certain times of year. Although this is somewhat speculative, the social contexts of food are also likely to have altered as the subsistence role of fish changed. With the alteration in skills required, it is possible that responsibility for procurement of fish shifted to different age and gender groups. As the skills involved changed, the practice of procuring fish may also have afforded fewer opportunities for gaining status in the Neolithic. Similarly, the abandonment of seasonal fishing may have reduced the tie to Vela Spila as an important seasonal location in the landscape. While it is impossible to fully unpick the social context of food and diet, in which fish and fishing practices were enmeshed, and while the reasons behind these transitions remain a matter of speculation, moving beyond quantity is essential in beginning to illuminate the roles that fish and fishing practice may have played in everyday life in prehistory.

Acknowledgements

The authors would like to thank Dinko Radić from the Cultural Centre, Vela Luka, for providing access to the material, as well as Sheila Hamilton-Dyer and Tamara Vučetić for their knowledge of fishes and fishing in the Mediterranean and Adriatic, Stašo Forenbaher for comments on sea-level change, and V. Pia Spry-Marqués for comments on earlier drafts of this paper. Acknowledgement is also due to the hard-working ‘Bone Team’ at the Vela Spila excavations. This work was initially prepared by Clare Rainsford as an MSc thesis, submitted to the University of York. We thank two anonymous referees for their comments on the original draft.

References

- Broodbank, C. 2006. The origins and early development of Mediterranean maritime activity. *Journal of Mediterranean Archaeology* **19**(2), 199–230.
- Caplan, P. 1997. Approaches to the study of food health and identity, pp. 1–32 in Caplan, P. (ed.), *Food Health and Identity*. London: Routledge.
- Choy, K. and Richards, M. P. 2009. Stable isotope evidence of human diet at the Nukdo shell midden site, South Korea. *Journal of Archaeological Science* **36**(7), 1312–8.
- Cleyet-Merle, J. J. and Madelaine, S. 1995. Inland evidence of human sea coast exploitation in Palaeolithic France, pp. 303–8 in Fischer, A. (ed.), *Man and Sea in the Mesolithic*. Oxford: Oxbow Books.
- Forenbaher, S. 2002. Prehistoric populations of the Island of Hvar – an overview of archaeological evidence. *Collegium Antropologicum* **26**(1), 361–78.
- Forenbaher, S. and Miracle, P. T. 2005. The spread of farming in the Eastern Adriatic. *Antiquity* **79**(305), 514–28.
- Guixé, E. G., Richards, M. P. and Subirà, M. E. 2006. Palaeodiets of humans and fauna at the Spanish Mesolithic site of El Collado. *Current Anthropology* **47**(3), 549–56.
- Hernández, J. J. C. and Ortega, A. T. S. 2000. *Synopsis of Biological Data on the Chub Mackerel (Scomber Japonicus Houtuyn, 1782)*. Rome: Food & Agriculture Organisation.
- Lambeck, K., Antonioli, F., Purcell, A. and Silenzi, S. 2004. Sea-level change along the Italian coast for the past 10,000 yr. *Quaternary Science Reviews* **23**(14–15), 1567–98.
- Lane-Serff, G. F., Rohling, E. J., Bryden, H. L. and Charnock, H. 1997. Postglacial connection of the Black Sea to the Mediterranean and its relation to the timing of sapropel formation. *Paleoceanography* **12**(2), 169–74.
- Lightfoot, E., Boneva, B., Miracle, P. T., Šlaus, M. and O'Connell, T. C. 2011. Exploring the Mesolithic and Neolithic transition in Croatia through isotopic investigations. *Antiquity* **85**, 73–86.
- Lotze, H. K., Coll, M. and Dunne, J. A. 2011. Historical changes in marine resources, food-web structure and ecosystem functioning in the Adriatic Sea, Mediterranean. *Ecosystems* **14**(2), 198–222.
- Lubell, D., Jackes, M., Schwarcz, H., Knyf, M. and Meicklejohn, C. 1994. The Mesolithic–Neolithic Transition in Portugal: isotopic and dental evidence of diet. *Journal of Archaeological Science* **21**(2), 201–16.
- Lubinski, P. 1996. Fish heads, fish heads: an experiment on differential bone preservation in a salmonid fish. *Journal of Archaeological Science* **23**(2), 175–81.
- Mann, K. H. 1993. Physical oceanography, food chains, and fish stocks: a review. *ICES Journal of Marine Science: Journal du Conseil* **50**(2), 105.
- Meigs, A. 1997. Food as a cultural construction, pp. 95–106 in Counihan, C. and Van Esterik, P. (eds.), *Food and Culture: A Reader*. London: Routledge.
- Milner, N., Craig, O. E., Bailey, G. N., Pedersen, K. and Andersen, S. H. 2004. Something fishy in the Neolithic? A re-evaluation of stable isotope analysis of Mesolithic and Neolithic coastal populations. *Antiquity* **78**(299), 9–22.
- Miracle, P. T. 1995. *Broad-Spectrum Adaptations Re-examined: Hunter-Gatherer Responses to Late-Glacial Environmental Changes in the Eastern Adriatic*. PhD dissertation, University of Michigan, UMI.
- Miracle, P. T. and Radović, S. in press. Vertebrate remains from the Pleistocene–Holocene transition to the onset of the Neolithic at Vela Spila, in Miracle, P. T. and Radić, D. (eds.), *Hunters and Herders in Southern Dalmatia: the Palaeolithic, Mesolithic, and Neolithic of Vela Spila (Korčula, Croatia)*. British Archaeological Reports. Oxford: Archaeopress.
- Moore, A. M., Hillman, G. C. and Legge, A. J. 2000. *Village on the Euphrates: from Foraging to Farming at Abu Hureyra*. Oxford: Oxford University Press.
- Muus, B. J. and Nielsen, J. G. 1999. Sea fish, p. 340 in Muus, B. J., Nielsen, J. G., Dahlstrom, P. and Nyström, B. O. (eds.), *Scandinavian Fishing Year Book*. Denmark: Hedehusene.
- Mylona, D. 2003. The exploitation of fish resources in the Mesolithic Sporades: fish remains from the Cave of Cyclope, Youra, pp. 181–8 in Perles, C. and Galanidou, N. (eds.), *The Greek Mesolithic. Problems and Perspectives*. London: British School at Athens.
- Papathanasiou, A. 2003. Stable isotope analysis in Neolithic Greece and possible implications on human health. *International Journal of Osteoarchaeology* **13**(5), 314–24.
- Parker Pearson, M. (ed.) 2003. *Food, Culture and Identity in the Neolithic and Early Bronze Age*. British Archaeological Reports S1117. Oxford: Archaeopress.
- Payne, S. 1975. Faunal change at Franchthi cave from 20,000 BC to 3000 BC, pp. 120–31 in Clason, A. T. and Lepiksaar, J. (eds.), *Archaeozoological Studies*. New York: North-Holland Pub. Co.; American Elsevier.
- Perlès, C. 2003. The Mesolithic at Franchthi: an overview of the data and problems, pp. 79–87 in Perles, C. and Galanidou, N. (eds.), *The Greek Mesolithic: Problems and Perspectives*. London: British School at Athens.
- Pickard, C. and Bonsall, C. 2004. Deep-sea fishing in the European Mesolithic: fact or fantasy? *European Journal of Archaeology* **7**(3), 273–90.
- Powell, J. 2003. Fishing in the Mesolithic and Neolithic-of Cyclops, Youra, pp. 75–84 in Kotjabopoulou, E., Hamilakis, Y., Halstead, P. and Gamble, C. (eds.), *Zooarchaeology in Greece: Recent Advances*. London: British School at Athens.
- Radić, D. 2009. The beginnings of trans-Adriatic navigation: a view from Vela Spila Cave (Korčula Island), pp. 13–24 in Forenbaher, S. (ed.), *A Connecting Sea: Maritime Interaction in Adriatic Prehistory*. British Archaeological Reports S2037. Oxford: Archaeopress.
- Rainsford, C. 2010. *Fishing Practices and Transitions in the Mesolithic and Neolithic of Adriatic Croatia: Insights from the fish remains from the site of Vela Spila, Korčula*. Unpublished MSc dissertation, University of York, UK.
- Renfrew, C., Cann, J. R. and Dixon, J. E. 1965. Obsidian in the Aegean. *The Annual of the British School at Athens* **60**, 225–47.
- Richards, M. P. 2003. Explaining the dietary isotope evidence for the rapid adoption of the Neolithic in Britain, pp. 31–6 in Parker Pearson, M. (ed.), *Food, Culture and Identity in the Neolithic and Early Bronze Age*. British Archaeological Reports S1117. Oxford: Archaeopress.
- Richards, M. P., Schulting, R. J. and Hedges, R. E. 2003. Archaeology: sharp shift in diet at onset of Neolithic. *Nature* **425**(6956), 366.
- Rose, M. 1995. Fishing at Franchthi Cave, Greece: changing environments and patterns of exploitation'. *Old World Archaeology Newsletter* **18**(3), 21–6.
- Schulting, R. J. and Richards, M. P. 2002. The wet, the wild and the domesticated: the Mesolithic–Neolithic transition on the west coast of Scotland. *European Journal of Archaeology* **5**(2), 147–89.
- Schwarcz, H. P., White, C. D. and Longstaffe, F. J. 2010. Stable and radiogenic isotopes in biological archaeology: some applications, pp. 335–56 in West, J. B., Bowen, G. J., Dawson, T. E. and Tu, K. P. (eds.), *Isoscapes: Understanding Movement, Pattern and Process on Earth Through Isotope Mapping*. New York: Springer.
- Shackleton, J. C., Andel, T. H. V. and Runnels, C. N. 1984. Coastal paleogeography of the central and western Mediterranean during the last 125,000 years and its archaeological implications. *Journal of Field Archaeology* **11**(3), 307–14.
- Tagliacozzo, A. 1996. Economic changes between the Mesolithic and the Neolithic in the Grotta deU'Uzzo (Sicily, Italy). *The Accordia Research Papers* **5**, 7–37.
- Thomas, J. 2003. Thoughts on the 'repacked' Neolithic revolution. *Antiquity* **77**(295), 67–75.
- Trantalidou, K. 2003. Faunal remains from the earliest strata of the Cave of Cyclope, Youra, pp. 143–79 in Galanidou, N. and Perlès, C. (eds.), *The Greek Mesolithic Problems and Perspectives*. London: British School at Athens.
- Turney, C. S. and Brown, H. 2007. Catastrophic early Holocene sea level rise, human migration and the Neolithic transition in Europe. *Quaternary Science Reviews* **26**(17–18), 2036–41.
- Yatsu, A., Watanabe, T., Ishida, M., Sugisaki, H. and Jacobson, L. 2005. Environmental effects on recruitment and productivity of Japanese sardine *Sardinops melanostictus* and chub mackerel *Scomber japonicus* with recommendations for management. *Fisheries Oceanography* **14**(4), 263–78.