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Portmahomack on Tarbat Ness: Changing Ideologies in North-East Scotland, Sixth to Sixteenth Century AD

by Martin Carver, Justin Garner-Lahire and Cecily Spall

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Digest 4.1 INVENTORY OF BURIAL DATA

Sarah King and Shirley Curtis-Summers (University of Liverpool)

Table D4.1

Burial	Interv	Feature	Context	Period	Condition	Completeness (%)	Sex	Age range[1] (yrs)	Sub-adult[2] Age (assessed)	Stature (cm)	Stature (ft/in)	Pathology[3]	Burial type	C14 date (AD)
1	17	20	1079	4	Good	25–50	Probable male	Adult		168.72	5.6	Periostitis, OA, Trauma (?)		
2	17	56	1163	4	Good	>75	unsexed	1.1–2.5	1.5 yrs			Calculus, Cribra Orbitalia, Rickets (?)		
3	17	24	1084	4	Fair	25–50	unsexed	10.6–14.5	10–12 yrs					
4	17	39	1122	5	Good	50–75	unsexed	0–1	1–2 mths				Shrouded	
5	17	25	1085	4	Fair	50–75	Female	46–59		146.46	4.9			
6	17	22	1081	5	Good	50–75	unsexed	0–1	6–9 mths			Rickets. Scurvy (?)		
7	17	21	1077	4	Good	25–50	unsexed	2.6–6.5	3 yrs					
8	17	34	1117	4	Good	<25	Probable male	18–25		174.63	5.9	Osgood-Schlatter's	Coffined	
9	17	45	1139	4	Very good	25–50	Probable male	46–59		172.36	5.8		Coffined	
10	17	40	1124	4	Good	<25	unsexed	6.6–10.5	7.7 yrs					
11	17	36	1098	4	Fair	25–50	unsexed	2.6–6.5	6 yrs					
12	17	35	1119	5	Fair	>75	unsexed	0–1	2 mths			Scurvy		
13	17	39	1138	5	Fair	>75	unsexed	0–1	3–12 mths			Scurvy		
14	17	27	1101	4	Fair	50–75	unsexed	1.1–2.5	2.5 yrs					
15	17	41	1128	5	Fair	<25	unsexed	1.1–2.5	1.5 yrs					
16	17	28	1103	4	Fair	>75	unsexed	6.6–10.5	10.5 yrs				Shrouded	
17	17	7	1127	5	Poor	>75	Male	36–45		167.68	5.6		Coffined	
18	17	33	1114	4	Good	50–75	Male	36–45		170.80	5.7		Shrouded	
19	17	54	1158	4	Matched up with Burial 31									
20	17	49	1145	4	Fair	<25	Probable female	46–59		149.69	4.10			
21	20	75	1196	4	Fair	>75	unsexed	2.6–6.5	6 yrs			Cribra Orbitalia	Coffined	
22	17	50	1148	5	Poor	25–50	unsexed	0-0.5	0–6 mths			Infection (Ribs)		
23	17	7	1108	5	Good	>75	Female	46–59		165.09	5.5		Coffined and shrouded	
24	17	43	1133	4	Good	25–50	Probable male	14.6–17						
25	17	26	1099	4	Fair	>75	Male	46–59		162.74	5.4	SJD, DJD, Caries, Calculus, Sacralisation	Shrouded	
26	17	55	1162	4	Poor	50–75	unsexed	0–1	1–2 mths			Scurvy	Coffined	
27	17	38	1120	4	Good	>75	unsexed	10.6–14.5	9.6 yrs				Shrouded	
28	17	44	1135	4	Fair	25–50	Female	46–59		159.98	5.3	Entheseal changes		
29	17	77	1213	5	Fair	25–50	unsexed	1.1–2.5	2.5 yrs					

Burial	Interv	Feature	Context	Period	Condition	Completeness (%)	Sex	Age range[1] (yrs)	Sub-adult[2] Age (assessed)	Stature (cm)	Stature (ft/in)	Pathology[3]	Burial type	C^{14} date (AD)
30	17	76	1209	4	Good	>75	Male	36–45		176.13	5.9	Craniosynostosis, OA (ACC joints; R. StC joint, S. Iliac joints). Entheses R. CC lig. Non union of C1 foramina	Coffined; six skulls with Burial 36	
31	17	42	1130	4	Fair	>75	Male	36–45		159.94	5.3	OA? (R. ACC joint); C1-S5 caudal shift		
32	17	30	1106	4	Poor	25–50	Male	60+		169.84	5.7			
33	17	79	1224	5	Fair	>75	unsexed	0–1	3–4 mths			Scurvy		
34	17	51	1152	4	Poor	50–75	Male	46–59		167.56	5.6	Vert and R.Shoulder OA		
35	17	82	1225	4	Good	>75	Male	18–25		175.48	5.9		Shrouded	
36	17	76	1214	4	Fair	>75	Male	46–59		180.29	5.11	OA, DJD, SJD, Dental, Cranial Blade wounds	Coffined; six skulls with Burial 30	
37	17	32	1102	4	Fair	>75	Male	26–35		157.54	5.2	DEH, Calculus, Caries		
38	17	99	1272	2	Fair	>75	Male	46–59		170.28	5.7	Neoplasm, SJD, Dental, periostitis	Prob. shrouded	
39	17	96	1265	2	Fair	<25	Probable male	Adult		168.08	5.6	Fracture: R. Proximal Fibula		
40	17	120	1304	2	Fair	>75	Male	46–59		174.44	5.9			
41	17	84	1233	4	Poor	50–75	Male	18–25				OA (?), Dental disease, Bifid neural arch, Nasal concha bullosa, Kyphosis(?)	Shrouded	
42	17	108	1288	2	Fair	25–50	Male	46–59		177.55	5.10	L. Rib Fracture, OA, SJD, DJD, Spina bifida occulta, Dental	Head Support	
43	17	83	1228	4	FAIR	50–75	Male	46–59		172.62	5.8	SJD, Dental disease	Coffined, clothed, shod	
44	17	94	1261	2	Fair	<40	Male	46–59					Head support	
45	17	107	1285	2	Fair	<50	Male	46–59		170.86	5.7		Head support	
46	17	91	1254	1	Good	<40	Male	Adult		172.10	5.8		Long Cist	
47	17	98	1271	2	Good	25–50	Male	26–35		173.63	5.8	Dental, Entheses		
48	17	89	1250	2	Fair	25–50	Probable male	36–45		166.32	5.5	Entheses: L4, Calcanei		
49	17	90	1252	4	Poor	<25	Probable female	Adult		166.22	5.5		Shrouded?	
50	17	101	1274	2	Fair	<25	Probable male	Adult		163.98	5.5			
51	17	102	1276	2	Fair	50–75	Male	36–45		163.91	5.5	Fracture (R. 5th MT), OA, DJD		
52	17	109	1292	2	Good	25–50	Male	46–59		166.38	5.6	Periostitis (R. Fibula)	Shrouded	
53	17	106	1282	2	Poor	50–75	Male	46–59				SN, Calculus, caries, abscess, mand tori	Head support	
54	17	103	1278	2	Poor	50–75	Male	18–25		173.01	5.8	Pulmonary infection (TB?) Calculus, DEH		
55	17	8	1048	4	Fair	>75	Probable female	16–25		166.22	5.5	Caries, Calculus	Shrouded	
56	17	8	1015	4	Fair	50–75	Male	46–59		168.51	5.6		Coffin	
57	17	8	1031	5	Good	25–50	unsexed	0–1	7 mths					
58	17	79	1220	4	Poor	<25	unsexed	0–1	6 mths				Coffin	
59	17	8	1025	5	Good	>75	unsexed	2.6–6.5	3.5 yrs			Calculus	Flagstones	

Burial	Interv	Feature	Context	Period	Condition	Completeness (%)	Sex	Age range[1] (yrs)	Sub-adult[2] Age (assessed)	Stature (cm)	Stature (ft/in)	Pathology[3]	Burial type	C[14] date (AD)
60	17	14	1045	5	Good	25–50	unsexed	1.1–2.5	1.5 yrs					
61	17	8	1042	5	Fair	25–50	unsexed	0–1	11 mths			Metabolic (?)		
62	20	5	1016	4	Good	50–75	Female	46–59		160.64	5.3		Shrouded	
63	20	2	1011	4	Fair	>75	unsexed	2.6–6.5	3.6 yrs			Rickets (femora)	Shrouded	
64	20	8	1020	4	Good	>75	Male	46–59		164.17	5.5	OA,DJD, DISH, L.Fib Fracture	Shrouded	
65	20	16	1036	4	Fair	>75	unsexed	6.6–10.5	7–8 yrs			Blade wound(?), Cribra Orbitalia	Coffin	
66	20	9	1021	4	Good	50–75	Male	26–35		156.13	5.1	SJD/SN, Sinusitis, Rib Periostitis, OA (?) (L. Femur)		
67	20	7	1019	4	Good	50–75	Female	26–35		158.09	5.2	SJD (SN)		
68	20	7	1019 x 2	4	Good	50–75	unsexed	Perinate	7–8 f.mths			Cribra Orbitalia		
69	20	10	1022	4	Good	50–75	Female	46–59		156.89	5.2	DJD, OA, Entheses	Shrouded	
70	20	15	1035	5	Fair	50–75	unsexed	1.1–2.5	1.2 yrs				Shrouded	
71	20	18	1038	4	Fair	50–75	unsexed	2.6–6.5	5 yrs					
72	20	46	1099	4	Poor	<25	Unknown	18–25						
73	20	11	1027	5	Fair	50–75	unsexed	0–1	6 mths			Scurvy	Shrouded	
74	20	25	1063	4	Good	25–50	Male	46–59		165.08	5.5	L. 3rd MC Fracture, SJD(?)		
75	20	13	1030	4	Poor	25–50	Probable male	Adult		160.18	5.3	OA: L. & R. knee, R. 1st MC–P and 3rd prox IP joint	Shrouded	
(Not used)														
77	20	6	1017	4	Good	50–75	Male	36–45		170.02	5.7	SJD, DJD (R.shoulder)	Shrouded	
78	20	19	1041	4	Good	25–50	Female	26–35		152.41	5.0		Shrouded	
79	20	51	1122	4	Matched up with Burial 114									
80	20	18	1039	4	Poor	25–50	Male	36–45				OA, SN, L. Rib fractures		
81	20	43	1100	4	Fair	>75	unsexed	10.6–14.5	12 yrs			Periostitis (L. Fibula)		
82	20	38	1101	4	Poor	25–50	Female	36–45				SJD? (marginal OP on Lumbar frag)		
83	20	42	1093	4	Fair	50–75	Female	36–45		158.33	5.2	SN (?): Lower Thoracic Vertebra		
84	20	39	1102	4	Fair	25–50	Male	46–59		175.35	5.9	Sacralisation, Entheses, SJD/DJD, L.Patella (avulsion?)		
85	20	36	1110	4	Fair	>75	Probable male	18–25		171.19	5.7	Calculus, Tooth agenesis, L5 sacralisation		
86	20	60	1144	4	Fair	>75	unsexed	6.6–10.5	8–9 yrs			Cribra Orbitalia, Parietal Porosity (Scurvy?)	Coffin	
87	20	52	1125	4	Matched up with Burial 81									
88	20	50	1117	4	Fair	>75	Female	36–45		148.97	4.11	OA/OP, SN, Dental	Coffin and shroud	
89	20	59	1142	4	Good	>75	unsexed	1.1–2.5	2.2 yrs			Congenital fusion of T3–4	Coffin?	
90	20	45	1106	4	Good	>75	Male	60+		172.79	5.8	OA, SN, DJD, Paracondylar process, Dental	Shrouded	1460–1660
91	20	62	1147	4	Good	>75	Female	26–35		148.69	4.10		Shrouded	
92	20	66	1159	4	Fair	<25	Female	26–35		148.94	4.10		Coffin	
93	20	28	1115	4	Good	>75	Male	36–45?		166.51	5.5	OA, SJD, Neoplasm/Infection	Coffin	

Burial	Interv	Feature	Context	Period	Condition	Completeness (%)	Sex	Age range[1] (yrs)	Sub-adult[2] Age (assessed)	Stature (cm)	Stature (ft/in)	Pathology[3]	Burial type	C[14] date (AD)
94	20	94	1048	4	Good	<40	Probable male	Adult					Coffin	
95	20	70	1169	4	Fair	>75	Female	46–59		149.69	4.11			
96	20	57	1135	4	Good	<25	Probable male	Adult		173.12	5.8	Entheses: Achilles Heel		
97	20	48	1107	4	Fair	25–50	Probable female	46–59				Scheuermanns–Schmorls disease; thoracolumbar border shifting	Shroud	1440–1640
98	20	49	1113	4	Fair	>75	Male	26–35		175.35	5.9		Coffin	1420–1620
99	20	76	1183	4	Good	<25	Female	60+		150.18	4.11			
100	20	64	1155	4	Good	<25	Female	36–45		156.75	5.2			
101	20	47	1105	4	Fair	<40	Female	46–59		158.97	5.3		Coffined and shrouded	1440–1630
102	20	31	1123	4	Good	50–75	Female	36–45		155.86	5.1			
103	20	32	1119	4	Good	>75	Male	26–35		165.65	5.5	Dental disease, Bifid rib, Congenital Abnormalities (R. humerus and Lunate)		
104	20	37	1120	4	Good	<25	Male	Adult		173.92	5.8	Non-specific infection: L. Tibia		
105	20	56	1131	4	Poor	25–50	Female	46–59		154.06	5.1	OA, SJD/DJD, Fracture (R. Fibula), Infection (L. Femur)	Anomalous diet	
106	20	54	1138	4	Good	50–75	Female	60+		157.58	5.2			
107	20	1	1010	4	Good	<40	Probable male	14–17		166.06	5.5			
108	20	75	1180	4	Good	>75	Male	36–45		172.49	5.8	OA, SJD, Dental disease, Entheses, Infection (Tibiae, Fibulae), Treponemal (?)	Coffin	
109	20	77	1189	4	Fair	>75	Male	46–59		165.73	5.5	Oro–A Fistulas, caries, L. & R. 3rd MC fracture, Entheses	Coffin	
110	20	79	1193	4	Fair	50–75	unsexed	10.6–14.5	11yrs			Dental, CO, Infection, Scurvy (?) Treponemal (?)	Shrouded	1280–1400
111	20	86	1209	3	Poor	50–75	Male	26–35		168.03	5.6		Head support	
112	20	69	1174	4	Good	>75	Male	46–59		174.30	5.9		Coffin	1280–1420
113	20	84	1206	4	Good	>75	Male	36–45		165.60	5.5	OA, SJD, Dental, Fracture, Rickets (?R. Fibula) Blade wound (trepanation?), Os acromiale, O. dissecans (?)	Coffin and shroud	1290–1430
114	20	82	1200	4	Fair	>75	Female	18–25		156.47	5.2	OA, NS Infection, Entheses, Trauma (Patella)		
115	20	83	1202	4	Poor	25–50	Female	Adult		160.11	5.3	OA (?) SJD (?) DJD (Hips, knees)		
116	20	96	1228	2	Poor	25–50	Male	46–59				OA: verts, L. shoulder	Head support	680–880
117	20	93	1222	4	Fair	50–75	Male	18–25		163.27	5.4	R. 3rd MC Styloid fracture, Blade wounds (L. cranium, L. & R. Femora), SN.		1150–1270
118	20	102	1242	2	Fair	25–50	Male	Adult				Fracture: R. 5th MT Tuberosity		
119	20	81	1198	4	Fair	25–50	unsexed	10.6–14.5	12 yrs			Granuloma, Calculus, Entheses	Coffin	
120	20	58	1140	4	Good	50–75	Male	36–45		160.79	5.3	Schmorls Nodes. No photos taken		
121	20	110	1259	2	Fair	>75	Male	26–35		167.16	5.6	Compression (L1), Spondylolysis (L5), SN, Os Acromiale, DJD		

Burial	Interv	Feature	Context	Period	Condition	Completeness (%)	Sex	Age range[1] (yrs)	Sub-adult[2] Age (assessed)	Stature (cm)	Stature (ft/in)	Pathology[3]	Burial type	C^{14} date (AD)
122	20	112	1263	2	Fair	>75	Male	46–59		174.05	5.9	OA, SJD, Dental, Fractures (T7, R. Fib, L. Rad)	Head and torso cover, prob. shrouded	
123	20	100	1273	2	Poor	25–50	Male	60+		175.17	5.9	Fracture (R. 5th Prox phalanx), OA (Hip, L4–5)		
124	20	109	1256	2	Fair	25–50	Male	18–25		177.02	5.10	Scurvy (?) C1 to Occitpital fusion, SN		
125	20	113	1265	2	Poor	>75	Male	60+		173.01	5.8	Fracture (L. Tib/Fib), OA (L. Hip, C.verts)	Head support (?), shrouded (?)	
126	20	97	1229	2	Fair	50–75	Male	46–59		169.93	5.7	SJD, OA, SN, DJD, Dental Abscesses, Calculus	Head support	
127	20	128	1300	2	Poor	50–75	Probable male	36–45		162.09	5.4			
128	20	103	1244	2	Poor	<40	Probable male	46–59					Head support	640–770
129	20	118	1277	2	Fair	>75	Probable male	18–25		165.81	5.5		Shrouded	670–880
130	20	133	1309	2	Fair	>75	Probable male	46–59		170.41	5.7		Head support	660–780
131	20	135	1312	1	Fair	<25	Female	46–59						
132	20	80	1195	Matched up with Burial 120										
133	20	122	1288	2	Fair	25–50	Male	60+		168.84	5.6	DJD, SJD, OA (Verts, Hips, Tarsals)	Prob. Shrouded	
134	20	14	1034	4	Fair	25–50	Male	18–25		171.86	5.8	Periostitis, Fracture (?) (L. 1st MC)		
135	20	120	1280	2	Fair	25–50	Probable male	46–59				SJD, SN, Possible Scheuermanns (T11)		
136	20	121	1286	3	Fair	50–75	Male	36–45		173.93	5.8		With Burial 156	970–1040
137	20	119	1278	2	Poor	25–50	Probable male	36–45		174.24	5.9		Head support	
(Not used)														
139	20	106	1251	2	Fair	25–50	Male	46–59		164.08	5.5	Scurvy, Vert OA, SN	Head support	
140	20	123	1289	2	Fair	>75	Male	18–25		166.13	5.5	SN, R.Os acromiale, CC Entheses	Prob. shrouded	
141	20	101	1240	2	Fair	>75	Male	36–45		168.75	5.6	SN, Spondylolysis, Sacralisation, R. Fibula, Fracture	Shrouded	
142	20	111	1260	2	Fair	25–50	Male	46–59		173.62	5.8	OA, Fracture (R. 5th MT), O.Dissecans?		
143	20	90	1214	2	Fair	>75	Male	60+		167.55	5.6	SN, OA, Infection	Shrouded	
144	20	98	1232	2	Fair	50–75	Male	46–59		161.00	5.4	OA(Verts), SN, DJD, Dental diseases	Anomalous diet	680–890
145	20	139	1329	3	Fair	25–50	Male	Adult				Vert OA, L.Clavicle Fracture, Caries		
146	20	137	1318	1	Fair	25–50	Female	26–35		160.13	5.3		Long Cist	660–780
147	20	125	1294	3	Fair	50–75	Male	26–35		171.60	5.7		Wood/wicker bier	720–960
148	20	99	1235	2	Fair	25–50	Male	60+		177.79	5.10	OA (R. Wrist, R. Hip, L. Knee and verts), Periostitis (L. Femur), DJD/SN	Prob. shrouded	
149	20	117	1275	1	Poor	50–75	Male	60+				Fractured R. ribs, Poss Neoplasm (R. Orbit), OA, DJD, SN, Dental, Maxillary Sinusitis	Long Cist	

Burial	Interv	Feature	Context	Period	Condition	Completeness (%)	Sex	Age range[1] (yrs)	Sub-adult[2] Age (assessed)	Stature (cm)	Stature (ft/in)	Pathology[3]	Burial type	C[14] date (AD)
150	20	94	1224	4	Good	25–50	Male	Adult		172.23	5.8	DJD, Periosteal changes, Entheseal changes		
151	20	140	1322	2	Fair	50–75	Male	46–59		171.60	5.8	OA, SJD, DJD, L. Mid Rib Fracture	Head support, shrouded	
152	20	132	1307	3	Fair	50–75	Male	26–35		173.93	5.8	Blade wounds × 3, Dental, Max Sinusitis (?)	Head support	780–1000
153	20	114	1268	2	Fair	50–75	Male	36–45		170.55	5.7	SN/Scheuermanns, Vert fractures, Dental	Shrouded	650–780
154	20	141	1331	2	Fair	50–75	Male	46–59		172.61	5.8	SJD, DJD, OA, Infection (R. Tibia), Dental	Head support, shrouded	
155	20	146	1338	2	Poor	50–75	Female	46–59		164.81	5.5	SJD, Osteoporosis (?)	Shrouded	
156	20	121	1284	3	Poor	50–75	Male	36–45		170.50	5.7		Head support; with Burial 136	970–1040
157	20	104	1247	2	Fair	50–75	Male	46–59		173.32	5.8		Head support	
158	20	138	1328	3	Fair	50–75	Male	46–59		172.71	5.8	Blade wound (L. Parietal), Fractured L. Ribs, OA: L. & R. ACC; Verts, SN, Dental disease	Shrouded	680–900
159	20	115	1270	2	Fair	50–75	unsexed	10.6–14.5	10 yrs					
160	20	148	1346	2	Poor	25–50	Probable male	Adult		165.95		OA: R (and L?) Hip, L3	Prob. shrouded	680–880
161	20	74	1177	4	Good	>75	Male	36–45		169.76	5.7	OA, DJD, SJD, SN	Poss. coffin	
162	20	159	1373	1	Poor	25–50	Male	Adult		167.56	5.6		Long Cist	430–575
163	20	160	1374	1	Poor	25–50	Male	36–45		174.12	5.9		Prob. shrouded	640–690
164	20	151	1353	2	Fair	>75	Male	46–59		165.65	5.5	Lytic (Neoplasm?), Entheses, sacralisation Fractured ribs, OA/SJD/DJD, Dental		
165	20	158	1371	2	Poor	<25	Unknown	Adult						650–780
166	20	161	1381	1	Poor	<25	Probable female	Adult		153.73	5.1			
167	20	156	1366	2	Poor	<40	Male	Adult		167.32	5.6			
168	20	153	1357	2	Poor	25–50	Probable male	36–45						
169	20	155	1362	1	Fair	50–75	Male	26–35		176.36	5.9			610–680
170	20	157	1368	1	Poor	>75	Male	26–35		176.65	5.10	Calculus, Fracture (L. clavicle), SN, Neoplasm?		580–660
171	20	154	1360	2	Good	>75	Male	36–45		175.17	5.9			660–850
172	20	152	1364	1	Poor	50–75	Female	46–59		160.37	5.3	OA: L5–Sacral R. facet, L. knee, poss granuloma	Long Cist	570–650
173	20	116	1271	2	Good	25–50	Male	46–59				SJD, Granuloma/Abscess, Scheuermann's, SN, Max Sinusitis, Ankylosing Spondylitis (?)	Head support	
174	20	144	1334	2	Poor	25–50	Female (?)	Adult				Neural arch entheses	Shrouded	
175	20	40	1090	4	Good	50–75	unsexed	6.6–10.5	6.6 yrs			Calculus		

Burial	Interv	Feature	Context	Period	Condition	Completeness (%)	Sex	Age range[1] (yrs)	Sub-adult[2] Age (assessed)	Stature (cm)	Stature (ft/in)	Pathology[3]	Burial type	C^{14} date (AD)
176	17	95	1267	2	Fair	>75	Male	46–59		161.57	5.4	OA, SJD, Dental, Fracture, Infection (sinusitis), Cribra Orbitalia, Spondylolysis (L5)	Head support, probably shrouded	
177	17	37	1086	5	Good	25–50	unsexed	0–1	39.37 f.wks					
178	20	65	1157	4										
179	20	136	1314	1										
180	20	164	1342	1									Long Cist	
181	20	27	1074	1									Long Cist	
182	20	142	1343	1									Long Cist	
183	20	149	1348	1									Long Cist	
184	20	162	1378	1										
185	20	163	1379	1									Long Cist	
186	14	515	2987	1	Fair	>75	Male	26–35		169.89	5.7	Spondylolisis (L5), L. Os acromiale, Entheses.	Long Cist	420–610
187	14	516	3346	1	Fair	50–75	Probable male	36–45		180.02	5.10	Spina bifida occulta, L. & R. 5th MT fracture, Periostitis (R. Ulna)	Long Cist	540–650
188	14	517	3367	1	Very Poor	<25	Probable male	Adult				SJD(?): C2	Long Cist	
189	16	1	1012	2	Poor	25–50	Male	26–35				Calculus & DEH		
190	20	3	1006	4	Good	<25	Unsexed	2.6–6.5	3 yrs			Infection (lower limbs)		
191	17	37	1083	4	Good	<25	Unknown	36–45						

1 Sub-adult age categories used: perinate (under 38 weeks gestation); birth to 1 year (infant), 1.1–2.5 years, 2.6–6.5 years, 6.6–10.5 years, 10.6–14.5, 14.6–17.0 (following Magilton et al 2008: 174). In the last category, individuals were estimated to be older than 17 when the root of the third molar was complete (Rc = 17.5) but the apex remained open (Moorrees et al 1963).

2 Sub-adult age based on assessments.

3 Abbreviations used in the pathology column:

ACC Acromioclavicular; CC Costoclavicular; DDD degenerative disc disease; DEH Dental enamal hypoplasia; DISH Diffuse idiopathic skeletal hyperostosis; DJD degenerative joint disease; Max. maxillary; MT metatarsal; OA osteoarthritis; S.Iliac sacroiliac; SJD spinal joint disease; SN Schmorls' nodes; StC Sternoclavicular; TB tuberculosis; Vert. vertebral.

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Digest 4.2 SUMMARY REPORT ON THE TARBAT POPULATIONS

SARAH KING (summary from full archive report, OLA 7.2.1)

The Tarbat skeletons were analysed early in the course of the project and the burials were at that point assigned to two phases: an eighth to eleventh century phase (Phase 1 and 2) (n = 67) and a twelfth to sixteenth century medieval period (Phase 3 and 4) (n = 99). Later there was some refinement of the phasing, thanks to the completion of an intensive programme of stratigraphic analysis and radiocarbon dating. King's Phase 1 is equivalent to Period 1, but is now better defined; her Phase 2 embraces the burials of Period 2 and 3, but, as shown in Chapter 5.2, Period 3 is simply the tail end of the Period 2 cemetery and is continuous with it. Phase 3 and 4 are grouped as Period 4. All the burials are tabulated in the updated inventory in D4.1. Although there has been some migration of graves between periods, they have not affected the conclusions drawn by Sarah King. To help the reader follow the argument, the groups will be labelled as Monastic (Periods 2 and 3) and medieval (Period 4). It is an important aspect of burial at Portmahomack that there is a marked hiatus between these two episodes of burial, one that is reflected by the rather different character of the populations being commemorated.

Similarities and differences

In the *Monastic Period* (Period 2/3) the individuals interred were mostly males who lived until middle or old age, whereas the *medieval period* (Period 4) was represented by individuals of all ages. In this later period, there was a more equal representation of females to males, with a ratio of 1:1.6, whereas in Period 2/3, the ratio of females to males was 1:9.2.

There were no differences in cranial morphological features through time at Tarbat (when examined as averages). Overall, the males and females had medium-shaped crania, low skull height, narrow faces and nasal apertures, medium-sized eye orbits and broad palates. However, when examined as proportions, an equal number of individuals from Period 2/3 had narrow heads or medium-shaped heads. In the medieval period, most individuals had medium-shaped heads, although a third also had broad heads. Most of the individuals from other Scottish medieval assemblages had medium or broad-shaped heads. Overall, the physical features of the Tarbat individuals were not unlike to those observed on individuals from other Scottish sites.

The demographic pattern in Tarbat Period 2/3 was most similar to the Isle of May, also thought to represent a monastic community. In contrast, the medieval period at Tarbat was more representative of a family community – consisting of children, women and men. The age and sex profile of the medieval phase was most similar to that observed at Glasgow Cathedral. As the burials were recovered within the parish church at Tarbat and Glasgow Cathedral, they might be expected to be of a higher status than those buried outside of the church. As both of these sites have relatively higher percentages of older individuals in their medieval phases, it is conceivable that Scottish people of relatively high status sometimes lived to older ages, or that old adults were often given more prestigious burials.

The Portmahomack individuals had a similar lower limb shape to the individuals buried at Isle of May (fifth to twelfth century phase) – that is, the majority of individuals had anterior-posterior flattening of the femoral shaft, and broad tibiae. The lower limb shape of the monastic individuals was also similar to those from the medieval period at Tarbat. Medieval Scottish assemblages generally demonstrate a pattern on anterior-posterior flattening of the femora, whereas tibiae were either broad or moderately flattened – depending on the site.

The body build and head shape of the Tarbat individuals (from the monastic and medieval periods) was similar to their Scottish contemporaries. There was paleopathological evidence to suggest that the monastic individuals differed from those of the medieval period in terms of diet and, perhaps, activity patterns. Moreover, there is evidence to suggest that although the medieval individuals suffered from childhood illnesses, they may have been healthier in older ages than other contemporary Scottish population groups, with the exception of Glasgow Cathedral.

The early medieval cemetery is presented and discussed in Chapter 5.2, p 106 and the medieval cemetery in Chapter 7, p 296.

Early medieval population

The majority of the occupants of the Portmahomack monastery lived longer than their colleagues at the contemporary establishments at the Isle of May and Hallow Hill. However, as at Tarbat, very few females were buried at the Isle of May during the monastic phase. The stature of the females and males (5' 3" and 5' 7" respectively) was comparable to the Isle of May and Hallow Hill.

Physique

Fifty-two per cent of the monastic population were affected by spinal joint disease, particularly, T10, L1 and L2. These observations, along with three cases of spondylosis (a condition which may occur as a result of bending and lifting in an upright posture) and three cases of compression fractures of the vertebrae (possibly as a result of a vertical force injury) suggested that the Period 2/3 individuals may have participated in activities resulting in lower back stress more frequently than the medieval individuals. There is also evidence to suggest that this stress began at younger ages in Period 2/3 than in the medieval period.

Teeth

Calculus, abscesses, ante-mortem tooth loss and dental wear were more frequently observed in the monastic than in the medieval period. Overall, the prevalence of caries in Period 2/3 and in the medieval period was similar to other contemporary Scottish sites. In the medieval phase at Tarbat, however, there was more ante-mortem tooth loss and dental enamel hypoplasia than in the Glasgow Cathedral dentitions.

These findings suggested that there were differences in diet and oral hygiene between the two phases, between the females and males from the medieval period, and between the Tarbat and Glasgow Cathedral individuals. In Period 2/3, the diet may have been more coarse than during the medieval period at Tarbat. Indeed, a small particle of stone was embedded in the pulp cavity of one of the well worn teeth from Period 2/3. The heavy wear may have also resulted in exposure of the pulp cavities, causing dental abscesses. The presence of heavy calculus may be associated with diet type and/or the lack of oral hygiene to remove plaque build-up.

Trauma

Thirty-two per cent of the monastic population had suffered fractures. In addition, similar types of fractures were consistently observed on the Period 2/3 skeletons, including three fractures of the left clavicle and three of the right proximal fibula. It is possible that these individuals experienced similar accidents. There was also evidence of interpersonal conflict at Tarbat – sharp-edged weapon wounds were present on three skeletons from Period 2/3, and one from the medieval period (as well as four cases in the disarticulated remains). Weapon wounds have been observed in other Scottish sites spanning all time periods. Overall, a higher percentage of fractures were observed in earlier Scottish assemblages compared to the medieval assemblages.

Blade injuries

Two individuals from the end of the monastic cemetery (Period 3) had suffered violent attack. A middle adult male (Burial 152) had three sharp cut marks to the skull. One was approximately 72mm in length and extended across both parietals with radiating fractures extending from both ends (one curved into the right side of the frontal bone and the other curved along the left parietal). The cut was angled such that one side was sharp and the other was broken post-mortem, but it did not extend into the endocranial surface (although there was a fracture line along the wound). The second wound bisected the lamboid suture on the left side. It was 41mm in length, was slightly angled and did not penetrate the inner table. The last fracture was on the right side of the occipital, however, much of the area was broken post-mortem and the extent of the wound was difficult to assess. A radiating fracture extended from this cut towards the cranial base. There was no evidence of healing thus suggesting this individual did not survive after the wounds were inflicted. As two of the cuts were on the back of the head, it is likely that the assailant attacked from behind. Given that one of the fractures was on the crown of the head, the individual may have been below the assailant at one point (eg kneeling). As injuries with larger weapons are more likely to produce terminal fractures (Wenham, 1987), it is possible that a weapon such as a large sword may have been used to produce these fractures.

An old adult male (Burial 158) had two well-healed fractures on the left parietal. They were smooth parallel depressions extending

Table D4.2.1
Period 1–3 Trauma

Burial	Period	Age	Sex	Bone	Side	Description
170	1	middle adult	M	clavicle	L	Well-healed fracture near the conoid tubercle – slightly displaced, so that the lateral end is slightly inferior to the rest of the shaft
39	2	adult	M	fibula	R	Proximal end – well healed (with callus formation), complete, oblique fracture
42	2	adult	M	rib		Healed fracture with new bone formation which has developed into a facet for articulation with a middle rib
51	2	middle adult	M	5th metatarsal		Non-united fracture at the base (tuberosity)
122	2	old adult	M	fibula	R	Proximal end – well healed (with callus formation), complete, oblique fracture
123	2	old adult	M	5th proximal phalanx	R	Well-healed, complete, straight fracture across the shaft
125	2	old adult	M	tibia fibula	L	Both are well-healed, complete, oblique fractures on the distal ends, but the tibia also has gaps and cloacae present along the fracture line. The ends of the fracture overlap by approximately 35mm and, as a result, the L tibia is shorter than the right. In addition, the proximal end of the fibula shaft is angled slightly medially and the fracture ends overlap by approximately 22mm. This individual also has OA of the left hip (secondary?), and probably walked with a limp
141	2	middle adult	M	fibula	R	Proximal end – well healed (with callus formation), complete, oblique fracture
142	2	old adult	?M	5th metacarpal 5th metatarsal	R	Fusion at an angle with the proximal phalanx – trauma? Non-united fracture at the base (tuberosity)
151	2	old adult	M	rib		Healed fracture of a middle rib
164	2	middle adult	M	rib		Rib fracture as well as a trauma or infection to the pelvis (see below)
176	2	middle adult	M	clavicle ribs	L	Non-united fracture approximately 25–30mm from the acromial end. One side is flared, and the other is rounded, forming a pseudo-joint. Five healed middle ribs
145	3	middle adult	M	clavicle	L	Non-united fracture approximately mid-shaft, with healed irregular new bone formation on both sides which articulated with one another. The ends of the bones are displaced such that the medial portion of the clavicle overlaid the lateral portion (anteriorly)
158	3	old adult	M	ribs		Mid-shaft fractures on four middle ribs. One rib also has a lytic lesion (oval with rounded edges – approximately 4.4 × 2.8mm in size) approximately 20mm away from fracture, possibly indicative of infection. This individual also had evidence of trauma to the skull (see below)

from the coronal suture approximately 46 and 30mm posteriorly, and 12 and 10mm wide, but did not extend into the internal table. Given the linear nature of the injuries, it is possible that a large blade was used to inflict these injuries, probably in a 'face-to-face' position.

Disablement

Three middle adult males from Period 2/3 also had collapsed vertebrae. Burial 153 had T6 to T8 flattened on the left side of the body, and T9 flattened on the right side of the body, resulting in scoliosis. In contrast, the anterior surface of the first lumbar vertebrae of Burial 121 was wedge shaped, resulting in kyphosis. Burial 176 also had kyphosis as a result of three wedge-shaped vertebrae (T12, L1 and L3). In this case, the vertebrae appear to have collapsed as a result of large lesions on the inferior surfaces of the body (with the exception of L3). It is possible that these individuals sustained these fractures as a result of a vertical force injury. As well as suffering from collapsed vertebrae, Burial 121 had spondylosis of L5. Skeleton 141 also had spondylosis of the fifth lumbar vertebra, while uncommonly, Burial 171 had spondylosis of both L3 and L4.

An old adult ?male (Burial 128) had a fused sacro-iliac joint on the right side (the left side was missing), as well as fusion between T3 and T4 and the fourth ribs (with no joint space left between the vertebrae) and fusion between C5 to C7 (T5 to L1 were missing). The osteophytes on the cervical vertebral bodies were square and 'bamboo' like in appearance, with fusion also occurring between the lamina and transverse processes. In addition, the atlas was fused to the occipital in such a way that this individual's head would have been slightly raised and tilted to the right side.

There was one possible case of osteochondritis dissecans in the Tarbat sample (not included in the prevalence Illus above). A middle adult male from Period 2/3 (Burial 171) had a depression on the superior portion of the articular surface of both acetabulae (approximately 10mm in size, but triangular in shape). In addition, the femoral heads had plaques of new bone formation (associated with porosities) near the fovea capitis.

Medieval Portmahomack

The majority of individuals from the medieval period at Tarbat lived to relatively older ages in comparison to other medieval Scottish assemblages, with the exception of Glasgow Cathedral (twelfth to fifteenth century phase). At that site, most individuals died as middle or old adults. There was also an almost identical ratio of females to males at Tarbat and Glasgow Cathedral.

The stature of the medieval individuals from Tarbat was slightly less than their Scottish contemporaries. In addition, the medieval females were, on average, less tall than the females from Period 2. Overall, however, the average medieval female height of 5' 1" and the average male height of 5' 6" were not largely different than the average modern Scot (females: 5' 4" and males: 5' 10" (Knight 1984)).

Similarly, the high frequency of dental disease in medieval females may be indicative of a difference in diet (and oral hygiene) between the sexes. It is possible that women may have been eating more high carbohydrate foods (or more sugary foods) than the males. It has been suggested that the consumption of animal protein may be associated with better dental health (Larsen 1997). However, medieval teeth were more likely to have caries and dental enamel hypoplasia. In addition, female teeth from the medieval period were more likely to have caries, dental enamel hypoplasia, calculus and ante-mortem tooth loss than the male teeth.

The high prevalence of dental enamel hypoplasia at Tarbat in comparison to Glasgow Cathedral suggests that environmental stress during childhood may have been experienced more often (or more severely) by the Tarbat individuals, particularly by the females.

In contrast to other Scottish assemblages (with the exception of Glasgow Cathedral), the Tarbat individuals did not have very many infectious lesions on their bones (Phase 2 = 8.1% and the medieval period = 9.3%). In all assemblages, including Tarbat, the majority of the lesions were on the lower limbs.

Analysis of the articulated burials suggested that metabolic disease was low at Tarbat, with very few individuals showing signs of cribra orbitalia (9% in Phase 2 and 3.8% in the medieval period). A similarly low percentage was also observed at Glasgow Cathedral (4.2%), whereas in other assemblages, higher percentages of individuals were affected. It is noted, however, when the disarticulated remains were analysed, several orbits were affected by cribra orbitalia, suggesting that the prevalence of anaemia may have been underestimated in the articulated sample from Tarbat.

Unlike other Scottish assemblages, there were several cases of rickets observed in the Tarbat articulated and disarticulated remains. These children may have been swaddled or kept indoors (out of the sun) and/or ate foods which lacked Vitamin D.

Tarbat also differed from other Scottish assemblages by having five possible cases of neoplastic disease (two from articulated burials, one from the disarticulated material and two from the 'charnel' deposit). One case was a possible metastatic carcinoma, perhaps secondary to prostate cancer. Another was a possible primary tumour to the face (basal cell carcinoma?) with secondary changes (metasteses) to the scapula, pelvis, ribs and a lumbar vertebra. The changes on the disarticulated bone remains undiagnosed, although osteoclastoma may be a possibility.

Although the Tarbat individuals died at relatively older ages in comparison to most other Scottish groups, there was evidence that the medieval men, and particularly the women, suffered from some environmental stress. They were slightly shorter in stature than their contemporaries, and the high prevalence of dental enamel hypoplasia suggests that they likely suffered from nutrition-infection interactions during childhood. The number of medieval children with rickets (and perhaps also anaemia) at Tarbat is suggestive of nutritional deficiencies, although anaemia may also result from other conditions – including chronic disease or parasitic infection (Roberts & Manchester 1995). There was also evidence of non-specific infection on the crania of several sub-adult skull fragments from the disarticulated remains. Thus, while the adults who survived childhood lived to relatively old ages, childhood morbidity and mortality were prevalent at medieval Tarbat. Those individuals who did survive to adulthood suffered from age related diseases including osteoarthritis, spinal joint disease and osteoporosis.

The low percentage of individuals with infectious lesions at Tarbat, and the lack of specific diseases such as tuberculosis and leprosy may suggest that the population was not dense enough for these diseases to become prevalent (see Larsen 1997). The presence of infectious lesions on the skeleton is indicative of long-term responses to pathogens. Thus, while acute diseases may have been present, there is evidence to suggest that some individuals survived long enough to ilicit a skeletal response, and therefore, may have had relatively healthy immune systems (Ortner 1991).

Medieval trauma

Twelve per cent of the medieval population had suffered fractures. Two medieval individuals had suffered blade attacks. The first case was a young adult male (Burial 117) who had three sharp-edged cut marks on the skeleton. One was present on the left parietal (near the occipital), and extended 53mm in length. It was slightly angled, so that it sheared the outer table of the skull, and only partially extended into the internal table. The second cut was

Table D4.2.2
Period 4 Fractures

Skeleton	Phase	Age	Sex	Bone	Side	Description
62	4	old adult	M	5th metatarsal		Non-united fracture at the base (tuberosity)
5	4	old adult	F	rib		Healed fracture of a middle rib
64	4	old adult	M	fibula	L	Incomplete fracture on distal end (appears like a crack in the articular surface) with evidence of healing
74	4	old adult	M	3rd metacarpal	L	Fracture of the styloid process
105	4	old adult	F	fibula	R	Well-healed incomplete fracture on distal end

on the proximal end of the posterior surface of the left femur, and was 33mm in length. Another was found on the proximal end of the right femur (posterior-lateral surface). This cut was approximately 4mm deep, but only the cortex was affected. There was no evidence of healing suggesting that the individual died at the time the cuts were made. The placement of the cuts – and the type of cuts – suggested a violent attack from behind, with a sharp weapon such as a sword.

An old adult male (Burial 113) had a healed wound to the right parietal bone (near the occipital), possibly as a result of a sharp blade. The wound was oval – approximately 45mm by 35mm – with definite edges associated with a flat surface, suggesting that the bone was sheared. Within the oval, the bone surface was very slightly irregular, but did not affect the inner table of the skull. The interpretation of a healed blade injury may be supported by the number and type of other fractures present on the skeleton. Together, these injuries suggest that this individual likely experienced violent conflict earlier in his life.

There was one case of a mother and her pre-term foetus dying together (Burial 67, 68).

Disablement

Trauma to the vertebrae can result from compression fractures caused by a vertical force induced by a hyperflexion injury, or secondary to osteoporosis (Roberts & Manchester 1995). One example of the latter may be observed on Burial 95, an old adult female from the medieval period. The bones of this individual were light and it is likely that one of her thoracic vertebral bodies collapsed as a result of osteoporosis.

An old adult male from Phase 4 (Burial 90) demonstrated fusion of the bodies (square), apophyseal joints and laminae between T4 and T5 (all vertebrae were present). In addition, T4 was slightly collapsed on the right side, resulting in scoliosis. Ossification of ligaments was also present on a number of lumbar vertebrae, but only L4 and L5 were fused. In this case, the fusion was large and bulbous in appearance. It was also noted that this individual had an area of ossification on the base of the skull (lateral to the left occipital condyle), resulting in limited mobility to raise the head, and causing the head to be permanently faced slightly to the left side. No sacral-iliac fusion was present.

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Digest 4.3 STABLE ISOTOPES OF CARBON AND NITROGEN AND DIET

SHIRLEY CURTIS-SUMMERS (University of Liverpool) (summary from full archive report, OLA 7.2.2.1)

Introduction

Human bones and teeth from forty burials were analysed for stable isotopes of carbon and nitrogen, with a view to determining choices and changes in diet. Of these, five were from Period 1 (pre-monastic), thirteen from Period 2 (monastic), four from Period 3 (post-monastic) and twenty from Period 4 (medieval) (see Illus 3.25 for summary).

Faunal

Faunal samples were included to provide baseline isotopic data to interpret the human δ^{13}C and δ^{15}N values. Mean δ^{13}C and δ^{15}N values for the monastic period cattle ($n = 7$) were $-22.1‰ \pm 0.3‰$ (1σ) and $5.9‰ \pm 1.2‰$ (1σ) respectively. One cattle sample (C3122/10) from the monastic period is considerably lower when compared to mean δ^{15}N values from cattle in the same period. This difference ($\Delta = 3.0‰$) may be due to a number of factors, such as originating from a different geographical region and consuming different types of fodder or grazing on unimproved pasture, which resulted in lower δ^{15}N values. For example, δ^{15}N values in chaff and cereal straw are suggested to be lower and more variable than in grain.

The faunal baseline shift in δ^{15}N values from the monastic to the late medieval period is reflected in the human isotope ratios. The δ^{15}N ratios for monastic individuals are around +2–5‰ higher than the corresponding cattle and pigs, reflecting a trophic level increase, which are higher than the fauna by around δ^{15}N +2–6‰ and in δ^{13}C by around +2–3‰

Human – Period 1 (550–700)

The pre-monastic (Period 1) burials (Burial 166, Burial 169 and Burial 172) showed similar δ^{13}C values to the Monastic burials (Period 2) that followed. One adult male from Period 1 (Burial 169) had slightly lower δ^{15}N values than the rest of the monastic group, although not of sufficient magnitude to suggest a trophic level difference. The two adult females from Period 1 (Burial 172 and Burial 166) were buried in long cist graves, which may suggest their burials were of a status higher than that of a servant. However, the isotope values of these individuals suggest that they were consuming similar foods to the monks, who succeeded them in Period 2. The female sample numbers for Period 1 ($n = 2$) and Period 2 ($n = 2$) were too small to provide an informative statistical comparison against the corresponding males.

Period 2 Monastic (c 700–c 830)

The monastic human ($n = 21$) δ^{13}C values range between –21.2‰ and –18.9‰ ($\Delta = 2.3‰$), with a mean of $-20.4‰ \pm 0.6‰$ (1σ). The δ^{15}N values range between 10.0‰ and 14.6‰ ($\Delta = 4.6‰$), with a mean of $12.2‰ \pm 1.2‰$ (1σ). Relative to the faunal data, human δ^{13}C values for the monastic periods reflect a predominantly terrestrial C3-based diet with no input of C4 or marine resources. δ^{15}N values for these individuals are a trophic level higher (+2–5‰) higher than the corresponding cattle and pigs. This, along with the archaeological faunal remains, suggests the early medieval monastic community were consuming a significant amount of terrestrial animal protein, such as pork, beef and dairy products. One adult male from Period 2 (Burial 144; cal AD 680–890) had atypical isotope results, with δ^{13}C and δ^{15}N values within the range of the Period 4 inhabitants, suggesting this individual's diet may have included some marine protein.

Period 3 (post-Monastic)

Only seven burials were defined as belonging to this period (ninth–eleventh century), which follows the destruction of the monastery. The results from the four analysed here (Burial 136, 147, 152, 158) suggests that it belongs nutritionally to the monastic group (Period 2), rather than the medieval group (Period 4).

Period 4 (medieval, twelfth–sixteenth century)

Medieval human ($n = 19$) δ^{13}C values range between –20.4‰ and –17.1‰ ($\Delta = 3.3‰$), with a mean of $-18.8‰ \pm 0.9‰$ (1σ). Medieval human δ^{15}N values range from 12.7‰ to 16.6‰ ($\Delta = 3.9‰$), with a mean of $14.8‰ \pm 1.0‰$ (1σ). The δ^{13}C and δ^{15}N values are therefore higher in the lay individuals compared to the earlier monastic individuals, representing a diachronic change in diet over these periods at Portmahomack.

The faunal baseline shift, which is reflected in the human isotope ratios, suggests that contrary to the earlier periods, δ^{13}C and δ^{15}N values from the lay individuals reflect a significant trophic level increase in δ^{15}N and a shift towards higher δ^{13}C ratios. Based on archaeological and isotopic evidence, the lay inhabitants at Portmahomack had a diet that probably included beef, cereals (eg wheat, barley), pork, lamb, dairy foods and marine fish.

Although it has been suggested that manuring significantly increases δ^{15}N values in cereals, a major component of cereal grain in the late medieval individual's diet would be needed to reflect such high δ^{15}N values, which does not appear evident. Other explanations for greater δ^{13}C and δ^{15}N values in these individuals include increased δ^{13}C values in herbivores that grazed on seaweed, or on salt marshes, which can increase δ^{15}N values. Such occurrences would result in a shift in human carbon and nitrogen isotope ratios, through consumption of these animals.

Mean δ^{13}C and δ^{15}N isotope values for the medieval lay male and female bone collagen revealed little significant statistical difference, suggesting both men and women from this group consumed similar foods of C3 plants and terrestrial and marine protein. However, atypical isotope results were found in one adult female (Burial 105) from Period 4 who had the lowest δ^{13}C (–20.4‰), and δ^{15}N (12.7‰) values of this group. The isotope results from this individual fell within the Period 2 group and differed from the other medieval individuals in both δ^{13}C ($\Delta = 1.3‰$) and δ^{15}N ($\Delta = 2.0‰$), suggesting a more terrestrial-based diet.

When individual δ^{13}C and δ^{15}N values are plotted for the 26–45 years and 46+ years age groups from the monastic burials, no significant difference in diet relating to age is apparent for the corresponding males. The 26–45 male (Burial 93) has the highest δ13C and δ^{15}N isotope values out of the whole group and a whole trophic level difference compared to, for example, the two 45+ males (Burial 64 and Burial 113) that have the lowest δ^{15}N isotope values out of the males from this group. This may reflect a division in the types of animal protein that were being consumed, with some of the younger individuals possibly consuming different types of marine protein than the older individuals.

Conclusion

When the early medieval/monastic and late medieval/lay isotope data from Portmahomack are compared with a selection of comparable sites, a pattern emerges that is consistent with recent studies, which suggests a diachronic change in diet. The early medieval monastic community ate predominantly terrestrial plant and animal protein, while the subsequent parish church community at Portmahomack ate terrestrial plant and animal protein plus marine fish. This temporal increase in carbon and nitrogen isotope ratios was also found in the faunal baseline and may reflect a change in husbandry practices in the later medieval period, such as increased manuring and/or salt marsh grazing. No dietary differences relating to sex was found in the medieval population, but younger adults had higher $\delta^{15}N$ values and although this finding was only weakly significant, it may suggest they ate more marine protein than the older individuals. No significant change in diet from childhood to adulthood was found in either the monastic or medieval populations.

Overall, the results are suggestive of a monastic community that reared animals for a number of uses, including human consumption, but chose not to exploit nearby marine resources, relying heavily on terrestrial-based foods. In contrast, the isotope evidence suggests the mid–late medieval (*c* AD 1100–1600) inhabitants at Portmahomack consumed a wide variety of foods, including animal protein from pork, beef, lamb and fish, which is supported by the faunal remains present. These individuals exploited marine resources, either by choice or through necessity.

Table D4.3.1
$\delta^{13}C$, $\delta^{15}N$ human bone and dentine collagen results and archaeological data from Portmahomack

Burial No[a]	Mass Coll (mg)	$\delta^{13}C$	$\delta^{15}N$	Collagen Yield (%)[b]	C:N[c]	Age[d]	Sex[d]	Period[e]
166	44.4	−21.0	10.8	10.4	3.2	Adult	F?	1
169	37.8	−20.7	10.0	8.8	3.2	26–45	M	1
172	41.9	−20.8	10.9	10.1	3.2	46+	F	1
116	43.9	−20.3	13.0	11.0	3.2	26–45	M	2
124	21.3	−20.8	11.4	5.1	3.2	17–25	M	2
124T	1.2	−21.2	11.7	0.6	3.3	17–25	M	2
127	45.4	−20.4	11.8	10.6	3.2	26–45	M?	2
128	18.4	−20.5	11.7	4.4	3.3	46+	M?	2
140	8.1	−20.3	12.5	2.0	3.2	17–25	M	2
144	10.6	−19.1	14.6	2.4	3.2	46+	M	2
144T	25.5	−19.9	14.6	8.1	3.2	46+	M	2
147	21.5	−20.4	11.2	5.4	3.2	26–45	M	3
147T	12.0	−20.5	12.2	4.7	3.2	26–45	M	3
151	25.8	−20.6	12.6	6.6	3.2	46+	M	2
152	25.3	−20.5	11.7	6.0	3.2	26–45	M	3
152T	7.4	−20.9	12.6	3.5	3.2	26–45	M	3
154	37.5	−20.4	11.8	9.3	3.2	26–45	M	2
158	33.9	−20.3	12.4	8.6	3.2	46+	M	3
158T	12.0	−20.5	12.8	4.7	3.2	46+	M	3
160	32.7	−20.7	11.1	7.7	3.2	46+	M?	2
164	34.1	−20.2	12.8	8.3	3.2	26–45	M	2
168	15.1	−20.0	12.3	3.8	3.2	26–45	M?	2
171	11.7	−19.7	12.2	2.9	3.2	26–45	M	2
174	53.5	−21.1	11.4	12.4	3.2	adult	F?	2
112	28.1	−18.9	14.3	7.1	3.2	46+	M	4
112T	17.1	−19.5	14.1	7.5	3.2	46+	M	4
136	5.5	−21.1	11.9	1.3	3.3	46+	M	3
35	9.4	−17.3	15.4	2.4	3.2	17–25	M	4
64	29.5	−19.3	13.9	7.8	3.2	46+	M	4
69	4.8	−19.7	14.4	1.2	3.6	46+	F	4
83	26.8	−19.4	14.9	6.4	3.2	26–45	F?	4
85	22.1	−18.0	15.1	5.2	3.2	17–25	M?	4

Burial No[a]	Mass Coll (mg)	δ13C	δ15N	Collagen Yield (%)[b]	C:N[c]	Age[d]	Sex[d]	Period[e]
88	14.8	−18.4	15.0	3.5	3.2	26–45	F	4
88T	10.5	−19.2	13.8	4.9	3.2	26–45	F	4
90	14.5	−17.9	15.1	3.7	3.2	46+	M	4
91	15.1	−19.8	14.0	3.5	3.2	26–45	F	4
93	35.1	−17.1	16.6	8.7	3.2	26–45	M	4
97	22.4	−18.3	14.9	5.2	3.2	46+	F?	4
98	32.5	−17.9	15.8	7.7	3.2	26–45	M	4
100	16.6	−19.3	15.0	3.8	3.2	26–45	F	4
100T	12.1	−19.1	15.8	5.6	3.2	26–45	F	4
102	31.5	−17.8	16.1	7.5	3.2	26–45	F	4
103	27.1	−18.0	15.5	7.0	3.2	26–45	M	4
105	27.4	−20.4	12.7	6.8	3.2	46+	F	4
106	14.8	−18.7	15.5	3.4	3.2	46+	F	4
108	28.2	−19.5	14.7	6.8	3.2	26–45	M	4
109	49.2	−18.2	14.4	11.5	3.2	46+	M	4
113	23	−19.1	13.8	5.8	3.2	46+	M	4
113T	16.1	−20.0	13.1	7.7	3.2	46+	M	4

a Human bone samples taken from ribs. ‘T’ denotes tooth sample (permanent 1st molar root)
b Yield (%) = Mass mg collagen / weight (bone) mg × 100
c Acceptable C:N ratio (see DeNiro 1985)
d Ageing and sexing (M = male, F = female, ? = probable) information extracted from King (2000)
e Periods: 1 = Pre-monastic, 2 = Monastic, 3 = Post-Monastic, 4 = Medieval

Digest 4.4 COMBINED STRONTIUM AND OXYGEN ISOTOPE DATA AT PORTMAHOMACK

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and JANE EVANS (British Geological Survey)

(see Illus 3.26 for summary)

Introduction

The movement of people and populations in past societies is an abiding theme in both archaeology and bioarchaeology. The migration of peoples to different areas and environments may explain changes in the archaeological record but can arise through many causal factors, such as marriage, agriculture, war and cultural differences (Price et al 2004). Both radiogenic and stable isotope analysis is increasingly used to directly detect migration and diet in the past by analysing the skeletons of the people who migrated, rather than inferring human mobility from the appearance of new artefacts and cultural practices. The isotope systems most frequently used to detect human migration are those of strontium and oxygen. These provide independent information related to the place of origin of an individual: strontium isotopes in the environment vary geographically with solid and drift geology (Bentley 2006; Evans et al 2010) and oxygen isotopes vary with climate, altitude and distance from the sea (Longinelli 1984; Darling et al 2003; Daux et al 2008). These two elements are found in the environment and, primarily through the ingestion of food (strontium) and water (oxygen), become incorporated into the human skeleton, linking the person to the place they sourced their food and drink. Strontium and oxygen isotope analysis was, therefore, undertaken on thirty-one individuals buried at or near Portmahomack, to investigate the degree of residential mobility amongst the population by identifying local and non-local origins.

Materials

Tooth samples for strontium and oxygen isotope analysis were obtained from human permanent dentition (molars and premolars) of twenty-nine individuals from the Tarbat Old Church (St Colman's Church) site in Portmahomack and two individuals from Balnabruach, near Portmahomack. In addition, two prehistoric individuals were included that were discovered in 1992 during ground preparation for a pump house near Balnabruach. Daphne Home Lorimer conducted the skeletal report on the prehistoric human remains in 1995 (Lorimer 1995). Field Archaeology Specialists Ltd (FAS) excavated the skeletons at Tarbat Old Church between the 1994 and 2002 field seasons (Carver 2003) and Sarah E King (2000) performed the skeletal analysis. Thirty-one teeth were selected for strontium and oxygen isotope analysis to determine possible local origins of individuals buried in and near the church. Periods represented within this sample include: Period 0 (prior to sixth century AD); Period 1 (AD 550–700); Period 2 (AD 700–830); Period 3 (AD 830–1100); Period 4 (1100–1600); and Period 5 (1600–2000). Two main socio-economic populations were represented:

1. Periods 2 and 3 represented a monastic/post-monastic settlement at Portmahomack during the early medieval period, which was determined from the population demographic of the burials (Carver 2008). A large number of male burials, aged between 17 and 46+ years at death, were excavated, whilst few females and non-adults were present (King 2000; Carver 2008).
2. Period 4 contains males, females and non-adult burials ranging in age at death and is believed to represent the inhabitants of a medieval settlement (Carver 1997; King 2000; Carver 2008).

The analysis of the thirty-one enamel samples (one from each individual) was completed on two separate occasions. An initial pilot study of twelve teeth was followed by a larger sample of nineteen teeth (Walther 2012). Prior to sampling, a digital photographic record of each tooth was taken from the buccal, lingual, mesial, distal, occlusal and root angles.

Methods

Core enamel was used for strontium and oxygen isotope analysis because several studies have shown that it is considerably less susceptible to diagenetic change than bone or dentine and retains lifetime values from the time of tooth formation, ie childhood (Budd et al 2000; Montgomery 2002; Hoppe et al 2003). Each tooth forms during a well-constrained period of time in an individual's life and thus contains elemental strontium and oxygen absorbed from the diet during that period. With few exceptions, all the teeth in human permanent dentition complete their crowns between 2.5 and 15 years of age (Table D4.4.1). Consequently, the period of life represented by each isotope measurement will depend on the specific tooth selected for analysis (see Table D4.4.2 for details of the samples measured in this study).

Tooth sample preparation followed guidelines outlined by Montgomery (2002). Enamel was removed from the teeth using tungsten carbide burrs and diamond-edged dental saws. All surface enamel and adhering dentine was mechanically removed and enamel that was visibly cracked, discoloured or carious was not sampled. In addition, a dentine sample was taken from the crown of four teeth (16, 41, 127 and 140) to monitor diagenetic strontium: dentine has been shown to absorb labile soil strontium and is a useful indicator of local strontium ratios pertaining during the period of burial (Montgomery et al 2007). Cleaned chips of core enamel and dentine were sealed in containers and transferred to the class 100, HEPA-filtered laboratory facility at the NERC Isotope Geosciences Laboratory (NIGL) in Keyworth, UK. Strontium isotope samples were prepared and measured as outlined in Evans et al (2006). The concentrations of $^{87}Sr/^{86}Sr$ were determined by Thermal Ionisation Mass spectrometry (TIMS) using a ThermoTriton thermal ionisation multicollector mass spectrometer. The NBS 987 International $^{87}Sr/^{86}Sr$ standard gave a value of 0.710251 ± 0.00001 (2s, $n = 18$). Laboratory contamination, monitored by procedural blanks, was negligible (< 100pg).

Oxygen isotope ratios are reported in parts per mil (‰, $^{18}O/^{16}O$) relative to the international standard Standard Mean Ocean Water (SMOW). Oxygen isotopes for the twelve pilot samples were measured by conversion to silver phosphate, following the method outlined in Chenery et al (2010). Phosphate oxygen isotope ratios ($\delta^{18}O_p$) were obtained using thermal conversion continuous flow isotope ratio mass spectrometry (TC/EA-CFIRMS) with a ThermoFinnigan thermal conversion elemental analyser gas chromatography (GC) column coupled to a ThermoFinnigan DeltaplusXL via a ConFlo III continuous flow interface. The samples were measured in triplicate, corrected for non-linearity and drift, and converted to the VSMOW scale against NBS120C. Estimated analytical precision,

Table D4.4.1
Permanent dentition crown mineralisation and root completion times for the teeth used in this study.
Source: Gustafson and Koch (1974); third molar data from Anderson et al (1976)

Tooth	Initial crown mineralisation	Crown complete	Eruption	Root complete
First molar	Peri-natal–birth	2.5–4.25 years	5–8 years	9–11.5 years
Second molar	2.5–3 years	7–8 years	10–14 years	14–16 years
Third molar	8–11 years	11.5–15 years	–	17–19 years
First premolar	1.5–2 years	4.5–7 years	8–12 years	12–14.25 years
Second premolar	2–2.5 years	6–8 years	9–14 years	12–15.5 years

based on the reproducibility of international and in-house standards, is ±0.16‰ (1SD).

Oxygen isotopes for the second batch of nineteen enamel samples were determined by measurement of enamel carbonate using a GV IsoPrime dual inlet mass spectrometer. Carbonate oxygen isotope ratios ($\delta^{18}O_c$) were normalised to v-PDB using an in-house reference material calibrated against NBS19 certified reference material. Analytical precision was estimated as ±0.02‰ (1SD). In order to facilitate comparison between the initial pilot batch and the subsequent nineteen samples, $\delta^{18}O_c$ values were reported relative to SMOW using the equation from Coplan (1988) (SMOW = 1.03091 × δ^{18}O PDB +30.91). These ratios were then converted to $\delta^{18}O_p$ using the regression formula published by Chenery et al (2012):

$$(\delta^{18}O_p = 1.0322(\pm 0.008) * \delta^{18}O_c - 9.6849 (\pm 0.187))$$

This equation has an associated maximum error of ±0.013‰, 1SD.

Results

The isotope results are presented in Table D4.4.2. The $^{87}Sr/^{86}Sr$ sample for Skeleton 152 failed and could not be re-measured during the timescale of this project. Strontium isotope ratios for the thirty individuals measured exhibit a wide range of ratios from 0.7097 to 0.7152, with a median value of 0.7112 (Illus D4.4.1). The assumption of normality is rejected with 95% confidence (Anderson-Darling, $p = 0.038$). Strontium concentrations range from 57ppm to 200ppm and are consistent with other archaeological individuals from Britain (Evans et al 2012). There is no correlation between $^{87}Sr/^{86}Sr$ and strontium concentrations ($r^2 = 0.16$).

The $\delta^{18}O_c$ values for the nineteen samples range between 24.6‰ and 27.4‰ (±0.16‰ 1SD), with a mean value of 26.0‰ ± 1.6‰ (2SD). As described above, to facilitate comparison with the pilot data these were converted to $\delta^{18}O_p$ using the equation from Chenery et al (2012). The resulting range of $\delta^{18}O_p$ values obtained from the Portmahomack individuals was 15.7‰ to 18.6‰, with a median and mean value of 17.4‰ (± 1.6, 2SD, n = 30) (Illus 4.4.2). The assumption of normality is accepted with 95% confidence (Anderson-Darling, $p = 0.254$). There is no correlation between $\delta^{18}O_p$ values and $^{87}Sr/^{86}Sr$ of individuals ($r^2 = 0.09$). An estimated uncertainty to encompass reasonable measurement and conversion errors for $\delta^{18}O_p$ values of ±0.2‰ (1SD) is shown in Illus D4.4.3 and 4; at 1SD there is only a 66% probability that the true value lies within this range and this should be borne in mind when assigning origins. In contrast, there is a 99.9% probability that the true value for $^{87}Sr/^{86}Sr$ lies within the symbols.

The range of strontium isotope ratios that would be expected for human inhabitants of the Devonian Old Red Sandstone of the Tarbat peninsula was estimated from published measurements of mineral waters, stream waters, plants and archaeological dentine from geologically comparable biospheres in Scotland. These provide a range of values from 0.7093 to 0.7116 with a single outlier at 0.7133 and a mean of 0.7098 ± 0.0010 (1s, n = 29) (Evans et al 2010). The four dentine samples measured from burials at Portmahomack range from 0.7098 to 0.7116, which agrees well

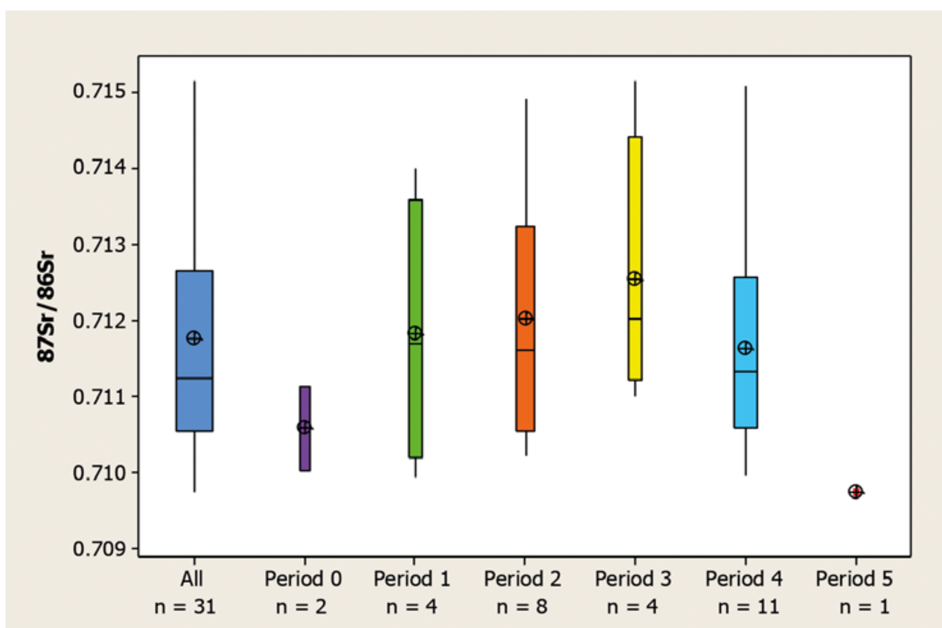

Illustration D4.4.1
A Box and Whisker plot of strontium isotope results by period. Mean (circle) and median (line) values are shown. Box width indicates size of sample (n) and contains 50% of the individuals (the Interquartile Range). Whiskers indicate the range of the data. No outliers (values that exceed 1.5×IQR) are present

Table D4.4.2

Sample details and strontium and oxygen isotope results for skeletons from Portmahomack. The $\delta^{18}O_p$ values for the twelve pilot samples are measured but for the remainder they are calculated from the $\delta^{18}O_c$ c value. Calculated $\delta^{18}O$ phosphate and drinking water (from phosphate) values are in italics and were obtained using the equations in Chenery et al 2012 and Daux et al (Eq. 6, 2008). External reproducibility and measurement errors are estimated at ± 0.002% (2SD) for $^{87}Sr/^{86}Sr$, ± 0.02‰ (1SD) for $\delta^{18}O_c$ and ± 0.16‰ (1SD) $\delta^{18}O_p$

Burial	Period	Sex	Age	Tooth	Tissue	$^{87}Sr/^{86}Sr$	Sr ppm	$\delta^{18}O_c$‰	$\delta^{18}O_p$‰	$\delta^{18}O_{dw}$‰
Balnabruach A	0	n/k	n/k	M2	enamel	0.71003	142	26.6	*17.7*	*–6.5*
Balnabruach C	0	n/k	n/k	M2	enamel	0.71113	90	25.8	*17.0*	*–7.5*
016	4	juv	6.6–10.5	M1	enamel	0.70995	129	–	18.4	*–54*
					dentine	0.7098	348	–	–	–
017	5	m	26–45	P1	enamel	0.70975	146	27.4	*18.6*	*–5.7*
030	4	m	46+	M3	enamel	0.71068	106	25.4	*16.6*	*–8.2*
035	4	m	17–25	M1	enamel	0.71158	74	–	18.5	*–5.2*
036	4	m	46+	M3	enamel	0.71258	76	27.1	*18.3*	*–5.5*
041	4	m	17–25	M1	enamel	0.7.1510	147	–	18.5	*–5.2*
					dentine	0.71160	210	–	–	–
054	2	m	17–25	M1	enamel	0.71040	141	–	17.5	*–6.7*
062	4	f	46+	P2	enamel	0.71285	200	25.7	*16.8*	*–7.8*
086	4	juv	6.6–10.5	M1	enamel	0.71256	104	–	18.0	*–6.1*
088	4	f	26–45	P1	enamel	0.71065	124	27.4	*18.6*	*–5.1*
110	4	juv	10.6–14.5	M1	enamel	0.71134	149	–	18.4	*–5.4*
111	3	m	23–45	M3	enamel	0.71224	143	26.2	*17.3*	*–7.1*
117	4	m	17–25	M3	enamel	0.71019	153	26.0	*17.2*	*–7.2*
119	4	juv	10.6–14.5	M1	enamel	0.71059	101	–	18.5	*–5.2*
127	2	m?	26–45	M2	enamel	0.71112	165	–	17.5	*–6.7*
					dentine	0.71129	167	–	–	–
129	2	?m	17–25	M3	enamel	0.71492	109	24.6	*15.7*	*–9.5*
130	2	m	23–45	P2	enamel	0.7.1212	113	26.4	*17.6*	*–6.6*
136	2	m	46+	M3	enamel	0.71102	187	25.8	*16.9*	*–7.7*
140	2	m	17–25	M2	enamel	0.71334	85	–	17.3	*–7.1*
					dentine	0.7.1127	225	–	–	–
144	2	m	46+	M2	enamel	0.7.1022	152	26.0	*17.1*	*–7.4*
147	3	m	26–45	M3	enamel	0.71101	142	–	17.8	*–6.3*
152	2	m	26–45	P2	enamel	tailed	failed	25.1	*16.2*	*–8.8*
153	2	m	26–45	M3	enamel	0.71301	64	24.7	*15.8*	*–9.4*
156	3	m	26–45	M3	enamel	0.7.1182	124	26.1	*17.3*	*–7.1*
158	3	m	46+	P2	enamel	0.71516	87	26.2	*17.4*	*–6.9*
170	1	m	26–45	M2	enamel	0.70993	185	–	17.3	*–7.0*
172	1	f	46+	M1	enamel	0.71104	99	–	17.8	*–6.3*
186	1	m	26–45	P2	enamel	0.71235	82	25.0	*16.1*	*–8.9*
187	1	m	46+	M2	enamel	0.71401	57	26.0	*17.1*	*–7.4*

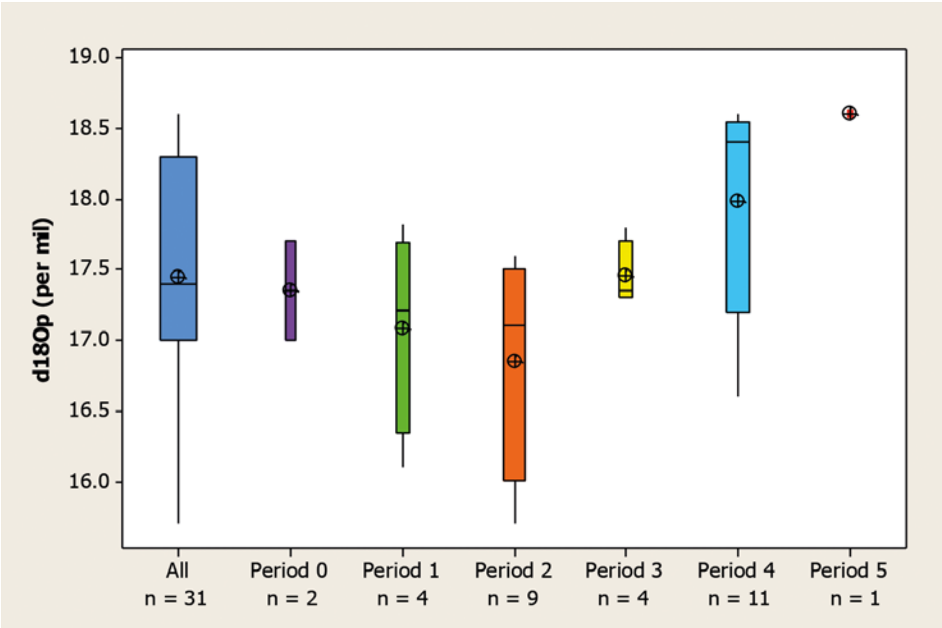

Illustration D4.4.2
A Box and Whisker plot of oxygen isotope results by period. Mean (circle) and median (line) values are shown. Box width indicates size of sample (n) and contains 50% of the individuals (the Interquartile Range). Whiskers indicate the range of the data. No outliers (values that exceed 1.5 × IQR) are present

with the published data above and suggest the dentine is incorporating strontium with an isotope ratio below 0.710 from the burial soil. These values may reflect the combination of soils derived from the underlying rocks and atmospheric strontium due to the coastal, maritime location of the site: rainwater, marine shell-sands, sea-splash and spray can lower or raise biosphere and human strontium isotope ratios towards 0.7092, which is the value of seawater and marine products (Montgomery et al 2003; Evans et al 2010). Sixteen individuals have a strontium isotope ratio that is consistent with origins on the coastal Old Red Sandstone at Portmahomack (Illus D4.4.3). Fourteen individuals from Periods 1 to 4 exhibit strontium isotope ratios which are higher than those expected for individuals originating from the Tarbat Peninsular and indicate origins in regions of older silicate or granitic rocks. These can be found widely in the Highlands of Scotland, where biosphere values and a small number of human enamel values exceeding 0.716 have been obtained (Evans et al 2012). No individuals have strontium isotope ratios indicative of origins in regions of basalts, chalks or limestones.

Evans et al (2012) defined the range for $\delta^{18}O_p$ in archaeological human enamel from across Britain to be 16.3–19.1‰ (mean = 17.7‰ ± 1.4‰ 2SD, n = 615). Inhabitants of eastern Britain were found to have a mean value of 17.2‰ ± 1.3‰ (2SD, n = 83) and western Britain a mean value of 18.2‰ ± 1‰ (2SD, n = 40). Using these estimates, the ranges for eastern and western Britain were calculated at the 1SD level and used in Illus D4.4.3 and 4. Only four individuals from Periods 1 and 2 (Burials 129, 152 (not plotted), 153 and 186) fall outside this 1SD range, having lower values; these are discussed further below. To facilitate comparison with geographical variation of mean annual precipitation in Britain, which ranges from −4.0‰ in the west to −9.0‰ in the east, measured and calculated $\delta^{18}O_p$ values can be converted to precipitation values; rainwater in Britain has been shown to be the principal source of ground and surface waters, and hence, drinking water (Darling & Talbot 2003; Darling et al 2003). However, there are several published equations to do this and all give slightly different results. Those in Table D4.4.2 were calculated using Daux et al (2008) Eq. 6 and range from −5.1‰ to −9.5‰ but the associated error is large (Pollard et al 2011). Based on the published oxygen isotope ratio precipitation map of Darling and Talbot (2003), individuals with $\delta^{18}O_{dw}$ above −7.0‰ are likely to originate in the higher rainfall regions of the western and south-western seaboard of Britain (and by extension Ireland) or the Western and Northern Isles. Individuals with values below −7.0‰ would be consistent with eastern, central and upland Britain and Ireland. Illus D4.4.3 shows that the majority of the early medieval population (Periods 1, 2 and 3) are consistent with origins in eastern or central Britain, whilst only individuals in Period 4 and 5 have $\delta^{18}O_p$ values above 17.9‰, suggesting origins in western Britain or the Northern Isles for a significant proportion of this later medieval sample. There is a statistically significant difference between the early medieval (Periods 2 and 3) and later medieval (Periods 4 and 5) $\delta^{18}O_p$ values (t-Test; $p<0.004$, $n = 27$). It is possible that some of the higher oxygen isotope ratios in this group may be due to analytical uncertainty, the sampling of first molars with a significant breastfeeding component, or a radically warmer climate in the second millennium AD, but none are likely to produce the required ~2‰ shift in $\delta^{18}O_p$ values away from the expected local values at Portmahomack. It is worth noting that the single named individual in the study, William Mackenzie in Period 5, is known to have originated in the west of Scotland and has an oxygen isotope ratio consistent with that which would be expected from the western seaboard (Evans et al 2012). These non-local individuals are discussed further below.

Discussion

Although the population sampled from Portmahomack is small, it nonetheless exhibits a wide range in both strontium and oxygen isotope ratios that are not indicative of a wholly sedentary population. Unfortunately, northern Scotland is not currently a well-characterised region for either oxygen or strontium isotopes of ancient humans due to its heterogeneous and ancient geology, the highland regions, and the shortage of excavated human and animal remains. Until these regions are better characterised for both isotope systems in humans, it is difficult to identify all possible places of origin within Britain, let alone beyond its shores. However, it is clear that the range of both strontium and oxygen isotopes obtained from Portmahomack represents a variety of origins for the population in the first and second millennium AD, both within and possibly outside Great Britain.

Period 0 and Period 1

There are a total of six samples dating from Period 0 (prior to the sixth century AD) and Period 1 (AD 550–700). The two Period 0 individuals from Balnabruach are within the local range for both strontium and oxygen isotope ratios (ie coastal Old Red Sandstone and east coast precipitation). In contrast, the four individuals dating to Period 1 are isotopically varied. A male skeleton (170) falls within the local isotope range for Portmahomack. The female long cist burial (172) falls in the oxygen isotope range for western, or possibly central,

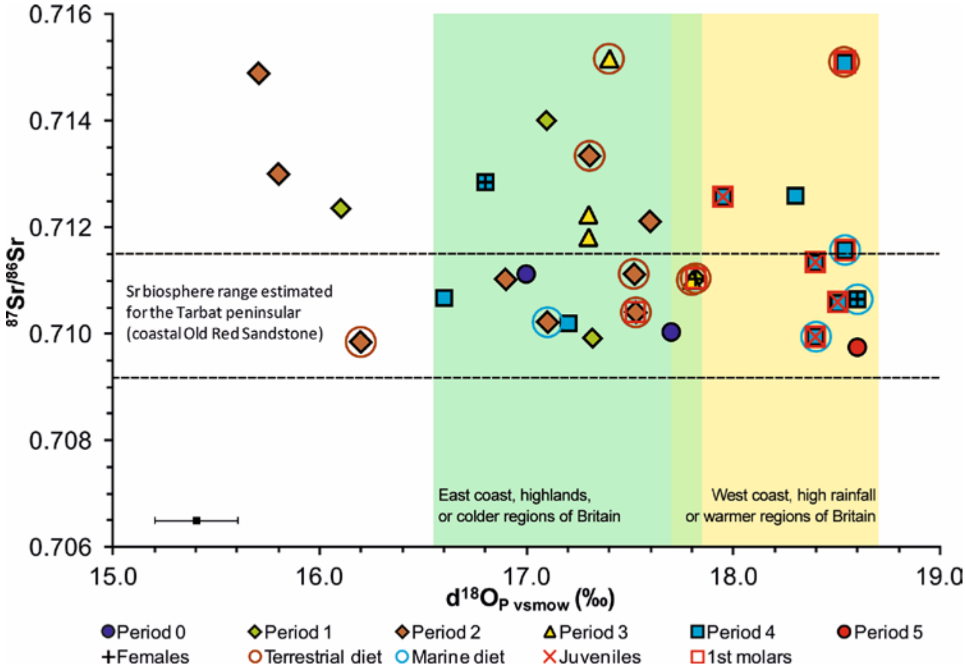

Illustration D4.4.3

A scatterplot of strontium and oxygen isotope ratios for the thirty individuals from Portmahomack. Burial 152 from Period 2 had a $\delta^{18}O$ value of 16.2‰ but no $^{87}Sr/^{86}Sr$ result so cannot be plotted here. The ranges for phosphate oxygen isotopes of humans originating from eastern and western Britain are given at 1SD level (Evans et al 2012). Estimated measurement error at 2SD is within the symbol for strontium (2SD) and for oxygen is conservatively estimated at ±0.2‰ (1SD) to encompass all measurement and calculation errors

Britain. The other two male long cist burials (186 and 187) have high strontium isotope ratios, indicating they are not of local origin and came to Portmahomack from regions of older or granitic rocks, possibly away from the coast and/or in upland regions. The oxygen isotope ratio of 16.1‰ for skeleton 186 is very low and outside the range for eastern Britain at the 1SD level (ie 66% probability) as depicted in Illus D4.4.3, but would fall within the range at 95% probability. In contrast, such a value would lie outside the range for Britain as a whole at the 95% probability level (Evans et al 2012). It is, therefore, borderline, and this individual cannot be securely identified as of non-British origin.

Period 2 and Period 3

The majority of the burials dating to Periods 2 (AD 700–830) and Period 3 (AD 830–1100) consist of younger to older adult males with one female and no juveniles. Of the thirten individuals from Periods 2 and 3, only four males/probable males (54, 127, 136, 144) fall within the local range for Portmahomack. These four individuals were buried according to the predominant tradition: supine, unaccompanied and unmarked. Only one individual (147) from Period 2 or 3 has an oxygen isotope ratio that could be consistent with origins in the west: although measurement error introduces a margin of uncertainty to this conclusion, it is worth noting that this male individual was also unique with regards to burial style being the only wood-wicker matrix burial. There is evidence of migration from western Scotland, when Christians are believed to have visited the Northern Isles as early as the sixth century (James 1999) and migrations south from these islands, as well as east, may explain this individual. The remaining eight individuals have either strontium isotopes (111, 130, 140, 156 and 158), oxygen isotopes (152), or a combination of strontium and oxygen isotopes (129 and 153), that place them outside the range estimated for Portmahomack. Burial 156 was buried as a double burial with Burial 136, who seems to be of local origin; these two males have the same oxygen isotope ratios but a slightly different strontium isotope ratio. It is possible that they have the same geographical origins and the difference in strontium isotopes arises through a slightly different access to food resources, which can result in a range of ratios amongst a population (Montgomery et al 2007). Nonetheless, in sharp contrast to the local individuals, these eight appear to have been buried either shrouded or with a head support. Monasteries would contain

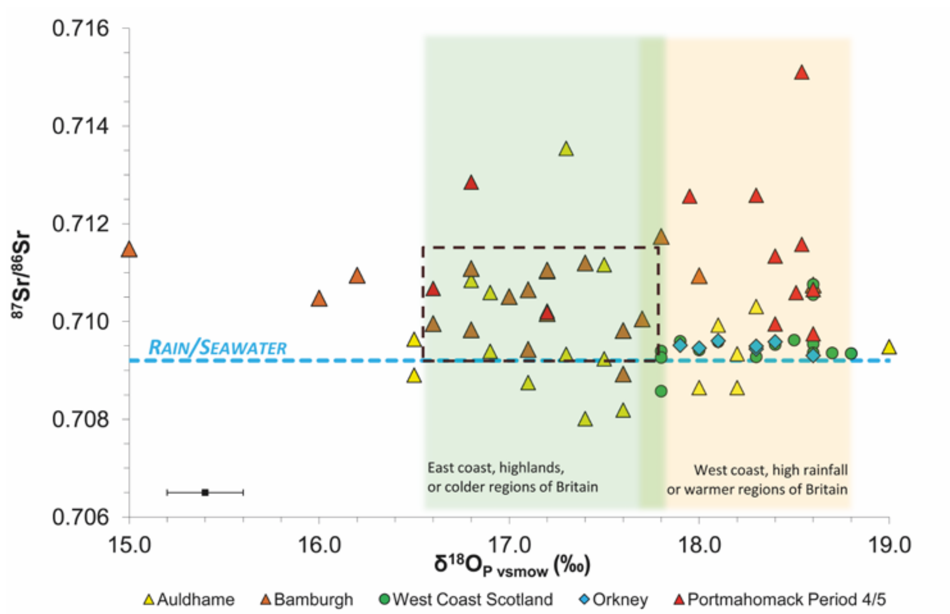

Illustration D4.4.4

A scatterplot of strontium and oxygen isotope data from Period 4 and 5 at Portmahomack compared to other published data from the Western Isles of Scotland (Evans et al 2012) and three medieval sites at Auldhame (Lamb et al 2012), Bamburgh (Groves et al 2013), Orkney (Toolis 2012). The ranges for phosphate oxygen isotopes of humans originating from eastern and western Britain are given at 1SD level (Evans et al 2012). The box indicates the estimated range for Portmahomack. Estimated error at 2SD is within the symbol for strontium (2SD) and for oxygen is conservatively estimated at ±0.2‰ (1SD) to encompass all measurement and calculation errors both clerics and lay individuals from a variety of places and it is perhaps not unusual or unexpected to find individuals in a monastic cemetery who originated elsewhere; such a finding was made in a recent isotopic study of the clerics buried at Whithorn Priory in Dumfries and Galloway (Müldner et al 2009).

The first five (111, 130, 140, 156 and 158), have oxygen isotopes which could indicate origins in eastern Britain or Ireland rather than their western or southern seaboards. However, of particular note are the three male individuals from Period 2 (129, 152 and 153), whose oxygen isotope ratios of 15.7‰, 16.2‰ and 15.8‰ respectively are exceedingly low for either Great Britain or Ireland. Whilst statistically these are not sufficiently low to feature as outliers amongst the Portmahomack population (Illus D4.4.2), such values fall outside the 2SD $\delta^{18}O_P$ range (16.3‰ to 19.1‰) but within the 3SD range for Britain (15.6‰–19.8‰). This gives only a 2.5% probability based on oxygen that these individuals are of British or (by extension as a result of comparable $\delta^{18}O$ precipitation values) Irish origin (Evans et al 2012). Such low oxygen isotope ratios are indicative of origins at higher altitude or in colder, more northerly or more continental regions. Scandinavia, central Europe or mountainous regions of Scotland may thus all be suitable regions of origin. The strontium isotope ratios for 129 and 153 (the sample for 152 failed) would also support origins on old rocks which are found in Scandinavia and the Scottish Highlands. It is worth noting here that Burial 152 had three severe, and possibly fatal, blade wounds.

Period 4 and 5

The medieval burial assemblage from Period 4 (1100–1600) is very different from that of Periods 2 and 3 and includes males, female, and non-adults ranging in age from approximately six to 46+ years. As was found in Periods 2 and 3, there is considerable variability in strontium isotope ratios amongst this group: they range from 0.7099 to 0.7151 (Illus D4.4.1) and, in isolation, this may simply reflect the heterogeneous and ancient geology of northeastern Scotland beyond the Tarbat peninsula. However, of the eleven individuals in Period 4, only two adult males (30 and 117) fall within the strontium *and* oxygen isotope range estimated for Portmahomack (Illus D4.4.3). One other individual, an older adult female (62), has an oxygen isotope ratio consistent with eastern Scotland, but her strontium isotope ratio suggests origins away from the coast on ancient Palaeozoic rocks. The most striking characteristic of the individuals in Period 4 is that, whilst possessing a range of strontium isotopes that suggests they do not share a single common geographic origin, the remaining eight have high oxygen isotopes ratios (ie 18.0‰ or above) that are unlikely to be consistent with origins in eastern or central Britain or Ireland. This non-local group is not restricted to male individuals but includes a female (88) and all the juveniles (16, 86, 110 and 119) measured in the study (Illus D4.4.3). As the first molars measured for these four individuals complete crown formation by the age of five, they must have arrived in Portmahomack during childhood, between the ages of five and death at, variously, 6.5 to 14.5 years of age. It is possible, therefore, that their time at Portmahomack was short, as at least two of these children (16 and 86) appear to have died within two years of arriving. In addition, the non-local group includes the three Period 4 individuals in this strontium/oxygen study (Burials 16, 35 and 88) who were found to have consumed a diet high in marine protein (Curtis-Summers & Montgomery D4.3), one of which is a juvenile (16). The clustering of the strontium, oxygen, carbon and nitrogen isotope data thus suggest a group of immigrant consumers of marine protein, possibly from the western seaboard or Northern Isles, is present in the later medieval period. It is also possible such migrant individuals may be involved in, or connected with, the medieval fishing trade, which may underpin the high level of mobility in this population (Barrett et al 2004).

The analysis of human skeletal remains from Portmahomack by King (2000) revealed the general health of people in Period 4 was poor in comparison to contemporaneous sites within the region. They are slightly shorter in stature and this is particularly apparent amongst females. Stress indicators – such as linear enamel hypoplasia and cribra orbitalia – were recorded and this combination may evidence a population under environmental stress and possible malnutrition (King 2000), which could have been a migratory push factor if these conditions were indicative of their putative homeland in the west.

Combined strontium and oxygen isotope data is only available for a few geographically and temporally comparable populations: on the east coast of northern Britain from seventh–seventeenth century Auldhame in East Lothian (Lamb et al 2012) and Bamburgh in Northumberland (Groves et al 2013); from the thirteenth–fourteenth century cemetery at St Thomas' Kirk in Orkney (Toolis 2008); and burials of various date from the west coast of Britain (Evans et al 2012). As expected, the data from Orkney and the west coast cluster in the range for western Britain and have strontium isotopes dominated by marine strontium ($^{87}Sr/^{86}Sr = 0.7092$) (Illus D4.4.4). The individuals from Auldhame and Bamburgh exhibit wide ranges in oxygen isotopes across the full range for Britain (Auldhame) and beyond (Bamburgh). Several individuals from Auldhame have $^{87}Sr/^{86}Sr$ below 0.7092, which is indicative of the Carboniferous limestone that occurs extensively in southern Scotland, and only one individual has $^{87}Sr/^{86}Sr$ above 0.712, which points to origins on the older and granitic rocks of northern Scotland. Lamb et al (2012) concluded that very little migration to Auldhame was visible in the individuals analysed, which contrasts with the situation at Portmahomack where migrants appear to predominate amongst the study sample.

Environmental and dietary stress is unlikely to explain the presence at Portmahomack of the single individual in Period 5 (1600–2000). Burial 17 was buried in a coffin and has been identified as William Mackenzie. According to Carver (2008), William Mackenzie was a parish minister of Tarbat from 1638 until his death in 1642. His strontium and oxygen isotope ratios are entirely consistent with origins in the Western Isles (Illus D4.44). Based on age at death and the first premolar selected for analysis, William Mackenzie travelled to Portmahomack from the western part of Scotland after the minimum age ranges of 4.25–7 years of age.

Conclusion

Migration to Portmahomack from various regions within and outside of Great Britain was detected during the monastic phases of Periods 2 and 3 (AD 550–1100) and the medieval Period 4 (1100–1600). However, in Periods 2 and 3 the majority of the migrants appear to be from the eastern part of mainland Great Britain or Ireland and there are suggestions that origins may be linked to burial rite. Two, possibly three, burials within this phase have such low oxygen isotope ratios that there is only a 2.5% probability that they originate from Great Britain and Ireland. Such values would be found at higher altitude, and in colder, more continental or more northerly regions such as Scandinavia or central Europe.

In the medieval Period 4, the majority of individuals investigated appear to originate from the western or southern seaboard of Britain or Ireland, or the Northern Isles. This non-local group includes males, females and juveniles and implies the medieval population at Portmahomack were highly mobile. Given the evidence that they were marine protein consumers and the osteological evidence for nutritional stress, this may be linked to the fishing trade or to migration due to economic factors. The lack of comparative sites in the north-eastern part of Scotland makes it difficult to compare Portmahomack to similarly sited, contemporaneous sites, and further isotopic studies of humans excavated from Scotland are recommended to elucidate and interpret Scotland's past more clearly.

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Digest 4.5 STARCH

BECCA WALTERS (formerly of University of York) (summary of full report, OLA 7.2.3)

Fifteen individuals were examined from the main periods of occupation at Tarbat, but only thirteen starch granules were recovered from seven individuals.

Out of the thirteen starch granules that were discovered, seven could be considered as either oat or wheat granules, while one could be possibly be identified as a barley granule.

There was no result from Period 1. Two individuals in Period 2 had been eating barley, and oats or wheat. Three individuals in Period 4 had been eating oats or wheat and some tubers. The individual from Period 5 (The Rev Mackenzie) had been eating oats or wheat.

Table D4.5.1
Starch granules identified in dental calculus

Burial	Period	Size of granule	Shape of granule	Possible identification
22	5	9.53µm, 9.13µm	Round	Oat or wheat
16	4	27.61µm (length) 20.79µm (width)	Oval	Tuber
16	4	9.11µm, 10.28µm	Round	Oat or wheat
16	4	10.85µm, 9.87µm	Round	Oat or wheat
91	4	14.55µm (length), 11.23µm (width)	Oval	Bean
91	4	7.32µm (length), 5.27µm (width)	Oval	Bean
100	4	13.13µm, 13.69µm	Round	Oat or wheat
100	4	5.80µm, 4.04µm	Round/slightly oval	Undetermined
144	2	15.09µm (length), 17.46µm (width)	Round/slight oval	Barley
127	2	13.82µm, 11.71µm	Round	Oat or wheat
127	2	13.72µm (length), 11.02µm (width)	Round/slightly oval	Oat or wheat
Burial 127 [F128] (attached to above mentioned granule)	2	10.20µm (length), 9.45µm (width)	Round/slightly oval	Oat or wheat
149	1	11.27µm, 11.83µm	Round/bell-shaped	Undetermined

From OLA 7.2.3, Table 5.7: The measurements were taken for the length and width, or in the cases of round granules, measurements were taken along the arms of the cross.