

The Deep-Sea Tortugas Shipwreck, Florida: the Animal Bones

Philip L. Armitage

Curator, Brixham Heritage Museum, UK

The excavation of the Tortugas shipwreck between 1990-91 at a depth of 405m off the Tortugas islands in the Florida Keys incorporated the pioneering use of a sediment removal and filtration sieving system (SeRF), which was built into the rear of the Remotely-Operated Vehicle Merlin. Coupled with excavation by Remotely-Operated Vehicle, this tool enabled a collection of 165 animal bones to be recovered from this Tierra Firme fleet *navio* lost in 1622 and identified as the Portuguese-built and Spanish-operated 117-ton *Buen Jesús y Nuestra Señora del Rosario*.

The bones were re-examined by the author in 2011, which resulted in the identification of a typical assemblage characterized by the consumption onboard ship of pig, sheep, cattle and chickens. The presence of black rat bones is not unexpected in light of the historically attested 'plague' that ran riot on the 1622 fleet. More rare are the discovery of the ship's cat and the unparalleled identification of a small parrot (cf. blue-headed), possibly a type of high-status cargo formerly known only from historical sources.

© Odyssey Marine Exploration, 2013

1. Introduction

A collection of 165 animal bones was recovered from the deep-sea Tortugas shipwreck in 1990-91 and was submitted for analysis in 2011. Analytical techniques followed standard zooarchaeological procedures. Wherever possible, identifications of taxa and anatomy were made using the author's modern comparative osteological collections and with reference to established works (Boessneck *et al.*, 1964; Gilbert *et al.*, 1981; Kozuch and Fitzgerald, 1989; Schmid, 1972). For specimens of species outside the range of the author's collections, identifications were made with the kind assistance of colleagues working at the Natural History Museum (Tring) and Royal Albert Memorial Museum, Exeter.

Measurements (in mm) were taken on selected specimens using Draper dial calipers (graduated 0.02mm), following the system of von den Driesch (1976) for the mammal and bird bones and Kozuch and Fitzgerald (1989) for the shark vertebrae. Determination of sex in the sheep innominate (TOR-90-00175-BN) was based on the criteria of Armitage (1977: 78-81) and the criteria of West (1982) for the domestic fowl tarsometatarsus (TOR-90-00216-BN). Wear stages recorded in the pig molar teeth followed the classification system of Grant (1982). A summary of the results of the analysis carried out on the recovered faunal assemblage is presented in Tables 1-2.

2. Preservation

Although a few of the Tortugas shipwreck's bones were remarkably well preserved, the majority were assessed as

poorly/moderately well preserved with many exhibiting evidence of post-depositional attritional damage from seabed sedimentary disturbance and, in some cases, also corrosion effects from prolonged exposure in sea water.

Whereas the overall condition of the bones and pattern of butchery recorded in the cattle vertebra, pig mandible and bird radius was consistent with that of other 17th-century archaeological food waste examined by the author, the two sawn pieces of pig vertebrae raised some concerns owing to their exceptionally good state of preservation, unstained appearance and evidence of fine-toothed sawing, all of which suggested the distinct possibility that these specimens were intrusive.

The use of saws in butchery practice dates from the latter half of the 18th century at the earliest; before this period, disjuncting/cutting up the carcass in preparation for cooking was performed using axes, cleavers and boning knives. It seemed highly improbable, therefore, that the sawn pig vertebrae were contemporary with the other food bones from the shipwreck. This observation is further supported by the fact that these specimens match exactly bones of modern pork chops/'baby back ribs' in the author's comparative osteological collections. In consequence, these specimens have been omitted from the final analysis and interpretation below.

Three other specimens displayed evidence of butchery marks contemporary with the final voyage. The thoracic vertebra of a cattle bone (TOR-90-00182-BN; Fig. 21) had been chopped, as had the mandible of a pig (TOR-90-00192-BN; Fig. 9). The radius of a bird, possibly a turkey (TOR-90-00301-BN; Fig. 15), exhibited knife cuts.

Class	Taxon	Common Name	NISP
Mammalia	<i>Bos</i> (domestic)	Cattle	3
	cf. <i>Bos</i> (domestic)	cf. cattle	2
	<i>Ovis</i> (domestic)	Sheep	1
	<i>Ovis/Capra</i> (domestic)	Sheep/Goat	3
	<i>Sus</i> (domestic)	Pig	22
	<i>Sus</i> (?) (domestic)	Pig (?)	4
	<i>Felis</i> (domestic)	Domestic cat	2 (MNI = 1)
	<i>Rattus rattus</i>	Black Rat	21 (MNI = 5)
	Family <i>Delphinidae</i>	Dolphin	1
	Indeterminate		18
Aves	<i>Gallus gallus</i> (domestic)	Chicken	4
	cf. <i>Pionus menstruus</i>	cf. blue-headed parrot	2 (MNI = 1)
	<i>Meleagris gallopavo</i> (?)	Turkey (?)	1
	Unidentified		3
Elasmobranchiomorphi	Family <i>Carcharhinidae</i>	Requiem sharks	6
Osteichthyes	Family <i>Serranidae</i>	Grouper spp.	3
	Unidentified	Reef fishes	37
Reptilia	Family <i>Chelonidae</i>	Marine turtle	1
	Unidentified	Turtle/tortoise (?)	5
Indeterminate	Bone fragments		26

Table 1. Numbers of animal bones present (NISP) on the Tortugas shipwreck.

3. Interpretation & Discussion

Numerically (even after excluding the two sawn vertebrae), pig bones from the wreck predominated over those of cattle and sheep/goats (Table 1; Figs. 1-12), reflecting the significant contribution this animal made to the diet of Spanish mariners serving on board Indies ships, an observation in keeping with the official ration system for such vessels in the 17th century (Phillips, 1986: 241). Some of the bones on the Tortugas wreck could have derived from live pigs carried on board ship to provide fresh meat for the captain's table during the trans-Atlantic crossing, a common practice testified in historical accounts (cf. Newton, 1928: 374).

However, other historical sources suggest an alternative interpretation should also be considered for the pig extremity foot bones. Among the supplies of foodstuffs carried on board the *Nina* for the voyage to the New World in 1498 were "three pannier baskets of pigs' feet" (Lyon, 1989: 64). Pigs' feet are also mentioned in the official ration lists for sailors serving on Spanish Indies

ships in the 17th century (Phillips, 1986: 168). Based on such records, it is suggested that the seven metapodial bones from the Tortugas wreck may not necessarily have derived from live animals, but could instead represent the remains of preserved (dried/salted) pigs' trotters.

Similarly, it was not possible to establish with any confidence whether the chopped pig jawbone (TOR-90-00192-BN; Fig. 9) from the wreck originated from a live animal that had been slaughtered/butchered on board as a source of fresh meat or was from preserved salt pork that formed part of the ship's store of provisions. In the Tortugas specimen the bone had been chopped/cleaved transversely through the ascending ramus just below the condylar process, a butchery technique similarly noted on four pig jawbones from the wreck of the Spanish Armada wreck *La Trinidad Valencera* of 1588, which were believed to be cured (dry-salted) cheek pieces (including the tongue) – a convenient, easily packed/transported meat ration (Armitage, 1995a: 35-6).

Inv. No.	Class/Taxon/ Common Name	Bone Element/ NISP/Side	Preservation; Corroded/Eroded; Abraded/Attrition; Staining	Notes
CATTLE				
TOR-90-00165-BN	Mammalia, <i>Bos</i> (domestic), cattle	Patella 1	Moderate/good; corroded, pitted, abraded; grayish iron staining	
TOR-90-00176-BN	Mammalia, <i>Bos</i> (domestic), cattle	Radius 1	Good; graying brown staining	Piece of shaft, spiral fractured/broken
TOR-90-00182-BN	Mammalia, <i>Bos</i> (domestic), cattle	Thoracic vertebra; 1	Good; brownish staining	Chopped piece of centrum/fused epiphysial plate
TOR-90-00194-BN	Mammalia, cf. cattle	Vertebra 1	Moderate/good; abraded; dark graying staining	Broken piece of unfused/detached epiphyseal plate
TOR-90-00195-BN	Mammalia, cf. cattle	Vertebra 1	Moderate; pitted; some abrasion; creamy with iron staining	Broken piece of unfused/detached epiphyseal plate
SHEEP/GOAT				
TOR-90-00175-BN	Mammalia, <i>Ovis</i> (domestic), sheep	Innominate; 1 Right	Good; some erosion & abrasion; graying brown staining	Female; depth rim of acetabulum 1.54mm, LA 28.1mm, LAR 26.7mm
TOR-90-00179-BN	Mammalia, <i>Ovis/Capra</i> (domestic), sheep/goat	Rib 1	Poor; corroded; very abraded; brownish gray staining	2 broken pieces of shaft
TOR-90-00180-BN	Mammalia, <i>Ovis/Capra</i> (domestic), sheep/goat	Rib 1	Moderate/good; browning staining	Articular end & shaft
TOR-90-00309-BN	Mammalia, <i>Ovis/Capra</i> (domestic), sheep/goat	Rib 1	Moderate/slightly abraded; grayish staining	Shaft
PIG				
TOR-90-00166-BN	Mammalia, <i>Sus</i> (domestic), pig	Femur 1	Moderate/good; corroded & abraded; grayish iron staining	Shaft only survives; from young animal
TOR-90-00167-BN	Mammalia, <i>Sus</i> (domestic), pig	Radius 1	Moderate/good; corroded & abraded; grayish staining	Shaft - prox. & distal epiphyses unfused/detached; from young animal under 1 year
TOR-90-00169-BN	Mammalia, <i>Sus</i> (domestic), pig	Femur; 1 Right	Good; grayish with iron streaks	Shaft with prox. & distal epiphyses unfused/detached; subadult
TOR-90-00177-BN	Mammalia, <i>Sus</i> (domestic), pig	Humerus; 1 Right	Very poor; heavily corroded & abraded; creamy white	Shaft
TOR-90-00178-BN	Mammalia, <i>Sus</i> (domestic), pig	Metapodial 1	Very poor; heavily corroded & abraded; creamy white	Distal end only; distal epiphysis unfused/detached
TOR-90-00181-BN	Mammalia, <i>Sus</i> (domestic), pig	Metapodial 1	Good; very pale graying staining	Distal epiphysis unfused/detached
TOR-90-00183-BN	Mammalia, <i>Sus</i> (domestic), pig	Metacarpus IV 1	Good; slightly; very slightly; grayish staining	Complete except for unfused/detached distal epiphysis

Table 2A. Catalogue of diagnostic faunal remains from the Tortugas shipwreck.

Inv. No.	Class/Taxon/ Common Name	Bone Element/ NISP/Side	Preservation; Corroded/Eroded; Abraded/Attrition; Staining	Notes
(PIG)				
TOR-90-00184-BN	Mammalia, <i>Sus</i> (domestic), pig	Fibula 1	Poor; very corroded; very eroded; light grayish staining	Piece of shaft only
TOR-90-00185-BN	Mammalia, <i>Sus</i> (domestic), pig	Tibia; 1 Right	Good; graying/ tinged iron staining	Unfused/detached distal epiphysis; young animal
TOR-90-00190-BN	Mammalia, cf. pig	Vertebra 1	Very good; creamy white	Unfused/detached epiphyseal plate
TOR-90-00191-BN	Mammalia, cf. pig	Vertebra 1	Very good; creamy White/slight iron staining	Part of an unfused/ detached epiphyseal plate
TOR-90-00192-BN	Mammalia, <i>Sus</i> (domestic), pig	Mandible; 1 Left	Good; very slightly abraded; brownish gray staining	Condylar process/piece of ascending ramus; butchered/chopped
TOR-90-00290-BN	Mammalia, <i>Sus</i> (domestic), pig	Metapodial 1	Moderate; slightly abraded; grayish staining	Distal epiphysis unfused/detached
TOR-90-00292-BN	Mammalia, <i>Sus</i> (domestic), pig	Metapodial 1	Moderate; slightly abraded; grayish staining	Distal epiphysis unfused/detached
TOR-90-00294-BN	Mammalia, <i>Sus</i> (domestic), pig	Metapodial 1	Moderate; abraded; grayish staining	Distal end broken off
TOR-90-00295-BN	Mammalia, <i>Sus</i> (domestic), pig	Metapodial 1	Good; grayish staining	Distal epiphysis only/ unfused & detached
TOR-90-00302-BN	Mammalia, <i>Sus</i> (domestic), pig	Incisor 1	Very good; not stained	
TOR-90-00303-BN	Mammalia, <i>Sus</i> (domestic), pig	Premolar tooth	Very good; not stained	Lower P2
TOR-90-00304-BN	Mammalia, <i>Sus</i> (domestic), pig	dp4 1	Very good; not stained	Deciduous fourth premolar tooth; wear stage d
TOR-90-00305-BN	Mammalia, <i>Sus</i> (domestic), pig	Molar tooth 1	Good; some patches brown staining	Some damage (post depositional) to roots, otherwise complete; cf. second lower molar, left; wear stage b
TOR-90-00306-BN	Mammalia, <i>Sus</i> (domestic), pig	Molar tooth 1	Good/fragment; not stained	Crown only survives, in pieces
TOR-90-00307-BN	Mammalia, <i>Sus</i> (domestic), pig	Molar tooth 1	Good/fragment; not stained	Crown only survives, in pieces
TOR-90-00308-BN	Mammalia, <i>Sus</i> (domestic), pig	Molar tooth 1	Good; not stained	Some damage (post depositional) to roots, otherwise complete; bag includes small frag. from another molar tooth (not acc. separately)
CAT				
TOR-90-00193-BN	Mammalia, <i>Felis catus</i> , domestic cat	Mandible 2 Right & left	Very good; white	Right & left paired jawbones from adult cat. Measurements (mm): [1] 53.5; [5] 18.4; [7] 6.7; [8] 24.9; diastema 5.9
BLACK RAT				
TOR-90-00196-BN	Mammalia, <i>Rattus rattus</i> , black rat	Tibia 1 Right	Good; gray brown staining	Tibia & fibula intact except for unfused/detached prox. Epiphysis (dist. epiphysis is fused)

Table 2B. Catalogue of diagnostic faunal remains from the Tortugas shipwreck.

(BLACK RAT)				
TOR-90-00197-BN	Mammalia, <i>Rattus rattus</i> , black rat	Tibia 1 Right	Good; gray brown staining	Lacks fibula, otherwise intact apart from unfused/detached prox. epiphysis
TOR-90-00198-BN	Mammalia, <i>Rattus rattus</i> , black rat	Tibia 1 Left	Moderate; gray brown staining	Lacks fibula plus part of proximal end/broken off
TOR-90-00199-BN	Mammalia, <i>Rattus rattus</i> , black rat	Tibia 1 Right	Moderate; slightly abraded; gray brown staining	Lacks fibula plus part of proximal end/broken off
TOR-90-00200-BN	Mammalia, <i>Rattus rattus</i> , black rat	Tibia 1 Left	Good; slightly abraded; gray brown staining	Lacks fibula plus part of proximal end/broken off
TOR-90-00201-BN	Mammalia, <i>Rattus rattus</i> , black rat	Innominate 1 Right	Moderate; slightly abraded; gray brown staining	Acetabulum is fused (adult); owing to broken/incomplete ischium unable to ascertain sex
TOR-90-00202-BN	Mammalia, <i>Rattus rattus</i> , black rat	Femur 1 Right	Moderate; gray brown staining	Shaft intact except for damaged distal end; prox. epiphysis unfused/detached, probably same with distal Epiphysis
TOR-90-00203-BN	Mammalia, <i>Rattus rattus</i> , black rat	Humerus 1	Poor/moderate; slightly abraded; gray brown staining	Shaft, distal end broken off; prox. epiphysis unfused/detached
TOR-90-00204-BN	Mammalia, <i>Rattus rattus</i> , black rat	Humerus 1 Left (?)	Poor; abraded; gray brown staining	Shaft fragment
TOR-90-00205-BN	Mammalia, <i>Rattus rattus</i> , black rat	Metapodial 2	Good; gray brown staining	Two complete metapodials (foot bones)
TOR-90-00206-BN	Mammalia, <i>Rattus rattus</i> , black rat	Incisor 1	Good	Upper incisor
TOR-90-00207-BN	Mammalia, <i>Rattus rattus</i> , black rat	Incisor 1	Good	Upper incisor
TOR-90-00208-BN	Mammalia, <i>Rattus rattus</i> , black rat	Incisor 1	Good	Upper incisor
TOR-90-00209-BN	Mammalia, <i>Rattus rattus</i> , black rat	Incisor 2	Good	1 upper & 1 lower incisor
TOR-90-00210-BN	Mammalia, <i>Rattus rattus</i> , black rat	Incisor 1	Good	1 lower incisor
TOR-90-00211-BN	Mammalia, <i>Rattus rattus</i> , black rat	Incisor 1	Good	1 lower incisor
TOR-90-00287-BN	Mammalia, <i>Rattus rattus</i> , black rat	Metapodial 1	Fragment; abraded; grayish staining	Dist. part of bone
TOR-90-00289-BN	Mammalia, <i>Rattus rattus</i> , black rat	Metapodial 2	Good; gray brown staining	Complete; distal epiphysis fused
DOMESTIC FOWL				
TOR-90-00212-BN	Aves, <i>Gallus gallus</i> , domestic fowl	Coracoid; 1 Left	Good; gray brown staining	Small scrawny chicken. Measurements (mm): GL 51.0 est.; Lm 48.5; BF - ; Bb -
TOR-90-00214-BN	Aves, <i>Gallus gallus</i> , domestic fowl	Humerus 1	Moderate; gray staining	Shaft; prox. & distal ends damaged (post deposition); SC 6.2; rat gnawing (incisor grooves) marks mid shaft

Table 2C. Catalogue of diagnostic faunal remains from the Tortugas shipwreck.

(DOMESTIC FOWL)				
TOR-90-00216-BN	Aves, <i>Gallus gallus</i> , domestic fowl	Tarsometatarsus 1	Moderate/good; very slightly abraded; gray staining	Prox. end missing; unspurred = female; Measurements (mm): SC 5.4
TOR-90-00224-BN	Aves, <i>Gallus gallus</i> , domestic fowl	Carpometacarpus 1 Left	Moderate; some abrasion; gray brown staining	Broken/incomplete specimen; small scrawny chicken
PARROT				
TOR-90-00170-BN	Aves, cf. <i>Pionus menstruus</i> , blue- headed parrot	Tarsometatarsus 1 Left	Moderate; some damage, whitish	Measurements (mm): GL 17.3; Bp 7.0; Bd 8.8; SC 4.0
TOR-90-00217-BN	Aves, cf. <i>Pionus menstruus</i> , blue- headed parrot	Femur 1 Left	Good; very slightly abraded; gray staining	Measurements (mm): GL 38.35; Bp 6.9; Bd 6.4; SC 2.9
MISCELLANEOUS				
TOR-90-00168-BN	Mammalia, unidentified	Fragments 2 --	Poor/moderate; corroded & abraded; grayish staining	
TOR-90-00186-BN	Mammalia, not pig (?)	1	Moderate; abraded/ waterworn; grayish staining	
TOR-90-00213-BN	Aves, indeterminate	Tibiotarsus 1	Moderate; slightly abraded; gray brown staining	Shaft fragment
TOR-90-00215-BN	Aves, indeterminate	Tibiotarsus 1	Moderate; very slightly abraded; gray staining	Shaft only
TOR-90-00296-BN	Aves, indeterminate	Humerus 1	Moderate/good; grayish brown staining	Shaft only; both ends broken
TOR-90-00301-BN	Aves, indeterminate	Radius 1	Moderate; orange staining	Proximal part of radius of an immature bird, cf. size of a turkey; knife cut marks present
TURTLE				
TOR-90-00174-BN	Reptilia, Family <i>Chelonidae</i> , turtle	Coracoid 1	Poor; very corroded; very abraded; waterworn; whitish with iron staining	Large marine turtle (cf. size of green turtle)
cf. GROUPE				
TOR-90-00235.1-BN	Osteichthyes, Family <i>Serranidae</i> , grouper	1 Left	Very good; pale graying staining	
TOR-90-00235.2-BN	Osteichthyes, Family <i>Serranidae</i> , grouper	1	Very good; pale graying staining	
TOR-90-00237-BN	Osteichthyes, Family <i>Serranidae</i> , grouper	1 Right	Moderate; slightly abraded; graying staining	

Table 2D. Catalogue of diagnostic faunal remains from the Tortugas shipwreck.

SHARK				
TOR-90-00225-BN	Elasmobranchiomorphi, Family <i>Carcharhinidae</i> , Requiem shark	Vertebra 1	Poor; corroded; heavily abraded; chalky white	Post-depositional damage; measurements (mm): MLB 22.5; CCL 12.4; DVH - ; intraforaminal width 4.5; interforaminal width 6.3
TOR-90-00226-BN	Elasmobranchiomorphi, Family <i>Carcharhinidae</i> , Requiem shark	Vertebra 1	Poor; corroded; heavily abraded; chalky white	Post-depositional damage; measurements (mm): MLB [23.8]; CCL [14.1]; DVH [22.5]; intraforaminal width 3.4; interforaminal width 4.3
TOR-90-00227-BN	Elasmobranchiomorphi, Family <i>Carcharhinidae</i> , Requiem shark	Vertebra 1	Poor; corroded; heavily abraded; chalky white	Post-depositional damage; measurements (mm): too heavily abraded/worn
TOR-90-00228-BN	Elasmobranchiomorphi, Family <i>Carcharhinidae</i> , Requiem shark	Vertebra 1	Poor; corroded; heavily abraded; chalky white	Post-depositional damage; measurements (mm): MLB 17.3; CCL 6.6 ; DVH 17.2; intraforaminal width 3.1; interforaminal width 2.9
TOR-90-00229-BN	Elasmobranchiomorphi, Family <i>Carcharhinidae</i> , Requiem shark	Vertebra 1	Poor; corroded; heavily abraded; chalky white	Post-depositional damage; measurements (mm): MLB - ; CCL 4.5 ; DVH 13.7; intraforaminal width 2.1; interforaminal width 3.8
TOR-90-00230-BN	Elasmobranchiomorphi, Family <i>Carcharhinidae</i> , Requiem shark	Vertebra 1	Poor; corroded; heavily abraded; chalky white	Post-depositional damage; measurements (mm): MLB 14.8; CCL 7.9 ; DVH - ; intraforaminal width 3.6; interforaminal width 4.9

Table 2E. Catalogue of diagnostic faunal remains from the Tortugas shipwreck.

Four domestic fowl *Gallus gallus* bone elements were identified (one coracoid, one carpometacarpus, one humerus, one tarsometatarsus), which were not unexpected because it is well documented that live chickens were commonplace on Spanish ships sailing to and from the Americas in this period (Figs. 13-14). For instance, in the official records of the fleet sailing to New Spain in 1631, 210 hens were noted as having been consumed by sick sailors during the voyage (Hamilton, 1929: 441). An indication of the numbers of chickens carried onboard Spanish vessels is further revealed in records relating to the ill-fated galleon *Nuestra Señora de Los Tres Reyes*. When loading supplies at Portobello in preparation for the homeward voyage in 1634, 87 “live chickens in a cage” taken on board were intended for feeding sick sailors during the trans-Atlantic crossing (Phillips, 1990).

Measurements taken on selected *Gallus gallus* bones revealed that those on board the Tortugas vessel were scrawny, bantam-sized birds compared to modern boiling and laying chickens (Tables 4-5). The Tortugas chickens in this respect matched those from 16th-century Spanish

St. Augustine, Florida, whose very small size was “comparable to a Mediterranean class of Brown Leghorn Bantam” (Reitz and Scarry, 1985: 71).

In addition to hens, live sheep were frequently carried on Spanish ships to provide special food for sick sailors, as well as to supplement the diet of the ships’ higher-ranking officers/passengers (Phillips, 1986: 178). This practice probably accounts for the presence of the female sheep pelvis bone (TOR-90-00175-BN; Fig. 16) among the faunal assemblage recovered from the wreck.

Apart from a single specimen, little could be inferred from so few specimens of cattle bones other than that they are probably representative of the salt beef and/or fresh beef consumed on board (Figs. 16-21). Specimen TOR-90-00182-BN, a thoracic vertebra (Fig. 21), however, was particularly noteworthy because it exhibited evidence of multiple chopping, a tertiary butchery pattern observed previously by the author in five cattle vertebrae recovered from the wreck of the 1588 Spanish Armada vessel *La Trinidad Valencera* (Armitage, 1995a).

Skeletal Remains	Cattle	Cf. Cattle	Sheep	Sheep/Goat	Pig	Cf. Pig
Mandible					1	
Incisor					1	
Upper/Lower Cheek Teeth					6	
Indet. Vertebral Fragment		2				4
Thoracic Vertebra	1					
Lumbar Vertebra					1	
Rib				3		
Humerus					1	
Radius	1				1	
Metacarpus IV					1	
Innominate			1			
Femur					2	
Tibia					1	
Fibula					1	
Patella	1					
Metapodial					6	
TOTALS	3	2	1	3	22	4

Table 3. Skeletal elements of the main domesticates from the Tortugas shipwreck.

Site	Date		N	Mean	Min.	Max.	Reference
St. Augustine, Florida	16 th century	GL	3	52.0	51.0	53.0	Reitz & Scarry, 1985
		Lm	5	48.0	46.0	50.0	
Tortugas shipwreck, Florida, inv. TOR-90-00212-BN	1622	GL*	1			51.0 est.	Armitage, 2012
		Lm	1			48.5	
<i>Earl of Abergavenny</i> shipwreck, Dorset	1805	GL	2		54.5	62.4	Armitage, 2002
		Lm	2		51.7	59.2	
Laying hen, Booth Museum collections (102093)	Modern	GL	1			60.6	Armitage
		Lm	1			57.6	
Black Minorca bantam, English Heritage collections (AML 2787)	Modern	GL	1			52.9	Armitage
		Lm	No data				

* The Tortugas shipwreck specimen's GL value is estimated and allows for the slight reduction by post-depositional damage.

Table 4. Size of the chicken coracoid from the Tortugas shipwreck in comparison with archaeological and modern specimens. Measurements (in mm): GL greatest (diagonal) length; Lm medial length.

Such chopped pieces of vertebrae reveal the extent to which cattle carcasses were cut up in preparation for cooking meals onboard ship and perhaps were the basis of the “dishes of broth” referenced by Italian Priest Gemelli during his Pacific voyage from the Philippines to Mexico in the late 17th century (Macintyre, 1979: 115). Significantly, both the Tortugas wreck and *La Trinidad Valencera* bones derived from very small cattle. Similar small-sized

cattle were represented by vertebrae examined from the 16th-century Emanuel Point shipwreck, Pensacola, Florida (Baker, 1995). Comparison may be made with the exceptionally large/robust cattle raised by the Spanish on Hispaniola during the same period – as evidenced by the zooarchaeological evidence from Puerto Real (Reitz and Ruff, 1994: 706) – and said to be much superior in size and appearance to those from Spain (Reitz, 1992: 87).

Site	Date	SC	N	Mean	Min.	Max.	Reference
St. Augustine, Florida	16 th century	SC	4	5.1	4.6	6.0	Reitz & Scarry, 1985
Tortugas shipwreck, Florida, inv. TOR-90-00216-BN	1622	SC	1			5.4	Armitage, 2012
Stonewall Spanish shipwreck, Bermuda	Mid-17 th century	SC	4	6.3	5.2	7.1	Armitage, 1997
Readers Point British wreck, Jamaica	18 th century	SC	1			6.1	Armitage, 1995c
<i>Earl of Abergavenny</i> shipwreck, Dorset	1805	SC	1			6.6	Armitage, 2002
Laying hen, Booth Museum collections (102093)	Modern	SC	1			8.0	Armitage
Boiling hen (author's collections)	Modern	SC	1			7.6	Armitage

Table 5. Size of the chicken tarsometatarsus from the Tortugas shipwreck in comparison with archaeological and modern specimens. Measurement (in mm): SC minimum shaft width. All specimens female (unspurred).

Distinctive rodent tooth gnawing marks were identified on the mid shaft of a chicken humerus from the wreck (TOR-90-00214-BN; Fig. 13) and indicated that this bone had been scavenged by a hungry shipboard rat. Even more tangible evidence for the presence of these rodents on this vessel was provided by 21 bone elements indentified as the remains of at least five black rats, *Rattus rattus* (Figs. 22-27):

- Incisor: 7
- Humerus: 2
- Innominate: 1
- Femur: 1
- Tibia: 5
- Metapodial: 5

The Tortugas rat evidence sheds further light on the known problem of rat infestation on the 1622 fleet. Contemporary accounts reveal that the crews not only suffered hurricanes, but were also threatened by a plague of rats. On one ship, over one thousand were killed while the vessel was in Havana, with several thousand more subsequently discovered when the vessel was at sea (Phillips, 1986: 157). These rats reportedly caused widespread destruction, gnawing through stored food supplies and contaminating the fresh water in barrels, as well as invading the chicken coops to attack and eat the fowl (Stemm *et al.*, 2013: 55).

Despite the often reputed strong swimming abilities of rats, experiments carried out by Spennemann and Rapp (1987) revealed that even in the relatively calm and warm lagoonal waters of the South Pacific black rats experienced

difficulties remaining afloat for more than 20 minutes. On the basis of such evidence it is to be presumed that rats trying to swim away from the doomed vessels of the 1622 fleet would very quickly have become exhausted and drowned in the turbulent storm-tossed sea. Others trapped below decks also drowned; their bones found in the wreck serve as testimony to their fate.

Given the commonplace occurrence of rats on European vessels of the period (cf. Macintyre, 1979: 110; Phillips, 1986: 157; Armitage 1989; Armitage, 1995b), it is not surprising that cats were frequently taken on board in order to attempt to control the numbers of such unwelcome vermin. Contemporary eyewitness references were made to ships' cats (see, for example, Pedro Fernandez de Quiros: Markham, 1967: 393). Faunal remains from shipwrecks also bear witness to this practice, including from the Tortugas wreck, which yielded right and left lower jawbones (TOR-90-00193-BN; Figs. 28-29) from an adult cat. Metrical comparison with archaeological and modern data revealed that the Tortugas cat would have been of below average size for the 17th century and a very small individual when judged against the majority of present day domestic cats (Table 6).

Cat bones are also associated with a small number of Spanish and English shipwrecks of differing status. An ulna was recovered from the Spanish armada *Trinidad Valencera*, lost off the coast of Donegal, Ireland, in 1588 (Armitage, 1995a). The English merchant vessel *Sea Venture*, which foundered off Bermuda in 1609, contained a cat's fibula (Armitage, 1987; 1989), while a cat's mandible was present on HMS *Sapphire*, wrecked in Bay Bulls, Newfoundland, in 1696 (Cumbaa, 1979).

Although the majority of the bones of reef fishes in the Tortugas shipwreck faunal assemblage was probably intrusive material, deriving from fish that had lived and died in the vicinity of the wreck, and are thus omitted from this study, the three bones of grouper (dentary, maxilla and premaxilla) (TOR-90-00235.1-BN, TOR-90-00235.2-BN and TOR-90-00237-BN) may perhaps represent waste from food consumed on board. According to Randall (1968: 57), “groupers are [today considered] the most valuable food fishes of the tropical seas” and European mariners in the 17th century were also clearly acquainted with the food value of such fish, as illustrated by William Dampier’s declaration that the “grooper [sic] is good sweet meat” (Dampier, 1697; Gray, 1968: 70).

Archaeological evidence for the consumption of grouper on board a mid 17th-century Spanish ship lost off Bermuda was provided by a butchered (chopped) dentary of this species recovered from the Stonewall wreck (Armitage, 1997). Burnt and cut Cravalle Jack (*Caranx hippos*) bone elements from the wreck of the *Nuestra Señora de Atocha* further support the inclusion of fresh caught fish in the Spanish shipboard diet (Chapin, 1990: 40). It must be presumed that the Stonewall and *Atocha* specimens are not isolated instances of Spanish mariners exploiting locally abundant reef fishes as a food source. Historical sources reveal that crews of Spanish Indies treasure ships in this period were encouraged to augment their shipboard rations while at anchor and awaiting departure from New World ports, and for this purpose their ships were routinely equipped with “fish hooks and other fishing paraphernalia” (Hamilton, 1929: 437).

As with the reef fish bones, the Requiem shark vertebrae found on the Tortugas wreck could be intrusive material, but it is notable that while English seamen of the period considered sharks to be “malevolent fish” and “unwholesome as food” (see Unwin, 1961: 113), and would only catch and eat such creatures when faced with starvation (cf. Dampier, 1684; Masefield, 1906: 107), their Spanish counterparts in the New World apparently held no such qualms at eating shark meat. As noted by Reitz and Scarry (1985: 76) and Reitz (1992: 88-9), together with rays and marine bony fishes, sharks were a major vertebrate group exploited by 16th-century Spanish coastal settlements in Florida. However, all the shark vertebrae from the wreck site had every appearance of being intrusive owing to their poor preservation and absence of any evidence of butchery.

The single, positively identified marine turtle bone, a coracoid (TOR-90-00174-BN; Fig. 30) may be considered intrusive to the site in the absence of any butchery marks and the poor preservation (leached/abraded/water-worn condition). The identification of other presumed

Site	Date	N	Min.	Max.	Mean
Tortugas shipwreck, Florida	1622	1		18.4	
Cheapside	c. 1600	1		18.2	
Aldgate	First half 17 th century	2	18.8	19.9	
London Wall	Mid-17 th century	1		17.5	
Fulham Pottery	c. 1660-80	3	18.3	19.1	18.8
Modern Cats	Modern	7	18.5	23.6	20.6

Table 6. Size of the cat jawbone from the Tortugas shipwreck in comparison with archaeological examples from London and modern specimens. Measurement (in mm): [5] length of cheektooth row P3 - M1.



Fig. 1. Femur, Mammalia, Sus (domestic), pig (TOR-90-00166-BN).



Fig. 2. Radius, Mammalia, Sus (domestic), pig (TOR-90-00167-BN).



Fig. 3. Femur, Mammalia, Sus (domestic), pig (TOR-90-00169-BN).

Specimen	Greatest Length	Proximal Width	Distal Width	Min. Shaft Width
Tortugas shipwreck *	38.55	6.9	6.4	2.9
Comparative Femur				
<i>Pionus menstruus</i> , 1896.6.9.2	37.5	7.1	7.4	2.9
<i>Pionus menstruus</i> , 1925.1.27.1	38.2	7.1	7.1	3.0
<i>Pionus menstruus</i> , 1996.57.1	36.5	7.1	7.4	2.9

* Note that the Tortugas shipwreck specimens' GL, PW, DW are surviving dimensions, which are slightly reduced by damage.

Table 7. Measurements (in mm) taken from the Tortugas shipwreck parrot femur (TOR-90-00217-BN) in comparison with modern specimens of the blue-headed parrot *Pionus menstruus* held by the Bird Group, Department of Zoology, Natural History Museum. Data source: Dr. Joanne Cooper, Natural History Museum, Tring, UK.

reptile bones (turtle/tortoise) among the faunal assemblage proved elusive, despite consultation with several zooarchaeological colleagues. It is suggested, however, that these other specimens probably also represent intrusive remains of marine turtles. A periodic (inner ear bone) of a dolphin (TOR-90-00335-BN) was recovered from the wreck site and is also intrusive. These specimens are not listed in the diagnostic faunal site catalogue.

By far the most remarkable specimens in the Tortugas shipwreck faunal assemblage were two parrot bones: a tarsometatarsus (TOR-90-00170-BN; Fig. 30) and a femur (TOR-90-00217-BN; Fig. 31) believed to derive from a single individual. This unfortunate bird had probably been abandoned below decks and drowned when the vessel sank.

An initial identification of the tarsometatarsus as the remains of a parrot (Family *Psittacidae*) by Armitage was subsequently confirmed by Dr. Joanne Cooper, Curator of Avian Anatomical Collections, Bird Group, Natural History Museum, UK, who also found the morphology of the femur was consistent with parrots. Due to the preservation of the specimens, and the great diversity of smaller parrots in the Caribbean and Central South American region, it was difficult to assign the parrot bones without doubt to a specific taxon. However, the femur was compared to a wide range of small to medium Caribbean, South American and Africa taxa and was found to most closely resemble the genus *Pionus*, a genus of medium-sized, chunky, short-tailed parrots. In terms of size, the bones appear to be most similar to the Blue-headed *Pionus menstruus* (Table 7). According to Dr. Cooper, both bones are highly likely to be from the same bird and their identification as possibly *Pionus* is significant for several reasons (Cooper and Armitage, forthcoming).

Firstly, the seven species of *Pionus* are essentially birds indigenous to Central and northern South America



Fig. 4. Humerus, Mammalia, *Sus (domestic)*, pig (TOR-90-00177-BN).



Fig. 5. Metapodial, Mammalia, *Sus (domestic)*, pig (TOR-90-00181-BN).



Fig. 6. Metacarpus IV, Mammalia, *Sus (domestic)*, pig (TOR-90-00183-BN).



Fig. 7. Tibia, Mammalia, *Sus (domestic)*, pig (TOR-90-00185-BN).



Fig. 8. Incisor, Mammalia, *Sus (domestic)*, pig (TOR-90-00302-BN).



Fig. 9. Mandible, Mammalia, *Sus (domestic)*, pig (TOR-90-00192-BN).



Fig. 10. Premolar tooth, Mammalia, *Sus (domestic)*, pig (TOR-90-00303-BN).



Fig. 11. Dp4, Mammalia, *Sus (domestic)*, pig (TOR-90-00304-BN).



Fig. 12. Molar tooth, Mammalia, *Sus (domestic)*, pig (TOR-90-00306-BN).



Fig. 13. Humerus, Aves, Gallus gallus, domestic fowl (TOR-90-00214-BN).



Fig. 14. Tarsometatarsus, Aves, Gallus gallus, domestic fowl (TOR-90-00216-BN).



Fig. 15. Radius, Aves, indeterminate (TOR-90-00301-BN).

(including the Amazon region), and are not birds of the Caribbean Islands, suggesting trade with the mainland rather than the archipelagos. Opportunities for such trade would have been possible when the Spanish Tierra Firme fleet of galleons called at the important ports/way stations of Portobello (Panama) and Cartagena (Columbia) to load gold and silver from the mines of Peru, Ecuador, Venezuela and Columbia before sailing to join the convoy at Havana and the trans-Atlantic crossing to Seville, Spain (Mathewson, 1986: 18-19).

Secondly, evidence of trade in smaller parrot species is scarce, and indeed physical evidence of any parrots almost non-existent. The trade in parrots from the New World became established in the late 15th century, led by Spanish and Portuguese explorers and merchants. As early as 1494, 60 “long-tailed parrots (macaws)” were shipped to Cadiz from Hispaniola (George, 1980: 80). By 1526, New World parrots were so familiar that Gonzalo Fernandez de Oviedo was able to remark in his *General and Natural History of the Indies* that “so many species have been carried to Spain, it is hardly worth while to take time to describe them here” (Boehrer, 2004).

This sentiment was echoed in 1684 when buccaneer John Esquemeling observed that it was well known that parrots in Europe had been transported from the New World (Stallybrass, 1992: 42-3), indicating that mariners had discovered the profitability of bringing back live parrots (as well as other animals, notably monkeys: Armitage, 1983) in order to satisfy the demand for ownership of exotic creatures, especially those destined for royal menageries, such as at Versailles. Some idea of the profit in this trade is indicated by the cost of parrots sold in late 17th-century Amsterdam for “roughly sixty guilders” (Margócsy, 2010: 67).

Exotic and expensive, parrots commonly featured in paintings of the 1500s and 1600s, perhaps as inhabitants of paradise or accompanying images of their owners in portraits as status symbols. A review of the collections of the Museo del Prado, Madrid, reveals that macaws and amazons were most frequently depicted during this time, with smaller parrots rarely shown (Gomez Cano *et al.*, 2010). However, despite their abundance in art and other documentation, physical evidence of parrots in 16th and 17th-century Europe is extremely rare, limited to one other archaeological find amongst 17th-century rubbish excavated in Norwich, England (Albarella *et al.*, 1997: 51-2).

4. Conclusions

Alongside the Tortugas shipwreck, two other shipwreck faunal assemblages associated with the ill-fated 1622 homeward bound Tierra Firme fleet have been studied and



Fig. 16. Innominate, Mammalia, Ovis (domestic), sheep (TOR-90-00175-BN).



Fig. 17. Rib, Mammalia, Ovis/Capra (domestic), sheep/goat (TOR-90-00179-BN).



Fig. 18. Rib, Mammalia, Ovis/Capra (domestic), sheep/goat (TOR-90-00309-BN).



Fig. 19. Patella, Mammalia, Bos (domestic), cattle (TOR-90-00165-BN).



Fig. 20. Radius, Mammalia, Bos (domestic), cattle (TOR-90-00176-BN).



Fig. 21. Thoracic vertebra, Mammalia, Bos (domestic), cattle (TOR-90-00182-BN).



Fig. 22. Tibia, Mammalia, Rattus rattus, black rat (TOR-90-00197-BN).



Fig. 23. Tibia, Mammalia, Rattus rattus, black rat (TOR-90-00199-BN).



Fig. 24. Tibia, Mammalia, Rattus rattus, black rat (TOR-90-00200-BN).



Fig. 25. Femur, Mammalia, Rattus rattus, black rat (TOR-90-00202-BN).

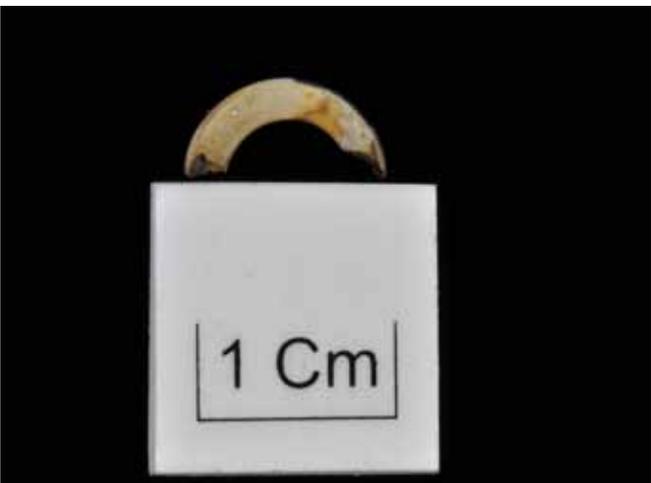


Fig. 26. Incisor, Mammalia, Rattus rattus, black rat (TOR-90-00206-BN).



Fig. 27. Incisor, Mammalia, Rattus rattus, black rat (TOR-90-00210-BN).



Figs. 28-29. Mandible, *Mammalia*, *Felis catus domestic cat* (TOR-90-00193-BN).



Fig. 30. Tarsometatarsus, Aves, cf. *Pionus menstruus*, blue-headed parrot (TOR-90-00170-BN).



Fig. 31. Femur, Aves, cf. *Pionus menstruus*, blue-headed parrot (TOR-90-00217-BN).



Fig. 32. Coracoid, Reptilia, Family Chelonidae, turtle (TOR-90-00174-BN).

documented and derive from the *Atocha* and the *Santa Margarita* (Chapin, 1990). The present analysis of the Tortugas material provides further insights into the preserved and fresh meat provisions of mariners serving on board vessels engaged in transatlantic voyages in the 17th century.

For all three vessels examined there is a concordance that demonstrates a heavy reliance on the customary Old World domesticates (pigs, cattle, sheep/goats and chickens) as principal sources of meat consumption, which was supplemented by lesser contributions from New World exotic animals (notably turtle and marine fish). Unlike the *Atocha* and *Margarita*, however, there is no evidence among the Tortugas wreck faunal remains that the vessel was carrying live horses and donkeys. At 550 tons each, these galleons were significantly larger than the 117-ton *Buen Jesús y Nuestra Señora del Rosario* and, therefore, probably were better suited through capacity to accommodate these animals.

However, the *Buen Jesús* differs from these other companion vessels in carrying at least one live parrot, which was perhaps originally part of a larger caged consignment. This discovery provides an unparalleled archaeological glimpse into the commercial trade of European merchants in exotic New World parrots in the 17th century. The importance of the Tortugas discovery lies in the fact that there are few other archaeological finds indicative of the transportation and trade in exotic New World fauna. Other identified examples include the remains of a South American yellow-footed land tortoise, *Geochelone denticulate*, in the wreck of a Dutch vessel of c. 1620-40 off Bermuda (Armitage, 1989) and a jawbone of a South American capuchin monkey, *Cebus nigrivittatus*, dated c.1640-80 from the River Thames foreshore (Armitage, 1983).

Acknowledgements

The author wishes to express his gratitude to Dr. Sean Kingsley (Director, Wreck Watch Int.) for his continued encouragement and support throughout the faunal analysis. Special thanks are due to Dr. Joanne Cooper (Curator of Avian

Anatomical Collections, Bird Group, Natural History Museum, UK) for all her comprehensive work on the parrot bones and their historical and archaeological significance. Sincere thanks also go to other colleagues for very helpful assistance in this project: Dr. Alison Locker (Andorra) for identifying the grouper bones and Mr. Dave Bolton (Curator of Zoology) for arranging access to the zoological collections at the Royal Albert Memorial Museum, Exeter, UK. The photos in this article were taken by Alan Bosel, Odyssey Marine Exploration.

Bibliography

- Albarella, U., Beech, M. and Mulville, J., *The Saxon, Medieval and Post-Medieval Mammal and Bird Bones Excavated 1989-91 from Castle Mall, Norwich, Norfolk* (English Heritage AML Report 72/97, 1997).
- Armitage, P.L., *The Mammalian Remains from the Tudor Site of Baynard's Castle, London: A Biometrical and Historical Analysis* (Ph.D. Thesis, Royal Holloway College & the British Museum (Natural History, 1977).
- Armitage, P.L., 'Jawbone of a South American Monkey from Brooks Wharf, City of London', *The London Archaeologist* 4.10 (1983), 262-70.
- Armitage, P.L., 'Victuals and Vermin: Life on Board the "Sea Venture" in 1609', *Bulletin of the Institute of Maritime History and Archaeology (Bermuda)*, 10 (1987), 8-10.
- Armitage, P.L., 'Ship Rats, Salted Meat and Tortoises: Selected Aspects of Maritime Life in the "Great Age of Sail" (1500-1800s)', *Bermuda Journal of Archaeology and Maritime History* 1 (1989), 143-59.
- Armitage, P.L., *Report on the Mammalian Bones Excavated from the Spanish Armada Shipwreck 'La Trinidad Valencera' (1588)* (Unpublished Report to Dr. Colin Martin, Scottish Institute of Maritime Studies, University of St. Andrews, 1995a).
- Armitage, P.L., 'Black Rats and House Mice'. In R.C. Smith, J. Spirek, J. Bratten & D. Scott-Ireton, *The Emanuel Point Ship: Archaeological Investigations, 1992-1995, Preliminary Report* (Bureau of Archaeological Research, Division of Historical Resources, Florida Department of State, 1995b), 78-81.
- Armitage, P.L., *Report on the Mammalian, Bird, Reptile and Fish Bones Excavated from the Shipwreck of a Late Eighteenth-Century British Merchant Vessel, St. Ann's Bay, North Shore of Jamaica* (Unpublished Report to Greg Cook, Director, Reader's Point Shipwreck Project, Greenville, North Carolina, USA, 1995c).
- Armitage, P.L. *Mammalian, Bird and Fish Bones from the Stonewall Wreck, Bermuda* (Unpublished Report to Richard Kelly Bumpass, Program in Maritime & Nautical Archaeology, East Carolina University, 1997).

- Armitage, P.L., 'Study of the Animal Bones – Section 1'. In E. Cumming (ed.), *The Earl of Abergavenny Historical Record and Wreck Excavation* (CD ROM, MIBEC Enterprises, 2002).
- Baker, B.W., *Emanuel Point Shipwreck Faunal Analysis* (Unpublished Report, Texas A&M University, 1995).
- Boehrer, B.T., *Parrot Culture: Our 2,500 Year Long Fascination with the World's Most Talkative Bird* (University of Pennsylvania Press, 2004).
- Boessneck, J., Müller, H.-H. and Teichert, M., 'Osteologische Unterscheidungsmerkmale Zwischen Schaf (*Ovis aries* Linné) und Ziege (*Capra hircus* Linné)', *Kühn-Archiv* Bd. 78 (1964), H.1-2.
- Chapin, R.L., *A Faunal Analysis of the 17th Century Galleon Nuestra Señora De Atocha* (MA Thesis, The University of Arizona, 1990).
- Cooper, J.H. and Armitage, P.L., 'A Parrot of the Caribbean? A Remarkable Find from a 17th Century Spanish Shipwreck', *Bulletin of the British Ornithologists' Club* (forthcoming).
- Cumbaa, S.L., *An Analysis of Animal Bones from the 1696 Wreck of HMS Sapphire, Bay Bulls, Newfoundland* (Unpublished Report, Parks Canada, Ref. 32, 1979).
- George, W., 'Sources and Background to Discoveries of New Animals in the Sixteenth and Seventeenth Centuries', *History of Science* 18.2, No. 40 (1980), 79-104.
- Gilbert, B.M., Martin, L.D. and Savage, H.G., *Avian Osteology* (Laramie, Wyoming: 1981).
- Gómez Cano, J., Orellana Escudero, G. and Varela Simó, J., *Las Aves en el Museo del Prado* (Madrid, 2010).
- Grant, A., 'The Use of Tooth Wear as a Guide to the Age of Domestic Ungulates'. In B. Wilson, C. Grigson and S. Payne (eds.), *Ageing and Sexing Animal Bones from Archaeological Sites* (BAR British Series 109, Oxford, 1982), 91-108.
- Gray, A., *A New Voyage Round the World by William Dampier* (New York, 1968).
- Hamilton, E.J., 'Wages and Subsistence on Spanish Treasure Ships, 1503-1660', *The Journal of Political Economy* 37 (1929), 430-50.
- Kozuch, L. and Fitzgerald, C., 'A Guide to Identifying Shark Centra from Southeastern Archaeological Sites', *Southeastern Archaeology* 8.2 (1989), 146-57.
- Lyon, E., 'Nina, Ship of Discovery'. In J.T. Milanch and S. Milbrath (eds.), *First Encounters. Spanish Explorations in the Caribbean and the United States, 1492-1570* (University of Florida Press, Gainesville, 1989), 55-65.
- Macintyre, D., *The Adventure of Sail 1520-1914* (London, 1979).
- Margócsy, D., "Refer to Folio and Number": Encyclopedias, the Exchange of Curiosities, and Practices of Identification before Linnaeus', *Journal of the History of Ideas* 71.1 (2010), 63-89.
- Markham, C., *The Voyages of Pedro Fernandez de Quiros 1595 to 1606. Vols. I & II* (Klaus Reprint Series II, Vols. 14-15, New York, 1967).
- Masefield, J. (ed.), *Dampier's Voyages by Captain William Dampier. Vol. I. A New Voyage Round the World* (New York, 1906).
- Mathewson III, D.R., *Treasure of the Atocha* (Houston, Texas, 1986).
- Newton, A.P. (ed.), *Thomas Gage. The English-American. A New Survey of the West Indies, 1648* (London, 1928).
- Phillips, C.R., *Six Galleons for the King of Spain. Imperial Defense in the Early Seventeenth Century* (John Hopkins University Press, Baltimore, 1986).
- Phillips, C.R., *The Short Life of an Unlucky Spanish Galleon: Los Tres Reyes 1628-1634* (The University of Minnesota Press, Minneapolis, 1990).
- Randall, J.E., *Caribbean Reef Fishes* (London, 1968).
- Reitz, E.J., 'The Spanish Colonial Experience and Domestic Animals', *Historical Archaeology* 2.1 (1992), 84- 91.
- Reitz, E.J. and Ruff, B., 'Morphometric Data for Cattle from North America and the Caribbean Prior to the 1850s', *Journal of Archaeological Science* 21 (1994), 699-713.
- Reitz, E.J. and Scarry, C.M., *Reconstructing Historic Subsistence with an Example from Sixteenth-century Spanish Florida* (Society for Historical Archaeology Special Publication 3, 1985).
- Schmid, E., *Atlas of Animal Bones* (Amsterdam, 1972).
- Spennemann, D.H.R. and Rapp, G., 'Swimming Capabilities of the Black Rat (*Rattus rattus*) in Tropical Lagoonal Waters in Tonga', *Alafua Agricultural Bulletin (Western Samoa)* 12.2 (1987), 17-19.
- Stallybrass, W.S. (ed.), *The Buccaneers of America* (Rio Grande Press, Inc., Glorieta, New Mexico, 1992).
- Stemm, G., Gerth, E., Flow, J., Lozano Guerra-Librero, C. and Kingsley, S., *The Deep-Sea Tortugas Shipwreck, Florida: A Spanish-Operated Navio of the 1622 Tierra Firme Fleet. Part 2: The Artifacts* (OME Papers 27, Tampa, 2013).
- Unwin, R., *The Defeat of John Hawkins. A Biography of his Third Slaving Voyage* (London, 1961).
- Von den Driesch, A., *A Guide to the Measurement of Animal Bones from Archaeological Sites* (Peabody Museum Bulletin 1, 1976).
- West, B.A., 'Spur Development: Recognising Caponised Fowl in Archaeological Material'. In B. Wilson, C. Grigson and S. Payne (eds.), *Ageing and Sexing Animal Bones from Archaeological Sites* (BAR British Series 109, Oxford, 1982), 255-61.