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The Red Bay vessel. An example of a 16th-century Biscayan ship

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The Red Bay vessel may be the best-known 16th-century Basque ship[1], but it is not the only one to have been investigated by archaeologists (Figure 1). Researchers in Texas in the 1970s found the remains of the *San Esteban*, built in San Sebastian and sunk in a hurricane in 1554[2], and recently at Cavalaire-sur-Mer in southern France, archaeologists have encountered the remains of a ship, dated to about 1480, that appears also to be Basque in origin[3]. At least seven other 16th-century shipwrecks may have been constructed in Biscay, although when they were studied, their provenance could not yet be precisely suggested. Two of these, largely unstudied, remain in the waters of Red Bay; three «Iberian» wrecks were investigated in the West Indies (Highborn Cay and Molasses Reef in the Bahamas; Western Ledge Reef in Bermuda); and two «Spanish» shipwrecks were excavated in England (Cattewater and Studland Bay)[4]. These wrecks share several characteristics with the Red Bay vessel and together, they contribute to a typology of 16th-century shipwreck sites that is increasingly considered by archaeologists to represent a «Basque» typology.

The most important characteristic of these shipwrecks is the use of oak for the frames, the planking of the hull, ceiling and decks, and for major timbers such as the keel, the stem, the stern post, the knees, the keelson and the rudder. The keel of the Red Bay vessel is a notable exception, for it is made from the trunk of a beech tree (Figure 2). The castle planking of the Red Bay vessel is of coniferous wood. A closer study of the frame timbers from Red Bay and Cavalaire has shown that they were taken from the trunks of oak trees that had grown to the somewhat unnatural, curved shape that was required for the ship. Many of the trees were cut at a uniform age of about 40 years in the case of the Red Bay ship, and about 65 years in the case of the Cavalaire wreck. These two indices —the unnatural shape and the uniform age of the trees— suggest that the oak plantations of the Basque coast were specially managed to produce shipbuilding timber.

The second characteristic of 16th-century Biscayan shipwrecks is the use of a combination of oaken treenails and iron nails to fasten the hull planks and frames. The treenails are about 25 mm in diameter and the iron nails are about 10-12 mm square in section. At each joint of a frame timber and a plank, two iron nails and two treenails are typically found. The use of both iron and wooden nails distinguishes Biscayan shipwrecks from more northerly wrecks, such as the *Mary Rose*, which have only treenails and from more southerly wrecks, especially from the Mediterranean, which have only iron nails. João Baptista Lavanha, a Portuguese naval administrator who died in 1620, left a manuscript on shipbuilding which states that in countries whose ships sailed in cold waters, wooden nails were used, while in countries whose ships sailed in warm seas, iron nails were used. He explained that in warm waters, wooden nails were destroyed by taredo worms and each treenail became a leak[5]. In Biscay, both oak and iron were plentiful and readily used as nails by shipbuilders. Analysis of the Red Bay ship has shown that the iron nails were used

1. GRENIER, R.: «Excavating a 400-year-old Basque Galleon», *National Geographic*, 168 (1985), 1: 58-68 and «Basque Whalers in the New World: the Red Bay Wrecks», BASS, George, ed.: *Ships and Shipwrecks of the Americas*, (London: Thames and Hudson, 1988), pp. 69-84.

2. ARNOLD, J.B. and WEDDLE, R.: *The Nautical Archaeology of Padre Island* (New York: 1978). ROSLOFF, J. and ARNOLD, J.B.:«The keel of the *San Esteban* (1554): continued analysis», in *International Journal of Nautical Archaeology*, 13 (1984), 4: 287-296.

3. LOEWEN, B. and DELHAYE, M.: «The 15th-century ship found at Cavalaire-sur-Mer (Var): a precursor to the Red Bay (Labrador) vessel?», paper read at the Society for Historical Archaeology, Corpus Christi, Texas, January 8, 1997.

4. OERTLING, T.J.; THOMAS, J.: «The Molasses Reef wreck hull analysis: Final report», *I.J.N.A.*, 18 (1989), 3: 229-243; and «The Highborn Cay wreck: The 1986 field season», *I.J.N.A.*, 18 (1989), 3: 244-253. REDKNAP, M.: *The Cattewater wreck: The investigation of an Armed Vessel of the Early Sixteenth Century*, BAR British Series 131 (Greenwich: National Maritime Museum Archaeological Series No. 8, 1984); and «The Cattewater wreck: a contribution to 16th-century maritime archaeology», in CEDERLUND, C.O.: *Postmedieval Boat and Ship Archaeology, Proceedings of the 4th I.S.B.S.A., Stockholm, 1982*, (Oxford: BAR International Series 256, 1985), pp. 39-59; SMITH, R.C.; KEITH, D.H.; LAKEY, D.C.: «The Highborn Cay Wreck: Further exploration of a 16th-century Bahamian shipwreck», *IJNA*, 14 (1985), 1: 63-72; WATTS, G.P.: «The Western Ledge Reef wreck: a preliminary report on investigation of the remains of a 16th-century shipwreck in Bermuda», *IJNA*, 22 (1993), 2: 103-124.

5. LAVANHA, J.B.: «Primeiro livro da arquitectura naval (ca. 1620)», in GAMA PIMENTEL BARATA, J. da: *Ethnos*, IV (Lisboa: 1965).

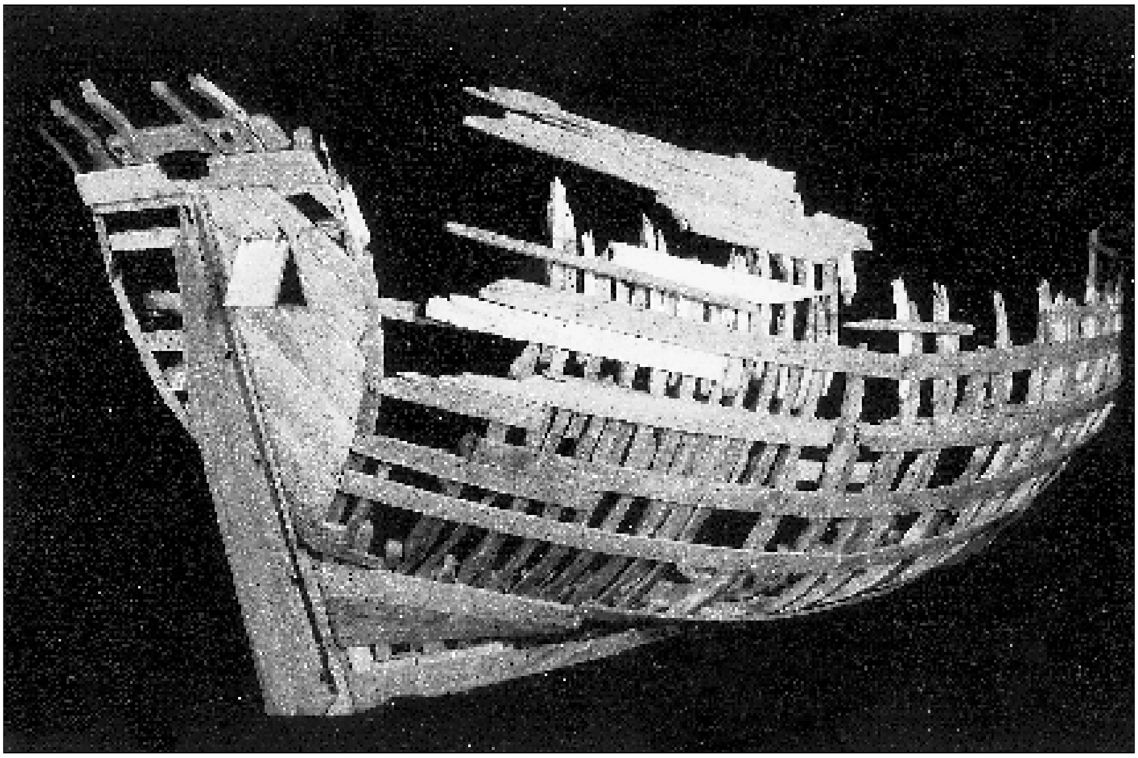

Fig. 1. The archaeological remains of the Red Bay shipwreck were modelled at a scale of 1:10 on the basis of technical drawings of each timber. The model was carved out pearwood by Marcel Gingras and Frederick Werthmann. Rock Chan, Parks Canada.

first to quickly assemble the planks and frames, and later, the treenails were used to solidify the assembly (Figure 3). Around each iron nail and treenail, on the outboard face of the plank, was a triangular countersink made with a small adze. This countersink kept the drill from slipping or from splitting the wood and later, it ensured that the head of the nail did not protrude from the surface of the plank[6].

The scantlings of frames and planks on Biscayan shipwrecks fall into a typical range. The floor timbers measure about 19-20 cm square in section, while the futtocks gradually decrease in section from 19-20 cm at the floor to about 14 cm square at the upper deck. There is little variation in the scantlings between large and small ships; the 400-*tonelada San Esteban* has the same frame scantlings as the 100-*tonelada* Cavalaire shipwreck. The width of the hull planks is also quite constant, within the range of 33 to 38 cm. The greatest thickness is found in the hull planks below the water line, which in the case of Red Bay are 5.5 cm, a fairly typical measure found in most shipwrecks. Above the water line to the height of the upper deck, the plank thickness is about 4.5 cm. The castle planks and the deck planks measured 19 cm in width and 3-3.5 cm in thickness. The maximum length of the planks is in the range of 10 to 11 metres, which appears to represent the original length of the planks, from which shorter planks could be cut according to the needs of the carpenters.

These scantlings correspond to the timbers measures found in the 1736 text of Pedro Bernardo Villareal de Berriz and in the 1688 text of Don Antonio Gaztanieta[7]. According to these texts, there were three ways of measuring naval timber in Biscay. First, the *codo de maderamiento* measured 8 *pulgadas* (19.1 cm) square by one *codo* (57.5 cm) in length. Second, the *codo de tabla* measured 16 *pulgadas* (38.2 cm) wide, one *codo* long, and in thickness, 8 planks made 1 *codo*. Third, the castle planks were gauged according to the formula of *dos por uno*, for they were only half as wide (19.1 cm) as the hull planks. The measures were taken after the timbers were sawn, in order to pay the sawyers. In the shipwrecks however, the surfaces of

6. LOEWEN, B.: «Le baleinier basque de Red Bay, Labrador (XVIe siècle): étude du clouage dans les murailles de la coque», *L'aventure maritime, du golfe de Gascogne à Terre-Neuve*, Actes du 118e congrès national annuel des sociétés historiques et scientifiques, Pau, octobre 1993 (Paris: Éditions du CTHS, 1995), pp. 145-158.

7. VILLAREAL DE BERRIZ, P.B.: *Máquinas hidráulicas de molinos y herrerías y govierno de los árboles y montes de Vizcaya*, (Madrid: Antonio Marin, 1736); GAZTAÑETA YTURRIBALZAGA, A. de: *Arte de Fabricar Reales*, FERNANDEZ GONZALEZ, Francisco, APESTEGUI CARDENAL, Cruz, MIGUELEZ GARCIA, Fernando, eds. (Barcelona: Lunwerg, 1992).

the planks and frame timbers have been subsequently adzed to a smooth finish, thus slightly reducing their thickness. Sometimes the adzemen missed an area, leaving the original sawing marks visible.

Along the keel, the floor timbers of the Red Bay ship were centred at intervals of 35 to 36 cm. This measure may seem odd compared to the 19 cm width of the floor timbers and first futtocks, but in fact these timbers were joined by a dovetail mortice-and-tenon joint that reduced the combined moulded dimension of the two timbers by about 2 to 3 cm (Figure 4). This dovetail lateral assembly, also characteristically found on Basque shipwrecks, occurs only on the master frame and on a small number of frames fore and aft of the master. In the case of the Red Bay ship, this lateral assembly is found on 6 frames forward and 7 frames aft. In other 16th-century shipwrecks, the number of assembled frames is greater aft (5-7 frames) than forward (1-5 frames). The dovetail shape of the mortice-and-tenon is the only shape found so far on Basque ships from this period[8]. However, the dovetail mortice is not only found in Basque carpentry, but also occurs in some Mediterranean shipwrecks. What distinguishes the Basque assemblage is the use of both iron nails and treenails to secure it, while in the Mediterranean, only iron nails are found (Figure 5).

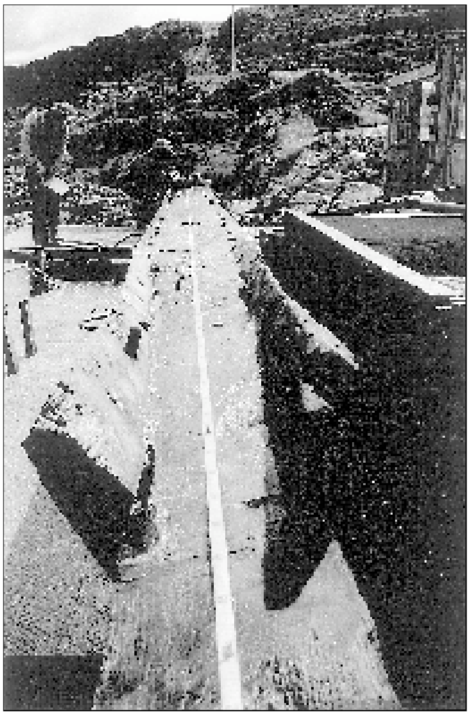

Fig. 2. Archaeologists at work recording the keel timber. Notice the garboards strakes incorporated in the keel timber, a masterpiece of shipwrightry. Gerd Taudien, Parks Canada.

It has been hypothesized by historians that the presence of a lateral assemblage indicates the group of *maderas de cuenta* used in the conception of the hull's shape, as described in several Iberian manuscripts from the period 1570-1620[9]. Archaeologists have explored this hypothesis by developing methods to study the frame timbers in order to learn the method of conceiving the hull's shape. The most important method consists of dismantling the wreckage and producing a technical drawing of each frame timber at a 1:10 scale, which can then be «reassembled» and studied at leisure under laboratory conditions. This method, pioneered at Red Bay, led to an analysis which confirmed that a sophisticated moulding method was used. First, the master frame was designed, using a flat floor and three arcs of different radii up to the dead works. Second, the frames fore and aft were designed by modifying the master mould, using the following modifications: the rising of the floor [*astilla*]; the narrowing of the floor; and a modification to the shape of the futtocks known from English manuscripts as «hauling down». This latter modification to the shape of the futtock occurs in the English manuscripts, from the period 1580-1620, instead of the *joba* that is described in Andalusian and Portuguese manuscripts from about the same period (Figure 6)[10]. In this way, 16th-century Biscayan shipbuil-

8. The c. 1535 Studland Bay wreck is an exception in which a simple lap scarf occurs. K. Jarvis, Poole Museum, personal communication.

9. The Iberian treatises which contribute to this study are three Portuguese texts, OLIVEIRA, Fernando: *Livro da fabrica das naos*, 1570 (tr. Manuel Leitão, Lisboa: Academia de Marinha, 1991); LAVANHA, J.B: «Primeiro livro da arquitectura naval» (ca. 1620), in GAMA PIMENTEL BARATA, J. da: *Ethnos*, IV (Lisboa: 1965); and FERNANDES, Manuel: *Livro da Traças de Carpenteria* (1616; facsimile Lisboa, Academia de Marinha, 1989), and six Spanish texts, ESCALANTE DE MENDOZA, Jhoan: *Itinerario* (Seville, 1575; reproduced in FERNANDEZ DURO, Cesáreo: *Disquisiciones Náuticas* (Madrid, 1880), Vol. 5, pp. 413-515), GARCIA DE PALACIO, Diego: *Intruccion Nauthica* (Mexico, 1587; repr. Madrid: Ediciones Cultura Hispánica, 1944; tr. and ed. E. Bankston, Bisbee, New Mexico, 1988), CANO, Thomé: *Arte para Fabricar y Aparejar Naos*, 1611, in MARCO DORTA, E., ed. (La Laguna, Tenerife: 1964); and three royal ordinances by Antonio de Aroztegui in 1607 (Museo Naval, Madrid, Collection Fernández de Navarrete, T.23, D.47), and by Martin de Aroztegui in 1613 («Palha manuscripts», Houghton Library, Harvard University, Cambridge, MS 4794, Vol. 2, unpaginated; published in ARTIÑANO Y GALDACANO, Gervasio de: *Arquitectura Naval Española en Madera* (Madrid, 1920), Appendix IX, and in 1618 («Palha» MS, *ibid*).

10. The method is called *espalhamento* in the Portuguese texts. The principal English treatises of the period are Mathew Baker's *Fragments of Ancient English Shipwrightry* (ca. 1580) at the Pepsyian Library, Magdalene College, Cambridge (MS 2820); an anonymous manuscript copied around 1600 bearing Newton's hand (Cambridge University Library, MSS Add 4005, Part 12), reproduced in BARKER, R.A.: «Design in the Dockyards, about 1600», REINDERS, R. and PAUL, K., eds.: *Carvel construction technqiues, 5th ISBSA Proceedings* (Oxford, 1991); another anonymous text of about the same date known as the Scott MS (Anonymous, MS 798, *A most excellent briefe and easie treatise*, Scott Collection, Royal Institute of Naval Architects); a ca.1608-1610 manuscript on shipbuilding and rigging by the mathematician Thomas Herriot (See PEPPER, J.V.: «Harriot's Manuscript on Shipbuilding and Rigging (ca.1608-1610)», *500 Years of Nautical Science, 1400-1900* (London: National Maritime Museum, Greenwich, 1981), pp. 204-216); the 1620 *Treatise on Shipbuilding* by Baker's colleague John Wells, another mathematician (Admiralty Library MS 9, ed. W.A. Salisbury, Society for Nautical Research, Occasional Publication No. 6, 1958); and a work on the early sixteenth-century ship *Mary Gonson* (See ANDERSON, R.C.: *Mariner's Mirror*, 46 (1960), pp. 201-202. These texts are passed in review by BARKER, R.A. (1991), *op. cit.*.

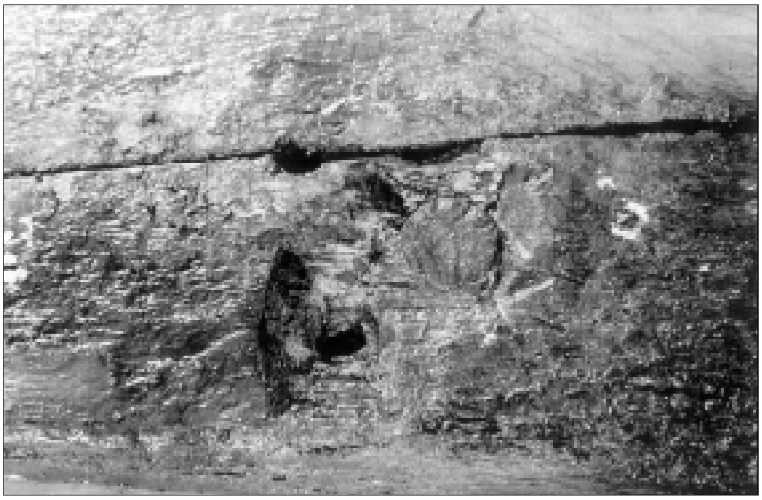

Fig. 3. Square iron-nail holes and round treenails were the standard fasteners recorded in the hull planks. Rock Chan/Gerd Taudien, Parks Canada.

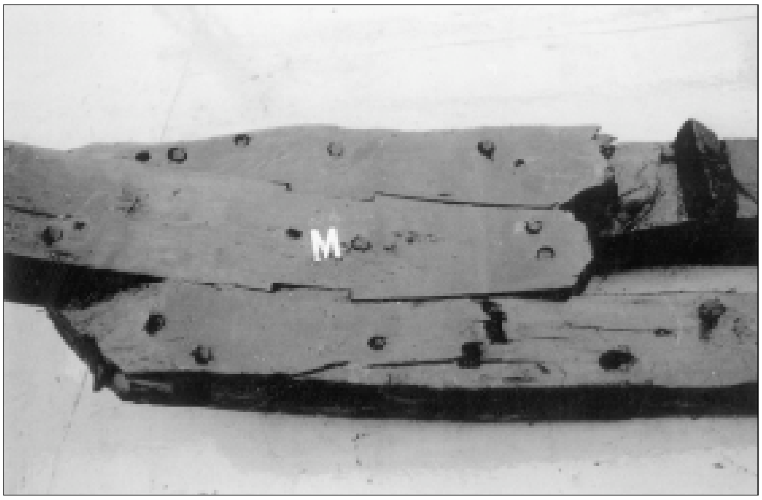

Fig. 4. Three floor timbers at midship, with the master floor timber in the middle, are shown here. They are identical in shape, except for the mortices where the futtocks were attached. Rock Chan/Gerd Taudien, Parks Canada.

ding methods were more similar to the English than to southern Iberian methods. This similarity between Basque and English methods may have disappeared soon after for in 1680, Don Antonio Gaztanieta mentioned the *joba* in a Cantabrian shipyard.

Fore and aft of the frames with a dovetail mortice, in all Biscayan shipwrecks, are frames in which the various timbers are not directly linked. The floor timbers [*varengas*], first futtocks [*genoles*], second futtocks and so on, are independent and are fastened only to the hull planks and the internal structures such as the ceiling planks and the beam shelves. Archaeologists refer to these unassembled frames as «floating frames». Clearly such a characteristic meant that the timber supply and the deck heights were inextricably interrelated. In the shipwrecks, archaeologists see an overlap of about 1 metre between the upper and lower ends of successive frame timbers. Thus, the upper ends of the floor timbers overlap about 1 metre with the lower ends of the first futtocks, and so on. It is in this area of overlap that the beam shelves and waterways are situated (Figure 7), and thus, the deck height is related to the typical length of the timbers. Michael Barkham has shown that, according to about three dozen construction contracts for large ships in the archives at Oñati, the decks of 16th-century, two- or three-decked Basque ships were typically located at heights of 4, 7 and 10 *codos*, with little variation among ships of different sizes[11]. The decks of the Red Bay vessel have these same heights, thus confirming the archival information.

As well, the archaeology offers an hypothesis as to why the deck heights did not vary according to the ship's tonnage. We know that the oak-plantation owners, who controlled the supply of timber, preferred

11. BARKHAM, M.: *Report on Spanish Basque Shipbuilding, c.1550 to 1600* (Ottawa: Parks Canada, 1981).

to harvest their trees at a certain age (40 to 65 years), a certain diameter (just over 19 cm), and a certain curvature. It seems that the trunks of these oak trees also had a typical height of 3 to 5 metres to the lowest branches, which imposed a limit on the length of the frame timbers. According to this explanation, Basque ship carpenters adapted to the local timber supply by designing their ships so that the decks were always located at the heights where the frame timbers overlapped. Thus, a ship of 100 *toneladas* could be built with the same trees as a ship of 400 *toneladas*, ensuring that there would always be a ready supply of timber in spite of the many years that it took to prepare an oak tree. The history of Basque naval forestry -an intensive and ancient activity- probably contains other reasons for the «characteristic» appearance of 16th-century Biscayan shipwrecks.

In preparing their typologies, archaeologists have noted other similarities between 16th-century shipwrecks of presumed Basque origin. For example, the keelson is a massive timber that is swollen in the middle in the area of the main mast step and buttressed on each side against the bilge clamps. Just aft of the mast step, on one or both sides of the keelson, a semi-circular cavity is notched into the timber where the pump was seated (Figure 8). Several pumps have been recovered and they have a typical style[12]. Another characteristic feature is the upper ceiling plank, known in Spanish-language documentary records only by its Basque name of *albaola*, which was elaborately carved to ensure a watertight joint between the hull, the futtocks and the ceiling[13].

The typology, developed by Thomas Oertling and Éric Rieth from 16th-century shipwrecks that they called, respectively «Iberian» and «Atlantic» in provenance[14], appears from the example of Red Bay to be in fact a «Basque» typology. The scientific value of this typology continues to grow. Recently, it was used to identify the 15th-century Cavalaire shipwreck as being of probable Biscayan origin. Once the common features noticed by archaeologists were associated with the Basque region, our understanding of these characteristics was greatly improved. The shipwrecks describe a decentralized, commercial shipbuilding activity whose basic characteristics remained stable over several human generations, primarily because the fundamental characteristics were determined years in advance by timber growers.

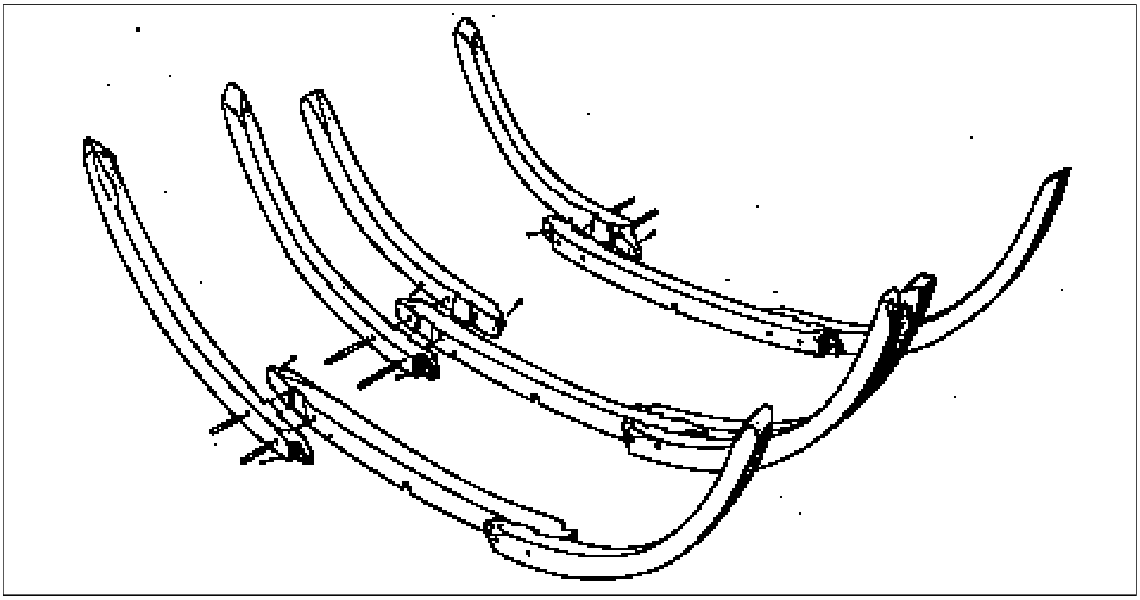

Fig. 5. In this drawing, the same three floor timbers are shown with their futtocks, illustrating the dovetail mortice assembly. Robert Hellier, Parks Canada.

12. WADDELL, P., published as «The pump and pump well of a 16th century galleon», *IJNA*, (1985) 14, 3: 243-259; OERTLING, T.J.: «The History and Development of Ships' Bilge Pumps, 1500-1840», Master's thesis, Texas A&M University, 1984.

13. MOTT, L.V.: «Identification of the words 'singla' and 'albaola' and their relation to timbers found on 15th-century Spanish shipwrecks», *International Journal of Nautical Archaeology*, 22, 3 (August 1993). The Basque word *albaola* was constructed from *albo* meaning «edge» (*alba-* when followed by a vowel in composite words) and *ola* meaning «plank». Thanks to Miren Egaña Goya for this explanation.

14. OERTLING, T.J.: «The few remaining clues...», in BARTO ARNOLD III, J., ed.: *Underwater Archaeology Proceedings from the Society for Historical Archaeology Conference*, Baltimore, 1989, pp. 100-103; RIETH, É.: «Signature architecturales», paper read at Aix-en-Provence, October 1995.

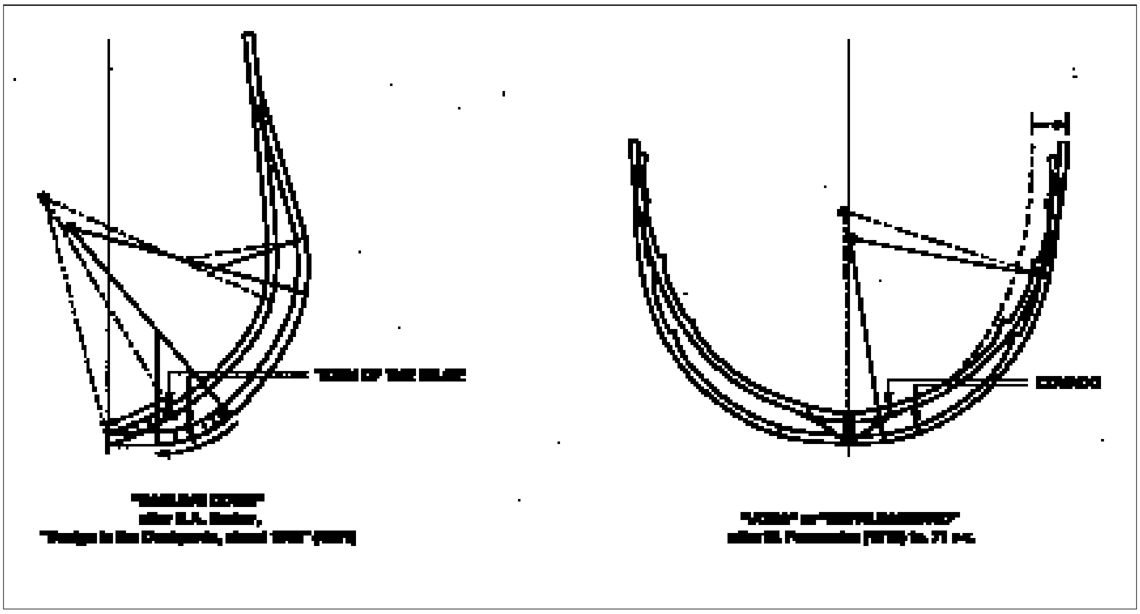

Fig. 6. English and Iberian manuscripts from the period 1570-1620 show two different methods of modifying the shape of the futtock from the master frame to the final madera de cuenta, or «tail frame», as shown here. The Red Bay method resembles the English method, called «hauling down the futtock». In this method, the cord of the futtock arc is progressively lengthened («hauled») downward, at the same time as the cord of the bilge arc is shortened and eventually disappears. In consequence, the futtock's outward angle is modified. The Iberian method, called joba or espalhamento, is described in texts as late as the 18th century and is shown at right. In this method, the futtock is progressively tilted outward from the covado. E. RIETH, Le maître-gabarit, la tablette et le trébuchet *(Paris: CTHS, 1996) and C. APESTEGUI CARDENAL, «Análisis técnico de la obra», in F. FERNANDEZ GONZALEZ, et al, eds.,* Arte de Fabricar Reales *(Barcelona: Lunwerg, 1992), vol 1, pp. 13-32.*

Dorothea Larsen, Parks Canada, after R.A. BARKER, «Design in the Dockyards, about 1600», in R. REINDERS and K. PAUL, eds., Carvel construction technique *(Oxford: Oxbow Monograph no. 12, 1991), pp. 61-69, and M. FERNANDES,* Livro da Traças de Carpenteria, *1616 (Lisboa, Academia de Marinha, 1989), fo. 71r-v.*

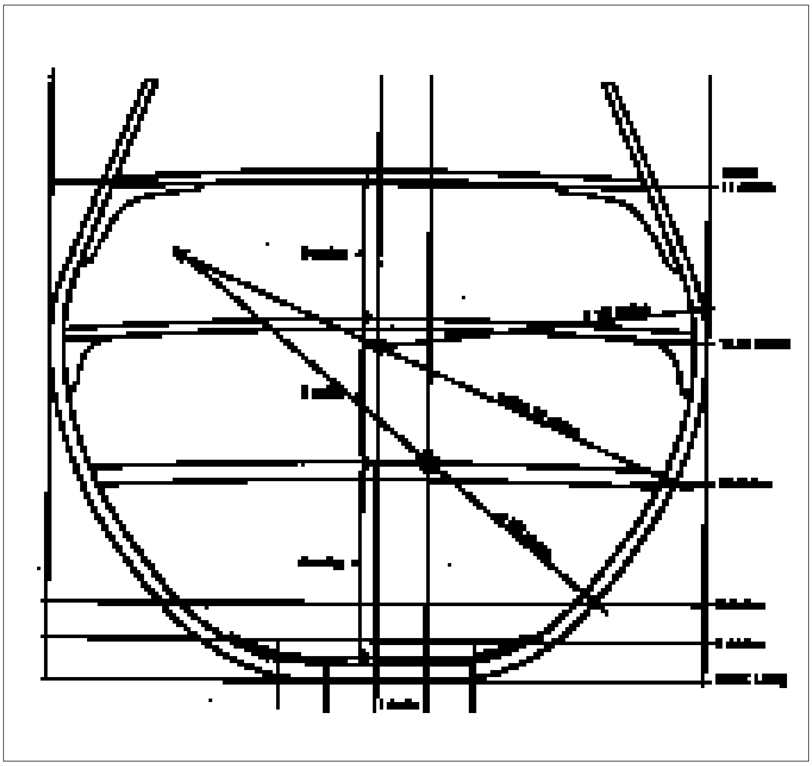

Fig. 7. The master frame of the Red Bay vessel was conceived with a flat floor, three tangent arcs and a straight tumblehome. This drawing simplifies the carpentry for the sake of showing the system of conception. Carol Pillar, Parks Canada.

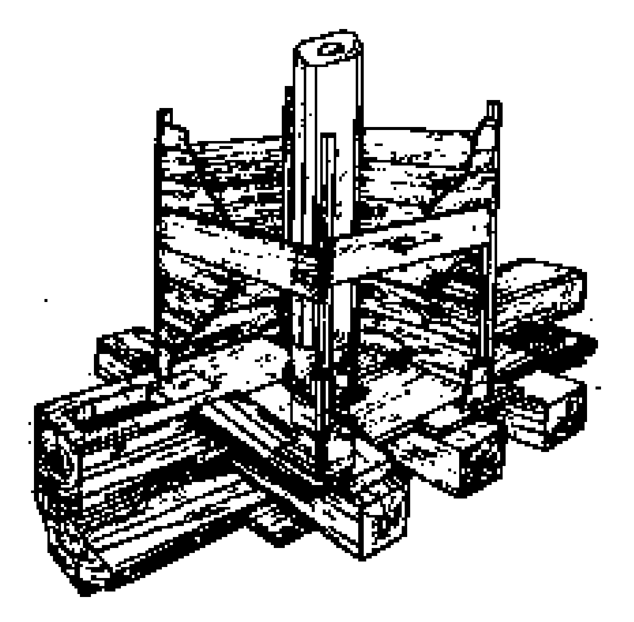

Fig. 8. The pump of the Red Bay vessel. Carol Pillar, Parks Canada.

This technological stability and the prosperity associated with it stands in contrast to the changes in shipbuilding technology and the economic crisis of the early 17th century[15]. Although our historical understanding of the Basque maritime economy around the year 1600 remains incomplete, it appears that heavy shipbuilding became concentrated in a smaller number of shipyards, which would have created local distortions in the supply of timber. It appears as well that the basic proportions of length, breadth, depth and especially, deck heights were altered to respond to the needs of the Indies Route[16]. What we see in the archaeology as a «new» style of shipbuilding, beginning in the 17th century, is the use of composite, «double-sawn» frames which used timber from trees of irregular length, diameter and curvature, thus putting an end to the ancient Biscayan characteristic of dovetail mortices and «floating» frame timbers.

15. CANO, Tome: *Arte para Fabricar y Aparejar Naos*, reprint of 1611 ed., ed. MARCO DORTA, E. (La Laguna, Tenerife: 1964); *cf.* CASADO SOTO, J.L.: *Los Barcos Españoles del Siglo XVI y la Gran Armada de 1588* (Madrid: San Martín, 1988) and CLAYTON, L.A.: «Ships and empire: the case of Spain», *Mariner's Mirror*, 62 (1976), 3: 235-248.

16. See for example the 1607, 1613 and 1618 shipbuilding ordinances that laid out the dimensions of ships for the Indies Route, Antonio and Martin de Aroztegui, «*El Rey...*», Houghton Library (Cambridge, Massachusetts), MS 4794, Vol. 2, unfoliated; also published in ARTIÑANO Y GALDACANO, G. de: *Arquitectura Naval Española en Madera* (Madrid, 1920), Appendix IX.