

THE CAREENING AND BOTTOM MAINTENANCE OF
WOODEN SAILING VESSELS

A Thesis

by

MICHAEL PETER GOELET

Submitted to the Graduate College
Texas A&M University
in partial fulfillment of the requirements for the degree
of

MASTER OF ARTS

May 1986

Major Subject: Anthropology

THE CAREENING AND BOTTOM MAINTENANCE OF
WOODEN SAILING VESSELS

A Thesis

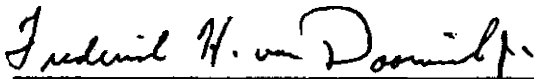
by

MICHAEL PETER GOELET

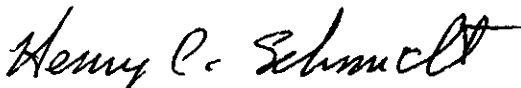
Approved as to style and content by:



J. Richard Steffy
(Chair of Committee)



Frederick H. van Doorninck, Jr.
(Member)



Henry C. Schmidt
(Member)



Vaughn M. Bryant, Jr.
(Head of Department)

May 1986

ABSTRACT

The Careening and Bottom Maintenance of
Wooden Sailing Vessels. (May 1986)

Michael Peter Goelet, B.A. Dartmouth College

Chairman of Advisory Committee: Mr. J. Richard Steffy

The careening of large wooden sailing vessels was a complicated, time-consuming, and potentially dangerous operation. It was a practice that endured from the time that some ships were too large to be easily hauled ashore to the beginning of the 20th century. During most of that time careening was the most widely used and, in many cases, the only method by which a vessel's bottom could be made accessible for maintenance.

That practice, once so commonplace, has now almost vanished from living memory. Paradoxically, careening in past eras was such a normal occurrence that relatively few individuals bothered to record it, and, if they did, customarily made no effort to explain the techniques used. As a result, most of the existing literature is fragmentary and of a cursory nature.

The major objective of this work is to rectify this situation by gathering together the scattered pieces of information and correlating them into a descriptive whole.

Research has focused on the assembly of a body of information encompassing a period commencing in the late-15th century and terminating about 400 years thereafter. The study deals almost exclusively with vessels which originated in northern Europe and North America and emphasizes the period between 1750 and 1850.

Both general and specific descriptions of the standard procedures required to careen large sailing vessels are included. In many instances, the reasons for various procedures are explained and the techniques employed on different vessels are compared. Where interpretation or clarification of material seemed necessary, this has been attempted. When no parallels for a technique were found, hypotheses were tendered.

Abbreviated sections describing some of the maintenance work that normally might have been accomplished in company with careening are included following the discussion of the major subject.

While the body of the work is basically of a descriptive nature, its relevance to nautical archaeology is discussed briefly in the concluding section.

DEDICATION

This work is dedicated to my wife, Hallie Marsteller Goelet, who remained steadfast in her support. She occasionally heeled but never capsized under the extra burdens I imposed on her by my time spent in researching and writing this paper.

ACKNOWLEDGEMENTS

I wish to thank all of the people who took an interest in this work and gave freely of their time and knowledge.

Special thanks are owed to Ann Marie Maguire who spent many hours translating Danish into English; Gote Sundberg of the Ålands Sjöfartsmuseum, for his cooperation and courtesy; Henning Henningsen, past director of the Kronborg Museum, for his hospitality and encouragement; Maria Ekberger of the Orlogsmuseet, Copenhagen, for her efforts spent in locating information; Joe Roome of the Water Transportation Department of the Science Museum, London, for his lucid outline of sheathing technology; and the staff of the Naval Historical Library, London, in particular Alan Francis, E.O., and Philip Wilton, Paperkeeper, for their cooperation in searching out useful materials.

Paul Johnston of the Peabody Museum, John Sands, Curator, and Ardie Kelly, Librarian, both of the Mariners' Museum, Newport News, Virginia, are due special thanks for their interest and encouragement.

I also wish to especially thank Michael Mross and Richard Cook of the Plasma Physics Laboratory at Dartmouth College, Carl Long of the Thayer School of Engineering, also at Dartmouth, and John Waterhouse, late of the Hart

Nautical Collections at M.I.T., for their technical help, without which certain sections of this work could not have been written.

Gratitude is owed also to John Taylor, who drew some of the sketches within, for his ability to interpret my concepts.

TABLE OF CONTENTS

	Page
ABSTRACT	iii
DEDICATION	v
ACKNOWLEDGEMENTS	vi
TABLE OF CONTENTS	viii
LIST OF TABLES	xi
LIST OF FIGURES	xii
INTRODUCTION	1
OBJECTIVES	8
DOCUMENTATION	11
PRELIMINARY CONSIDERATIONS	13
Alternatives To Careening	14
CAREENING SITES	23
INITIAL PREPARATIONS FOR CAREENING	37
Hull Preparation	37
Rigging And Accessories	45
SUPPORT SYSTEMS FOR THE MASTS AND STANDING RIGGING	55
General Description	55
Fishes	58
Mast Shores	60
Preventer Shrouds	76
Supplementary Longitudinal Support Rigging	90
Outriggers	91
Final Adjustments Prior To Careening	113
SETTING-UP TACKLE	115
Examples Of Setting-up Tackle	117

TRIPPING CABLES	127
Example Of Tripping Cable Arrangements	130
CAREENING TACKLE	133
General Description	133
Examples	135
Dismasted Vessel	150
CAREENING PITS	153
Shore Installations	153
Floating Installations	158
CAREENING CAPSTANS	168
Shipboard Capstans	168
Shore Mounted Capstans	170
HEMPEN CABLES AND HAWSERS	173
Classification And Description	173
Comparative Strengths	174
Comparisons Of Tackle Falls	177
AN ESTIMATION OF THE FORCES REQUIRED TO CAREEN THE <u>MELVILLE</u>	181
Analysis	185
Conclusions	193
STABILITY	196
Terminology	196
Changes Which Occur When A Ship Is Heeled	198
Equilibrium	199
Righting Moment	201
Curve Of Stability	202
Upsetting Moment	203
A Discussion Of Moment And Force Using The <u>Melville</u> As An Example	205
The Relationship Of Stability To Careening Preparations	215
Effects Of Configuration And Ballasting	222
Longitudinal Stability	226

BASIC MAINTENANCE AFTER CAREENING	231
Sheathing	232
Breaming	238
Graving	246
Recaulking	248
Final Procedures	256
SUMMARY	257
CONCLUSIONS	260
NOTES	262
GLOSSARY	273
REFERENCES	280
APPENDIX I	289
VITA	304

LIST OF TABLES

1. "References to the Carreening"	57
2. Spars used for mast shores and outriggers . .	68
3. "A scale of Blocks, Falls, Pendants, Strapping, Shrouds &c., used in Heaving Down the different Classes of H.M. Ships at Malta".	137
4. For ascertaining the strength of hempen cables	175
5. For ascertaining the strength of hawser-laid rope	176

LIST OF FIGURES

1. "Coal Briggs On Brighton Beach "	2
2. Barque being hauled up a wooden incline with tackles and capstans	3
3. Model of ship in drydock in the Science Museum, London	4
4. West-Indian vessel <u>Friendship Rose</u> careened recently in Bequi	7
5. Men cleaning the bottom of a small vessel in shallow water	8
6. Bottom scrubbing device	17
7. Design from a patent application for a bottom scrubbing device	18
8. Underwater patch for hull puncture	20
9. Dutch warship in canal at entrance to Amsterdam Harbor	22
10. Diorama of ship careened against barge in Hamburg Historich Museum	27
11. Diorama of ship careened against barge in Antwerpen National Scheepvaartmuseum	27
12. Diorama of an early French vessel careened against a barge	28

13. Deck view of a late-17th-century French ship careened against two barges	29
14. Bottom view of the ship in the preceding illustration	29
15. Mid-17th-century Dutch float and careening barge	30
16. The late-19th-century German brig <u>Friederike</u> hove down	31
17. Detail from a diorama portraying the Stora Shipyard in Stockholm as it appeared in 1781 . . .	32
18. The American whaling ship <u>James Arnold</u> hove down for repairs	34
19. "An Old Whaler Hove Down For Repairs Near New Bedford"	35
20. The American whaler <u>Josephine</u> hove down	36
21. Off-loading a ship's gun by means of tackles rigged to a lower yardarm	38
22. The French frigate <u>Artemise</u> , showing water in the waist	41
23. Sketch of a French frigate careened	42
24. The <u>Melville</u> careened against the <u>Rattlesnake</u> , with the <u>Blenheim</u> alongside	43
25. Diagram of the pumping system used aboard the <u>Melville</u> while careening	44

26. Mid-17th-century Dutch vessel careened with rigging intact 46
27. Dutch mid-17th-century ship partially careened 47
28. Dutch vessel being unrigged in preparation for careening 48
29. Deck view of Dutch ship careened against barges 49
30. Detail of a diorama portraying a late-18th-century Swedish vessel careened 51
31. Detail of diorama showing mid-18th-century British warship in the Science Museum, London 52
32. British hulk acting in the dual capacity of a careening hulk and a sheerhulk 53
33. Diorama of a 19th-century vessel from Åland heaved down against quays in Ålands Sjöfartsmuseum 54
34. Sectional view of ship in Fig. 32 showing various support systems 55
35. Detail of the ship section in Fig. 34 56
36. Carrack careened against a wharf, possibly showing shores lashed to the mainmast 61
37. Dutch kof being careened showing a simplified version of mast shoring 62
38. Tackles rigged to the bedding block of the foremost mast shore on the Artemise 66

39. Detail of a diorama representing the Danish harbor of Nyholm in 1766 in the Orlogsmuseet, Copenhagen 69
40. Illustration of the careening systems on a mid-19th-century Danish warship 70
41. The mast shoring system used on the Brandywine 76
42. A possible arrangement of the preventer shrouds during the careening of the Courageux 79
43. Portion of a diorama showing the hull of the Artemise in the Musée De La Marine 80
44. A Dutch fregat careened by main- and foremast 81
45. Diorama of a mid- to late-19th-century vessel in the Ålands Sjöfartsmuseum, Mariehamn 82
46. Deck view of the careening barge in the Hamburg Historich Museum diorama 83
47. Hull view of the Greenland trading vessel Hvalfiskén 84
48. Deck view of the Hvalfiskén 85
49. The whaleship Sunbeam hove down 86
50. An example of a Spanish windlass 88
51. Detail of ships from wedding scene in "The Legend of St. Ursula" 93

52. Two examples of the outboard ends of
outriggers 98
53. A pendant toggled to the upper block of an
outrigger shroud tackle 101
54. HMS Formidable careened in Malta, 1843 104
55. Detail of diorama in the Musée De La Marine,
Paris, depicting the careening of the Artemise
in Tahiti, 1839 104
56. Hull view of an earlier diorama of the
Artemise 108
57. A Swedish frigate heaved down against a wharf . . 110
58. A possible arrangement of one of the
Formidable's setting-up cables 118
59. Bow view of the diorama in the Musée De La
Marine, Paris, of the Artemise hove down 124
50. Deck view of an earlier diorama of the
Artemise careened 124
51. Diagram showing the relative positions of
the three ships during various stages of
careening the Melville 131
52. A careening tackle with a power of 9,
showing the various parts 134
53. Drawing of a fourfold careening block
showing its parts 139
54. The eight-part tackle "allowed" and the
nine-part tackle used to careen the Melville . . . 140

65. Careening a dismasted ship 150
66. Using a longer careening timber to heel
a dismasted ship 151
67. "Plan & View of the Carreening Wharf
at English Harbour, Antigua" 154
68. Stern view of diorama representing
mid-18th-century British warship careened 157
69. "A Careening Post at Merrill's Wharf,
New Bedford" 157
70. An American frigate hove down to a wharf 158
71. Several examples of knight-heads aboard
the Swedish warship Vasa 160
72. An early-19th-century sheerhulk 161
73. Sheerhulk with careening wheel (left)
being used to heave down a ship (right) 162
74. Swedish vessels careened against a hulk a
and the shore b 164
75. The arrangement aboard the Rattlesnake
for the careening of the Melville 166
76. A capstan on the maindeck of the Vasa
conserved in the Statens Sjöhistoriska Museum . . 169
77. An 18th- to early 19th-century capstan 170
78. A portable mid-19th-century Danish capstan 171

79. The Lucille careened by horse-powered capstan in San Francisco, 1901 172
80. From left to right, cable-laid, hawser-laid, and shroud-hawser-laid rope 174
81. Diagram of moment arms and forces on one of the Blenheim's main capstan bars during the careening of the Melville 190
82. The centers of gravity and bouyancy and the forces acting through them 198
83. Wedges of emersion and immersion 199
84. The three states of equilibrium 200
85. An example of a curve of stability 203
86. Forces and distances determining upsetting and righting moments 204
87. Determination of the forces acting perpendicular to the Melville's main- and foremast with the ship careened to a 72° angle of heel 208
88. The Melville careened to 28° and 74° inclination 209
89. Free-surface effect 217
90. Preservation of bouyancy on a wall-sided vessel by the addition of planking to the lee gangway 220
91. Differences at the main frame of mid-18th-century ships of various nationalities 223

92. "Breaming a small sailing vessel before
graving or re-tarring" 240
93. Breaming an early-18th-century Dutch ship 241
94. Detail of a French ship being breamed
from "Vue Du Port De Brest En 1776" 244
95. French ship being breamed in view of the
King at Havre, France 245
96. Caulking tools 250
97. Late-19th-century caulking paraphernalia
in the Bath Maritime Museum, Maine 252
98. Caulking mallet heads from the Machault 254

INTRODUCTION

All vessels require periodic maintenance as well as occasional repair of the below-waterline portion of their hulls. Before the advent of floating drydocks or steam engines and marine railways, the most common way to gain access to a large ship's bottom was to heel it over, or careen it, by means of heavy tackles attached to its masts. Other methods were both limited and limiting.

Work could be done as a ship lay aground during ebb tide (Fig. 1) or, in 19th-century England, "on the great wooden blocks which were provided for this purpose on many beaches and in tidal rivers" (Greenhill and Giffard, 1970: 32).

This, however, was uneconomical as the vessels could be worked on for only one or two hours each day. Moreover, river bottoms are often silty, which further restricted the work that could be performed. If, on the other hand, the bottom was not soft, there was the risk that the vessel could be injured by coming to rest on sharp projections, a hazard that increased dramatically in relationship to the vessel's size and displacement.

This thesis employs The International Journal of Nautical Archaeology as a model for style and format.

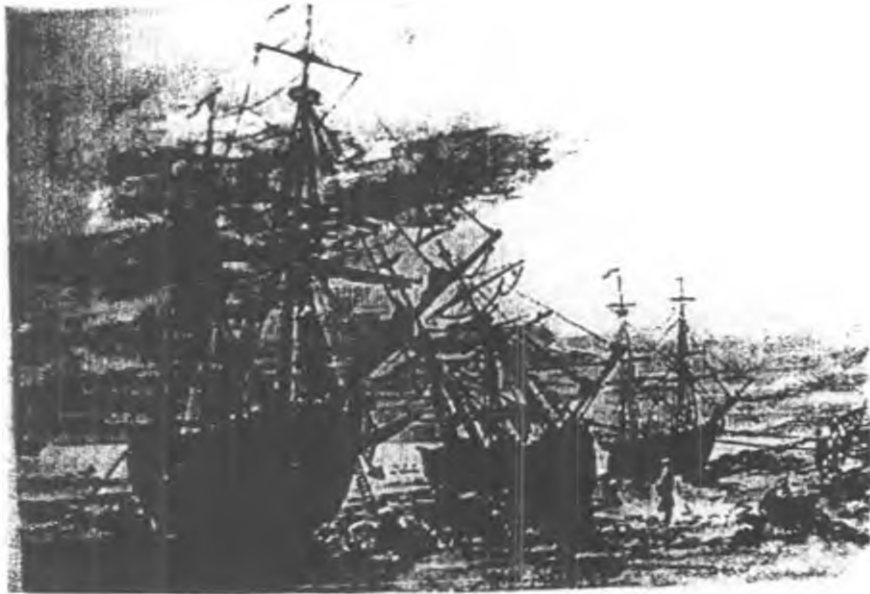


Figure 1. "Coal Briggs On Brighton Beach." Watercolor by John Constable c. 1800 (from Gaunt, 1975: 135, pl. 127). M. Goelet.

These methods could be applied practically only to small vessels in areas where tidal conditions permitted their use, and when it was not essential that work be performed in the area of the keel, which often remained inaccessible.

Alternatively, a vessel could be placed in a wheeled cradle and hauled up an incline. A similar concept is demonstrated by the small German barque hauled up an inclined wooden framework by tackles and capstans shown in Fig. 2. The tackles were attached to through-hull bolts, and the capstans anchored to posts driven into the ground. Instead of a wheeled cradle, the keel rested in a wooden

trough which was probably greased to alleviate friction. Bracing was installed at intervals near the vessel's waterline to prevent it from toppling.

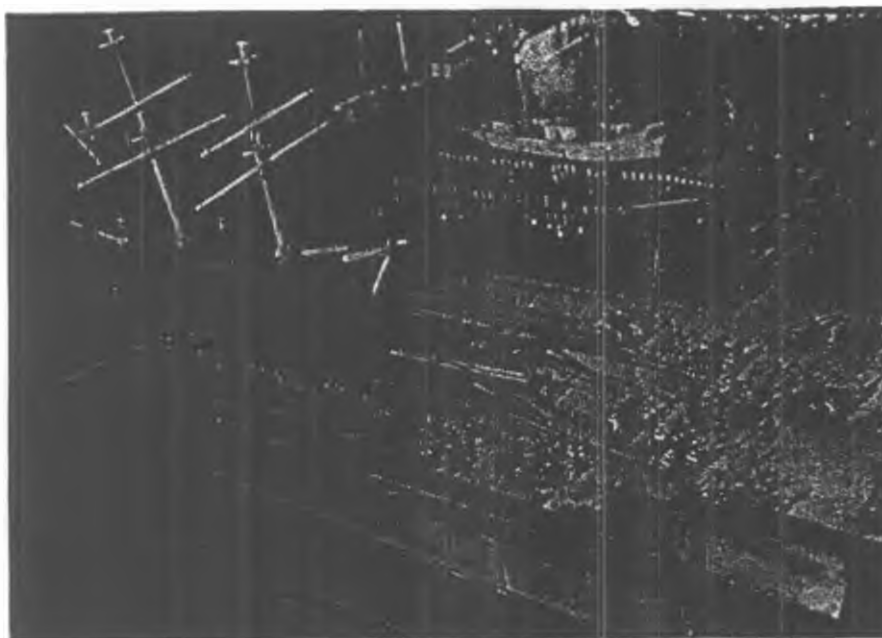


Figure 2. Barque being hauled up a wooden incline with tackles and capstans. Detail of diorama in the Hamburg Historich Museum. M. Goelet.

Even the relatively small vessel shown, probably falling within the 300 to 500 tons displacement range, required nine capstans to haul it from the water, yet much larger ships were sailing centuries earlier.

England's Henry Grace a Dieu, for example, had a tonnage when launched in 1514 ranging anywhere from 1000 to 1500, depending on the source quoted (McKee, 1972: 230; Kemp, 1976: 384), and a displacement tonnage at least

double that of the barque in Fig. 2, p. 3. The size and quantity of the tackle required to haul such a ship from the water would seem prohibitively great.

Although the earliest drydock in the world was built at Portsmouth, England, by direction of King Henry VII during the late 15th century (Rule, 1983: 28), sophisticated facilities such as that shown in Fig. 3 were

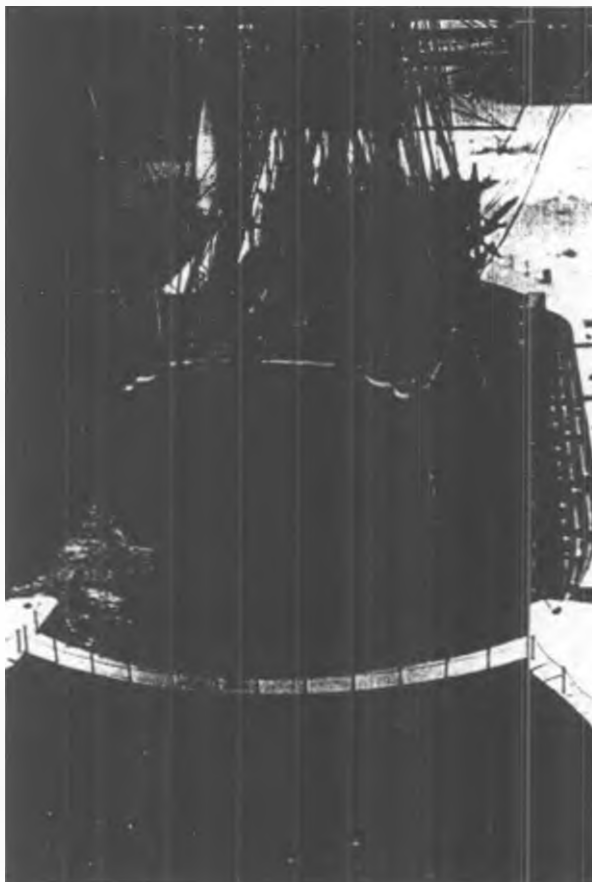


Figure 3. Model of ship in drydock in the Science Museum, London. M. Goelet.

probably quite scarce for a long time thereafter and were certainly not available for use by common merchant vessels.

Makeshift drydocks, where the narrow mouth of a small inlet could be temporarily blocked against the incoming tide, probably existed in England somewhat before Henry VII's time.

In America, the first drydock in the Boston area was built at Charleston in 1678 (Goldenberg, 1976: 15). As that city was a hub of colonial shipping, the drydock was presumably among the earliest in the colonies. However, the Charleston drydock seems to have been premature, as most colonial vessels of that period did not exceed 100 tons burthen and could in fact have been hauled ashore. In any event, it did not long survive, and 125 years later, the frigate Constitution was careened at Charleston (Bass and Bass, 1981). As late as 1825, Isaac Hull was arguing that a drydock should be built there (U.S. Secretary of the Navy, 1825).

With the sparsity of drydocks and in the context of the vast distances and inhospitable shores along which many ships customarily sailed, the captain of a vessel with a leaking hull and pumps barely able to keep the ship afloat could hardly count on finding a facility before it was too late. A prudent master would have made sure before sailing that his vessel carried the material

and equipment to both repair and maintain its underbody and to careen it if necessary.

During the age of sail, careening, the act of heaving down a vessel on one side to expose the other side for cleaning or repair (Kemp, 1976: 139; Paasch, 1977: 228), was certainly the most common technique employed on large vessels requiring below-the-waterline hull maintenance.

Today, truly large sailing vessels are rare due to cargo economics and natural attrition. Their rarity, coupled with the far greater availability of drydocks and marine railways, explains why the difficult and sometimes dangerous practice of careening is now assiduously avoided. The fact that almost all of the remaining great sailing vessels belong to museums or national maritime training facilities and are considered irreplaceable relics of the national heritage makes this avoidance all the more understandable.

Smaller vessels are still careened in areas where drydocks or marine railways are non-existent or their use is prohibitively expensive (Fig. 4). The practice is becoming less common and is accomplished with such a reduction in the complexities and dangers of the operation as to make comparisons to the procedures used on earlier and larger vessels completely inappropriate. For example, a conversation with the West Indian captain of a cargo vessel (slightly smaller than the one shown in Fig. 4)

revealed that it was commonly careened by its normal crew of three or four men heaving on the fall of a threefold tackle without the mechanical advantage of a capstan.¹

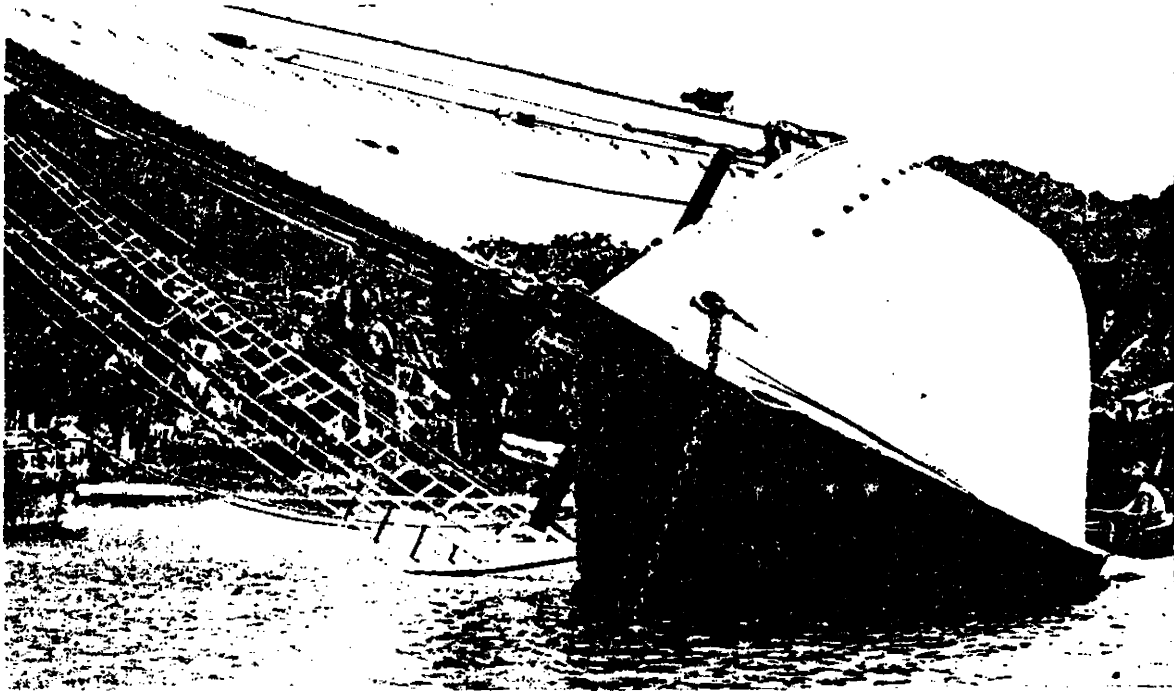


Figure 4. West-Indian vessel Friendship Rose careened recently in Bequi. From Pyle (1981: 56).

OBJECTIVES

The term "careened," derived from the Latin "carina," keel of a vessel, was commonly applied to a smaller vessel hauled into shallow water at high tide and laid on one side leaving the other more or less accessible for cleaning or repair when the tide receded (Fig. 5). This

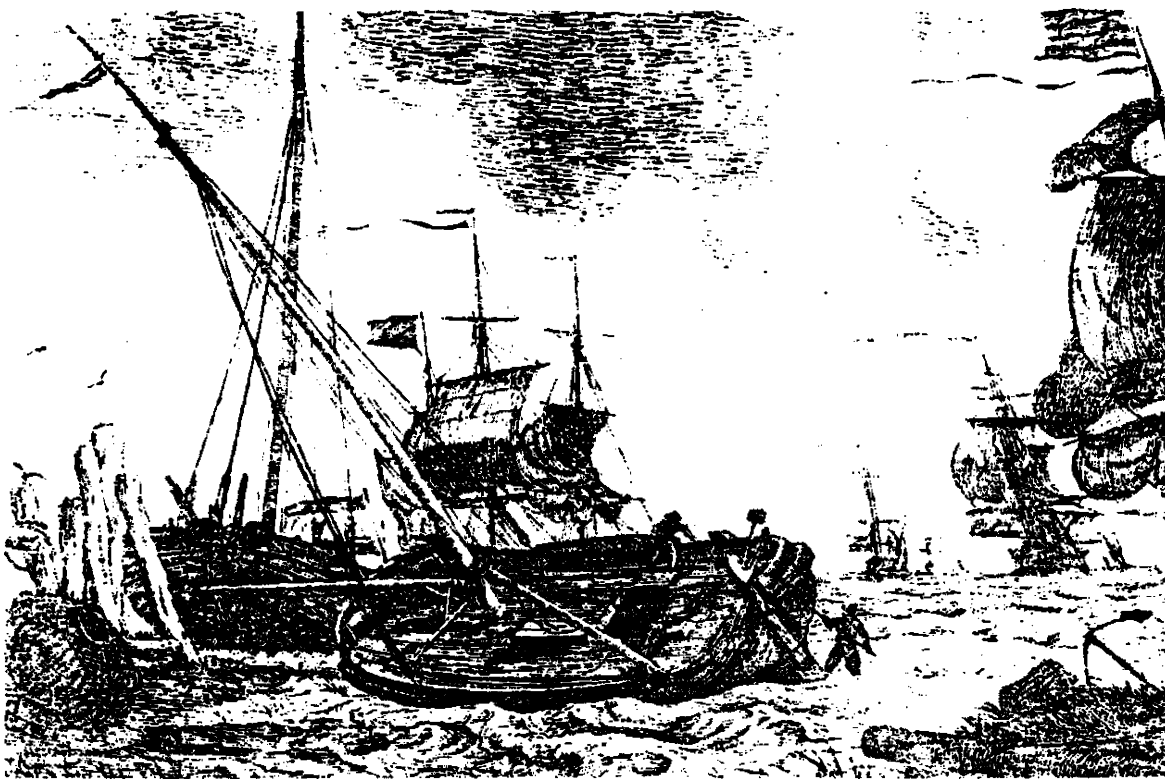


Figure 5. Men cleaning the bottom of a small vessel in shallow water. Detail of etching by Henrik Kobell, 1778. Pl. 188 from Sailing Ships, Prints By The Dutch Masters From The Sixteenth To The Nineteeth Century, edited by Irene De Groot and Robert Vorstman. Copyright (c) Uitgeverij Gary Schwartz, 1980. Reprinted by permission of Viking Penguin, Inc.

study focuses on the much more complicated careening of large vessels while they were afloat.

Careening, or "heaving down" (an expression, British in origin, describing the same event and used alternatively), is a familiar term to most people with some nautical knowledge, but the complexity inherent in bringing a large vessel over onto its side by means of tackle attached to one or more of its masts is not commonly appreciated. Paradoxically, the practice was once so prevalent that few bothered to record it. Henry Manwayring, for example, wrote in 1644: "For the manner of careening, it will be too long and un-necessary to set down all the particulars..." (1972: 20).

The primary objective of this thesis will be to rectify this lack of correlated, technical information by referencing as many different particulars as have emerged during a study of the careening practices employed over the last several centuries on vessels of Northern European, British, and North American origins. Related procedures applied to vessels from other geographic areas will be commented on, but only infrequently, and then primarily for the purpose of enlarging upon the technique under discussion.

An associated objective will be an analysis and interpretation of the literature. Perhaps the most important category of visual source material used to this

end is a series of dioramas located in some of the major European museums depicting ships being careened. These dioramas, photographed and extensively analysed, provided the three-dimensional perspective invaluable to the clarification of procedures described in writing.

A third objective is to determine whether and how careening techniques varied with time, a vessel's origin, or its size, configuration and function. The sometimes unconventional solutions to problems caused by abnormal circumstances will also be discussed.

In addition to these objectives, limited attention will be directed at some of the ordinary maintenance work that might have been done during the time a vessel was laid over on its side. It is not the purpose of this study to treat these ancillary subjects in any great detail but rather to address them as normally-practiced adjuncts of careening.

DOCUMENTATION

Documentation has come from two main sources: written and visual.

The majority of the written information has been derived from 18th- and 19th-century books and manuals on the subject of seamanship. Firsthand accounts by crewmen or naval officers describing the careening procedures employed aboard specific vessels also provided valuable material. Journals, diaries, and ships' logbooks did not contribute as much detailed information as was hoped for. When careening was mentioned, it was usually to state merely that it occurred; rarely were details included. Marine dictionaries and encyclopedias, for the most part, offered general rather than in-depth descriptions.²

Visual sources included book illustrations, original paintings, drawings, and etchings, and, for the last half of the 19th century, actual photographs of ships--mostly whaling vessels--being careened.

The dioramas compensated, to a degree, for the unavoidable deficiency in primary-source interviews. Very few people now living have actually witnessed the careening of a large ship, and of those even fewer would be capable of describing it. Even so experienced a mariner as Alan Villiers, describing the heaving down of the Joseph Conrad in 1934 wrote, "No one in the ship

(including myself) had ever seen it done before; it was prehistoric, almost, like the single tops'1 ship" (1937: 155).

Most of the dioramas were constructed during a time when the modelmaker, if he was not expert in the intricacies of careening as practiced within his geographic area, at least would have had access to people who were knowledgeable. Although some of the models were more skillfully rendered and showed more detail than others, they all in large part agreed with, and their accuracy was reinforced by, the available literature.

PRELIMINARY CONSIDERATIONS

Ordinarily, scant preparation was required to careen a small vessel. On the other hand, the preparation of a large vessel for careening was extensive and critical. Its hull was more vulnerable to damage than a small vessel's due to its increased size and weight. Its rigging was more complex and required more sophisticated supporting gear than did that of a smaller vessel, since the strength of each part relied more heavily on the integrity of the whole. A multitude of factors needed consideration, not the least of which was a determination of whether or not the work could be done using a less complex method than fully careening the ship.

Since a vessel was understood to be fully careened when its keel was free of the water, occasional references to the degree of heel are found in definitions of the term "careen," such as "dos tercios" (two thirds) or "media carena" (half careen) in De Lorenzo's Spanish maritime dictionary (1864: 133). It was often unnecessary to heave down a vessel keel out to accomplish the task at hand: for example, to repair a vessel which had been holed somewhat above its keel. In that instance, the complexities of some procedures could be reduced and others eliminated.

At best, to careen fully a large ship was an exacting

and time-consuming enterprise. At worst, it could be exceedingly dangerous, particularly with a large vessel at a time when the mathematics of stability were not well understood. For example, the Trade's Increase, a 1209-ton East Indiaman, and, according to Clark (1910: 23) "the largest ship launched in England up to that time," was lost in Java in 1609 as a result of being heeled over too far and falling over on her side while being careened for hull repairs. She could not be saved and was subsequently burned by the Javanese (Chatterton, 1914: 226).

With the dangers and complexities of careening in mind, a ship's captain might have been well advised to seek alternate means to achieve his objective.

Alternatives To Careening

In later years when drydocks became more common, careening was "a practice very rarely adopted in the British navy, never, indeed unless there is an absolute necessity, from the want of a dock" (Burney, 1974: 76). This contradicts Rees's statement (1819, vol. VI, "careening"), written several years later, that British warships were generally careened every three years, even though, by that time, all British warships were sheathed with copper. There was often no dock available and, moreover, the part of the hull needing attention extended

only a few strakes below the waterline.

Parliamentary heel

Probably the most common reason for exposing any part of a vessel's underbody was to remove the marine organisms which significantly reduced its speed and maneuverability. Their growth was most prolific in the vicinity of the waterline and required periodic removal. To service that area, a procedure known as a "parliamentary heel" was commonly used. It involved shifting ballast and ordnance from one side of the vessel to the other, thereby exposing the lightened side of the hull. It was the normal method of boottopping a ship (the Spanish "media carena," Velazquez, 1875: 128) and was a routine procedure.³

If a ship was heeled over too far and was structurally unsound, or improper procedures were followed, a parliamentary heel, like careening, could be extremely hazardous. The Royal George, a 100-gun ship-of-the-line, was lost off the coast of southern England in 1782 due to a combination of these factors. The ship had been put into a parliamentary heel to port in an attempt to repair a leaky sea-water valve 3 feet below her starboard waterline. According to survivors, her ribs and planks were rotten and too weak to bear the extra weight of the brass guns that had been moved to port to heel her

over. In addition, casks of rum were being hoisted aboard from lighters alongside in order to take advantage of her lowered main deck. This increased both the strain on her already overstressed timbers and her angle of heel. The leeward gundeck ports had been left open, and water began coming in through the them, increasing her angle of heel still further and providing the coup de grâce (Gulliver 1939: 74-77).

Captain Liardet, years later, in a short treatise on the extreme heeling of ships, was of the opinion that the Royal George would have stood an increased chance of survival had external means of heeling the ship been employed, i.e., had it been careened. As he interpreted the sequence of events, the crew, becoming aware of the danger too late, attempted to drag some of the ship's guns from the leeward side of the ship, but the added weight to leeward of the crew itself only intensified the problem and hastened the ship's end (Liardet, 1849: 114).

Scrubbing devices

If more of the bottom than the first few strakes below the waterline required cleaning, a scrubber, such as that designed by William Hutchinson sometime before 1777, might be employed (Fig. 6). The device consisted of two elm frames each surrounding a 10-gallon (37.85 l) cask to

provide bouyancy, with birch broom stuff secured on either side of each cask to provide the scouring medium. The two parts were joined by ironwork so they could better conform to the shape of the hull. Slings and rope were fastened to draw the device along the ship's bottom.

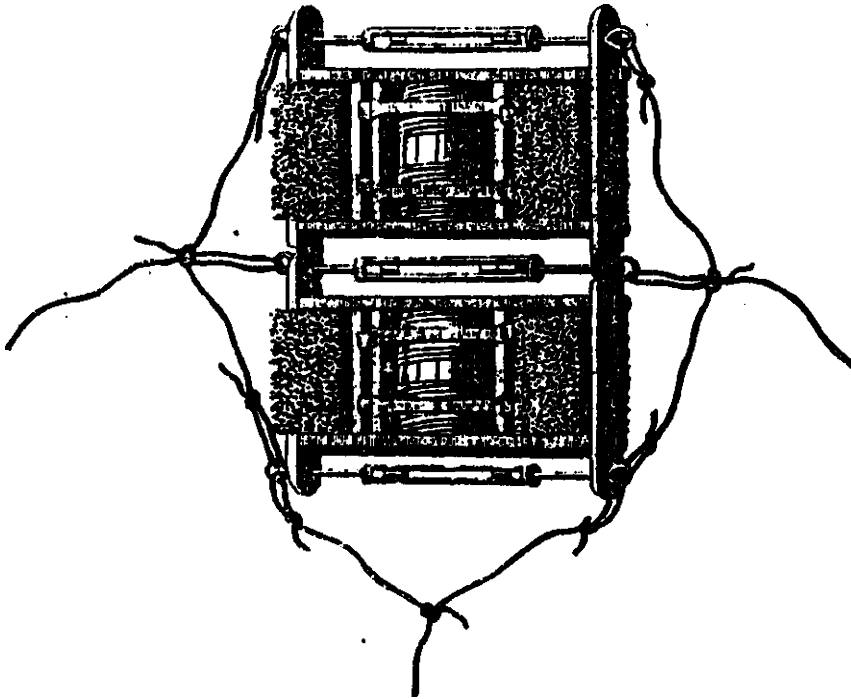


Figure 6. Bottom scrubbing device. From Hutchinson (1777: pl. 9).

In 1863, the patent for a somewhat similar device (Fig. 7) was applied for by another Englishman, William H. Phillips. His invention differed from Hutchinson's in that the scrubbing portion revolved freely on a central axis when drawn through the water by control chains or ropes. It was designed to rotate by tidal action while

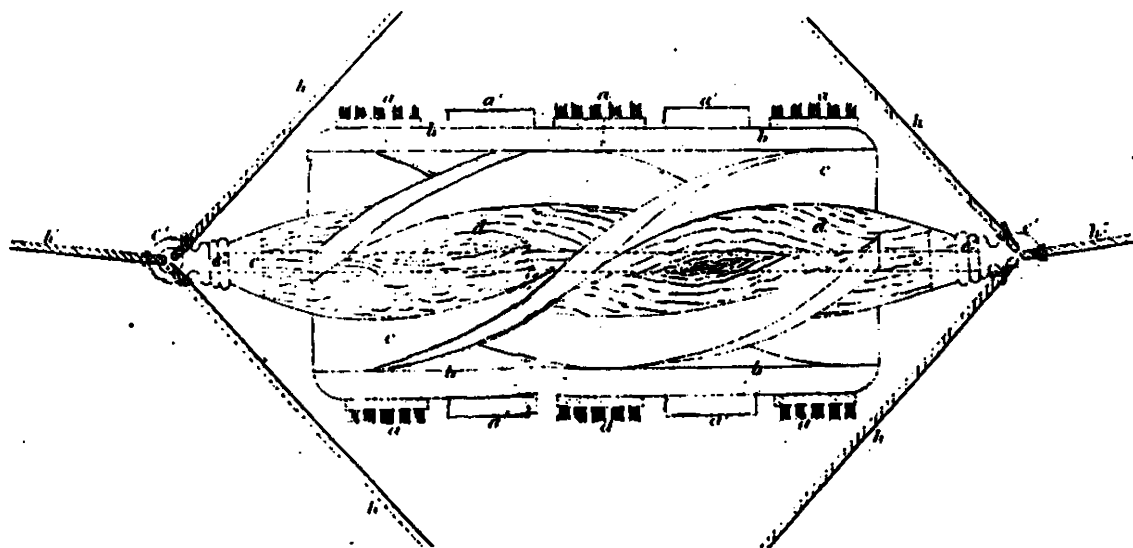


Figure 7. Design from a patent application for a bottom scrubbing device. From Phillips (1863: fig. 4).

stationary. Whether or not the device proved successful is not known.

Temporary repairs

If a ship was leaking, but not to the extent that sinking was imminent, it might have been possible to fother the leak, enabling the ship to reach a place where more permanent repairs could be made. In early days fothering consisted of drawing a basket or bag filled with chopped oakum, cotton, sawdust or the like underneath the hull to the position of the leak, then pulling a tripping line fitted to the bag releasing the material contained within. The intent was for the suction created by the leak

to draw the material into the opening, partially sealing it.

In later years thrummed squares of sail--sails with closely-stitched pieces of rope yarn projecting from them--were drawn into position by control lines manipulated from both sides of the vessel. These sections of canvas resembled present-day collision mats and provided much the same service (Chatterton, 1913: 263; Luce, 1884: 582-83; Kemp, 1976: 322).

For the temporary repair of through-hull punctures such as might have been caused by a cannon ball, Steel described a method, the invention of which he credited to a Mr. Hill. Hill's invention consisted of a circular piece of elm 2 to 4 inches (5.08-10.16 cm) thick, the outside convex, the inside somewhat concave, and of a sufficient size to cover the hole. The concavity was lined with several folds of flannel or similar material dipped in warm tallow. A tapered rope about 6 feet (1.83 m) long, with a double wall knot at the large end and an eye worked into the small end, was pulled through a hole in the wood and fabric until the wall knot butted against the outside of the elm (Fig. 8).

From the inside of the vessel, a light line (probably tied around a small piece of wood) was first worked through the puncture and fished up from the deck of the vessel as it reached the surface. This was secured to the

eye at the end of the tapered line and the whole drawn back from inside the ship until it was firmly seated against the puncture, sometimes with the use of a tackle (Steel, 1807: facing 12).

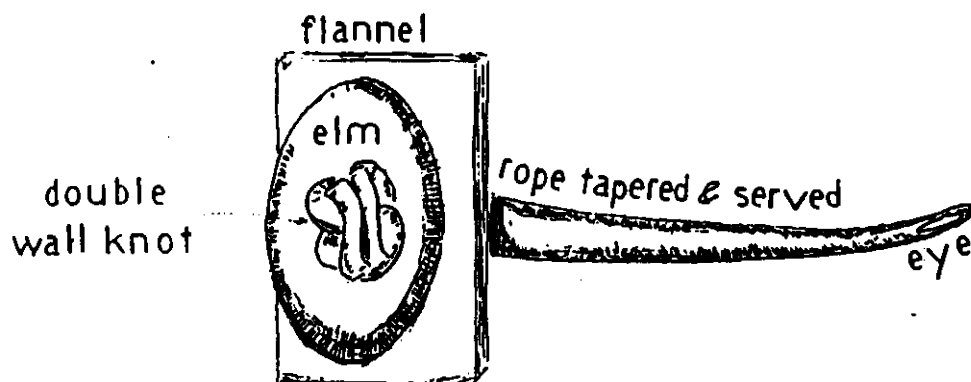


Figure 8. Underwater patch for hull puncture. After Steel (1807: 12).

Floating support systems

By 1815, ships requiring a less immediate but more sophisticated solution to a problem may have had access to wrought iron caissons, or floating drydocks, available in some English shipyards. These measured 220 ft (67.056 m) in length, 64 ft (19.507 m) in width, were 30 ft (9.144 m) deep, and were capable of lifting a first rate ship and having its keel dry in three hours (Burney, 1974: 64-65). Theoretically, the caissons may have been an option for merchant vessels requiring repairs, but their initial

rarity would probably have restricted their use to important military vessels in the few ports where they might have been found.

These first floating drydocks were, most probably, an adaptation of a device called a camel invented by the Dutch in about 1688 and used to help large ships over the shallows into harbors which they could otherwise not enter (Hamersley, 1884: 105). A camel consisted of two separate water-tight half hulls, each hull divided into several watertight chambers with one or more pumps. They were straight walled on one side and concave on the other so that when joined they molded to the shape of a vessel's hull. After being partially flooded, the two parts were placed on either side of the vessel and attached to each other by cables run under its keel, tensioned by means of deck-mounted windlasses. Once the camel was properly positioned and secured in place, the water was pumped out, thereby raising the ship.

Fig. 9 shows a Dutch warship partially supported by a camel so that it might clear the bar at the entrance to Amsterdam. Men standing on the camel's decks are pumping water from its twin hulls. Lifting timbers protrude through the tops of the lower-deck gunports and diagonal braces extend from their ends to the upper hull of the ship.

Burney stated that these devices were capable of

decreasing a ship's draught by 11 feet (3.35 m), although Cairo is more conservative, estimating a 7 or 8-ft (2.13 or 2.44 m) reduction in draught (Burney, 1974: 66; Cairo, 1976: 83).

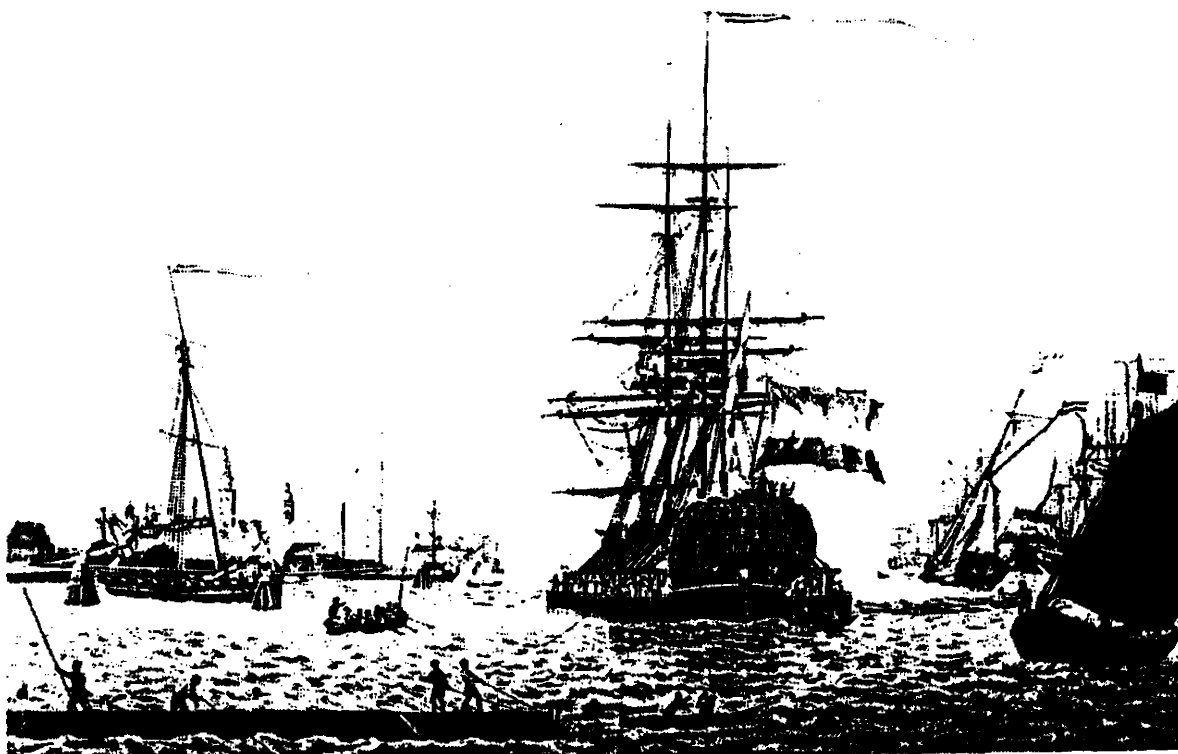


Figure 9. Dutch warship in canal at entrance to Amsterdam Harbor. Courtesy Hart Nautical Collections, MIT Museum, (Clarke Collection F 58), Boston.

CAREENING SITES

Choosing a careenage

The preferred location for a careening was a place where the land configuration would afford some protection against the prevailing winds and provide calm water for the low-freeboard work platforms or floats hauled close alongside the exposed hull.

In cases where the vessel had to be hove down in potentially hostile waters, the site had to be defensible, for even a warship, no matter how imposing under ordinary conditions, was vulnerable when hove down.⁴ If possible, some of the ship's guns would be positioned to defend entrances to the careenage.

Ships could either be careened against the shore, a pier or wharf projecting from the shore, or they could be hove down against another vessel. References are found to vessels being careened against heavy anchors, but the practice seems to have been uncommon and, with the forces involved, would have been safe only for small vessels.

Advantages of careening against the shore versus against another vessel

If the vessel was to be careened against the shore, a

fixed pier, or wharf, a place with a minimal tide was advantageous. Heaving-down gear consisted of one or more tackles, the top block of each affixed to one of the vessel's masts, the other to the land, pier or wharf. If the ship was to maintain a constant angle of heel, a substantial tide required constant attention and adjustments of the tackle falls; they had to be slackened as the tide rose and tightened as it fell.

This was probably the primary reason why Todd and Whall wrote that "Vessels are much easier hove down to a floating craft than they are to the shore..." (1911: 321). Sir Henry Manwaring, another Englishman, had also written more than two centuries earlier that "careening is to be done in harbour, where the slower the tide runs the better: and it is most commonly used in such places, where there are no docks to trim a ship in, nor no good graving places, or else that it doth not ebb so much that a ship may sew dry." He continued that, to careen a ship, they haul down against a lower ship, and right again with tackles (Manwaring and Perrin, 1922: 118).⁵

It would be wrong to conclude, however, that heaving down against a floating craft was everywhere the preferred way to careen a ship, even among the British. The number of careenages consisting of permanent shore installations that existed in England, the rest of Europe, and the New World quickly dispels such a notion. The two principal

advantages of a floating craft were its mobility and a reduction in the attention required by the ship's rigging. If these were the only, or even the paramount, considerations in determining whether to careen against a floating or fixed installation, the expense incurred in constructing permanent, shore-based facilities would seem unreasonable. Undoubtedly, other factors, such as the convenience with which top rigging, stores, armament, and ballast could be unshipped and later restored on board, as well as quick access to supplies on shore, were also important considerations.

The British in fact heaved their ships down indiscriminantly against both permanent shore facilities and floating hulks. It seems likely that for them, as well as for vessels of other nationalities, the depth of water close to shore was a major determinant as to which type of facility was to be used in a formal careenage. If the water shoaled too gradually to bring a large vessel, with a draught that often exceeded 20 feet (6.1 m), close enough to shore to be careened, then a hulk or barge would, of necessity, have been used.

Unaccompanied vessels requiring careening while on a voyage, no matter what the prevailing custom, had no choice other than to careen against the shore. The French frigate Artemise, for example, was careened against a Tahitian beach in 1839 (Boudriot, 1981), even though King

(1802: 309), describing the somewhat earlier heaving down of another French frigate, the Courageux, at the naval arsenal at Toulon in 1793, wrote that "The French do not heave their ships down to a wharf, but to a hulk adapted solely to that purpose, which is generally a small ship of the line cut down, and its stability increased by a great quantity of iron and shingle ballast."

Nations which favored careening ships against other craft

The majority of the pictorial evidence does indicate that the favored method of careening German, Belgian, French, and Dutch ships was to heave them down against floating craft specially designed for that purpose. Dioramas photographed in Germany and Belgium (Figs. 10 and 11) show mid-to-late 19th-century merchant vessels careened against barges. The substantially larger and earlier (probably late-17th- or early-18th century) French warship in Fig. 12, p. 28, is also shown careened against a barge. These barges, although serving the same function, varied somewhat among themselves in design.

Dioramas tend to represent the most common techniques employed in a given activity, so credence can be given to the assumption that seamen in Germany, Belgium, and France usually hove down their vessels against careening barges. That this was certainly true of earlier French vessels is

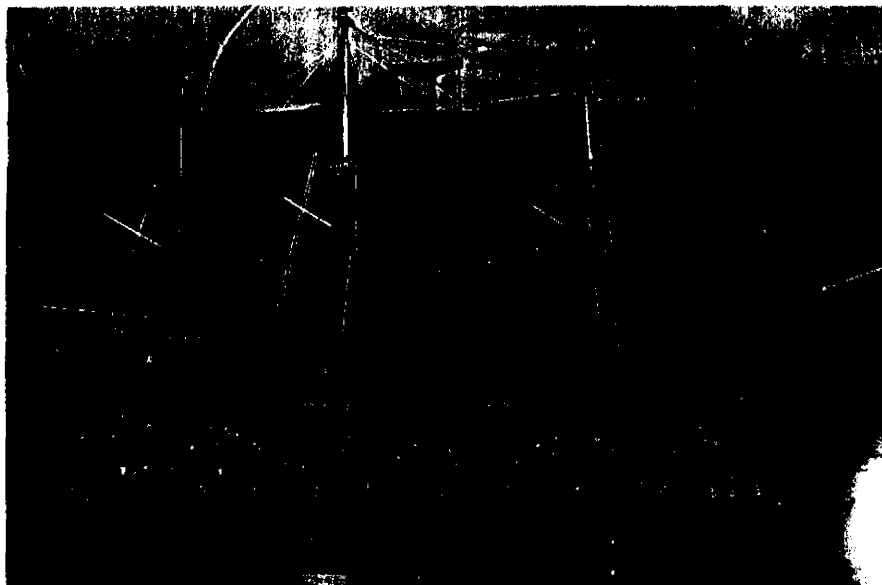


Figure 10. Diorama of ship careened against barge in Hamburg Historich Museum. M. Goelet.



Fig. 11. Diorama of ship careened against barge in Antwerpen National Scheepvaartmuseum. M. Goelet.

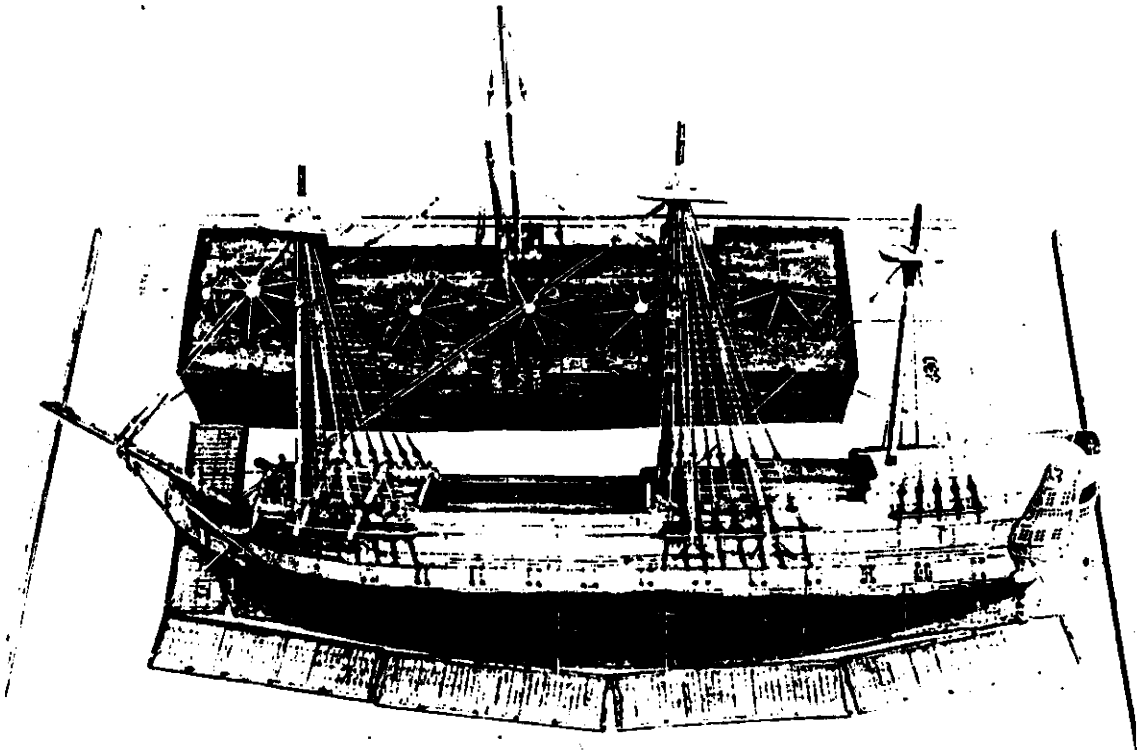


Fig. 12. Diorama of an early French vessel careened against a barge. Courtesy of the Musée De La Marine, Paris. Photograph No. 3,135.

further supported by views of a late-17th- or early-18th-century vessel of that nationality careened against two barges (Figs. 13 and 14).

The number of representations of Dutch vessels heaved down against one or two careening barges (the vessel on the right of Fig. 15, p. 30, is a typical mid-17th-century example) overwhelmingly indicates the predilection in that

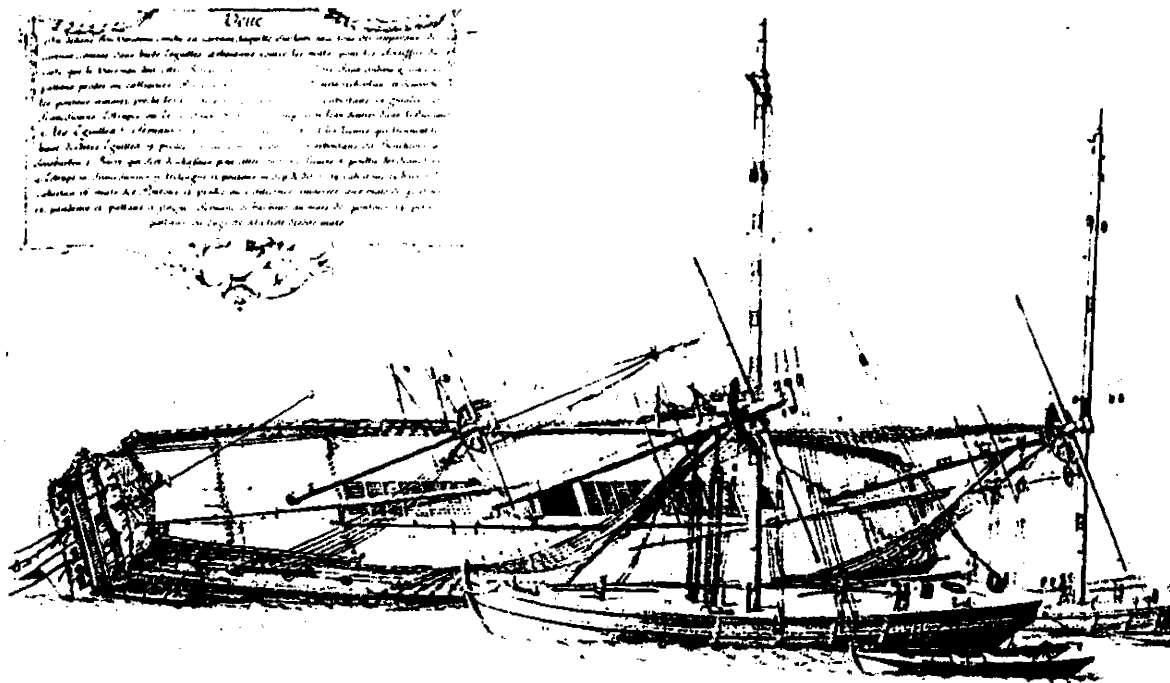


Fig. 13. Deck view of a late-17th-century French ship careened against two barges. From a series of drawings titled Album de Colbert. From Taillemite (1967: 76).

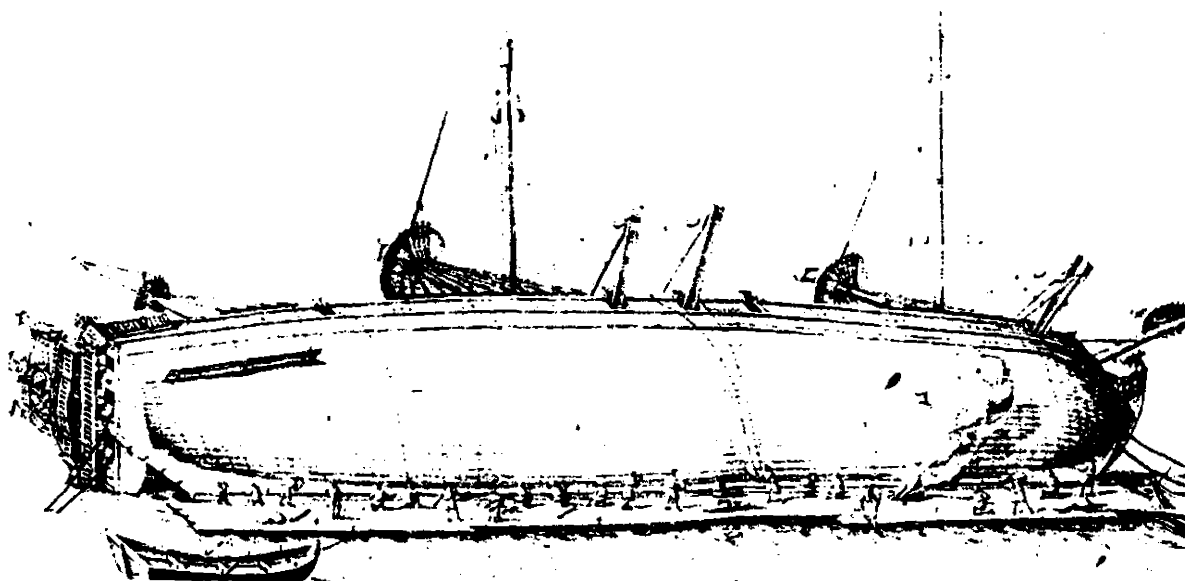


Figure 14. Bottom view of the ship in the preceding illustration. From Taillemite (1967: 77).

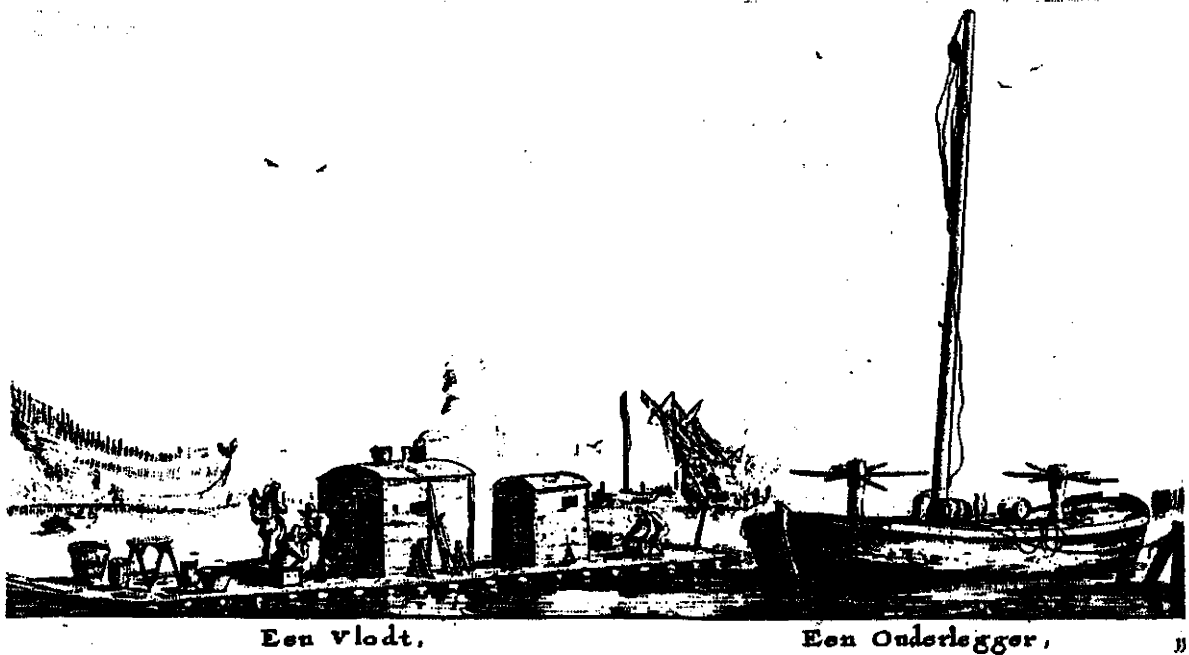


Figure 15. Mid-17th-century Dutch float and careening barge. Etching by R. Nooms. Courtesy of the Rijksmuseum, Amsterdam. Photograph No. 19,036.

country towards the use of barges. This preference was probably an outgrowth of the general shallowness of Dutch coastal waters.

The foregoing is not meant to suggest that all vessels of the four nations mentioned were invariably careened against a hulk or barge. Fig. 16, for example, shows a German schooner-brig hove down against the shore in the late-19th century, a time when other options certainly existed. As in other aspects of careening, the decision to heave down a vessel against a barge or the

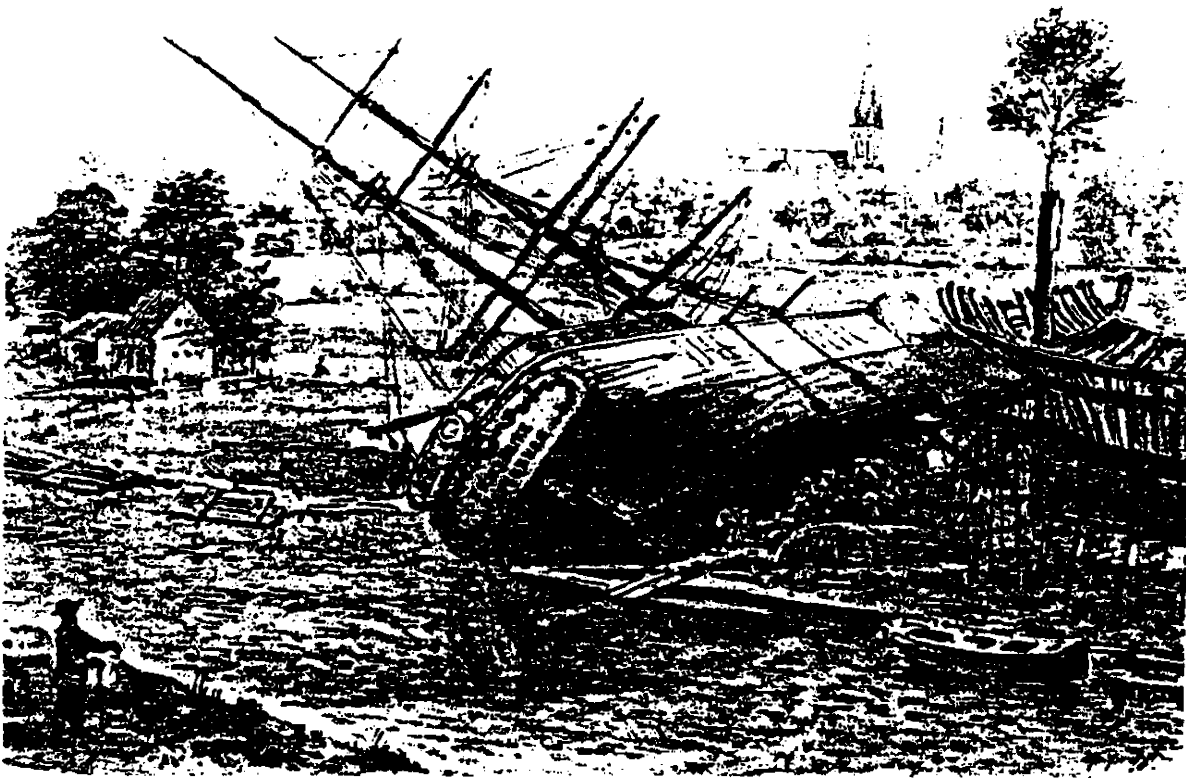


Figure 16. The late-19th-century German brig Friederike hove down. Watercolor signed Heinze, 29. 7. 90. (Meyer, 1976: 139).

shore was influenced by circumstance as well as the personal preference of the crewman in charge of the operation.

Nations which favored careening ships against the shore

The pattern seems to shift in the Scandinavian countries of Denmark, Sweden, and Finland, where most representations of careening show vessels hove down

against the shore or against projections extending from the shore.

A notable exception is a diorama representing the Stora shipyard in Stockholm, Sweden in 1781 (Fig. 17). A

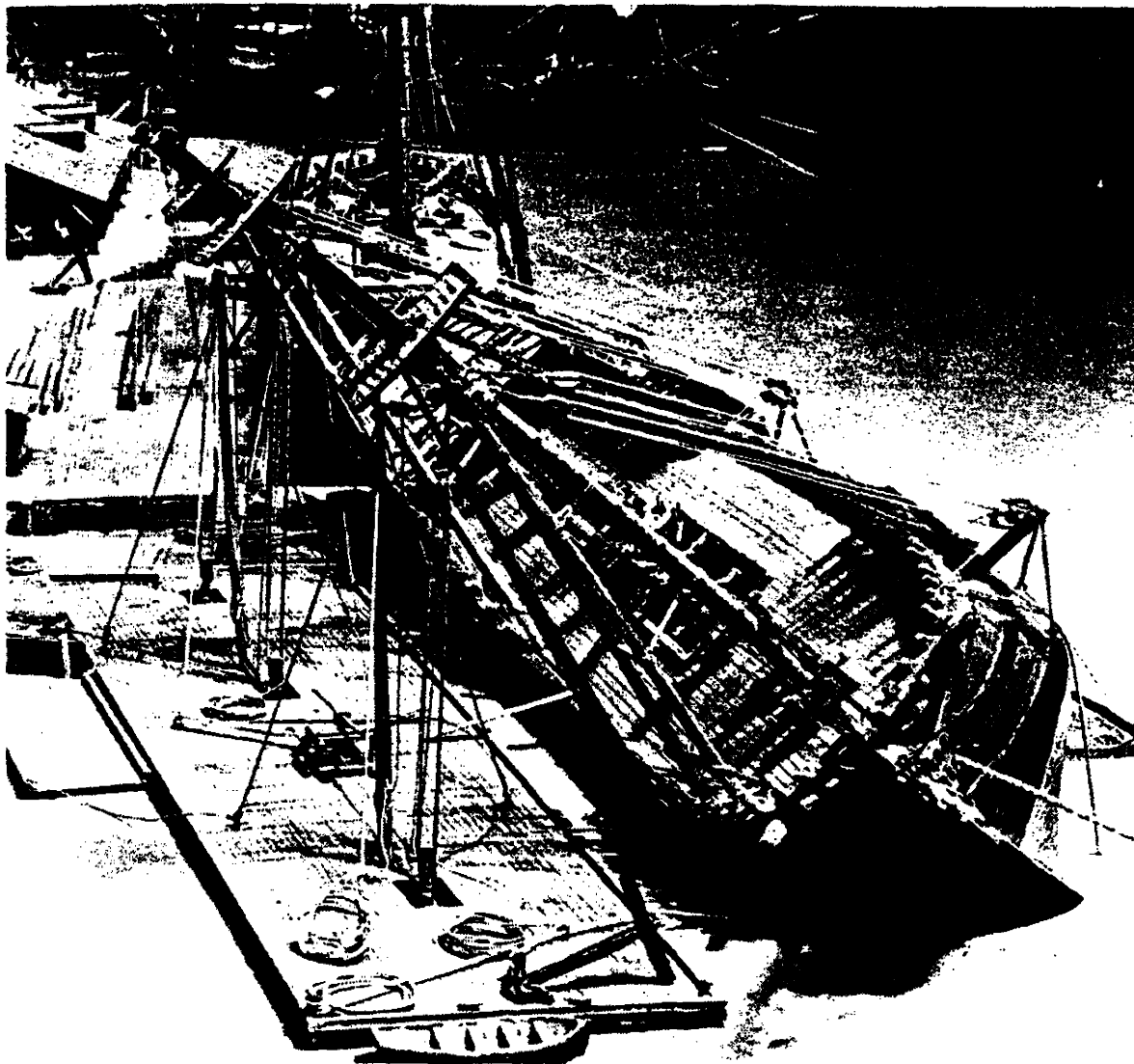


Figure 17. Detail from a diorama portraying the Stora Shipyard in Stockholm as it appeared in 1781. The vessel has been careened against a floating dock. Photograph courtesy of Statens Sjöhistoriska Museum, Stockholm.

portion of it shows a three-masted ship careened against a large floating platform securely attached to and acting as an extension of the wharf. This approach was an amalgamation of the best features of both philosophies, allowing direct access to land and permitting the ship and the platform to rise and fall in unison with the tide. The procedure is duplicated, to some degree, in the Belgian diorama (Fig. 11, p. 27) where the barge lies between the ship being careened and the wharf, solving the same problems in a somewhat more cumbersome manner.

In a preamble to a consolidation of notes taken when the U.S. frigate Brandywine was careened at the Brooklyn Navy Yard, Luce (1884: 584) remarked that "[t]ackles are brought from the mastheads to the shore, or to another vessel (emphasis mine), and these being hove on, turn the bottom up out of the water." That description must have been of a general nature rather than intended to describe standard U.S. naval procedure, as there is a complete lack of evidence to support a premise that American vessels were careened against other vessels other than from necessity. There is ample proof, on the other hand, to suggest that careening against a wharf was a very common practice. The notes Admiral Luce referred to indicated that the Brandywine herself was hove down against a wharf (1884: 586).⁶

The Constitution also was careened against a wharf at Boston in 1803 (Bass and Bass, 1981), and again "in shallow water" just before the War of 1812 (Magoun, 1928: 71). In further support of the thesis that United States vessels were rarely careened against floating craft, all the drawings, paintings, and many photographs of careened American whaling ships which I reviewed showed them careened against a wharf (Figs. 18-20, for example).

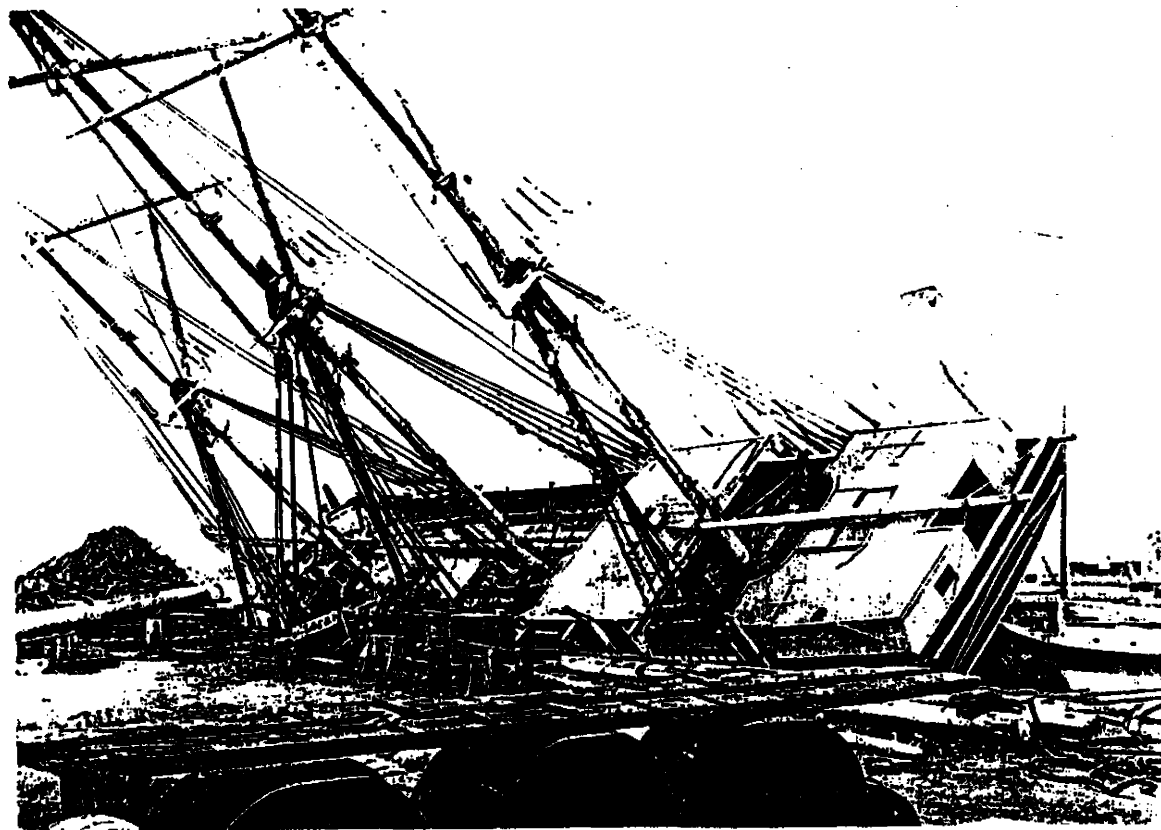


Figure 18. The American whaling ship James Arnold hove down for repairs. Courtesy of the Peabody Museum, Salem. Photograph No. 16,443.

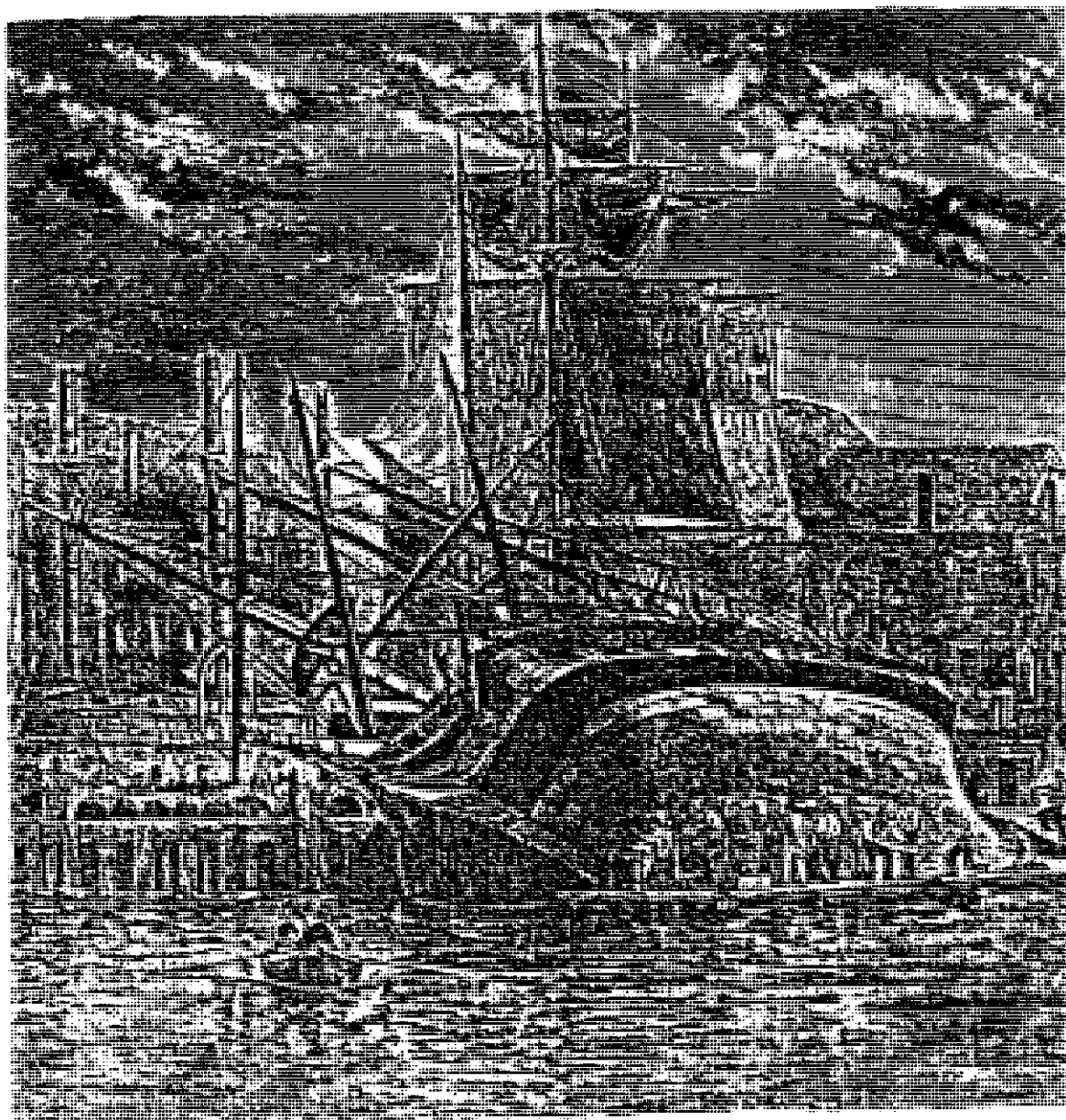


Figure 19. "An Old Whaler Hove Down For Repairs Near New Bedford." Drawing by F.S. Cozzins. From Harper's Weekly (vol. XXVI, 1355: 788).

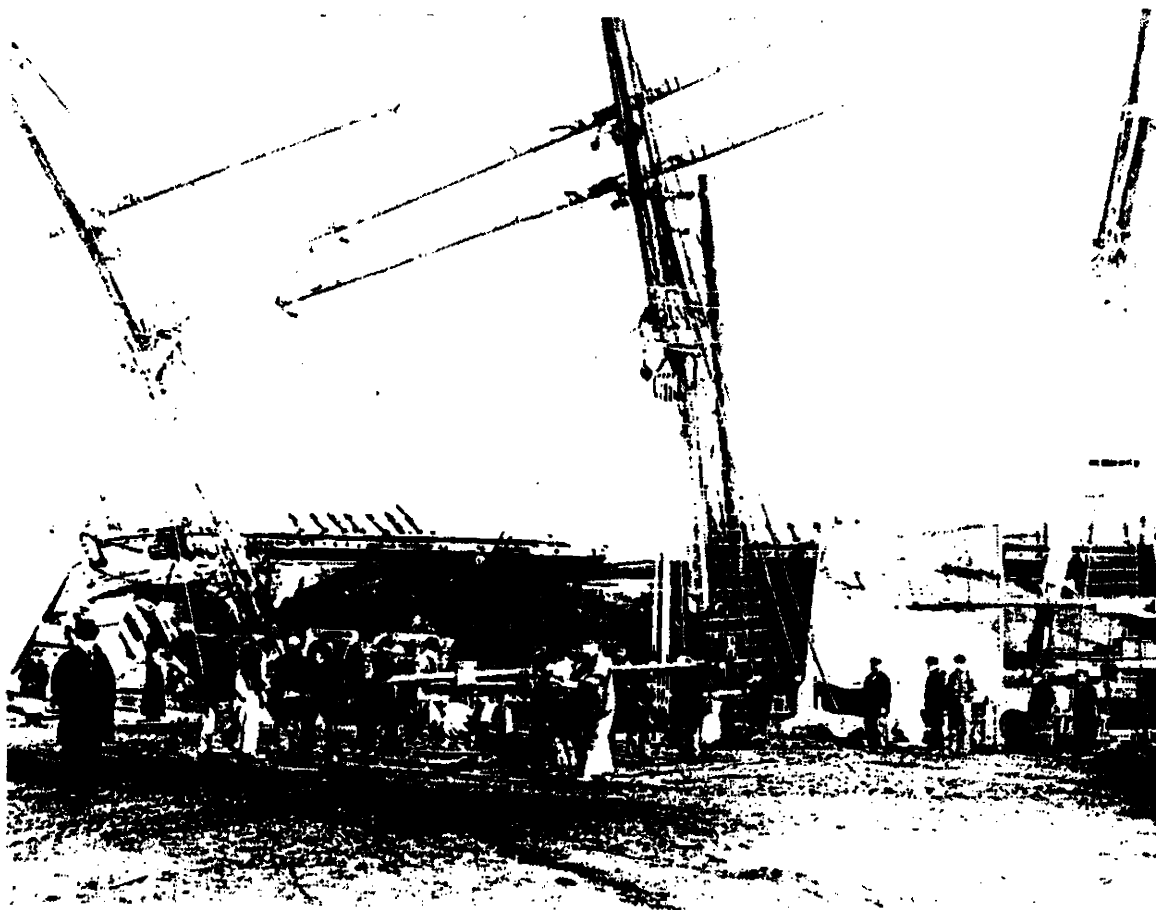


Figure 20. The American whaler Josephine hove down. Courtesy of the Peabody Museum, Salem. Photograph No. 9,346.

No documentation of the careening of an American ship was found pre-dating the 19th century. It must be concluded that at least from that time onward--and it was only then that American ships over 100 tons burthen began to be built in substantial numbers--careening against the shore or a wharf was heavily favored over heaving down against another vessel.

INITIAL PREPARATIONS FOR CAREENING

Once the site had been selected and the method by which a vessel was to be careened was determined, many things happened concurrently. The procedures to be described are those that would normally have taken place on a large vessel, techniques varying somewhat with national custom and over time. It bears repeating that these procedures could be supplemented, deleted, or modified as circumstances or a captain's individual preference dictated.

Hull Preparation

A vessel to be careened against the shore or a wharf was brought alongside with the side to be hove down (henceforth called the leeward side) parallel to and facing the shoreline.

If the careening was to take place in a hot climate, and one of Dr. Hale's mechanical ventilators or a similar device, none of which were invented until the early 1740s (Burney, 1974: 597), was lacking, a canvas ventilator might be rigged over an available hatchway to catch the breeze and funnel it below decks. This bit of unwonted consideration for those working below can be better understood by appreciating that, ultimately, almost

everything finds its way into a ship's bilges. The stench below decks with a ship careened and most of the bilge exposed, perhaps for the first time in several years, must have been unbearable in tropical heat, even to seamen inured to noxious odors.

The crew would begin lightening the ship, hand-carrying what they could across gangplanks laid from the ship to the wharf or shore and using tackle rigged from the lower yardarms to move heavier items such as cannon (Fig. 21). A ship that was to be careened against another floating craft would unload material onto shallow-draft

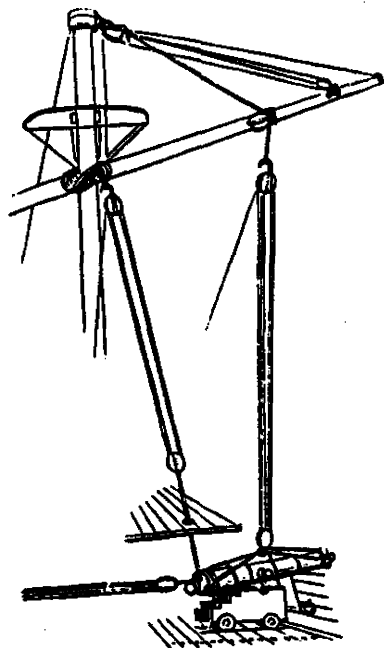


Figure 21. Off-loading a ship's gun by means of tackles rigged to a lower yardarm. From Brady (1857: 114).

vessels appropriately called lighters, which would temporarily store the material or convey it to shore.

The objective was not only to reduce the vessel's weight and stability, thereby imposing less strain on the careening tackle and the vessel's structure, but to limit the possibility of a sudden weight shift inside the hull as it was heeled over. Such an occurrence could be very dangerous, imposing a sudden extra strain on the hull structure, rigging, and the heaving-down tackle, or even threatening the positive stability of the ship.

Ordinarily, a vessel would off-load almost everything movable contained within, retaining only enough ballast to maintain stable equilibrium at the angle of heel anticipated.

While this was being done, ship's boys and convalescents would be put to work picking oakum. Carpenters and caulkers would plank over all gunports, cover them with tarred canvas, plug, caulk, and pitch over and otherwise secure all openings in the hull where water could enter the leeward side.

The French frigate Courageux, in addition to having had her main-deck gunports closed with double pieces of deal (fir planking) and caulked, is recorded as having had "two breadths of thick deal annexed to her gangways." The reason given for this was that the authorities in Toulon were concerned about water entering the waist of the ship

when it was careened keel out (King, 1802: 309-10).

The gangways mentioned, although possibly a reference to the opening through the vessel's bulwark used for entering and exiting, by context were probably the walkways of the same name that extended along the ship's side between the quarter deck and the forecastle.

Gangways, when first installed on English ships in the early-18th century, were narrow and extended from the quarter deck only as far forward as abeam the mainmast. By the 1790s, the period during which the Courageux was careened in Toulon, they had been considerably widened and reached to the forecastle (Howard, 1979: 188 and 190). Although the Courageux was French built, King mentioned that she had formerly been in the service of the the English navy (1802: 309). If the vessel had not originally been equipped with gangways, they may well have been added while she was in English service.

While water entering the waist was of obvious concern to the French, King (1802: 310) somewhat scornfully termed it a "supposed inconvenience." Notwithstanding that King's attitude is understandable in view of the many representations showing water in the waist of vessels being careened, including somewhat later French frigates (Fig. 22 and Fig. 23, p. 42), the French concern may well have been valid. This will be discussed in more detail in a later section dealing with ship stability.

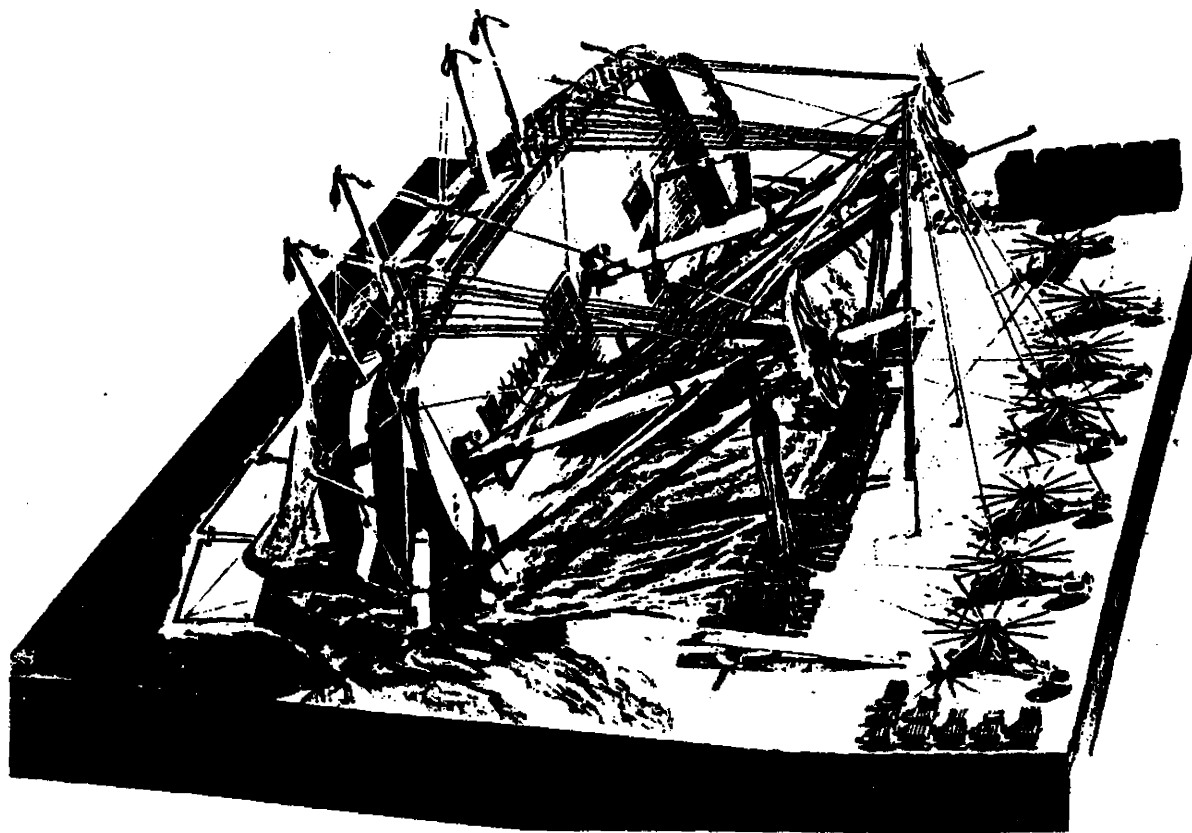


Figure 22. The French frigate Artemise, showing water in the waist. Courtesy of the Musée De La Marine, photograph No. 9,236.

Captain Alston (Walker, 1902: 537-38) mentioned bulkheads built athwartship from the leeward side to the centerline of the main deck, one at either end of the skids and one across the front of the poop deck, when the HMS Formidable was careened at Malta in 1843. These, however, differed in function from the longitudinal

bulkheading on the Courageux, as they were designed to confine the water entering the waist to that area of the ship rather than to prevent it from entering. Their purpose is confirmed in an account of the careening of the 72-gun HMS Melville against another ship in Chusan Harbor (Harris, 1841: 18; see Fig. 24).

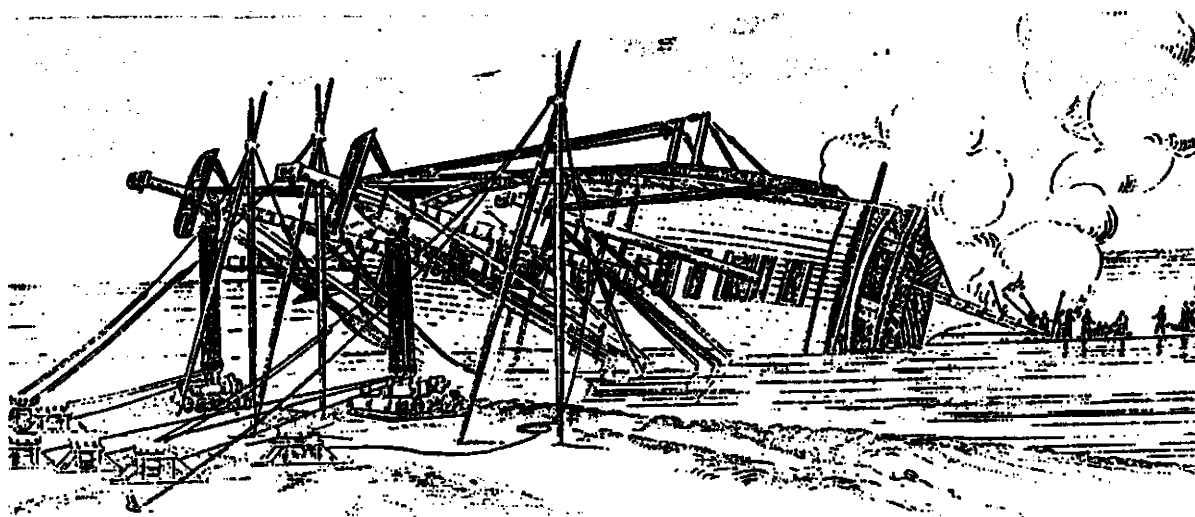


Figure 23. Sketch of a French frigate careened. From Bonnefoux (n.d.: pl. 3, F. 1.).

Carpenters were also employed in the construction of angled platforms in the hatchways. These functioned as work and staging areas on which to position crews to man the auxiliary pumps required to keep the ship clear of water while she was hove down. No matter how well carpenters and caulkers had done their jobs, water seepage was an incessant problem.⁷

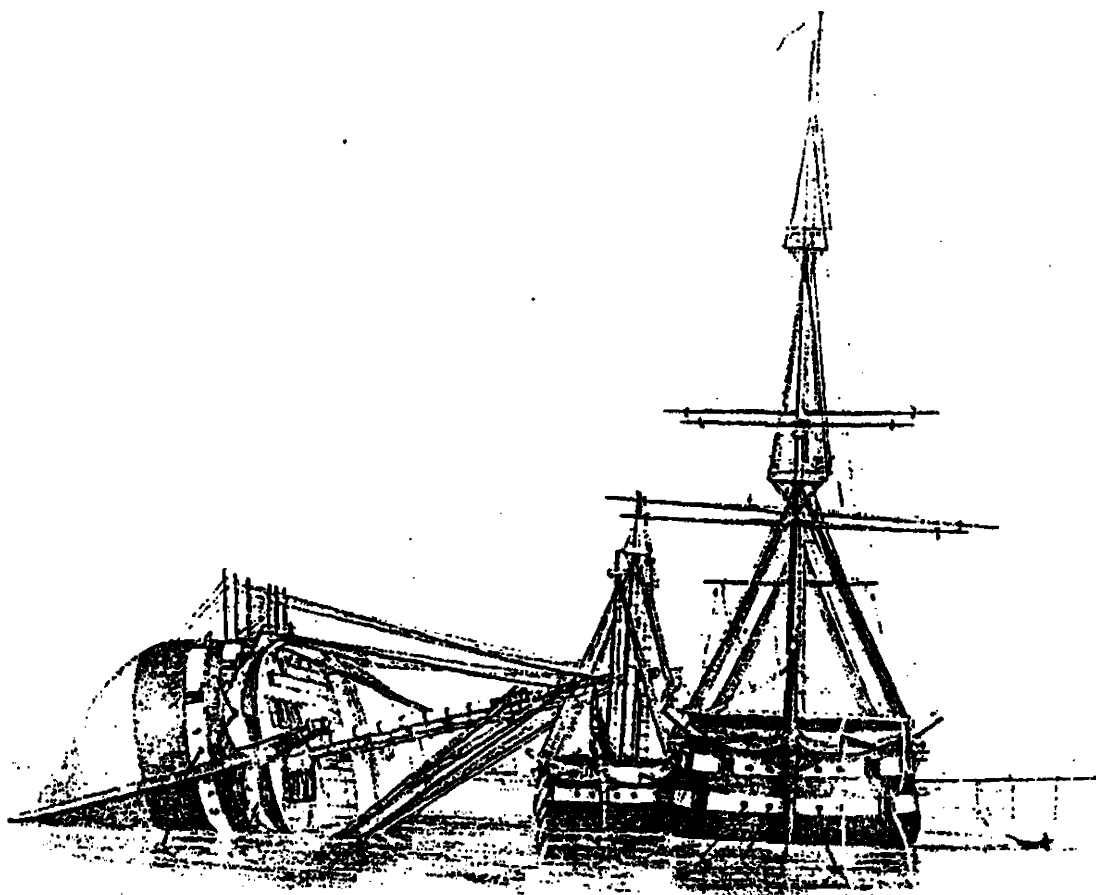


Figure 24. The Melville careened against the Rattlesnake, with the Blenheim alongside. From Harris (1841: frontispiece).

Since a vessel's main pumps were designed to operate only when the ship was essentially upright, they could not reach the water accumulating in the turn of the bilge. Often the pumps would be disassembled and then repositioned. If auxiliary pumps were unavailable, they would be built by the carpenters. Commonly, the auxiliary

pumps were either of four pieces of plank, assembled so that the shaft was square, or of spar wood, split and hollowed out. Both versions were well-caulked in the seams and tightly bound, with long hoses attached to their heads. If the water had to be lifted more than 30 feet (9.14 m), two pumps were required for each pumping station, the first lifting the water to a tub set between decks on another angled platform, the second lifting the water from the tub and releasing it on deck (Harris, 1841: 10; Brady, 1857: 267; see Fig. 25).⁸

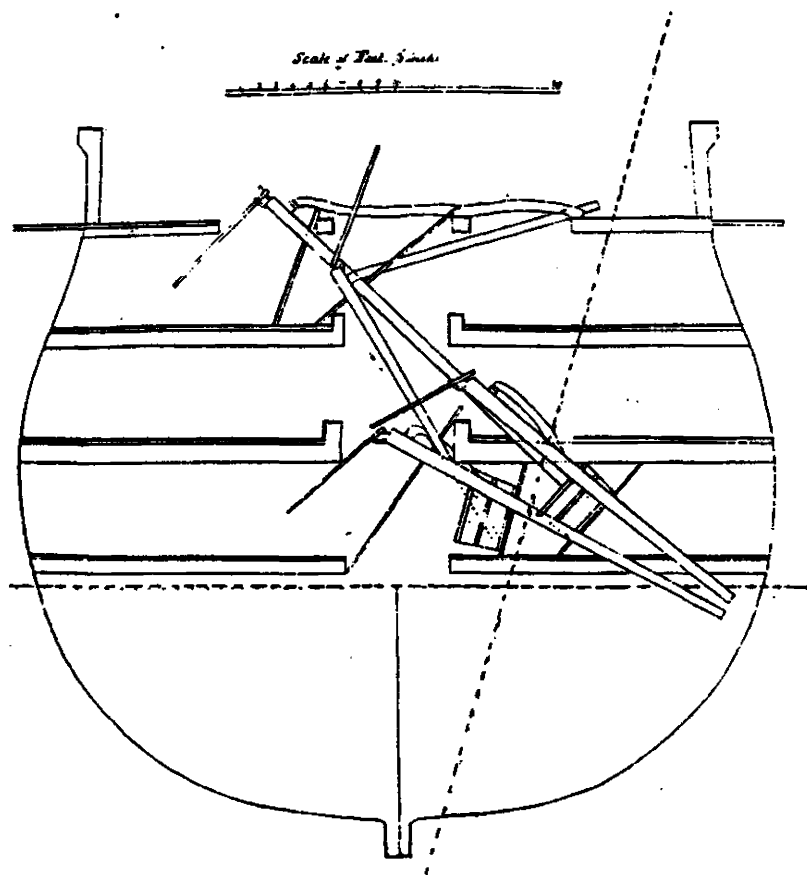


Figure 25. Diagram of the pumping system used aboard the Melville while careening. From Harris (1841: pl. 1).

After sufficient ballast had been removed, carpenters were sent to the vessel's hold to erect stout bulkheads or pouches, as Mainwaring called them in the 17th century. These ranged in a fore and aft direction abreast of and to either side of the keelson, extending from the ship's floor to the underside of the orlop deck (Manwaring and Perrin, 1922: 118 and 200). Their purpose was to prevent the remaining ballast from shifting too far to either side when the vessel was heeled or when it was moved to leeward to help start the ship into a careen. If considered necessary, athwartships bulkheads were erected at intervals to prevent longitudinal movement of the ballast.

Although not mentioned elsewhere, both Harris (1841: 10-11) and Brady (1857: 267) made the sensible recommendation that 4-inch thick battens were to be nailed fore and aft along each deck and Jacob's ladders hung at convenient intervals, noting that when a vessel had been careened, movement through its hull was quite difficult due to the angle of the decks.

Rigging And Accessories

While the carpenter and caulkers concerned themselves with making the leeward side of the ship watertight and doing the other work required of them, sailors were sent

aloft to dismantle the rigging. From the latter part of the 16th century, a time coincidental with the increasing size of ocean-going vessels and the concomitant need for a larger and more diversified top hamper, until the late 19th century, when composite hull construction and wire rope evolved, most ships were cleared of all spars and rigging above their lower masts.

Deviations, of course, existed. The mid-16th-century Dutch vessels in Figs. 26 and 27 retained their top rigging, although the ship in Fig. 26 has been heaved well down.

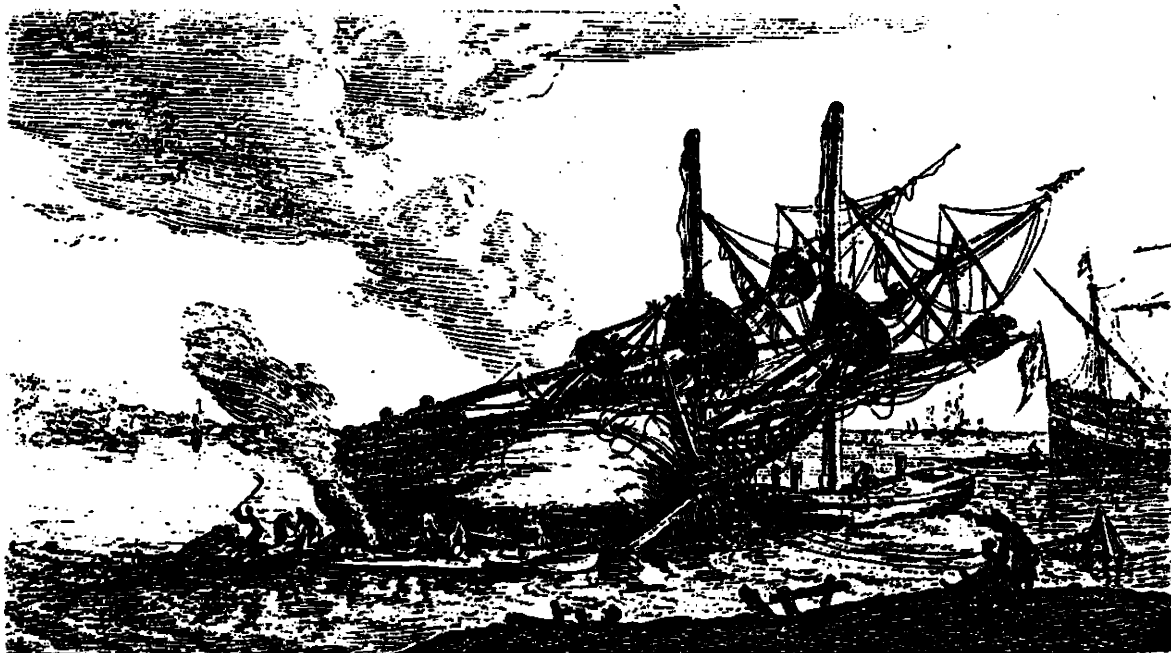


Figure 26. Mid-17th-century Dutch vessel careened with rigging intact. Etching by R. Nooms. Courtesy of the Rijksmuseum, Amsterdam. Photograph No. 22,177.

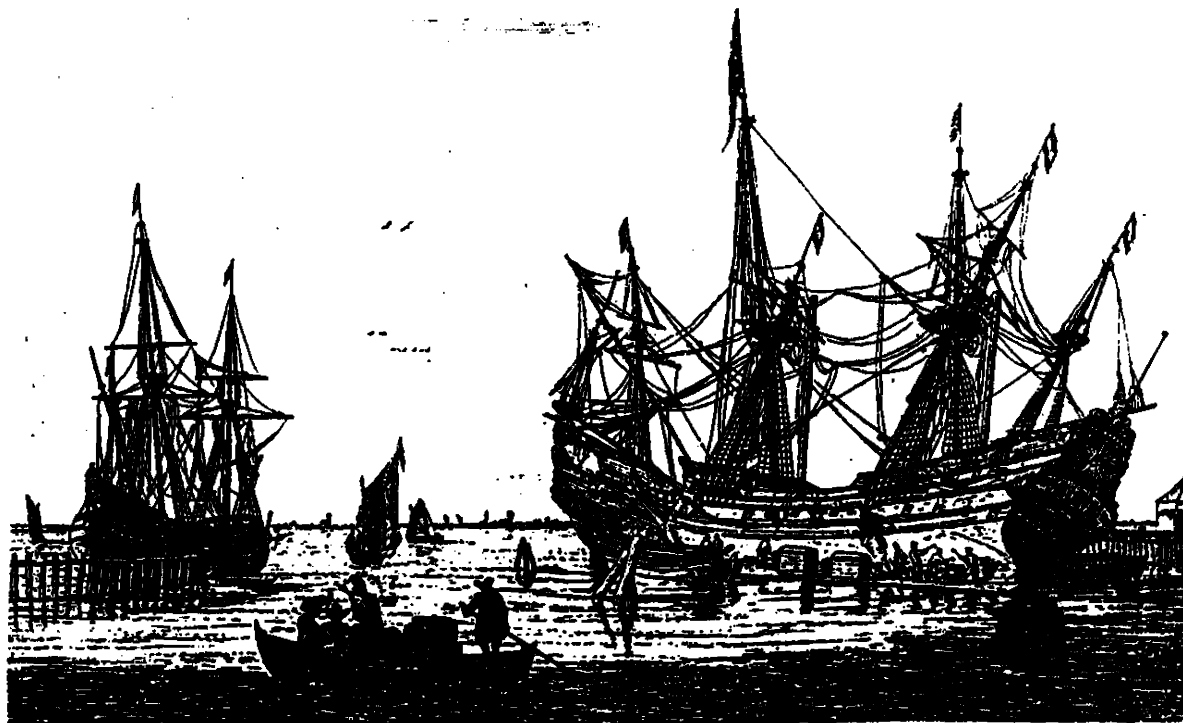


Figure 27. Dutch mid-17th-century ship partially careened. Etching by R. Nooms. Courtesy of the Rijksmuseum, Amsterdam. Photograph No. 29,590.

The vessel in Fig. 28 has had most of its top rigging removed and work is continuing, while the ship in Fig. 29, p. 49, still retains its fore- and mainmast tops and its foretopsail yard. The mizzen top of the latter vessel has been removed, the only instance in the four illustrations shown where this occurred. This would seem to indicate either some ambivalence on the part of the artist as to what was common practice (unlikely, since his nickname was Zeeman, "seaman" in English), or that Dutch seamen of the

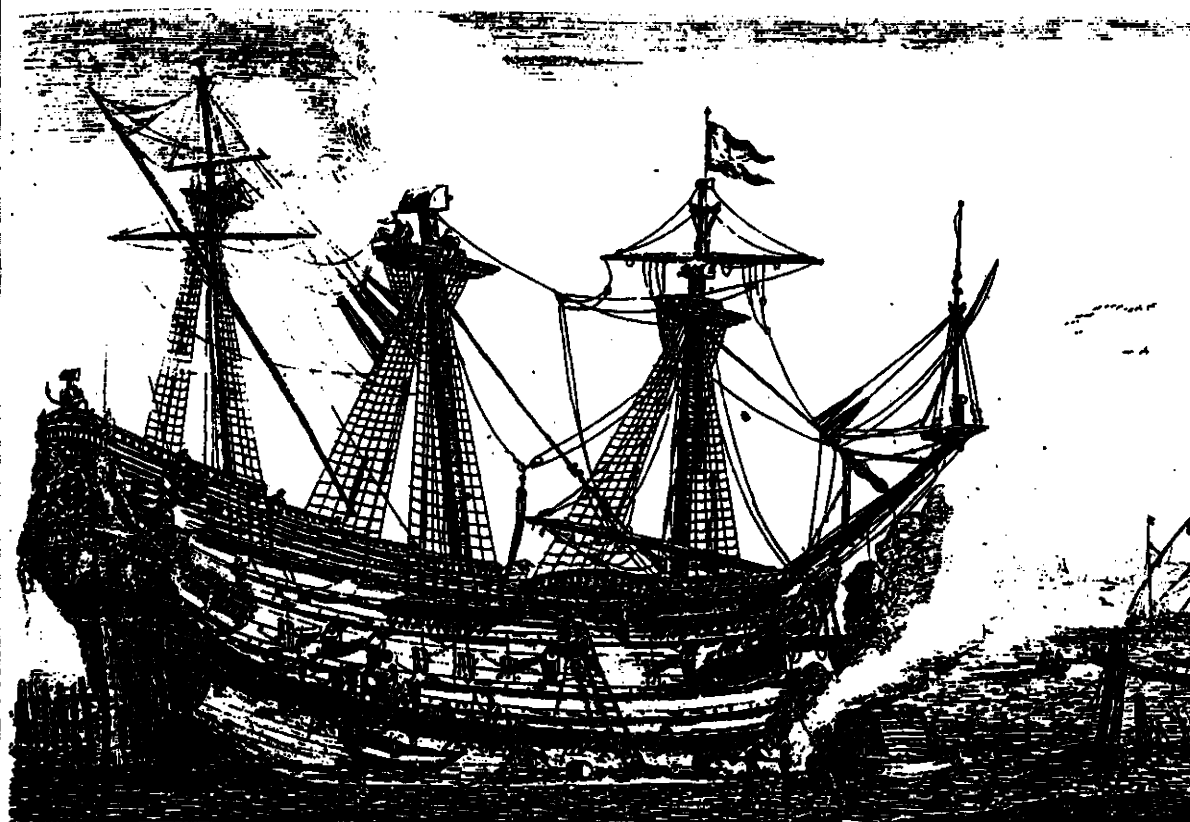


Figure 28. Dutch vessel being unrigged in preparation for careening. Etching by R. Nooms. Courtesy of the Rijksmuseum, Amsterdam. Photograph No. 22,181.

period exercised their own discretion as to whether or not to remove the tops before careening.

The upper rigging was normally cleared for several reasons. The cumulative weight of the spars and rigging above the lower masts of a large ship was surprisingly great. For example, the spars, caps, and tops above the lower masts of an early-19th-century 52-gun British frigate weighed more than 20 tons (20.32 metric tons), not including the lower yards which, in the British navy, were

also normally removed prior to heaving down. The total weight of the standing and running rigging was more than 51 tons (51.82 metric tons), most of it above the main-deck level (Edye, 1832: 44 and 100-01). The higher a vessel's rigging components were above its center of buoyancy, the greater were the strains that they would impose on both themselves and the ship's lower masts and hull as the vessel was heeled.



Figure 29. Deck view of Dutch ship careened against barges. Etching by R. Nooms. Courtesy of the Rijksmuseum. Photograph No. 22,180.

Furthermore, stretching of the weather standing rigging could be expected if a fully rigged-vessel was to

remain hove down for a substantial time. If the upper masts and yards were removed but their shrouds and stays merely unriggered and left substantially in place in an ill-advised attempt to save time and labor, there was a danger that they could foul the careening gear or be excessively bent when one tried to get them out of harm's way. Captain Liardet (1849: 152-53) warned that, "few things destroy standing rigging more than sharp bends, and exposure, for any length of time, to the weather," and recommended that vessels not adhering to the "Admiral's motions" (a probable reference to standard Admiralty operating procedures) unreeve the running rigging and stow it elsewhere. Additionally, if a vessel was voyaging and had to be careened utilizing its own resources, its spars and tackle were commonly requisitioned for various purposes, and its upper spars had to be struck if only for that reason.

However, by the last quarter of the 19th century, many vessels shown careened in shipyards still have their topmasts and rigging in place. This was probably the result of increased rigging strength achieved through technical improvements.

The operating requirements of certain types of vessels dictated unusual hull and rigging strength. One example is the mid- to late-19th-century American whaling ship which, almost invariably, is pictured careened with

its upper rigging intact (see Figs. 18-20, pp. 34, 35, 36). Church considered these vessels "the most strongly built ships afloat, rigged to withstand unusual strains which wrench their hulls beyond the ability of merchant ships to withstand" (1938: 23).

Occasionally, the jibboom and the flying-jibboom, if there was one, were removed (Fig. 22, p. 41, Figs. 30 and 31, and Fig. 32, p. 53). The entire bowsprit of the

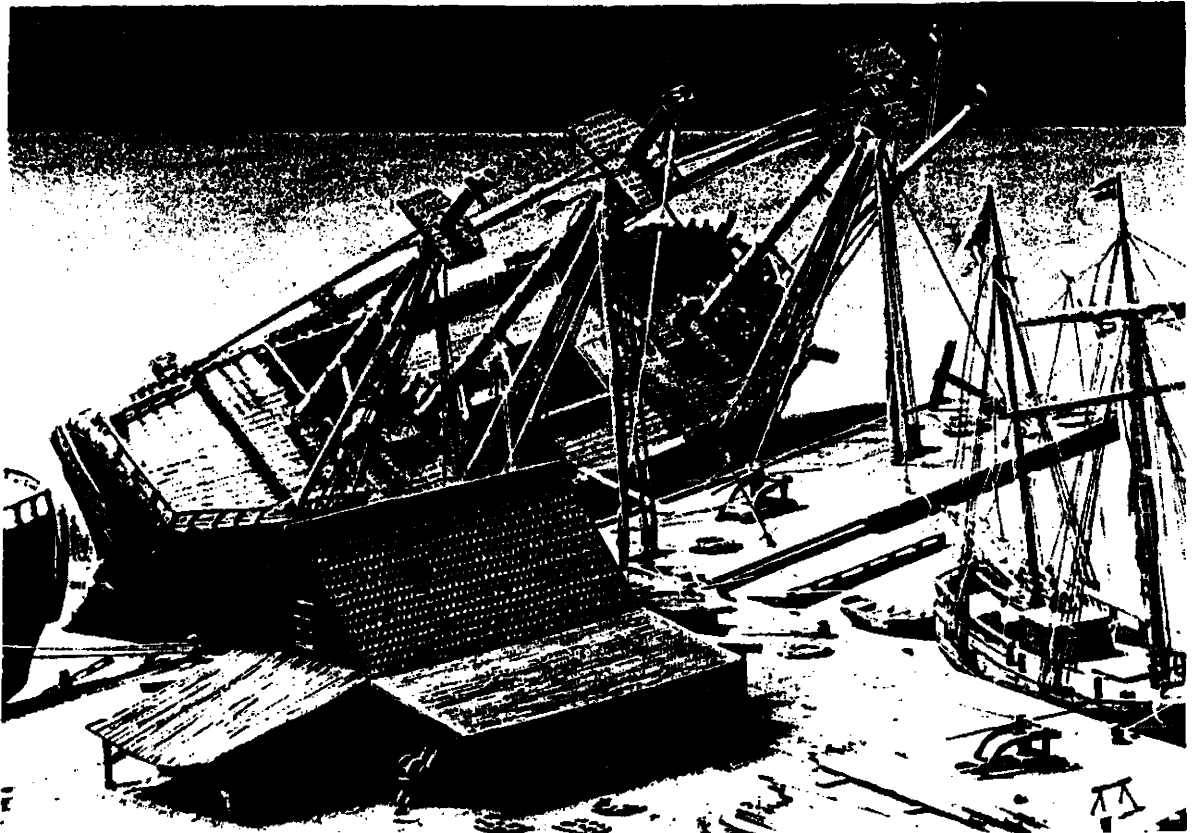


Figure 30. Detail of a diorama portraying a late-18th-century Swedish vessel careened. The jibboom has been removed. Photograph courtesy of the Statens Sjöhistoriska Museum, Stockholm.

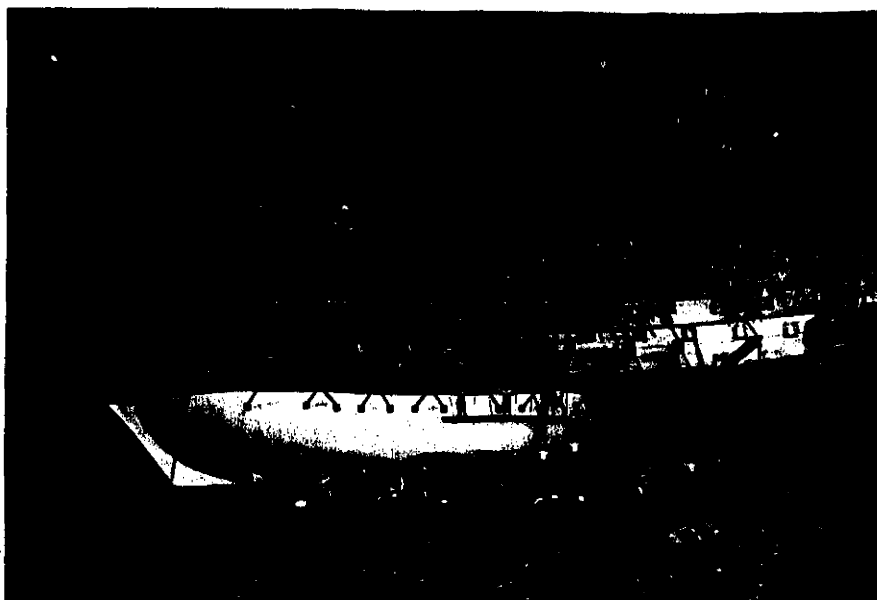


Figure 31. Detail of diorama showing mid-18th-century British warship in the Science Museum, London. The bowsprit has been removed. M. Goelet.

English warship in Fig. 31 has been removed, but that may only have been done in order to repair it.

The Hamburg vessel (Fig. 10, p. 27) and a late-19th-century ship from Åland (Fig. 33, p. 54) illustrate that in some later merchantmen the jibboom was kept in place when the ship was careened. Perhaps the non-removal of the jibboom on smaller vessels was a matter of personal preference or even expediency. Curiously, the jibboom was one of the only spars that was commonly removed when American whaling vessels were hove down (Fig. 19, p. 35, for example).



Figure 32. British hulk acting in the dual capacity of a careening hulk and a sheerhulk. One of a set of two drawings by Philip Gilbert, dated 1740, H 13 in the Naval Historical Library, London. M. Goelet.

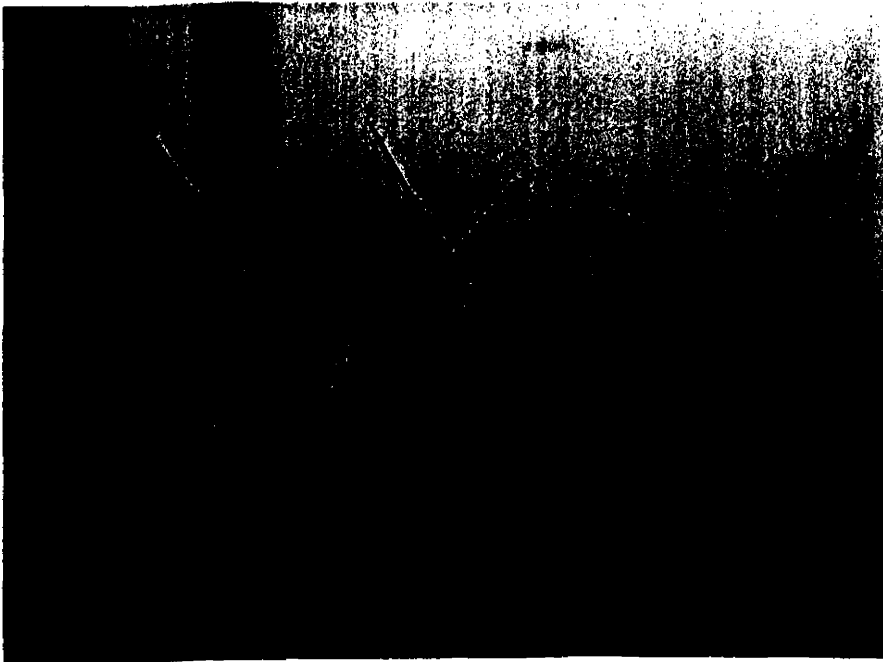


Figure 33. Diorama of a 19th-century vessel from Åland heaved down against quays in Ålands Sjöfartsmuseum. M. Golet.

If the ship was to be heeled substantially, its rudder was removed to preserve the pintels and gudgeons, which were not designed to support its weight with the ship in a careened attitude.

SUPPORT SYSTEMS FOR THE MASTS AND STANDING RIGGING

General Description

When a vessel was careened it was imperative that its masts and standing rigging be reinforced with auxiliary supports. Many of the methods used are shown to advantage by the two drawings in Fig. 32, p. 53, and Fig. 34. Fig. 35 is an enlargement of a portion of Fig. 34. Table 1, p. 57, is a transcription of the "References to the Carreening" table in the upper left corner of Fig. 34.

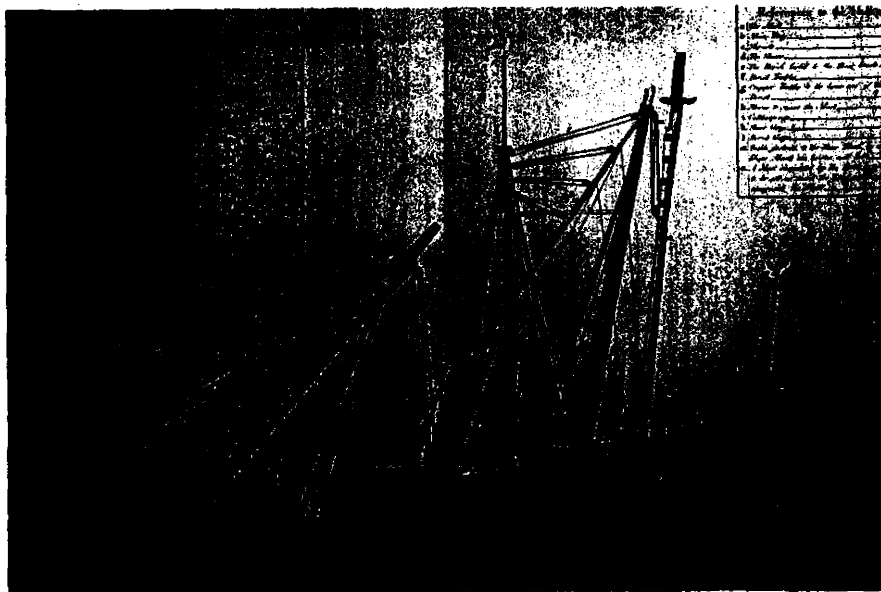


Figure 34. Sectional view of ship in Fig. 32 showing various support systems. The other of the two drawings by Phillip Gilbert, 1740, H 13 in the Naval Historical Library, London. M. Goelet.

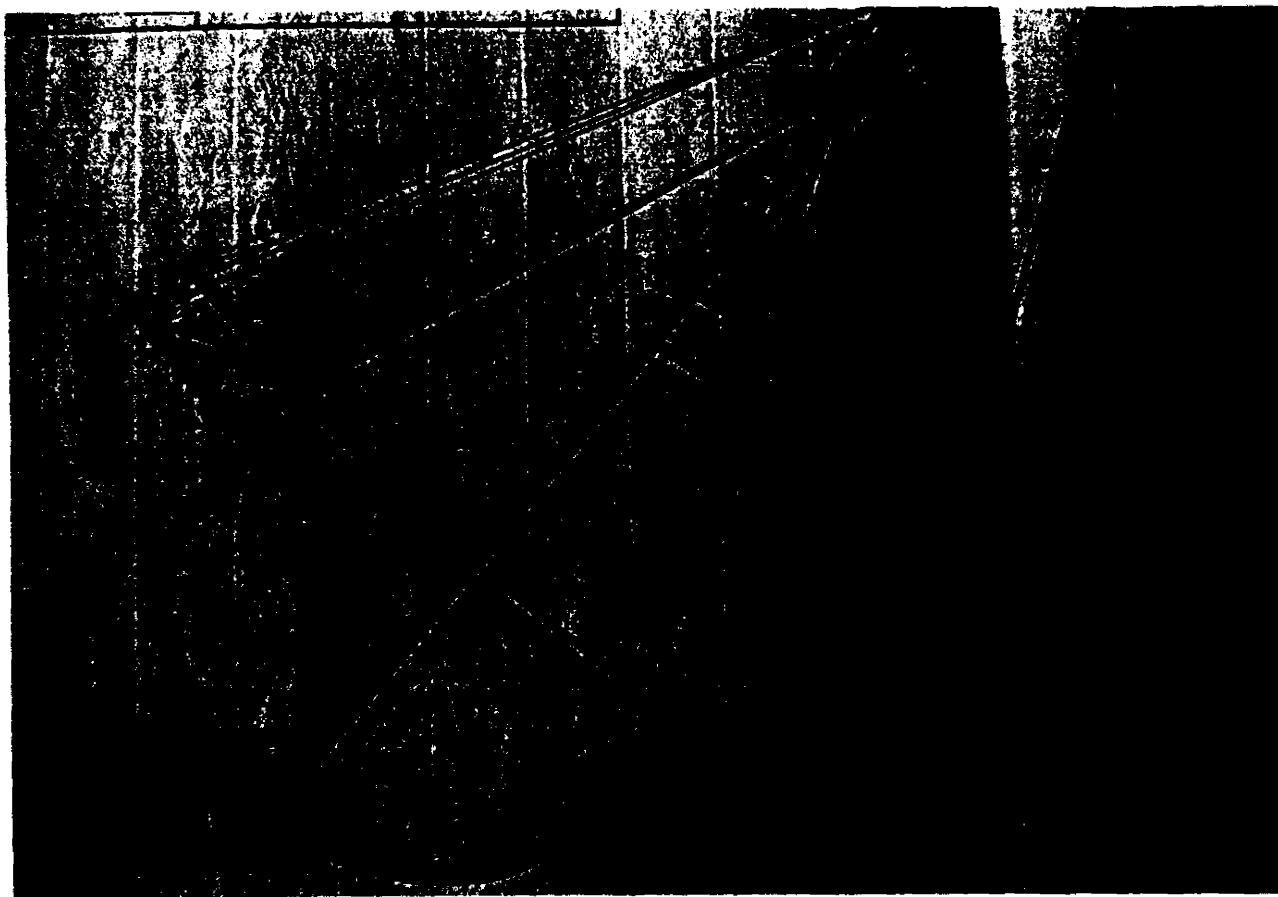


Figure 35. Detail of the ship section in Fig. 34. By Phillip Gilbert, 1740.
H 13 in the Naval Historical Library, London. M. Goelet.

Table 1. "References to the Carreening"

-
- A. Section of a ship careening or heaving down.
- B. The mast with the wedges drove out and set over to the weather partners.
- C. The shrouds frapped to the mast at the height of the catharpings.
- D. Shores, which are generally topmasts, lashed to the mast, to secure it against the strain in heaving down.
- E. Spans lashed round the mast and shores to secure the mast from springing.
- F. A showel (shoe) of plank to step the shores on.
- G. A plank set on edge between the heel of the shore and the spirketting.
- H. Spans from the topsail sheet and jeer bitts to the heels of the shores, woolded tight to prevent the shores sliding against the ship's side.
- I. Shores from the gundeck to the upper deck placed under the heels of the shores to the mast, to support the beams.
- K. Outriggers on the gun and upper decks.
- L. Shores to the outriggers to support them against the strain in heaving down.
- M. A span of rope passed round the outer end of the upper deck outrigger and through a clamp fastened to the wale and woolded very tight to prevent its rising.
- N. Chocks to secure the outriggers in the ports.
- O. Chocks and wedges to secure the heels of the outriggers within board.
- P. Outrigger pendants fastened round the head of the mast.
- Q. Tackles to set up the outrigger pendants.
- R. A six fold tackle by which the ship is hove down, one block fastened to the mast head, the other close down to the orlop (deck) of the hulk, and the tackle fall comes through a snatch block that leads to the capstan.
- S. The pump fixed for careening.
- T. Spout to carry the water over the upper deck comings.
- V. A relieving tackle to prevent the ship's coming down too fast, as they are often inclinable to do, and also to assist in righting the ship.
-

Internal Mast Wedges And Shores

The masts, in their capacity as the fulcrums by which the ship was heeled, had a tendency to fetch against the lee mast partners. Every precaution was taken to prevent this, as the result could be a sprung mast. Normally, the masts were unwedged and brought up hard against the weather partners to provide as much initial leeway as possible.

Ideally, when careened, a ship's masts were externally supported by its standing and supplementary rigging and did not touch the vessel at any point other than where they were stepped. Heavy shores were positioned against their heels and wedged in place where the orlop deck or lower-deck beams joined the weather side of the vessel (Luce, 1884: 585). This prevented the masts from kicking out of their steps to weather as the careening tackles levered their tops to leeward.

Fishes

On some large vessels, the masts used for heaving down were strengthened with long, heavy timbers called fishes. These were temporary supports as opposed to the side fishes and front fish or paunch, which were integral parts of a built-up lower mast's construction.⁹

These auxiliary fishes, concave on the inside to contour to the curve of the mast, convex on the outside, were often positioned against a mast's foreside and sometimes its after side as well. Fishes were woolded (lashed) to the mast at frequent intervals and the lashings firmed up with wide, flat wedges driven between the fishes and lashings. These were rounded along their outer edges to prevent the lashings from being cut (Ashley, 1944: 343).

Auxiliary fishes normally extended from below the trestletrees to the main deck but could continue to a lower deck for additional support should the opportunity present itself. The HMS Formidable, when careened in Malta in 1843, had her mast partners and wedges removed permitting the fishes to extend through her main and middle decks (Walker, 1902: 408). When required, the sides of masts could also be fished.

The USS Constitution, during her 1803 careening at the Charleston Navy yard near Boston, had her mainmast starboard side fish removed to accomodate a timber 50 ft (15.24 m) long, with a diameter of 19 in (48.26 cm) at the butt. This was in addition to fishes which had already been added to her fore- and mainmasts, and was to counter a considerable bellying of the mast to starboard when the ship was nearly hove out to port (Bass and Bass, 1981: 4-5).

Mast Shores

Mast shores were among the most effective ways of lending additional support to the masts (Funch, 1846: 7). These large, heavy timbers were placed in position after the masts had been brought against their weather partners. Their heads were butted and lashed to the upper parts of the masts or lashed alongside with their heels extending to leeward (see Fig. 35, p. 56).

They seem to have been used almost universally from the mid-17th century onward. The only later vessel observed which did not use them in one form or another was the late German vessel in Fig. 10, p. 27. With such an obvious and straightforward purpose, only a lack of clear evidence prevents stating that they were used much earlier.

The carrack illustrated in Fig. 36, for example, shows what seems to be a pair of shores crossed and lashed about half way up the mainmast, but the identification is not certain.¹⁰

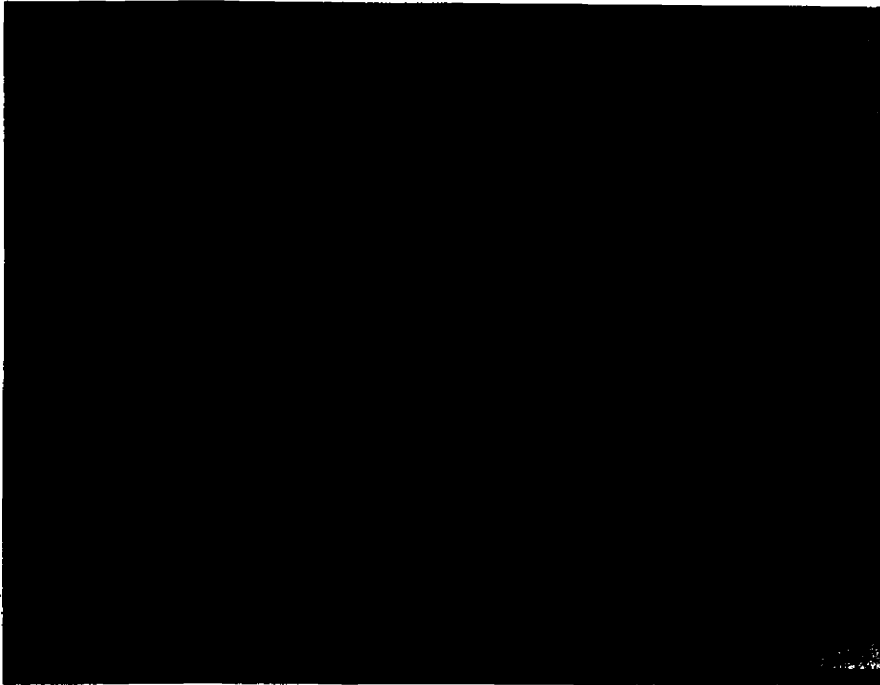


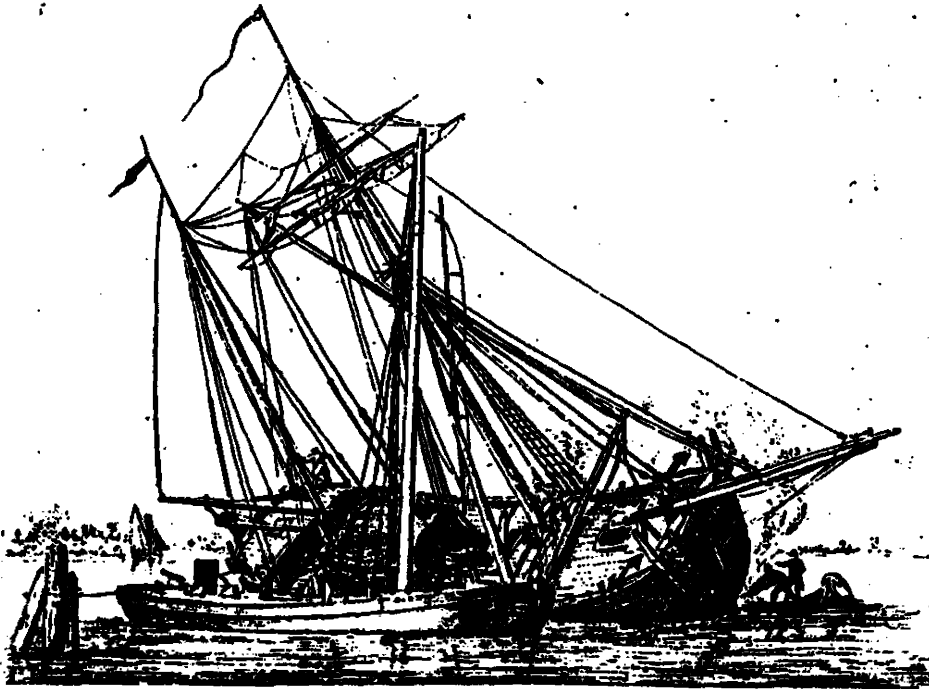
Figure 36. Carrack careened against a wharf, possibly showing shores lashed to the mainmast. Detail of the fifth panel of a fresco by Botticelli in the Sistine Chapel depicting the punishment of Korah, c. 1482.

Examples Of Mast Shores

Mast shores varied in number, sizes, and arrangements with the dimensions of a vessel and, to a lesser extent, its origin and the circumstances of its careening.

The small vessel in Fig. 37, drawn by the Dutch artist Groenewegen (1754-1826) shows a mast shore in its simplest form.

At the other extreme, the English ship of the line Formidable used three shores each for its fore- and



Kof die leijt te Kiellem 7

Figure 37. Dutch kof being careened showing a simplified version of mast shoring. By G. Groenewegen, c. 1800. Courtesy the Rijksmuseum, Amsterdam. Photograph No. 39539.

mainmast. Their arrangement compared to the single shore used on the small Dutch vessel exemplifies the complexities that could be expected when careening a large warship.

The Formidable's longest mast shore extended to within 6 inches (0.152 m) of the lower mainmast trestletrees and consisted of a rough 22-in (0.559 m) spar. A second shore was placed against the mast one third of the way down, and a third shore was placed between the

head of the second shore and the deck. All the shores were butted against the mast and lashed in place. Belly lashings, consisting of several turns of rope, were installed at intervals between the mast and each of its shores. For added support, horizontal belly shores were placed alongside the belly lashings. Made of 2 1/2- to 3-inch (0.064-0.076 m) thick oak plank, they extended from each of these shores to the mast and were lashed in place at either end. Five belly shores and lashings were employed for each mast: three for the longest shore, one each for the two lower shores (Boyd, 1860: 470; Walker, 1902: 410-11). They were considered to be "an immense support to the mast" (Walker, 1902: 411).

Harris, however, obviously considered side fishes more supportive than belly shores, since he specifically suggested fishing the fore- and mainmasts on the same side as the shores, rather than using belly shores (1841: 7 and 12). The strength of his conviction is evidenced by the fact that the Melville initially used belly shores which were later discarded in favor of side fishes (1841: 17). At no time did he mention forward or after fishes for the lower masts or that belly lashings were placed between the masts and shores.

Since the crew of the Formidable did fish the forward and after parts of that vessel's masts in addition to using belly shores and lashings, there is doubt as to what

was the standard practice in the British Navy with regard to belly shores and fishes, or if in fact a standard practice existed.

The feet of mast shores rested on thick pieces of protective planking usually placed on the main deck over the leeward waterway abreast the mast. If more than one shore was employed for each mast, as was commonly the case with large vessels, their feet were placed forward of and abaft the mast, forming a tripod to provide additional stiffness. Short vertical timbers, also resting on thick planks, were positioned on the deck below, under the heels of the mast shores to help support their heavy pressure (see Fig. 35, p. 56).

The heels of mast shores were braced, "well lashed and secured" (King, 1802: 310), to prevent them from slipping from the protective bedding and damaging the bulwarks or waterway. The Swedish merchant vessel in Fig. 30, p. 51, utilized a heavy rope run along the waterway and fastened at either end to a pair of through-deck ringbolts, one forward of the foremost shore, the other abaft the aftermost shore. Several turns were taken around the heels of each fore- and mainmast shore, preventing them from shifting longitudinally. The mizzenmast shores were footed on the poop deck, each of them secured to the base of one of the newel posts supporting the forward and after poop deck railings (see Fig. 30, p. 51).

To prevent the heels of the main- and foremast shores from slipping outwards, each was lashed about 4-5 ft (1.22-1.52 m) above the deck, and the lashings were run to through-deck ringbolts mounted inboard (note foremast shore, Fig. 17, p. 32). The aftermost of the mizzenmast shores had a rope lashed to its foot which ran across the poop deck and was secured to the port side of the vessel.

Techniques similar in some respects to those just described were employed aboard the French frigate Artemise (Fig. 38) to prevent the heels of its mast shores from moving. Although the bottom of only the forward foremast shore is visible due to the extreme heel of the ship--the rest being obscured by water--the method used to brace it is noteworthy.

As the foremost shore evidenced no lashing at its base, it seems probable that the bedding block was morticed to hold the heel of the shore firmly in place. Bolts driven into it vertically fore and aft served as the attachment points for a bridle which, in turn, was lashed to the strap of the running block of a double tackle extended across the deck. The fixed block of the tackle was fastened to the opposite side of the vessel.

Inexplicably, the foremost shore is the only one shown with a tackle running athwartships. Fig. 23, p. 42, however, which is suspiciously like a rendering of the careening of the Artemise, definitely shows pairs of

tackles running athwartships bracketing the mainmast at deck level.

Fastened to the forward bolt in the visible bedding block on the Artemise was the running block of another double tackle, the rest of which extends out of sight under the foredeck. Possibly, similar fore and aft tackles existed for the remainder of the shores but were hidden from view by the water.

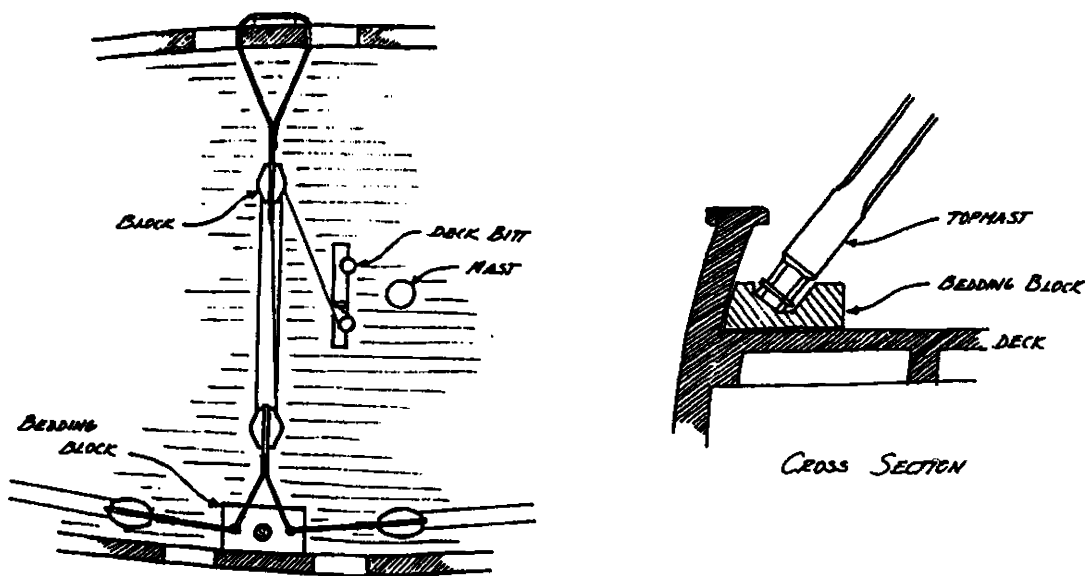


Fig. 38. Tackles rigged to the bedding block of the foremost mast shore on the Artemise. Note the use of the topmast for the shore. Interpretive sketch by J. Taylor.

In addition to its primary purpose of alleviating the pressure against the bulwark where the bedding butted against it, the athwartships tackle on the Artemise and

those shown on the vessel in Fig. 23, p. 42, may have been used to move the bedding blocks and thus the heels of the shores to make minute tensioning adjustments to the vessels' support riggings as they were careened.

The heavy rope crossing the poop deck and fastened to the foot of the after mizzenmast shore of the Swedish vessel (Fig. 30, p. 51) may have functioned similarly, although no tackle was evidenced. If required, it would have been a simple matter to lash one in place.

As previously stated, a prime reason for removing a vessel's upper spars and rigging was to gain their use for other purposes. A case in point was the Artemise whose crew was forced to use its own resources to careen the ship after it sustained keel damage on a reef near Tahiti. This required using the vessel's spars as shores for her lower main- and foremasts. The two major shores for either appeared to be made of each mast's topmast and a spare (see cross section Fig. 38, p. 66). These were lashed to the fore and after side of either mast about 10 ft (3.048 m) below the lower trestletrees. A smaller third shore, possibly a topgallant mast, was lashed to the forward side of either mast approximately 10 ft (3.048 m) further down.

That the requisitioning of spars for this purpose was not that uncommon can be deduced from Harris's suggested use of specific masts and yards to fulfill various requirements during the careening operation when other

timber was unavailable. Table 2 is a consolidation of his recommendations (1841: B).

Table 2. Spars used for mast shores and outriggers.

MASTHEAD SHORES

Mainmast

1 Maintopmast.
1 16-in (0.406 m) hand mast.

Foremast

1 Foretopmast.
1 14 in (0.356 m) hand-
mast.

OUTRIGGERS

Mainmast

1 Maintopmast.
1 Maintopsail yard.
1 Yardarm or bowsprit piece.

Foremast

1 Foretopmast.
1 Foretopsail yard.
1 Crossjack yard.

Danish warships displayed a variation in the shoring arrangement from that seen elsewhere. Two sources were reviewed: the diorama in the Orlogsmuseet in Copenhagen representative of the harbor of Nyholm in 1766, a portion of which is seen in Fig. 39, and Funch's illustration (Fig. 40, p. 70), dating from 1846. Both show two shores placed against either the fore- and mainmasts, one extending to leeward, the other to weather.

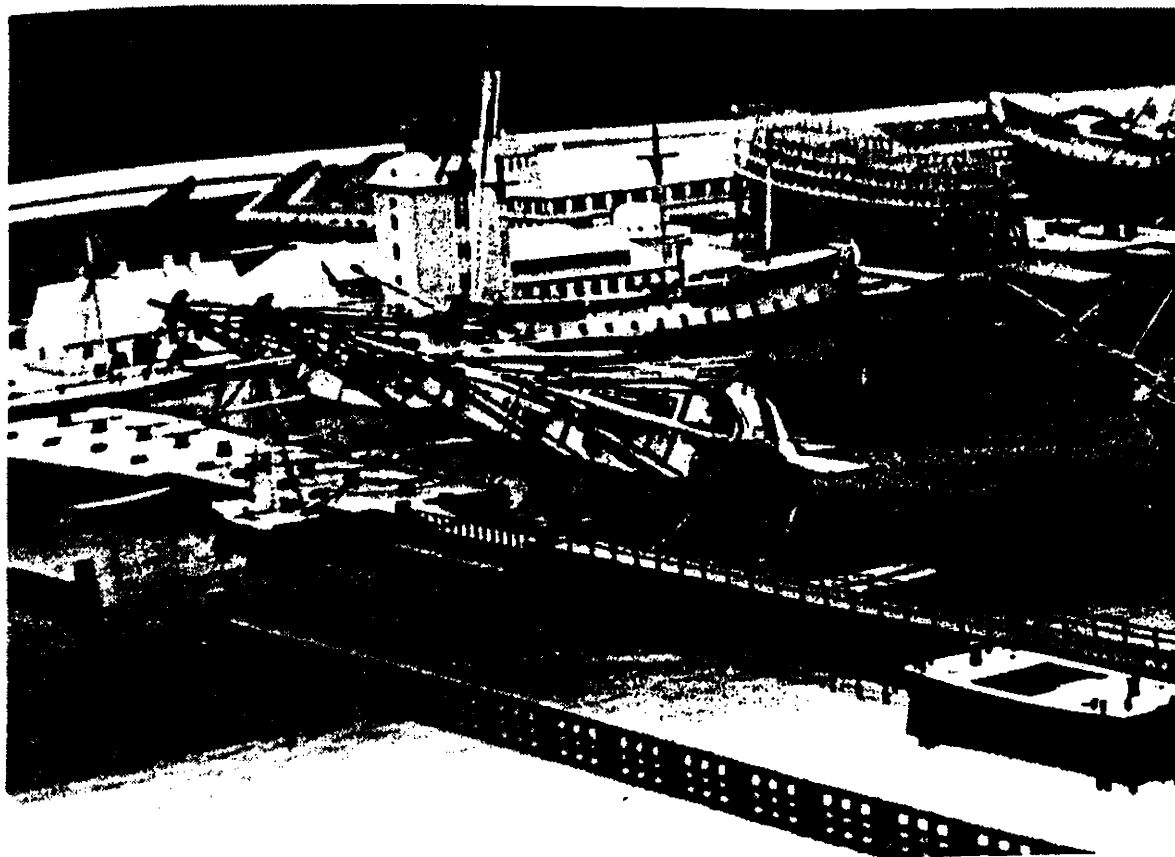


Figure 39. Detail of a diorama representing the Danish harbor of Nyholm in 1766 in the Orlogsmuseet, Copenhagen. Photograph courtesy of the Orlogsmuseet.

The most visible difference between the shores in the diorama and Funch's representation is that there are six horizontal wooden struts between the shores in Fig. 39 while Funch depicts only four (Fig. 40i). Funch, however, shows a very heavy lashing, which he termed a neck tackle, above the uppermost strut. This would have compensated for at least one strut. The feet of the shores are positioned slightly aft of the masts to allow room for the placement of the struts behind the masts.

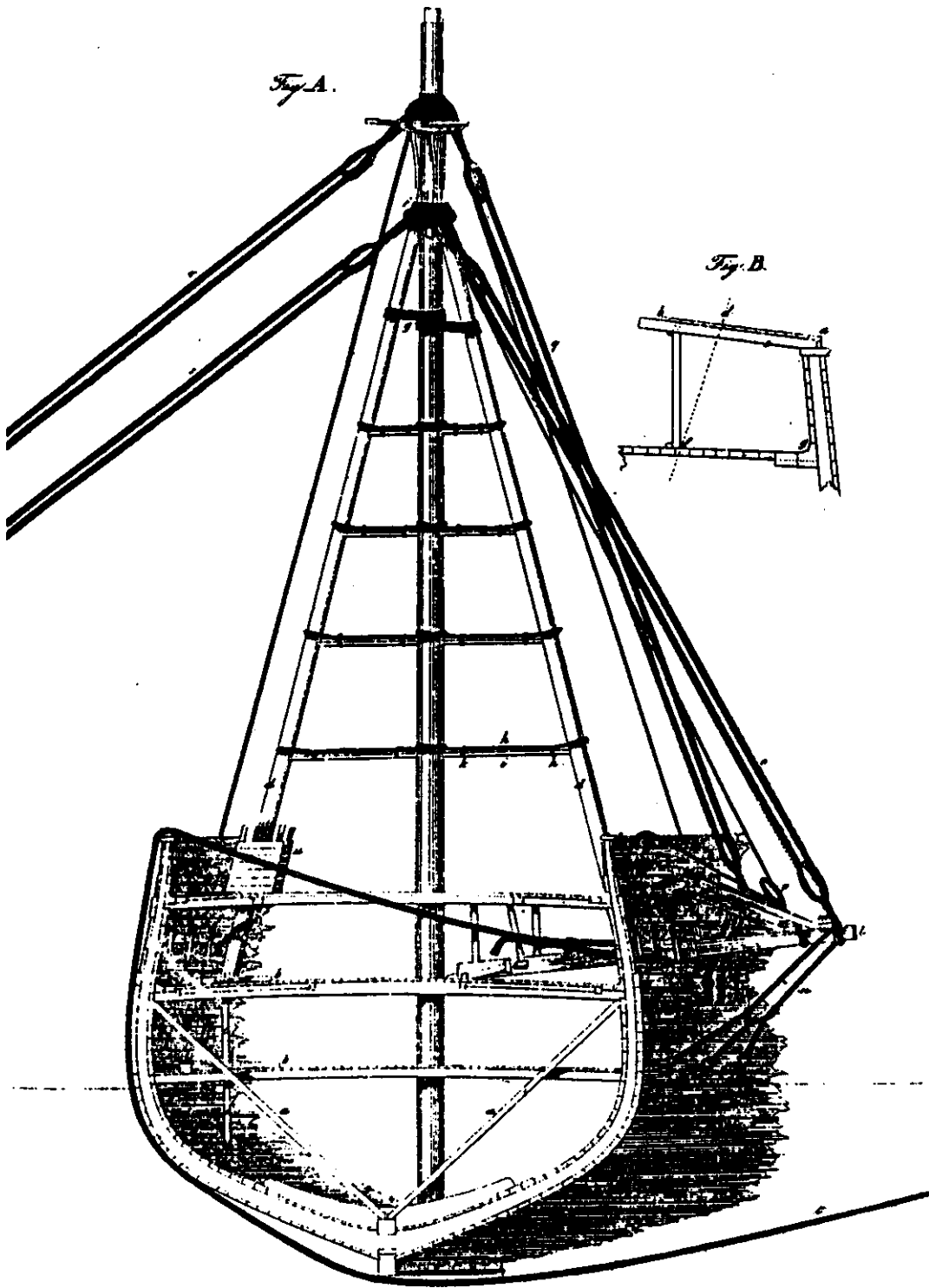


Figure 40. Illustration of the careening systems on a mid-19th-century Danish warship. From Funch (1846: pl. 4).

According to Funch, the struts prevented the tensioning of the cables (Fig. 40h) from bending the shores towards each other (1846: 8). From appearances, their more important function was to prevent the mast from bellying. They also provided points at which to tension the cables with lashings (Fig. 40k) thereby binding the two shores and each mast into a rigid, cohesive unit.

The representation shows the mast shores (Fig. 40d) breaching the main deck and resting on the deck below. This phenomenon has not appeared elsewhere and was unexplained in the text, although it probably was done to permit the shores to foot on the heavier framing of the gun deck. The structure which seems to surround the shore at the main deck (Fig. 40u) is also unexplained but appears to be a form of bulkheading, probably packed and sealed to prevent water from penetrating the scuttled deck when the vessel was hove down to a point at which its waist was submerged.

A Possible Anomaly

Before we leave the subject of mast shores, a somewhat ambiguous account in Luce (1884: 584-87) of the careening of the U.S. frigate Brandywine is worth commenting upon. Of special interest is his description of

the shoring system, which seems to have been highly unusual. Portions of his description are included below; salient points are discussed thereafter.

In preparation for the careening, bolsters were hoisted and "strung abreast the masts to windward." These were "large frameworks of timber to protect the channels from the heels of the shores and strong enough to bear the strain."

Five large bolts, each 3 1/4 in (0.083 m) at the large end, tapering to 2 1/4 in (0.057 m), were driven through the ship's hull about 1 ft (0.305 m) above the berth deck abreast the fore- and mainmasts and well secured within.

The shores were square, white pine timbers, tapering from 19 in (0.483 m) at the heels to 13 1/2 in (0.343 m) at the heads, each 75 ft (22.86 m) long with mortices cut through both ends.

"Each leg was hove up separately to windward" using threefold blocks, the upper one lashed to the masthead, the lower block lashed about one-quarter of the way down from the head of the shore. Four-inch (0.102 m) line was passed through the upper mortice in each shore and around the mast 10 times, and then cross-lashed 10 times more before being secured. The bottom parts of either pair of shores were spread so that the heel of one shore was forward of the mast and the heel of the other one was

abaft the mast. They were secured to the bolts with lashings (probably through the lower mortices and what must have been ringbolts), which were then frapped together. The heels of the shores were described as resting over the bolsters.

Three belly shores were lashed equidistant from each other between the mast and either shore, and belly lashings were positioned in the same place (Luce, 1884: 585).

If the bolsters were strung to windward to protect the channels and the shores were hove up to windward, then the shores must have been erected on the windward side of the ship. All other shores illustrated or described in the literature, with the exception of one leg of each pair used on the Danish ships immediately preceding this description, are placed to leeward.

Three other points lend substance to a theory that the shores were indeed placed to weather.

The first is the mention that, due to the very heavy weight of the shores, casks of water on the opposite side were used to counterbalance the ship and bring her back on an even keel (Luce, 1884: 585).

The second point is that no mention was made of outriggers. While this omission is certainly not conclusive evidence that they were not actually present, the account of the ship's careening was reasonably

detailed, lending credence to a supposition that they were not in fact used.

If the shores had been placed on the leeward side and no outriggers were used, it would hardly seem necessary to have gone to the effort of placing casks of water on the weather side to bring the vessel upright, as casks of water were often placed on the leeward side to give a vessel an initial heel preparatory to heaving it down (Bass and Bass, 1981: 4; Harris, 1841: 13). If the shores had been placed to leeward and outrigger timbers had been cantilevered from the weather side, they would have counterbalanced each other approximately as they normally did on other vessels, nullifying the need for water casks to bring the ship back to an even keel. It seems more likely that the water casks were used to offset the weight of shores which had been placed to weather.

The third point concerns the exaggerated length of the shores. In all other examples reviewed, mast shores were lashed to the masts below the trestletrees and were shorter than those used on the Brandywine. The largest mast shore used on the Courageux was approximately 54 ft (16.46 m) long, and she was a French, and therefore tall-masted, ship of the line, at least comparable in tonnage and mast height to the Brandywine.¹¹

The shores used for both the main- and foremast were all of a size. Even allowing for an overlap if the

mortices were cut somewhat inward from the ends of the shores and the shores had been lashed alongside the masts instead of butting against them, the lower ends would have extended substantially beyond the main channels, much less the fore channels, and would certainly have been far too long to have butted against the deck in either location.

Additionally, the shores seem not to have ended at the bolsters. The use of the word "over" to describe the position of the heels of the shores in relation to the bolsters projects an image of the heels of the shores resting against and extending beyond the bolsters instead of resting on them.

In light of the foregoing, there is a strong possibility that the shores were actually placed to weather as the description implies (Fig. 41 speculates how they might have been erected). While the timbers physically resemble shores, they could, as shown, more appropriately be described as a form of preventer (both preventer and outrigger gear will be described shortly). The relative non-ductility of the wood as compared to hempen shrouds would have inhibited movement of the masts to leeward and coincidentally, because of increased effectiveness, would have alleviated the need for outrigger gear.

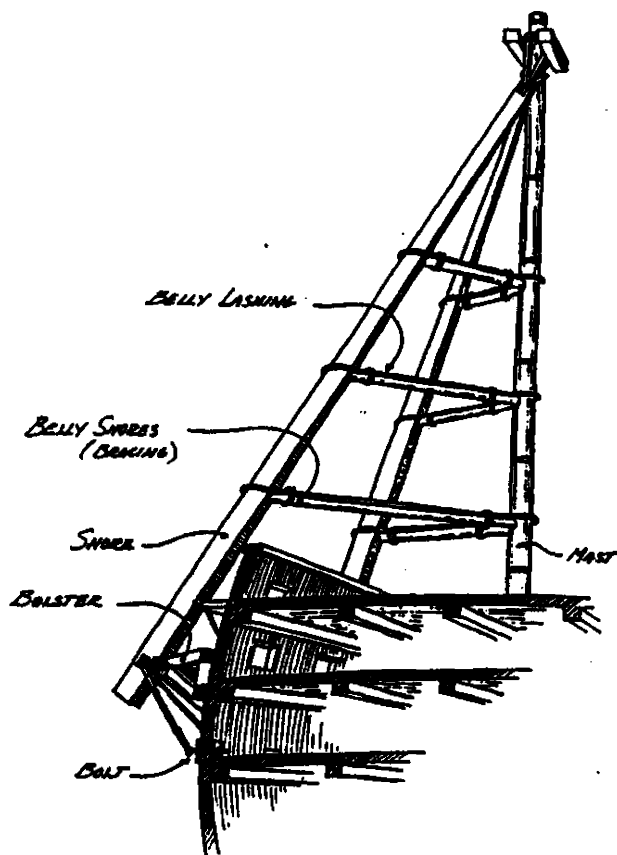


Figure 41. The mast shoring system used on the Brandywine. Interpretive sketch by J. Taylor.

Preventer Shrouds

Preventer shrouds, made of rope or chain, were commonly used to help support the masts to weather. As did most rigging preventers, they ran alongside the elements they were to support, in this case, the vessel's lower shrouds. If fabricated of rope, their upper ends were

often looped over the mastheads or lashed to them; in both instances, they were positioned just above the trestletrees. Their lower parts were led over the outside edges of the channels, which were normally bolstered, so they lay slightly outboard of the ship's working shrouds. Their lower ends were often attached to preventer bolts driven through the vessel's side just below or parallel to the chainbolts which secured the vessel's chainplates. Sometimes, tackle was incorporated into the shrouds to permit tensioning.

In later years, and especially on large warships, chain preventer shrouds were commonly used, the extra weight apparently accepted in exchange for additional strength. The rigging methods of both rope and chain preventer shrouds varied, as will shortly be shown.

The period during which preventer shrouds first appeared can not be determined; no written accounts or positive illustrations of them have been found that predate the early-18th century. Neither they nor mast shores appear to have been used in the early-17th-century series of careening sketches by the Dutch artist R. Nooms (Figs. 26-29, pp. 46-49). Nooms produced the bulk of his work in the 1630s, making his series depicting careening one of the earliest examined. His etchings, however, were neither detailed nor international enough in scope to enable one to state categorically that preventer shrouds

were not used during his day or, for that matter, earlier.

Examples of rope preventer shrouds

The following is a description of the preventer shrouds used for the mainmast of the Courageux when that vessel was careened.

The fifth, sixth, eighth, and ninth ports on the lower deck were left open, they were doubly bolstered, and secured with strong cleats on the outside, battened under the lower part of the chain wales.

To add to the security of the shores and rigging, and to take off from a great part of the heavy strain that the decks and larboard side of the ship must inevitably be subject to, strong pendants (of the dimensions of the ship's stream cable), were brought into the above-mentioned bolstered lower-deck ports, after the eyes had been placed over the mastheads, the ends of which were set up with double purchase tackles brought around the lower-deck beams (the deck being scuttled for that purpose), and spanned into each other (King, 1802: 310-11).

Fig. 42 illustrates how this may have looked.

The Artemise was one of two warships reviewed which did not use chain preventer shrouds, perhaps, in her case, because of the remote location of the careening coupled with a lack of sufficient chain on board. This was compensated for by the use of four heavy pendants both for the mainmast and the foremast, all fastened above the trestletrees and rigged with a short double tackle ending just above the channels. The tails of the lower blocks

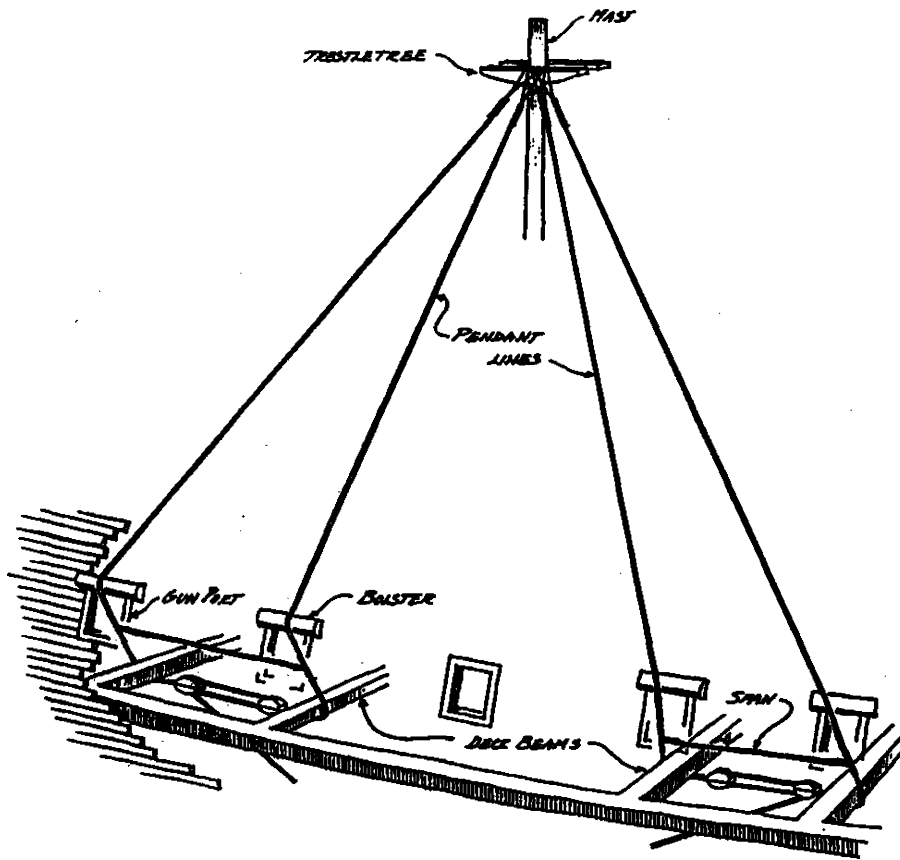


Figure 42. A possible arrangement of the preventer shrouds during the careening of the Courageux. Drawing by J. Taylor.

were brought over the channels and fastened to preventer bolts, as described above.

The lower part of one of the four preventer shrouds that helped support the mainmast can just barely be seen in a hull photograph of the diorama (Fig. 43a).

The relatively small warship drawn by Funch also shows a preventer shroud lashed above the trestletrees, almost its entire length consisting of a tackle (Fig. 40q, p. 70). It is apparently secured below by lashings to two

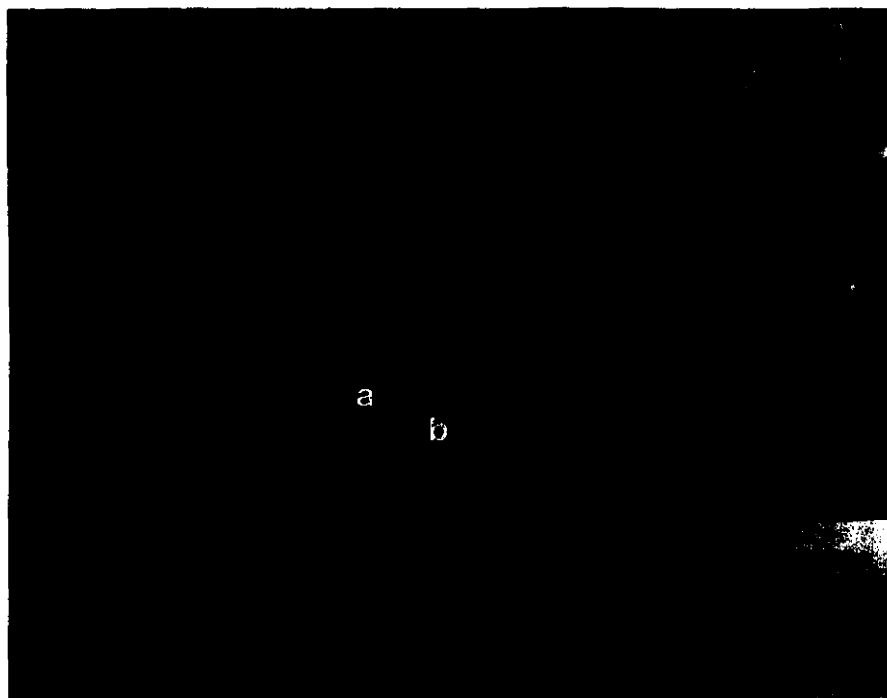
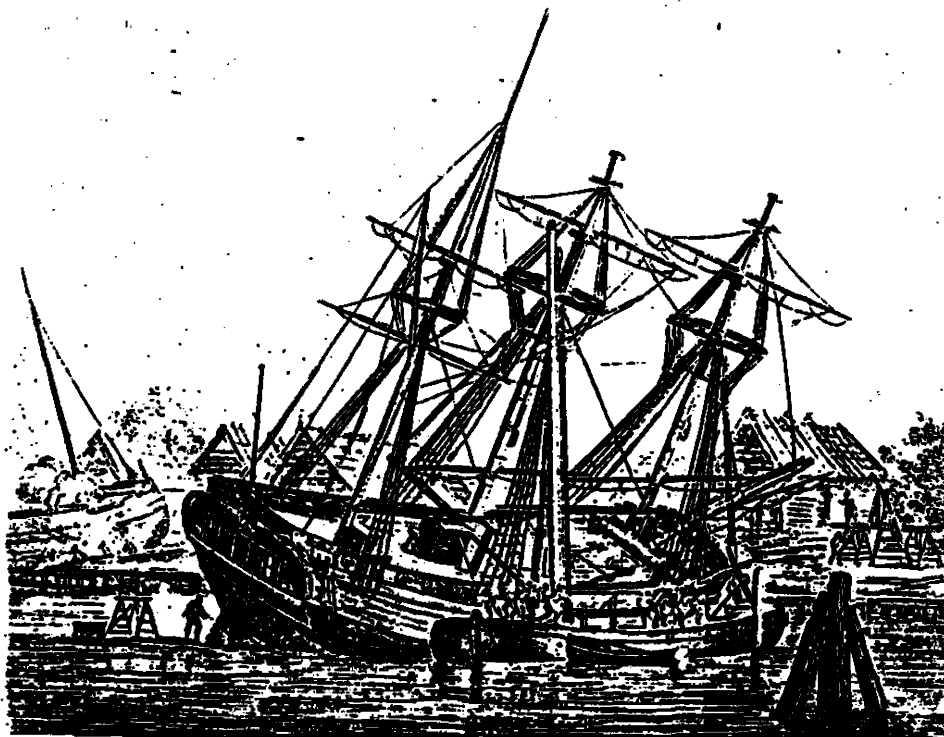


Figure 43. Portion of a diorama showing the hull of the Artemise in the Musée De La Marine. Note the lower part of one of the preventer shrouds brought over the main channel and secured to the hull at point a, slightly to the left and above the wooden cleat b. M. Goelet.

of the chainbolts, although that is not entirely clear from either the drawing or the translation from the Danish (Funch, 1846: 8).

The fregat in Fig. 44 uses a single rope preventer shroud with a tackle, seen just forward of the main- and foremast shrouds; another is visible aft of the mainmast shrouds on the previously-illustrated kof (Fig. 37, p. 62), also drawn by Groenewegen.¹²

Merchant vessels represented by dioramas in Hamburg



Fregat dat leijt te Kielen

6

Figure 44. A Dutch fregat careened by main- and foremast. Etching by G. Groenewegen, c. 1800. Courtesy of the Rijksmuseum. Photograph No. 39,538.

and Åland, Fig. 10, p. 27, and Fig. 45 respectively, of mid-to-late-19th-century vintage, also utilized rope preventer shrouds.

The preventer shrouds on those vessels, both of which incorporated treble-block tackles, were attached to the lower mastheads directly above the trestletrees.

The lower blocks on the Hamburg vessel were placed just above and outboard of each of the three channels. Large, rectangular balks of timber, the width of the

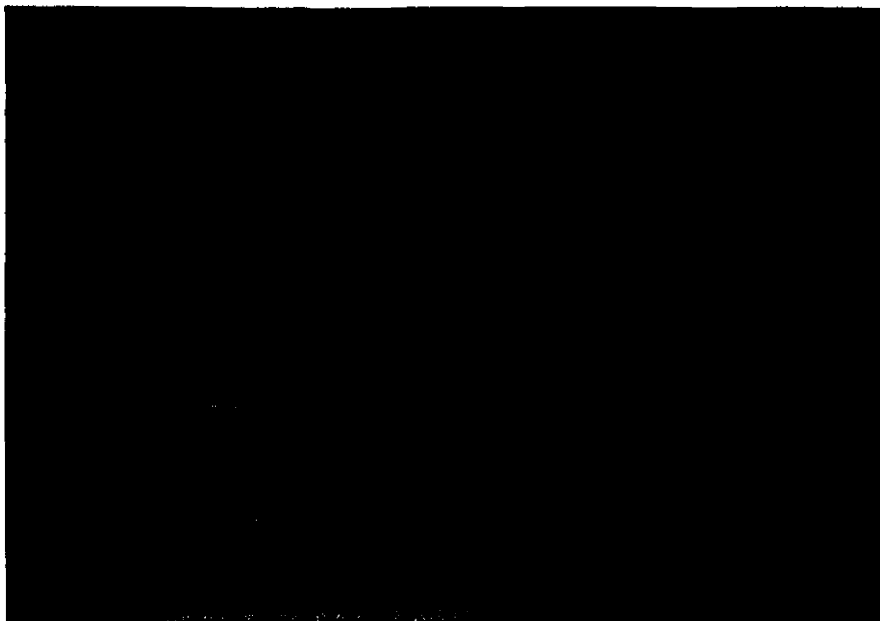


Figure 45. Diorama of a mid- to late-19th-century vessel in the Ålands Sjöfartsmuseum, Mariehamn. M. Goelet.

channels, extended under their forward three quarters and were apparently notched to accommodate the chainplates underneath. By extending the shrouds outboard the timbers prevented the outside edges of the channels from being chaffed. Their under surfaces also braced the exposed portions of the shafts of long preventer ringbolts fastened through the hull to which the lower blocks were lashed (Fig. 10, p. 27, and Fig. 46).

The channels on the Åland vessel were much narrower than those on the Hamburg ship, obviating the need for timber bunks. What pressure there was against the

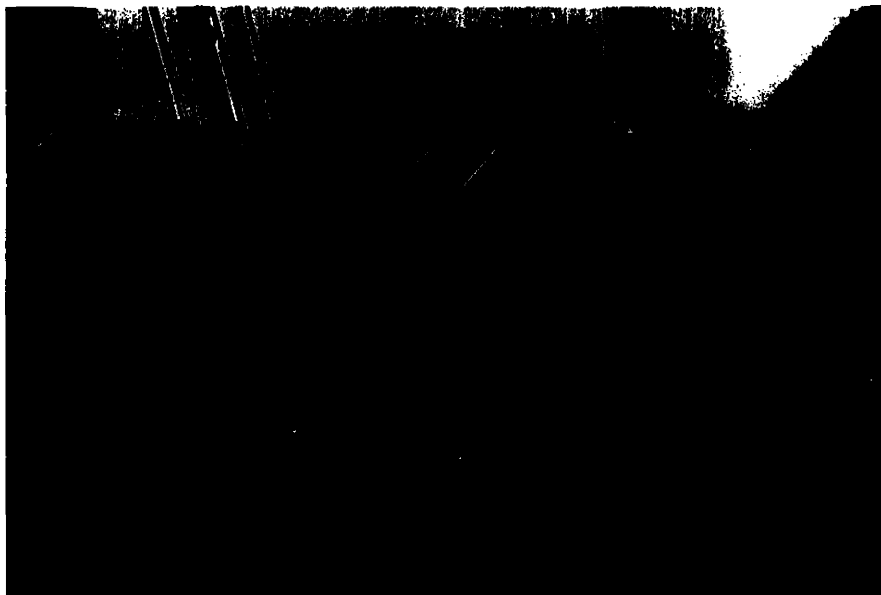


Figure 46. Deck view of the careening barge in the Hamburg Historich Museum diorama. Note the outer ends of the preventer bolts extending beyond the wood balks along the upper side of the careened ship. M. Goelet.

channels, however, was divided into two parts by threading a rope bridle through the eye of the lower block strap of each tackle. The bridle was attached at its ends to through-hull ringbolts set midway between the channels and the waterline (Fig. 45, p. 82).

Chain preventers

On the Helsingør vessel (Fig. 47), one end of a chain was looped and shackled around each of the two mastheads

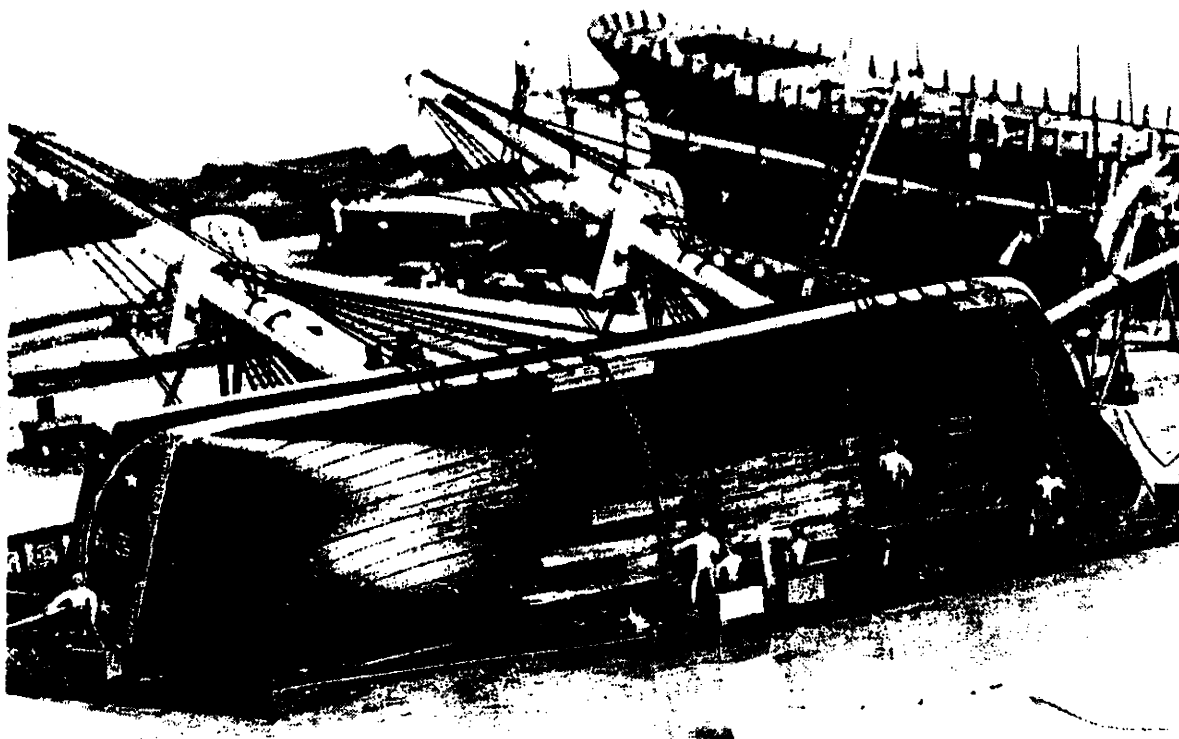


Figure 47. Hull view of the Greenland trading vessel Hvalfisken. Detail from a diorama in the Danish Maritime Museum Kronberg, Helsingør, of the Rasmus Møller shipbuilding yard in Faborg, Denmark, as it was in the 1870s. Photograph courtesy of Handels-Og Søfartsmuseet Pa Kronborg Helsingør.

just above the mast tops, which were left in place. Each chain was extended outboard of the channels by layered barks of timber placed above the turn of the bilge. They were then led under the vessel's keel and up the leeward side, passed through the lee rail, and brought over the bedding-timbers on which the heels of the mast shores

rested. Crossing the deck, they were given several turns around the base of the mast from which they originated and then shackled (Fig. 48). Although not obvious from the diorama, the chains were probably well parcelled to prevent damaging the vessel where they made contact.

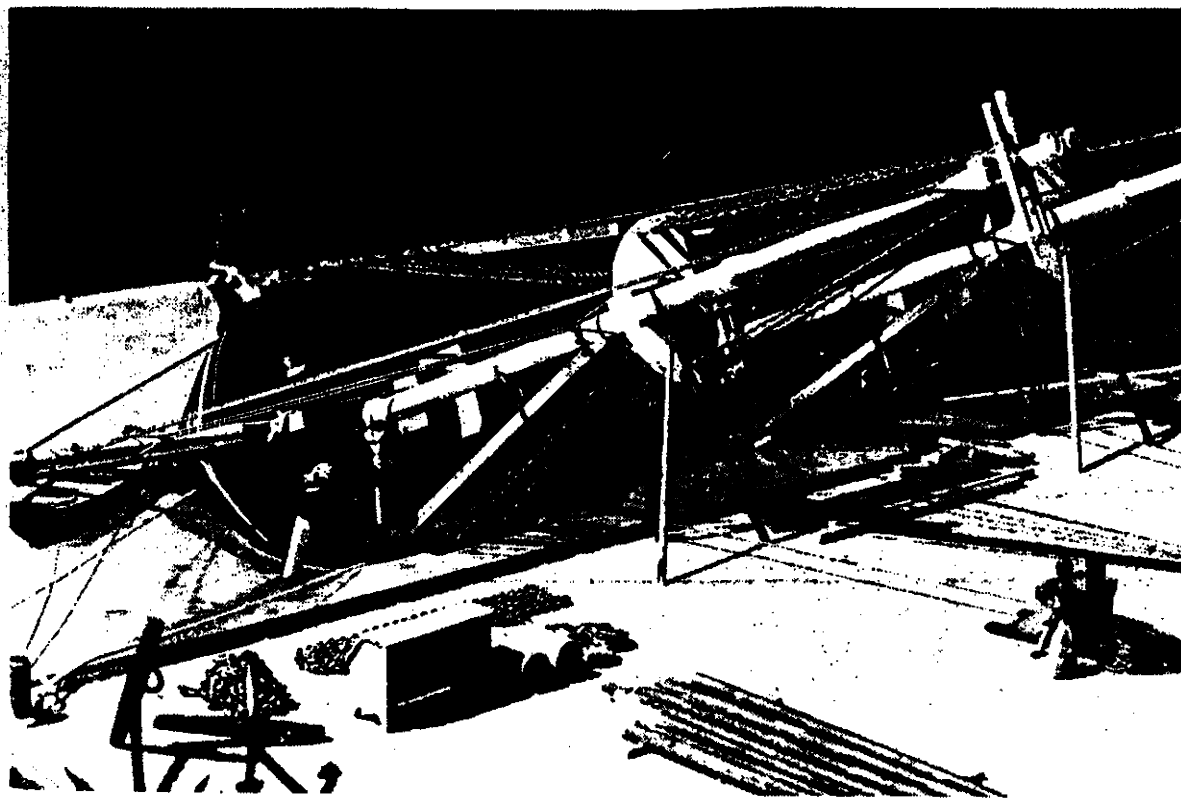


Figure 48. Deck view of the Hvalfisker. Courtesy of the National Maritime Museum, Greenwich, London. Negative No. B5178/19.

A similar arrangement is seen in a late-19th-century photograph of the New Bedford whaleship Sunbeam hove down (Fig. 49). The same photograph appears in Church's book on whaling, wherein he commented that, having been attached

to the mainmasthead, the chain was led over a block of wood wide enough to allow it to clear the bulwarks, and was fastened beneath the main chain plates, an arrangement differing from that used for the Helsingor vessel. This, he said, was to act as the principal relief to the main rigging (Church, A., 1938: 24-25). Only one chain was used, as American whaleships were commonly hove down by a single large tackle lashed to their mainmasts. Note the size of the chain passing over the balk of timber.



Figure 49. The whaleship Sunbeam hove down. Notice chain passing over balk laid against ship's side, upper right. Courtesy Peabody Museum, Salem. Negative No. 9,347.

Harris described an arrangement used on English warships in which chains were used as preventer shrouds. Two lengths of well-parcelled stream chain cable were placed over the mainmasthead and "set up through the lower deck ports."¹³ They were kept clear of the channels by short outriggers made from hard wood with grooves cut into their ends to receive the chain. These short timbers, Harris said, rested "in the channels" (probably on top of them), and were kept in position by cleats fastened to the hull forming a shoe into which their heels fit (1841: 9).

With the exception of Harris's reference to setting up the chain, none of the three aforementioned examples of chain preventer gear showed or described how it was tensioned. In Henningsen's description of the Helsingor diorama, he noted that wedges were placed under the chain where it passed over the timber balk (1959: 31-32). These may have been used to tension the chain on that vessel, and wedges may have been used on American whaleships as well for that purpose.

Spanish windlasses were used to tension chain preventers on the Brandywine when she was careened in Brooklyn. They were rigged on the berth deck, the chains previously having been led "through the air ports abreast the respective (main and fore) masts" (Luce, 1884: 584-85). Fig. 50 is a drawing of a Spanish windlass. It can be

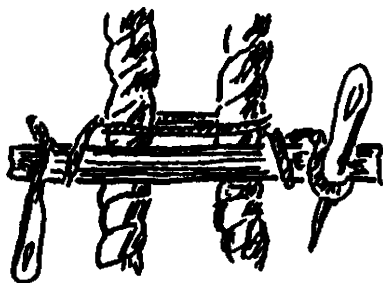


Figure 50. An example of a Spanish windlass. After Luce (1863: pl. 15, fig. 125a).

seen how a device similar to the one in the illustration could have been applied.

The berth deck on a frigate such as the Brandywine was the third deck down. Air ports are ventilation openings in either a vessel's side or deck (Paasch, Capt. H., 1977: 45). They were first installed through the Constitution's sides to service her berth deck in 1811, 14 years before the Brandywine was launched. Since the term "air ports" rather than "ventilators" or "gratings" (other openings in the decks to allow circulation of air) was used to describe them, it can be assumed that the reference was to openings through the vessel's side.

The chains used for the Brandywine's preventer shrouds were specifically referred to as being "small" (Luce, 1884: 584). Their small size was probably dictated by their need to make a right angle as they passed through the ports and by the size of the ports.

If the Brandywine's air ports were comparable in size

to those on the Constitution, the chains would have had to have been small. The diameters of the Constitution's air ports are quite small to begin with, probably no more than 7 1/2 in (0.191 m).¹⁴ On the Brandywine, that dimension would either have been diminished by the need for protective bolstering, or the effective size of the chains would have been increased by the need to parcel them; perhaps both protective measures were undertaken.

Probably because of their limited size, the chain preventers on the Brandywine were used in conjunction with two extra pairs of shrouds brought over each masthead and run to deadeyes "toggled with a long strap to the main deck ports" (Luce, 1884: 584). Since no outriggers seem to have been used, the preventers mentioned still would not have provided sufficient support for the masts. This supports the theory espoused earlier concerning the placement to weather of the mast shores on that ship. It is curious that the crew did not avail itself of heavier chains and pass them instead of the preventer shroud pendants through the gunports, as was done on the Melville.

Whether or not preventer shrouds were used on either the merchant vessel shown in the Stockholm diorama (Figs. 17 and 30, pp. 32, 51) or the warships in the Copenhagen model (Fig. 39, p. 69), both representative of the mid- to late 18th century, could not be discerned due to their

inaccessibility to a close scrutiny. They were not, however, included in the careening references pertaining to the 1740 drawings of the English warship in Figs. 32 and 34, pp. 53, 55, nor could they be seen on the mid- to late-19th-century Belgian merchant vessel in Fig. 11, p. 27.

Supplementary Longitudinal Support Rigging

Additional preventer rigging, designed to restrict longitudinal movement of the lower masts and to supplement that already discussed, was often used on large vessels.

A point which Harris strongly emphasized was the need to maintain a constant distance between the heads of the masts used for careening, a distance that was to remain equal at all times to the space between the lower blocks of the careening tackles. If the mastheads were to spread apart or draw together as the ship was hove down, the stays and rigging could be unevenly strained (1841: 11), with a resultant increased potential for disaster.

To prevent longitudinal movement of the mainmast and to provide additional support, Harris suggested the use of masthead runners to assist the mainstays. He also recommended that two tackles be led from the mainmasthead, one to the chesstree, the other to the after quarterdeck port. Two belly stays were to be lashed one third of the

way down the mast and set up to the skids, and two other tackles were to be lashed at the same height and run to the afore-mentioned chesstree and quarterdeck port.

The foremast was to be similarly supported with tackle lashed at the masthead running fore and aft. Forward, the tackle was set up to the weather cathead; aft, to the chesstree and skids. Two additional belly stays, one third of the way down the mast, were to be lashed halfway out on the bowsprit (Harris, 1841: 9).

While neither the bowsprit nor the mizzenmast (unless it was used to help careen the ship) were subjected to external pressure, their weight alone subjected their rigging elements to unusual stress at high angles of heel. Although this stress was not nearly so great as that on the standing rigging of the masts by which the ship was heaved down, precautions were nevertheless taken to ensure their safety. Harris suggested running foreyard tackles from the head of the bowsprit to the weather side and using mizzen burtons to help support the mizzenmast (1841: 9).

Outriggers

Another method used to prevent the masts from being pulled to leeward by the careening tackle was to install outriggers. These consisted of three parts: a large timber

extending outboard from the vessel's weather side; outrigger shrouds which reached from the upper part of the lower masts to the outboard ends of the outrigger timbers; and martingales, heavy ropes leading from the ends of the outriggers to the vessel's lower hull (see Fig. 35, p. 56).

Outrigger timbers extended the point of attachment of the outrigger shrouds outboard, providing a greater angle between those shrouds and the masts than between the masts and either the working or preventer shrouds. With forces generated by the careening tackle adjusted so that each shroud bore an equal strain, an outrigger shroud's horizontal component of force was greater than that of the other shrouds. Those forces, transmitted through the outrigger timbers, could be more evenly distributed to the ship's hull via internal shores and angled struts placed between the inboard portion of the timber and the ship's structural members than could the forces acting through preventer-shroud bolts.

Outrigger shrouds could be considered the vehicles by which careening tackle pressure was transmitted from the masts to the outriggers.

Martingales counteracted the upward force exerted against the ends of the outriggers by the tension on the outrigger shrouds.

Origins And History Of Outriggers

The earliest illustrations of outriggers appear in two paintings which date from the last two decades of the 15th century and depict carracks being careened (Fig. 36, p. 61, and Fig. 51). The vessels in both paintings are Venetian and, although Italian ships are not strictly

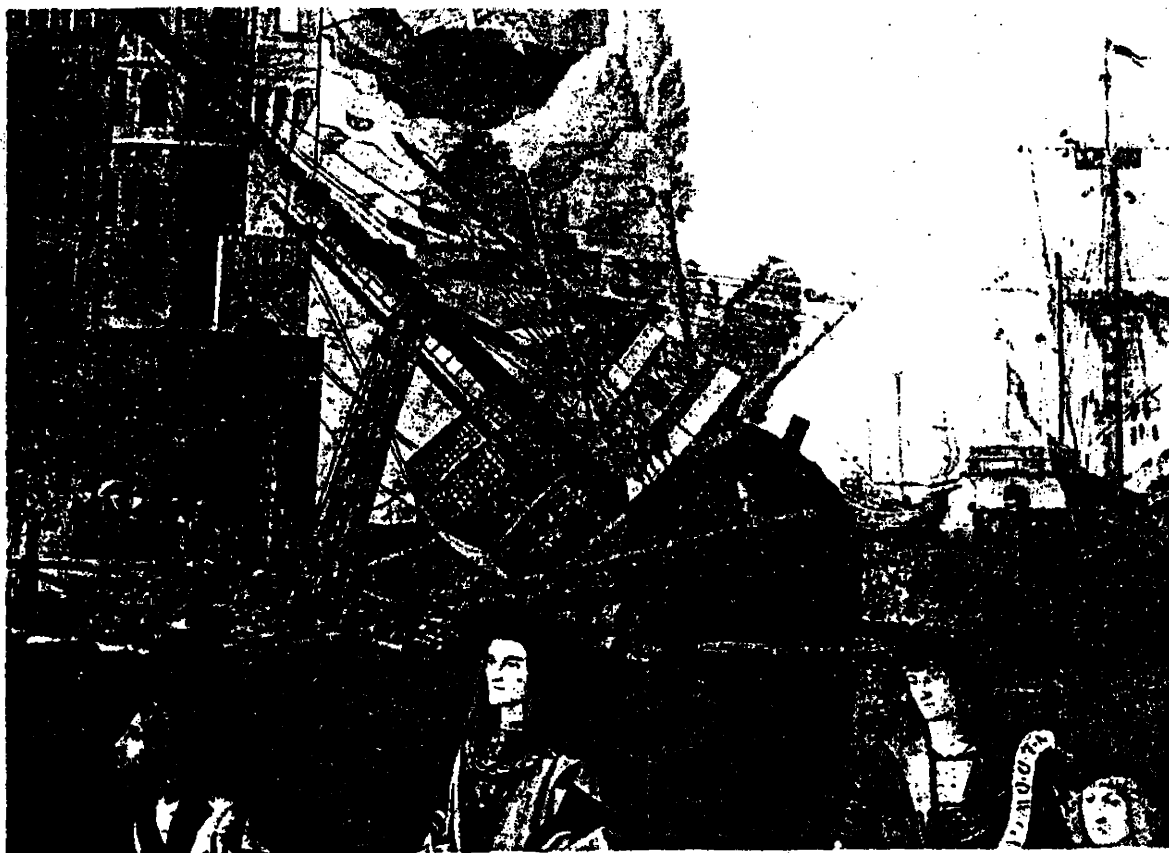


Figure 51. Detail of ships from wedding scene in "The Legend of St. Ursula." Oil painting by Vittore Carpaccio, 1490-96 seen in Casson (1964: 85, fig. 103). Note outrigger projecting upward to the right with two, or possibly three, tackles attached.

within the scope of this study, they are the earliest representations of careening yet noted, and the techniques illustrated seem worthy of inclusion.

The earliest representations of careening falling within the geographic study area of this thesis are Nooms' early- to mid-17th-century etchings of Dutch vessels of which Figs. 26-29, pp. 47-50, are representative. None of them show outriggers being used.

From the late 15th century to the mid 19th century, the average tonnage of large ships gradually increased, while stern- and forecastles decreased in size. These were changes that increased stability and the difficulty of heaving them down. It seems likely, therefore, in spite of what Nooms' etchings might suggest, that a gradual increase in the use of outriggers occurred.

Outriggers were able to offset larger careening tackle forces than preventer shrouds because of the greater angle of resistance of their shrouds and, what's more, were able to disseminate their strain to the hull more evenly. By the end of the 17th century, they were almost always employed to heave down large warships and were commonly used on merchant vessels of various nations.

In many large latter-day warships, outriggers were used in conjunction with preventer shrouds; less commonly they were used alone. In only two instances that I have

found (the ambiguous description of the careening of the Brandywine [Luce, 1884] and King's description of the careening of the Courageaux [1802]), were preventer shrouds mentioned while outriggers were not.

This was not generally so with either smaller merchantmen after the mid 19th century or whaling ships. Of the mid- to late-19th-century vessels represented in the European dioramas I have seen, only the Belgian vessel in Fig. 11 used outriggers (compare with Figs. 10, 33, and 47, pp. 27, 54, 84). As already noted, it was also the only one of the four that apparently did not use some form of preventer shroud. No photographs or illustrations of careened American whaling vessels of that period show outriggers, while every one used some form of preventer shroud.

The Swedish merchantman in Fig. 17, p. 32, and both the Dutch kof and fregat in Figs. 37 and 44, pp. 62, 81, respectively, all somewhat earlier vessels than those mentioned above, did use outriggers. The only later merchantman to use them was the German schooner-brig in Fig. 16, p. 31. Both it and the Belgian vessel must be considered anomalous in that respect, as there seems to be a general shift away from the use of outriggers on merchant vessels by the mid-1800s at the latest.

All these vessels were substantially smaller and lighter than large warships and, at least in the case of

whaling ships, very strongly built and rigged for their size. Their small size and the strength of their rigging and internal structure in conjunction with technological advances in some of the careening paraphernalia--wire rope in place of fiber rope, for example--must account for the general simplification of preparatory heaving down procedures which seems to have occurred during that time.¹⁵

Additionally, during that era another factor appeared which may have helped diminish the complexity of the operation. The introduction of composite ship construction promoted strength and lightness by utilizing wooden planking on an iron framework (Roome, 1984: personal correspondence).¹⁶

Outrigger timbers

Outrigger timbers used in the careening of large 19th-century English warships were enormous. Each of the nine outriggers extending from the lower deck gunports of the Formidable was 40 ft 6 in (12.34 m) long. The seven smaller outriggers which extended through main deck gunports above each had a length of 35 ft (10.67 m).

All the outriggers were square, those on the lower deck 2 ft (0.61 m) on side, those on the main deck 18 in (0.46 m) square. They were placed as nearly abreast the

main- and foremasts as gunport spacing permitted. Nine served the mainmast, five on the lower deck and four on the main deck. The remaining seven were used to help support the foremast, four extending from the lower-deck gunports, the other three projecting from the main-deck gunports (Walker, 1902: 409).

The main outriggers of the smaller, 72-gun Melville were cleated 18 ft (5.49 m) out from the hull to receive the auxiliary rigging (Harris, 1841: 8). Presumably, then, the Formidable's outrigger shrouds and martingales were attached to the lower-deck outrigger timbers at least that distance outboard.

The outboard ends of square or rectangular outrigger timbers were rounded where the lower parts of the outrigger shrouds and the upper part of the martingales were fastened. This was to prevent the ropes from being cut.

Sometimes the outriggers were made from round timbers, such as those on the vessel in Fig. 11, p. 27. On this much smaller vessel than the Formidable, the two outriggers used were only about 10 to 12 in (0.254-0.305 m) in diameter and approximately 18 to 20 ft (5.486-6.096 m) in length. Note the thoroughly bolstered main-deck ports through which they extended.

Generally, whether an outrigger was round or rectangular in section, its cross-sectional dimension was

abruptly increased or it was cleated just before the rounded end part began; the resultant shoulder prevented the various ropes from slipping inboard. Fig. 52a shows the outboard end of a square-sectioned outrigger on the mid-18th-century English warship in Fig. 31, p. 52, while Fig. 52b shows the same portion of a round-sectioned outrigger from the Belgian vessel in Fig. 11, p. 27.

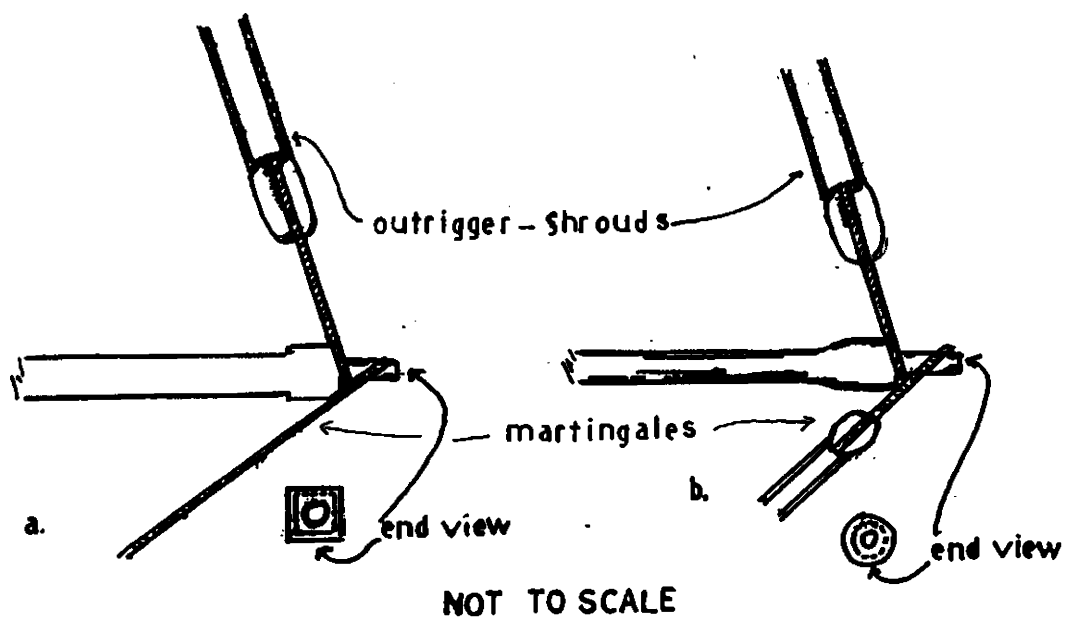


Figure 52. Two examples of the outboard ends of outriggers.

Installation of timbers

Since the weight of each of the outrigger timbers used aboard vessels of the Melville's class and larger

must certainly have exceeded 2 tons, the lower yards were probably employed to sling the timbers into position before the yards were removed.

Once positioned with approximately half their length outboard, the inboard portions of the timbers were braced downward in a manner designed to prevent their being lifted by the pull exerted by the outrigger shrouds.. This commonly would have included lashing the timbers to the breeching bolts, and further inboard, to a train bolt, both bolts used by elements of the previously removed ordnance.

The heels of the outriggers would be braced against bits, hatch combings, or other strong, raised timbers. If none were in the immediate vicinity, heel shores could be run to butt against the waterways on the opposite side of the vessel. Vertical shores would be run to deck beams above. Diagonal shores, positioned to spread the strain vertically and laterally, were run between the upper surfaces of the outriggers and the upper corners of the gunports; the upper sills and sides of the gunports would have been previously reinforced with protective timbers. Occasionally, the opening surrounding the outrigger timber would be completely blocked with wooden chocks as an additional precaution against the timber's movement.

Such comprehensive bracing apparently was not deemed necessary on the small 19th-century Belgian vessel in Fig.

11, p. 27. While each of the two outriggers was cursorily secured to the two barks of wood bolted to the deck on which it rested, the main inhibitors against its movement were the martingale tackle at the outrigger's end and the thoroughly-bolstered deck port through which it extended.

Outrigger shrouds

Outrigger shrouds commonly consisted of pendants in combination with a tackle. The pendants were led from the masthead in the same area as the preventer shrouds (just over the trestletrees) but were always placed after the preventer shrouds, since the latter, with their greater angle of extension from the mast, had to be installed first in order to prevent the two from fouling each other.

The lower ends of pendants were usually backspliced into an eye that was either lashed or toggled (Fig. 53) to the strap of the upper block of a tackle. The lower tackle block was, again, either lashed outboard of the cleat at the end of the outrigger timber, or its strap was worked into an eye which was looped over the same area.

Martingales

Martingales, as the term is applied with reference to careening, were made up of one or more parts, each

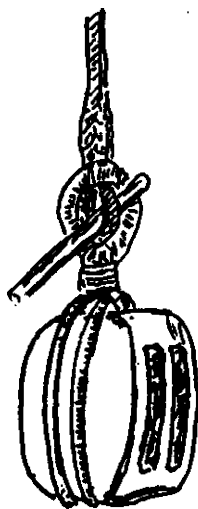


Figure 53. A pendant toggled to the upper block of an outrigger shroud tackle. After Rees (1970: rigging pl. II, fig. 13).

consisting of a heavy rope and sometimes a tackle. The upper end of each part was fastened to the end of the outrigger, and the lower end was attached below to the hull of the ship. Since they formed a lesser angle with the outrigger timber than did the outrigger shrouds, they were placed outboard of them (see Fig. 52, p. 98).

Many vessels employed martingales consisting of two parts for each outrigger, one part extending forward and downward, the second extending aft and downward. This arrangement inhibited lateral as well as vertical movement of the outrigger. If considered necessary, a third part running downward in line with the outrigger was added. The size of the martingale's parts varied with the size of the

vessel and with the size of the angle formed with the outrigger. The larger that angle was--in other words, the closer to the vessel's waterline the bottom part of the martingale was fastened--the smaller its parts could be. For a vessel such as the Melville, Harris found three-part martingales of 8-in (0.203 m) rope sufficient "if the bolts are near the water-line" (1841: 8).

The lower parts of martingales which braced outriggers extending from the maindeck gunports of ships with two or more tiers of guns could be fastened to the breech bolts bracketing a lower-deck gunport. Vessels with a single gun-deck, or large vessels which utilized outriggers extending from the lower gun-deck, required holes to be drilled as near to the vessel's waterline as was practical to accommodate long, thick iron span bolts to which the lower parts were attached. The holes were drilled with a slight upward angle so that, as pull was exerted against them, the bolts would set rather than tend to pull out.

If bolts were unavailable, they, as well as the plates, washers and forelocks which accompanied them, had to be fabricated by the ship's blacksmith.¹⁷ The bolts were run through the plates, the ship's planking, and sometimes an interior structural member such as a deck beam, then washered and forelocked in place. Often they were quite substantial in size. The Melville, for

instance, used bolts 10 spans in length and $1\frac{3}{4}$ in (0.044 m) or more in diameter (Harris, 1841: 8).¹⁸

Various outrigger designs

As might be expected, outrigger designs varied from area to area both in the numbers used and in the ways they were rigged. Some of these variations can be seen in the examples which follow.

The numbers of outriggers used to careen a vessel was to a substantial degree dependent on the ship's size, but also on other factors, most of which seemed to be related to the degree of difficulty with which the ship was heeled.

For example, 16 outriggers were installed when the 84-gun Formidable was careened in Malta (Walker, 1902: 409; Fig. 54).

In comparison, only two outriggers for either the fore- and mainmast were used to heave down the 52-gun Artemise (Fig. 55). Although the Artemise was substantially smaller than the Formidable, that alone does not explain the discrepancy in the numbers of outriggers employed during the careening of either ship.

Other evidence indicates that the French were consistently more conservative with outriggers than the British. The use of only four outriggers to careen

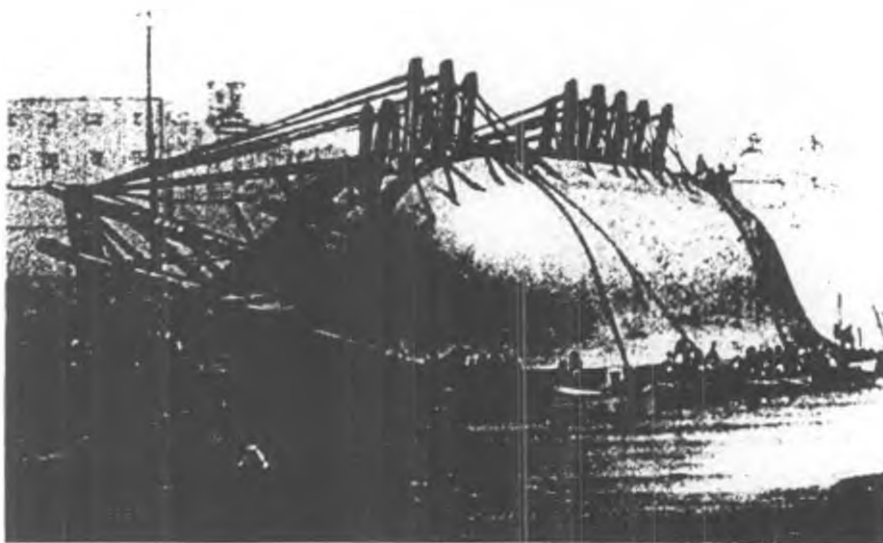


Figure 54. HMS Formidable careened in Malta, 1843. Lithograph by Schranz Bros. In Moore (1926: pl. 55).

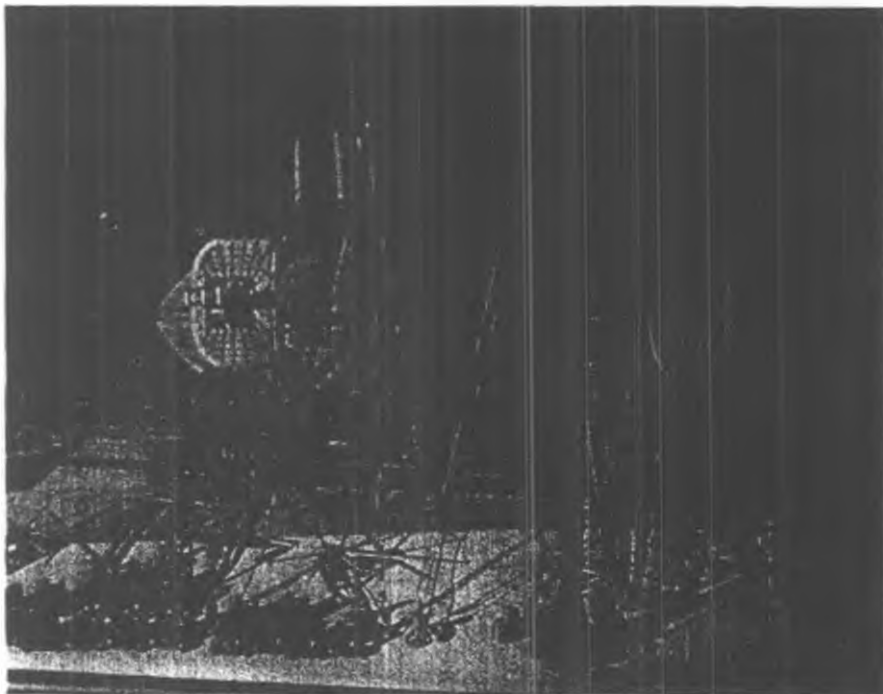


Figure 55. Detail of diorama in the Musée De La Marine, Paris, depicting the careening of the Artemise in Tahiti, 1839. M. Goelet.

substantially sized French vessels such as the Artemise was not unprecedented (see Figs. 13 and 14, p. 30), and, as previously noted, no mention at all was made of outriggers in the account of the careening of the Courageaux.

If the number of outriggers used can be taken as a general indicator of the relative force required to heave a ship down, then French vessels generally seemed to have required less force than English ships.

A comparison of some of the characteristics of the two ships offers reasons for this which are applicable to all vessels.

The beam of the Formidable exceeded that of the Artemise by well over 8 ft (2.44 m).¹⁹ This would have given the English vessel greater initial stability. In addition, the Formidable's higher freeboard, coupled with a greater tumblehome, would have provided her more righting moment than that possessed by the Artemise at an angle of heel which would have submerged the waist of the French ship but not that of the Formidable. Both of these phenomena would have made the English ship more difficult to heel than the French craft.

Furthermore, the shape of the bottoms of French warships was such that it led a French commission, convened in 1833 for the purpose of comparing French and

English warships, to comment that "now, in many English ships, some of the conditions of stability, owing to the form of the bottom, are found to be more favorable than in our ships" (Fincham, 1979: 256 and 262). Two differences were the generally narrower beam and greater draught of French vessels. More ballast was required than their similarly-armed English counterparts, decreasing their comparative stability and making them easier to heave down when all or part of the ballast was removed. Additionally, the masts of French ships, the arms or levers by which vessels were ordinarily careened, were somewhat higher than those of comparably-armed English ships, so a lesser force would have been required to produce the same moment.²⁰

The effects of configuration on careening forces, as well as beam, weight, etc., will become clearer during a later discussion of stability.

The method of rigging an outrigger shroud on a large 19th-century British man of war is exemplified by that employed on the Formidable. The lower end of the pendant was backspliced into an eye which was toggled to the upper block strap of a double tackle (Fig. 53, p. 101). The lower block straps were looped over the outboard end of the outrigger. After the outrigger shrouds had been properly tensioned--slightly tauter than the regular shrouds, since, with a longer drift, they were less

strained when offering the same support--the bitter end of the fall was secured (Brady, 1857: 264; Walker, 1902: 538).

We see on the English warship in Fig. 31, p. 52, outriggers projecting from the fourth through the seventh and the ninth through the twelfth lower-deck gunports. No tackles were used to tension the two parts of each outrigger martingale. Span bolts with large rings affixed to their heads passed through metal plates. The martingale parts consisted of a single heavy rope, doubled in the middle and seized to form a collar which was looped over the end of the outriggers. Each end of the rope was secured to one of the span-bolt rings, the parts of adjacent martingales overlapping each other.

Particulars in the careening of the Formidable which were unusual on an English ship included employment of lower treble blocks (double strapped) as replacements for the more commonly used double blocks and the retention of the fore- and mizzenmast tops, although the mainmast top was removed.

This last point can probably be explained by the fact that the ship was not heaved down very far, and the weight of the tops may not have been viewed as negatively as the inconvenience of removing them. The mainmast top, in fact, may have been removed only to provide room for the wide spread of the outrigger shrouds. The relatively slight

heel may also explain why only the mainmast was used to careen the ship and how the rudder could have been safely left in place.

Photographs provided by the Musée de la Marine in Paris (Fig. 22, p. 41, and Fig. 56) show a different model of the Artemise being careened than is now exhibited.

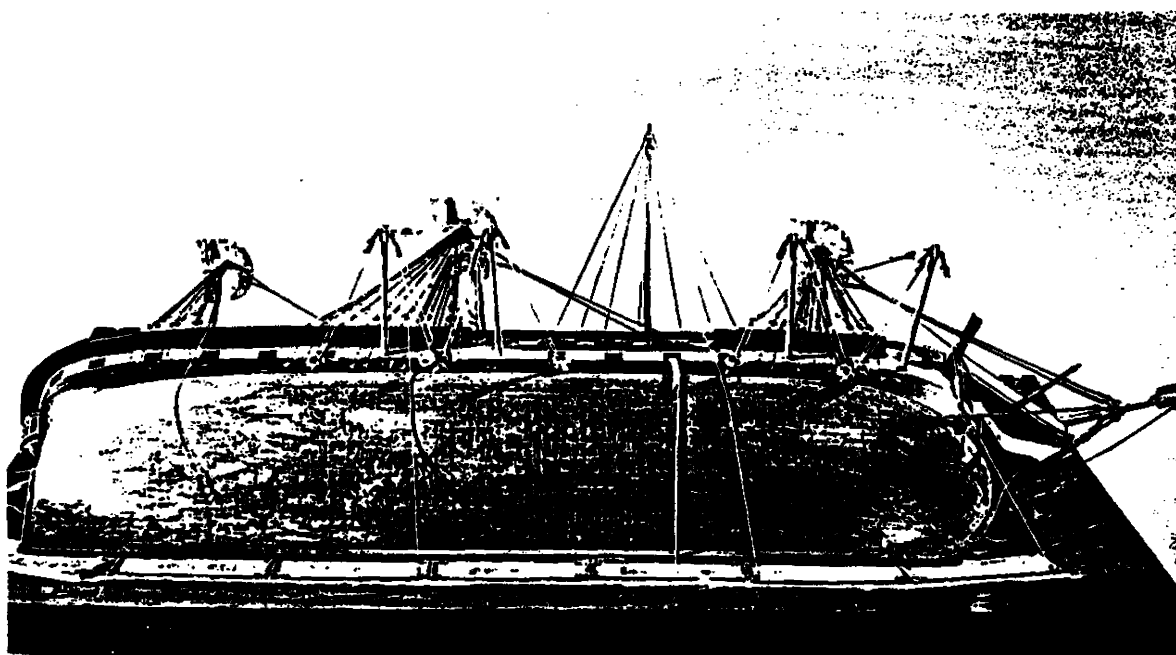


Figure 56. Hull view of an earlier diorama of the Artemise. Courtesy of the Musée De La Marine, Negative No. 9,234.

The present diorama (Fig. 43, p. 80) shows an important modification to the outrigger gear which must, at the very least, have diminished its efficiency. A pendant led through a notch cut in the outboard end of the

outrigger joins a tackle below which acts as the martingale. The eye of the lower block strop is worked through the ring of an iron hook attached to the eye of a short, heavy rope secured to a large wooden cleat bolted vertically to the hull in the vicinity of the waterline (Fig. 43b, p. 80). The tackle tensions both the pendant and the martingale which are, essentially, a single unit.

A comparison between the earlier arrangement (Fig. 56, p. 108) and that currently displayed (Fig. 43, p. 80) shows that the latter provides much less security against vertical movement of the outboard end of the outrigger than did the earlier model. In the current model, there seems to be nothing to prevent the outboard end of the outrigger timber from sliding up the pendant along the groove. At the same time, the lack of fore or aft martingale parts eliminates their protection against the timber's lateral movement.

Harris described a more effective outrigger plan, which he apparently observed used on a Portuguese double-banked frigate. Three outriggers were placed in the after part of three main-deck ports and three in the after part of three gun-deck ports, all contiguous to the mainmast. Each was braced with a diagonal shore led from its foreside to the forward part of the deck port sill. Their heels were securely fastened down, and six outrigger shrouds, one to each outrigger, were set up running from

the mainmast to the ends of each of the outriggers.

Span bolts with rings at their ends, two for each outrigger, were driven into the hull (probably below and to the sides of each outrigger). Three turns of rope were loosely passed around the outrigger cleats and run through the span-bolt rings. A capstan bar was used to twist the parts together until they were taut and was then securely lashed to the outrigger to prevent the whole from loosening. The foremast had four outriggers set up in the same way (Harris, 1841: 27). A similar method of tightening martingales is illustrated in a coeval drawing by the Swedish admiral and artist Jacob Hagg (Fig. 57).

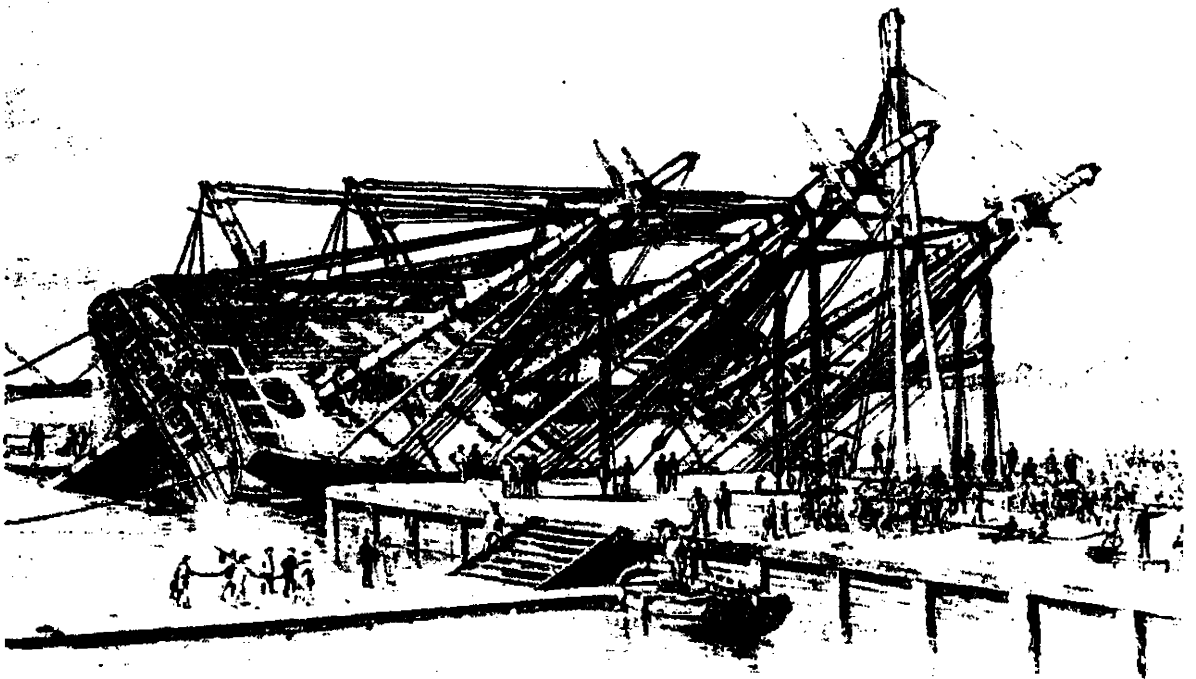


Figure 57. A Swedish frigate heaved down against a wharf. Drawing by Joseph Hagg, 1840. Seen in Halldin (1963: 214).

A single outrigger supported each of the masts of the two mid-18th-century Danish warships in Fig. 39, p. 69, both of which were hove down by all three masts. Each outrigger was braced by a heavy timber strut lashed to its upper side near its outboard end. The inboard ends of the struts were securely wedged under the channels where they butted the hull preventing the outrigger from lifting as force was exerted by the careening tackle. The outriggers were further restricted from being lifted by three-part martingales consisting of heavy ropes leading from the end of each outrigger to span bolts positioned near the waterline forward of, abreast, and abaft them. No tackles were used to tension the parts of the martingales.

Two pendants (probably pairs of shroud lines) were led from the lower mastheads just above the trestletrees, and each was attached to a double-block tackle. Of the two lower blocks, the strap of one was incorporated into the lashing which bound the outer end of the strut to the top of the outrigger timber; the innermost block of the two was heavily lashed to the strut so as to be just clear of the channel. From its position, the inner pendant and tackle fulfilled the function of a preventer shroud more than it did that of an outrigger shroud and probably should be so identified.

From his experience gained in Danish shipyards during

the first half of the 19th century, Funch (1976), illustrating the careening of a warship, drew a modified three-part martingale (see Fig. 40n, p. 70) which he called a "cock foot." Only two of the parts are actually attached to the end of the outrigger. The upper end of the short middle part, anchored to a ringbolt as are the outer parts, seems to provide a point at which to tension the outer parts. Although it is not clear from the illustration, an eye may have been formed in the upper end of the middle part and a lashing rove through it and around the other parts after they had initially been forced together by means of a Spanish windlass.

No martingale tackles are exhibited, nor were they used on the warships in Fig. 39, p. 69, which also utilized three-part martingales (although all three parts were attached to the outriggers on those vessels). Perhaps they were not normally incorporated as part of the martingale apparatus on Danish vessels.

Two struts are shown in Fig. 40, p. 70, instead of the one shown in Fig. 39, p. 69. Their outboard ends are braced against two cleats (Fig. 40m, p. 70), which Funch calls "horns," spiked to the outer end of the outrigger. Their inboard ends seem to be similarly braced under two more horns attached to the hull of the ship, although the representation is again not clear.

Two outrigger shrouds (Fig. 40o, p. 70) are secured

to the substantial lashing joining the shores to the mast. Like the preventer shroud (Fig. 40q, p. 70), their entire lengths consist of tackles.

Slightly further to the north in Stockholm, two outrigger shrouds were used for each outrigger, one of which was used to support each of the three masts employed to careen the ship. Once again their entire lengths were made up of tackles which, in that instance, consisted of a pair of double blocks (Fig. 17, p. 32). The lower blocks were fastened near the outboard ends of each outrigger, one inboard of the other just enough to provide clearance. Both were secured 6 to 7 ft (1.829-2.134 m) below the masttops which were retained in place. No struts were used to brace the outriggers.

Final Adjustments Prior To Careening

Once the mast shores were positioned and the auxiliary rigging installed, the shores were wedged (possibly, in some cases, adjusted with tackle). The shrouds were then tuned so that all support systems bore their fair share of the load. Any slack in the leeward standing rigging, eased prior to moving the masts against the weather partners, was taken in to the mast to prevent it from hanging in a bight and possibly fouling the careening tackle as the ship was heeled.

If the ship had not already been securely anchored fore and aft, this was done and additional ropes run ashore or to the floating craft against which it was to be careened.

SETTING-UP TACKLE

The kind of formal ship design that allowed the application of mathematical principles to questions of stability was a late-17th-century phenomenon. Plans incorporating lines drawings evolved at about the same time or perhaps somewhat later.²¹ Considering these facts, it is understandable why earlier seamen, lacking the mathematics with which to calculate a ship's stability at various inclinations, would try to ensure that it could not heel too rapidly or too far before careening it. If, either by accident or necessity, a ship was heeled to an angle at which its stable equilibrium was compromised, it was essential that the means of righting it were in place. After the 17th century, the precautions taken before then probably persisted as a matter of custom, or because stability equations were either lacking or none of the ship's officers knew how to use them.

The physical safeguards against too-rapid heeling or possible capsizing were alternatively called relieving, righting, or setting-up tackles. These terms refer to arrangements which had the same basic purposes but which could differ in detail from one vessel to another.

When it was obvious either from computations or empirically that the ship in question would remain in

stable equilibrium throughout the range of heel contemplated, relieving tackle was sometimes, but not always, eliminated. The Melville was a case in point. Harris declared that "[r]elieving tackles will not be necessary for a ship of this class," demonstrating that the metacenter could not have moved below the center of gravity at the required angle of heel (1841: 13). On the other hand, the Formidable was fitted with relieving tackles even though it was understood that they were only precautionary measures; in fact, no strain was ever brought upon them (Walker, 1902: 414).

Relieving gear, it will be noted, had two basic designs: either cables run under the keel to right the hull, or vertical poles or sheers fitted with tackles which were fastened to the masts or rigging to prevent the vessel's further inclination. Sometimes elements of both designs were used in combination with one another.

Although the details of each of the two designs could vary somewhat from vessel to vessel, there remained a constancy in both form and application, even internationally. Unfortunately, not enough examples of ships of different nationalities have been recorded in this study for it to be possible to determine if the ships of individual countries favored one design over the other.

Either design, if properly utilized, was entirely capable of fulfilling its main function of preventing the

vessel from exceeding its limits of stable equilibrium, or, if that should inadvertently occur, reducing the angle of heel to a point at which the ship would right itself.

Examples Of Setting-up Tackle

Cables

The relieving tackle used aboard the Formidable, initially hove down on her starboard side, employed two stream cables, one forward, one aft, passed under her hull and led through upper-deck ports on the port (weather) side. From there each was run across the deck and clinched around two adjacent upper-deck gunports. Their free ends were fastened to the running blocks of tackles made from a pair of 40-in (1.016 m) treble blocks rove with new 9-in (0.229 m) hawser. Lying between the ship and the shore, the running blocks were kept free of the bottom by what Walker called "lumps," probably a flotation device of some kind (Walker, 1902: 413-14). The fixed block was lashed to the bars in the careening pits. Fig. 58 illustrates the arrangement as it might have appeared.

Funch described a very similar system used on Danish warships during the same period. The only differences between Walker's and Funch's descriptions seem to be that the shipboard ends of the cables on Danish ships were

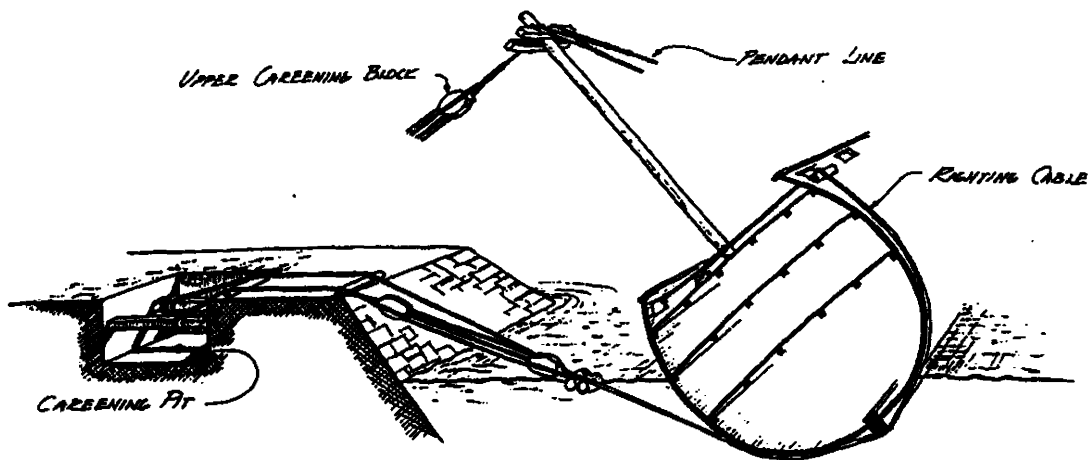


Figure 58. A possible arrangement of one of the Formidable's setting-up cables. Interpretive drawing by J. Taylor. Not to scale.

secured to the fore and main capstans instead of being clinched around a pair of ports, and the hauling parts of the falls were led to capstans on shore, a refinement not mentioned by Walker (Funch, 1976: 8).

Funch also commented that the relieving tackles were always kept taut during the hauling-over period (1976: 8). This and the higher state of readiness apparently displayed by the Danes seems to suggest that Danish seamen were more concerned with maintaining the stable equilibrium of their ships than were the English, but such was not the case.

Funch appears to have been talking about smaller vessels than the Formidable and the Melville. Large ships

such as those were inherently more stable than smaller ships. Harris himself seemed to intimate that more attention would be paid to smaller English vessels in regard to setting-up tackle (1841: 21). This suggests that the differences in attitude expressed by the care taken with regard to this aspect of careening were based on the different sizes of the vessels involved rather than any fundamental differences in stability between Danish and British ships.

Vertical poles

The relieving gear for the 18th-century Swedish vessel in Fig. 17, p. 32, employed a different concept. Two vertical poles, both supported by three guy ropes fastened to their heads, were mounted on the floating dock just aft of the fore- and mainmast careening pits. Both poles had the standing block of a double tackle lashed to their heads. The running block of either tackle was lashed to the ship's fore- and mainmasts just above the points at which the mast shores were lashed in place. The falls were slack but stood ready to function as the ship's masts fell below the height of the poles. The hauling part of each fall was loosely hitched to the lower part of the pole and was used without a capstan, since none was available.

Fig. 33, p. 54, shows the relieving gear used for the

Åland vessel. A set of sheers was set up on shore between the main- and foremasts, its timbers lashed together at their heads. The feet, spread about 14 feet (4.27 m) apart, rested on a rectangular timber kept in place by boulders. Two horizontal crosspieces, acting as stiffeners, were bolted to the vertical parts of the sheers about one fifth and three fifths of the distance to the top. Two guy lines hitched to the top led rearwards and splayed outwards, holding the sheers at a slight angle towards the vessel. These were secured by shackles to short lengths of chain about 50 feet (15.24 m) inland from the base of the sheers. The chains, in turn, were fastened to what appears to be iron pins hammered into the ground with their heads angled towards the shore, but these may be meant to represent the exposed arms of buried anchors.

The standing block of a fourfold tackle was lashed to the head of the sheers; the running block was lashed to what seems to be the main triatic stay. The hauling part of the fall passed under a lead block fastened to the timber on which the sheers rested and was secured to the lower horizontal crosspiece.

The arrangement evidently functioned in the same manner as the relieving tackle used for the Swedish vessel in the Stockholm diorama. When needed, however, it seems that it would have imposed a severe strain on the triatic stay with a corresponding tendency to draw the main- and

foremastheads together if precautions were not taken to prevent it, violating Harris's admonition to preserve a constant distance between them.

The relieving gear used for the American frigate Brandywine was quite similar in concept to that used on both the vessels above. Two sets of small, stout sheers were erected on the wharf. Each pair was placed near one of the two careening pits and braced by guy ropes. At the head of each set of sheers the standing block of a tackle was lashed.

As the vessel was hove down and its mastheads declined below the height of the sheers, the running blocks of the tackles were hooked to pendants fastened to the mastheads. The hauling parts of the falls were run (evidently through lead blocks) to capstans which could apply restraining force if the ship exhibited a tendency to heel too rapidly.

Once the keel was free of the water, the falls were bitted to the capstans and stoppered. Shores were then positioned on the wharf and their heads butted under the mastheads to take the strain from the relieving tackles and prevent the ship from heeling further (Luce, 1884: 586).

The Artemise was careened off a remote Tahitian beach and the crew, probably restricted by their circumstances, used relieving tackle that was an amalgamation of much

that has been discussed. Hove down on the port side, three cables (the foremost two of which can be seen in Fig. 43, p. 80) were secured within the hull, run through the third, sixth, and eleventh starboard gunports from the bow, and led down the side and under the keel. The aftermost cable was noticeably smaller than the other two.

Three sets of sheers, apparently fabricated from the vessel's topyards, were erected on the beach in line with each other. Two sets were placed between the fore- and mainmast (Fig. 55, p. 104). The third set, the smallest (not visible in the photograph) was positioned between the main- and mizzenmast. All were angled towards the ship and placed so as not to interfere with the ship's masts as the ship was careened.

To prevent movement, the feet of each set rested on wooden blocks butted against and lashed to posts driven into the sand. A long lashing joined the legs of each set of sheers about 8 feet (2.44 m) above their bases to provide additional rigidity.

The strap eye of the fixed block of a threefold tackle was merged into the lashing which bound the top parts of both of the two forward sets of sheers together. A double block was similarly lashed to the aftermost set. The strap eye of each running block was lashed to an eye worked into the end of its corresponding cable several feet (1-2 m) beyond where it surfaced from the water after

passing beneath the keel of the vessel. The hauling part of each fall ran through a lead block lashed at the base of one of the legs of each set of sheers and was then secured to a corresponding post behind, one of six driven into the sand about 50 ft (15.24 m) inland and in line with those securing the legs of the sheers.

Each set of sheers was maintained at the proper angle by a pendant middled and lashed to the top of one of its legs. The running block of a twofold tackle was fastened to either end of the pendant. Fixed blocks were lashed to the corresponding posts inland. The hauling part of each fall was secured to the same post to which its standing block was lashed, with the excess coiled alongside.

Combinations and other forms

A comparison of Fig. 55, p. 104, Fig. 59, and the description above to Fig. 22, p. 41, and Fig. 60, an earlier representation of the Artemise being careened shows differences in the relieving tackle. Note in Fig. 22, p. 41, and in Fig. 60, the single setting-up mast with the hauling part of the fall run from the lead block at its base to a capstan. As in the more recent diorama, the tackle was fastened to a heavy rope brought under the keel and up through a starboard gunport (see Fig. 56, p. 108).

Both dioramas of the Artemise differed from the model



Figure 59. Bow view of the diorama in the Musée De La Marine, Paris, of the Artemise hove down. M. Goelet.

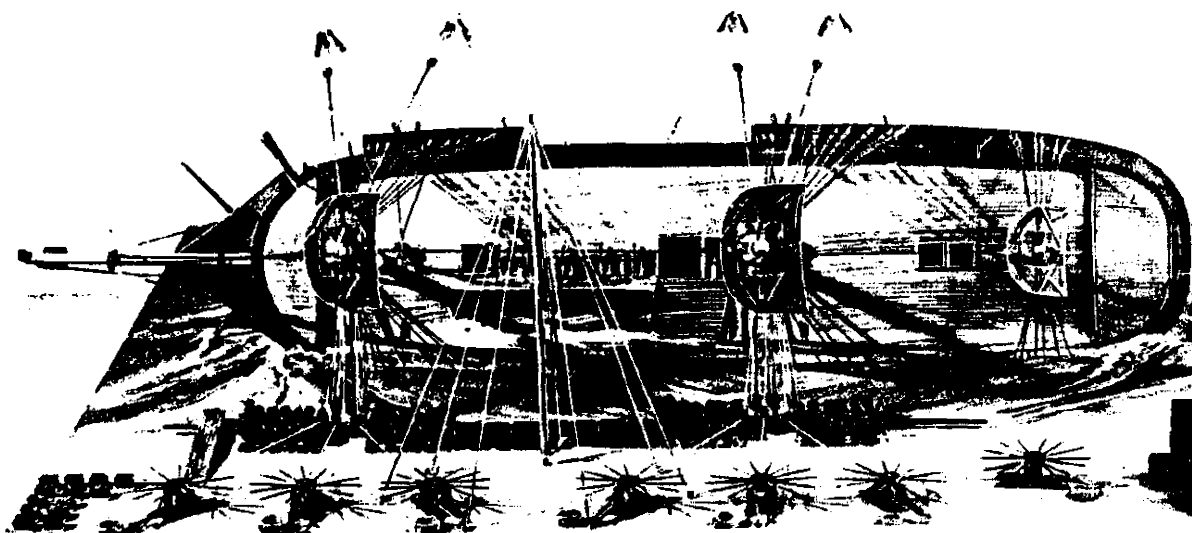


Figure 60. Deck view of an earlier diorama of the Artemise careened. Courtesy of the Musée De La Marine. Photograph No. 9,235.

of the earlier French warship in Fig. 12, p. 28, which had tackles fitted between the main- and foremasts to the head of the mast crane mounted on the side of the barge nearest the ship. The crane was restrained by heavy guy ropes set to turnbuckles bolted through the bulwarks on the opposite side. Like other arrangements previously described, the vessel could be prevented from being careened either too fast or too far by exerting sufficient tension on the fall only after the tackle blocks on the ship's masts were lower than those lashed to the barge's mast crane.

The relieving tackle used on the Belgian vessel careened on her port side in Fig. 11, p. 27, consisted of a cable fastened to the main- and foremasthead immediately above the trestletrees, each with a thimble spliced into its free end. These were brought down the starboard (weather) side of the vessel and under its keel.

Cat blocks serving as the running blocks of tackles were hooked to the thimbles in the cables about 10 ft (3.05 m) above where they exited the water between the ship and the careening barge. The strap eyes of the fixed blocks were looped over the barge's masthead, and the hauling parts of the two falls were brought down along its mast and cleated on opposite sides about 5 ft (1.52 m) above the deck.

A relatively late account (1905) of the careening of

an old "Shoreham Brig" in Alexandria, Egypt, also mentioned the vessel's mastheads as the originating points for relieving gear. The brig was careened against a hulk which, in this instance, lay to seaward. On its weather side, a quay extended from shore, upon which were mounted mooring bollards. A 6-in (0.152 m) manila hawser was secured to each lower masthead and led to the bollards. The purpose of the hawsers was "to check the hull of the vessel when careening and to prevent her going over too rapidly, also to bring her back if anything carried away, etc." (Wright, 1936: 1369).

Since, however, the angle between hawsers and mastheads was lessened as the vessel heeled, it seems that this arrangement would have been the least effective just when it might have been needed the most.

While relieving tackle was evidently not used for the Danish brig Hvalfisken shown careened in the Helsingør diorama, two pairs of shores were mounted on the quay and lashed together slightly above the height of the mast tops with the vessel heeled (Fig. 48, p. 85). The mastheads were cradled in the crotches formed; the shores thus prevented the vessel's further inclination, providing the same service as did those used by the Brandywine.

TRIPPING CABLES

Two or more heavy cables, called tripping cables, were usually run from the side of a vessel about to be heaved down in a direction opposite the careening pits. Their first use was to keep the ship away from the wharf or vessel against which it was to be careened while preliminary work was ongoing. Later, as the heaving down began, they ensured that the careening tackles did not merely draw the ship toward the careening pits without heeling it. The cables were also used to adjust the vessel's position relative to the pits so that strains on its rigging and careening tackles remained in proper proportion while it was being heeled.

The outboard ends of the tripping cables were fastened to immovable objects such as the ship's bower anchors or, for greater security, two anchors in tandem. These were positioned by a work scow or, if a scow was unavailable, a pair of the ship's boats. The anchors were lashed to timbers extending between the boats after the ship's yards were used to lower them aboard. When the anchors were set, care was taken to allow enough scope to prevent them from dragging.

Sometimes, at formal careenages, sufficiently strong dolphins were available and were used in place of anchors. At other times a combination of a dolphin and an anchor

was used, as for the Brandywine, when one cable was secured to a dolphin abreast the foremast, while another was run to an anchor set abreast the mainmast (Luce, 1884: 586). Occasionally, the vessel was careened in a waterway narrow enough for the cables to reach the opposite shore and be fastened there to stationary objects.

The shipboard ends of the cables were usually brought under the vessel's keel and led through appropriate ports on the leeward side. They were secured within, often being run across the deck and clinched around gun or deck ports on the opposite side. Funch illustrates the basic concept in Fig. 40t, p. 70, although in this instance the cable is shown led over the ship's main-deck railing and then run below deck.

Tripping cables were more often than not combined with tackles to provide extra power. These could either be joined to the cables outside the ship or installed after the cables had entered the ports. In the latter instance, they could be stretched across the deck with the standing block lashed to the opposite side, as were the threefold tackles employed on the Melville and the "stout tackles" used in the Brandywine (Harris, 1841: 11; Luce 1884: 586).

When a vessel was ready to be heaved down, it was hauled a sufficient distance from the careening pits by the tripping cables so that when heeled to the necessary inclination, its running blocks would lie directly above

the fixed blocks in the careening pits. This distance, in the case of the Melville, was between 70 and 80 feet (21.34-24.38 m) (Harris, 1841: 13). Weight, in the form of whatever men could be spared and, often, kegs filled with water, was placed on the leeward side to give the ship an initial heel in the direction it was to be heaved down.

At this point tripping cables performed the important function which apparently earned them their names. Harris stated, as did Brady, that a ship would incline about 15° before the slack was entirely out of the tackles and that it would be drawn towards the pits until reaching an inclination of about 35° , at which angle it would begin to "go off" (Harris, 1841: 13; Brady, 1857: 268) .

Although no account specifically states it, the arrangement suggests that when the vessel reached an inclination of about 35° (the degree of inclination probably varied somewhat from vessel to vessel), all slack had been drawn from the tripping cables. At this point the cables, acting in concert with the careening tackles, which were attempting to pull the ship by its masts towards the careening pits, tripped the vessel in much the same way as a person with his feet tied to an immovable object would be toppled if someone pulled on his hands.

It was essential that the ship be kept parallel to the pits during the tripping operation or unequal strain might have been exerted on one or the other of the cables.

That the tension on them could be tremendous is evidenced by Walker's account in which he mentioned that the Formidable's forward tripping cable had been brought over the forechains which, although well shored up, were "burst down" from the strain placed on them (1902: 414). The Melville's crew had to back her tripping anchors with additional lengths of chain and kedge anchors when one of her original tripping anchors dragged due to the pressure on the cables (Harris, 1841: 17, see also Fig. 61, "final position").

Examples Of Tripping Cable Arrangements

The fixed blocks of the tripping tackles used on the Formidable were lashed around the arches of a building on the other side of the 60-fathom-wide creek where the ship was careened. The running blocks, supported by lumps like those used for the running blocks of the setting-up tackles, were attached to cables which ran under the keel. These, ascending the leeward side of the hull, were brought through upper deck ports and across to the opposite side of the ship where they were clinched around two adjacent deck ports.

In at least one example, the positioning ropes and the tripping ropes were separate entities. After the tripping anchors had been positioned abeam the Melville,

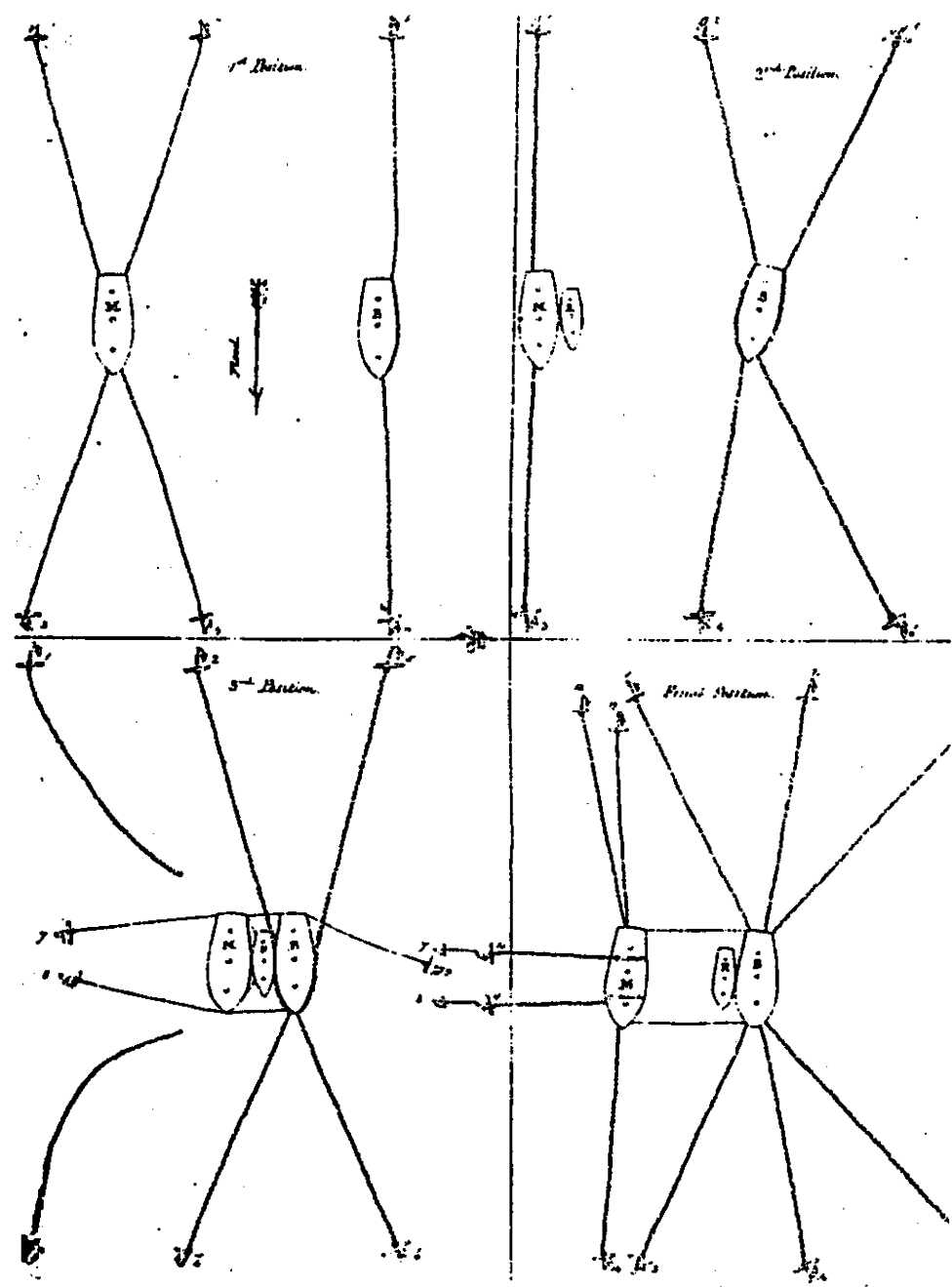


Figure 61. Diagram showing the relative positions of the three ships during various stages of careening the Melville. From Harris (1841: pl. 3).

hawsers were bent to the rings of each and brought aboard through lower deck ports on the weather side of the vessel. It was these ropes that were used to initially position the ship. The chains of the two sheet anchors used as tripping anchors were tailed with cables which ran under the keel and through leeward ports, where threefold tackles were added as previously described. These were the cables used for the actual tripping of the ship (Harris, 1841: 11).

A different method of maintaining a vessel's distance from the careening pits and tripping it seems to have been utilized by the late-15th-century carrack shown in Fig. 51, p. 93. Two long poles, bracketing the craft, were lashed in place, one to the bow, the other to the stern. The ends of the poles were braced on shore to prevent the vessel from moving in that direction. The bow lashing, extending through a hawse pipe, appears to have been flexible enough to allow the ship to pivot within the brackets while it was being heeled, as if it was in gimbals. Presumably, the stern lashing was similarly designed, although only the one at the bow is visible in the painting. This was an admirable solution when applied to a small vessel in a congested area with insufficient space to give anchors enough scope to prevent them from dragging or being fouled by other craft.

CAREENING TACKLE

General Description

The blocks and ropes used to heave a vessel down were referred to as careening or heaving down tackles. A careening tackle normally consisted of a pair of blocks and a fall. Usually, several were used in conjunction with one another to heave a ship down.

The upper of the two blocks, called the moveable or running block, was generally attached to the lower masthead just above the lower-mast trestletrees which prevented it from slipping lower. If preventer shrouds were used, at least two pairs were rigged first so that where they encircled the mast they acted as a bolster for the block (Bass and Bass, 1981: 5; Walker, 1902: 538). The number of ropes extending down from the running block determined the mechanical advantage theoretically gained from the tackle, apart from friction loss. Fig. 62 shows a tackle with a before-friction mechanical advantage of 9.

The lower immoveable block, called the fixed or standing block, was securely fastened on land, to a wharf, or to another vessel. A rope called the fall was rove through the blocks. The part of the fall lying between the two blocks was called the running part. The end of the

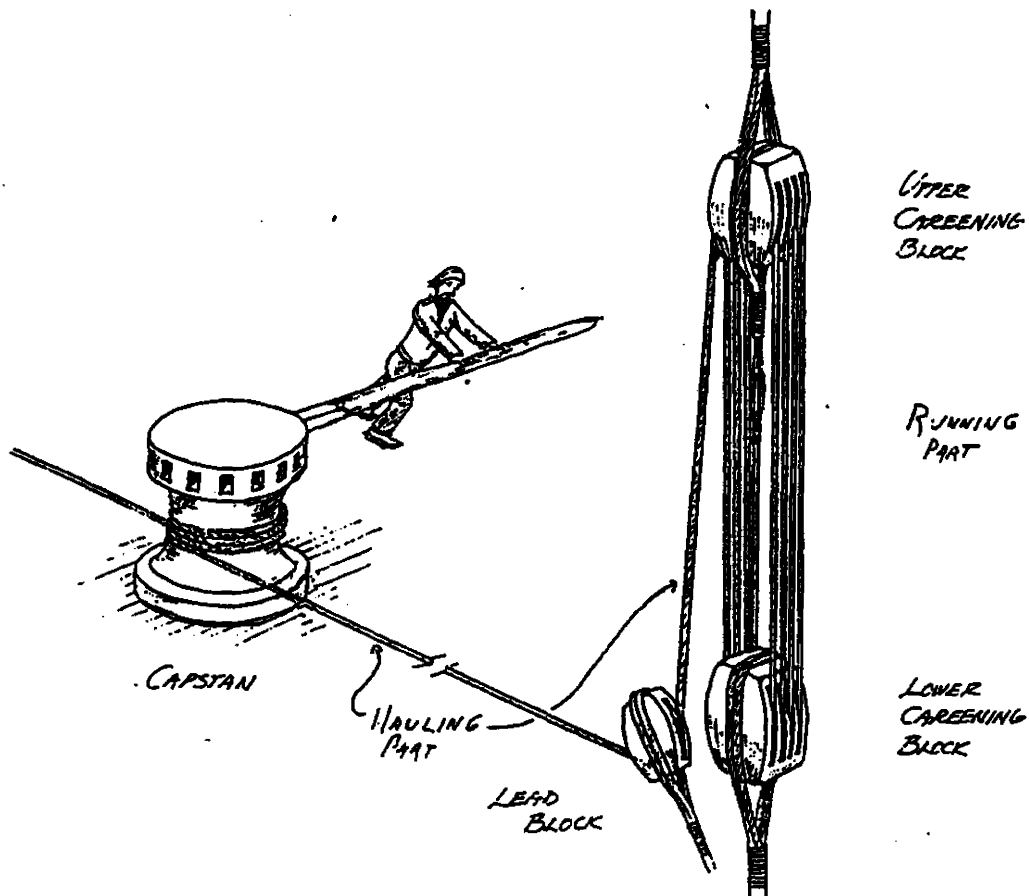


Figure 62. A careening tackle with a power of 9, showing the various parts. J. Taylor.

fall which was secured to one of the blocks was called the fixed or standing part of the fall. The other end of the fall, beyond where it made its last turn, was called the hauling part. It usually passed under a lead block fastened adjacent to the standing block which provided no increase in the mechanical advantage but merely directed the fall to the capstan. The lead block was so placed that

the hauling part of the fall paralleled the tackle as closely as possible to avoid more than a negligible loss in the available power (Luce, 1863: 76).

As the fall used in the careening purchase of a large vessel was heavy and cumbersome, it was common to tail it with a smaller rope and reeve the smaller rope through the blocks first. The free end of the smaller rope was then brought around a capstan which supplied the power to reeve the heavier fall. Brady noted that at American naval facilities, cattle were sometimes clapped on to the falls to facilitate the reeving process (Brady, 1857: 265).

Many vessels with two or more masts were hove down by one or more tackles attached to both their lower fore- and mainmasts, but this was, by no means, an exclusive practice. The vessels shown careened in Hamburg, Germany (Fig. 10, p. 27) and Marienham, Åland (Fig. 33, p. 54), both cargo vessels of mid- to late-19th-century vintage, were heaved down by all three of their masts, as was the earlier Stockholm vessel modeled in 1781 (Fig. 17, p. 32) and the later Swedish vessel in Fig. 57, p. 110. At the other extreme, only two tackles, both attached to the mainmast, were used to haul down the mid-18th-century English warship in Fig. 31, p. 52.

Examples

The average size of vessels increased with time, and

hull configurations and rigging arrangements varied extravagantly with size and the function the ship was to perform. These factors affected ships' stability and the degree of difficulty with which they were careened, and thus the numbers and dimensions of the blocks and ropes required in both their careening tackle and support systems.

Some examples of the tackles used on various English and French ships and an American ship have been described to illustrate differences among them. Rather than having attempted to delineate them all, as the variations were considerable, it was considered more practical to reproduce Table 3 to illustrate the numbers and dimensions of the blocks and ropes used to careen variously-sized English naval vessels in Malta during the period when the Formidable and the Melville were careened (Boyd, 1860: 468-69). Both large, early-19th-century English warships are discussed extensively and represent the epitome of the technical complexities associated with careening.

Table 3 indicates the careening paraphernalia used on British vessels at Malta in the 1840s only, and the dimensions and numbers of items therein should not be considered definitive for British vessels careened elsewhere or at a different time, much less for ships of other nationalities.

For example, the Malta specifications called for a ship with a long tonnage greater than 1700 (1727 metric tons) to utilize two tackles on its mainmast, both consisting of an upper treble block and a lower double block, their lengths to be between 36 and 40 in (0.914 and 1.016 m). A single similarly-sized tackle was specified for the foremast.

The 72-gun vessel to which Harris directs his remarks would have been within this weight range.²² Yet Harris specifically stated that, for the mainmast, a "72" was "allowed" two blocks, an upper 30-inch (0.762 m) double-scored fourfold block and a lower 30-inch (0.762 m) double-scored threefold block (Fig. 63 shows scoring and the parts of a fourfold block). Together, two blocks would have provided only one tackle. The standing part of the fall was to be below, giving eight parts to the fall. A top block was added as a lead block. Harris considered this tackle to be "quite equal to the work required" (1841: 12). He left it optional as to whether another fourfold block was to be used in place of the threefold block.

In practice, however, the Melville was careened with both a main- and foremast tackle. The mainmast tackle consisted of fourfold blocks, the upper one made by the ship's carpenters of elm wood, the lower supplied by one of the accompanying vessels which happened to have one on

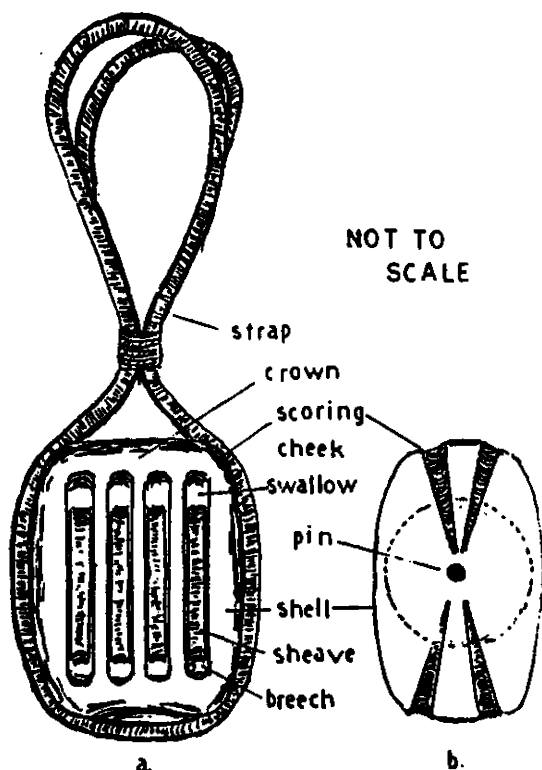


Figure 63. Drawing of a fourfold careening block showing its parts. M. Goelet.

board (Harris, 1841: 17). The standing part of the fall was aloft, creating nine parts to the fall as in Fig. 62, p. 134.

A simplified drawing of the eight-part tackle allowed and the nine-part tackle used can be seen in Fig. 64.

For the foremast tackle Harris deemed a pair of treble-sheaved jeer blocks sufficient, suggesting that "if you wish the purchase to be four-fold, add a top block above and below" (1841: 12).²³ The jeer blocks for the main yard of British vessels ranging from a 110-gun first rate down to and inclusive of a 74-gun ship were a

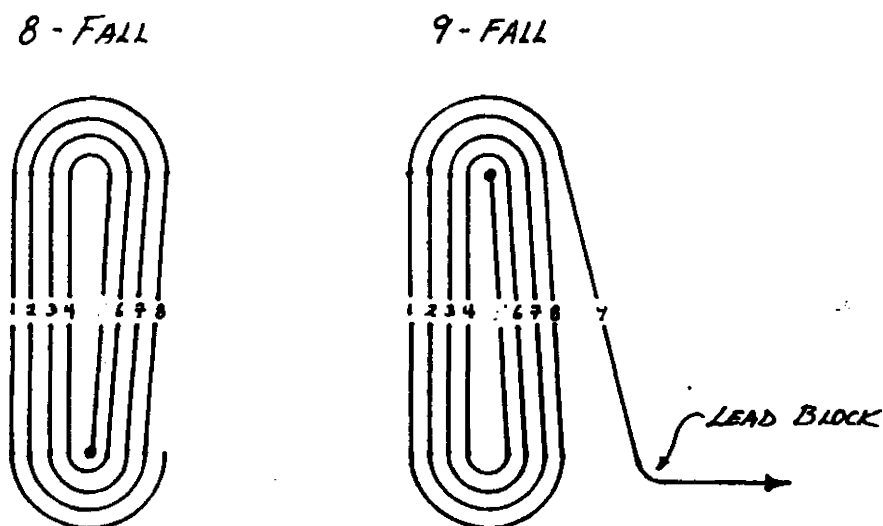


Figure 64. The eight-part tackle "allowed" and the nine-part tackle used to careen the Melville. Sketch by J. Taylor.

standard 28 in (0.711 m) in length (Gill, 1932: 243).

British custom had the mainmast assume the brunt of the burden during careening while the foremast was utilized only as an "assistant" (Harris, 1841: 14). This was unlike the technique employed by most other nationalities, which required all masts utilized to assume a fair share of the strain.

Normal procedure was, however, modified in the British navy, as it was elsewhere, according to circumstances. For example, it should be recalled that the mid-18th-century English warship in Fig. 31, p. 52, was hove down by the mainmast alone, contrary to both the

Malta standards and what Harris wrote. As I have conjectured, this may have been only because the vessel was not to be fully careened, and additional tackles were not considered necessary.

From the diary of the Constitution's sailing master, it appears that when that vessel was careened near Boston in 1803 a single tackle made up of 42-in (1.067 m) treble blocks was used for both the main- and foremasts (Bass and Bass, 1981: 5).

The Constitution's careening blocks incorporated brass sheaves and 2 1/2-in (0.064 m) pins (Bass and Bass, 1981: 5). The pins presumably were made of iron, since, had they been of wood, their diameters should have been 3 1/2 in (0.089 m) to meet the then current standards of block construction (Burney, 1974: 42).²⁴

Interrelationship of the parts of a tackle

To maintain its integrity, the size of the parts of a tackle had to be in proper relationship to one another. For example, the 30-in (0.762 m) main careening blocks used on the Melville, built of elm by the ship's carpenters, may have been somewhat out of proportion. They were very short compared to those used on the Constitution or recommended at Malta, and their pins, apparently also of iron, as were, probably, those used at Malta, may

therefore have had a smaller diameter.

Since the blocks were fourfold compared to the threefold blocks used at Malta or on the Constitution, they provided a greater mechanical advantage than either of the others. Because the fall rove through them was larger (11 in [0.279 m] used on the Melville versus a 10 1/2-in [0.267 m] maximum at Malta and 10 in [0.254 m] on the Constitution [Harris, 1841:13; Tab. 3; Bass and Bass, 1981: 5]) and had more parts, the Melville's blocks were wider than the others, and the pins were correspondingly longer.

A mechanical device of any kind is only as strong as the weakest of its parts, and, in the case of the Melville's careening tackles, the weakest parts were the blocks' pins, which bent (Harris, 1841: 18).

The French ship of the line Courageux utilized four fourfold tackles for its mainmast and three similar tackles for its foremast. Of the mainmast running blocks, two were lashed to the masthead (probably just above the trestletrees), and the other two were lashed about 10 ft (3.048 m) below the hounds. The three foremast running blocks were located one on the masthead and the others about 7 ft (2.134 m) below the hounds. By interpretation of those distances, the running blocks of the two lower mainmast careening tackles were fastened about 20 2/3 ft (6.3 m) below the running blocks of the upper tackles and

those on the foremast were lashed about 17 ft (5.182 m) below the running block of the upper tackle on that mast.²⁵

The size of the rope used as falls on the Courageux was 6 in (0.152 m), compared to the 10-in (0.254 m) rope used on the Constitution (probably a slightly smaller vessel), the 11-in (0.279 m) rope recommended by Harris for an English "72," and the 9 1/2-in (0.241 m) minimum-sized rope used in Malta for a vessel the size of the Courageux (King, 1802: 311; Table 3).

The length of a block averaged about 3 times the circumference of its fall (Lords Commissioners of the Admiralty, 1891: 147; Burney, 1974: 42). While this proportion must be considered variable and is somewhat less than the ratios described above, which are nearer 4 to 1, it may still be used as a rough guide. The 6-in (15.24 cm) falls used to careen the Courageux, even using the 4 to 1 ratio, were probably rove through blocks that were no longer than 24 in (0.61 m).

French practice

The Artemise used three treble-block careening tackles for both her fore- and mainmasts, each with seven-part falls. The six tackles were all fastened at the same height as the points at which the two larger mast shores

were lashed to either mast directly below the hounds, perhaps 10 ft (3.048 m) below the trestletrees.²⁶

The examples of the Courageux and Artemise suggest that the late-18th-early-19th-century French rationale concerning careening tackles, perhaps influenced by the principle of safety in numbers, may have been to use smaller tackles but more of them.

Lashing most or all of the upper careening blocks well below the trestletrees in contravention to the normal practice in most other countries of lashing them just above those fixtures may not have been as much of a disadvantage as it first appears. As noted earlier, French vessels were generally higher masted, of slightly greater draught, and more heavily ballasted than their English counterparts of that era, and, with their ballast substantially removed, would have been less stable and easier to haul over.

Six-sheave careening blocks

Three accounts involving different ships mentioned the use of six-sheaved careening blocks; two involved Danish ships of comparatively recent vintage. The first of these concerned the brig Hvalfisken (Whalefish), the subject ship in the Helsingor diorama, in which it is represented as being careened with the use of double-block

tackles. An article which appeared in the Sofartsmuseum publication describing the diorama, however, specifically noted heavy six-sheaved careening blocks (Henningsen, 1959: 32). The discrepancy must remain unresolved as Mr. Nielsen, the maker of the model, recently passed away.

The second mention of six-sheaved careening blocks on a Danish ship appeared in a 1939 issue of the magazine Vikingen, where a brief account by an anonymous author accompanied a series of three photographs showing a late-period three-masted vessel being careened at the Frederickssund Shipyard (Et Skib kølhales: 10).

The third reference to six-sheaved blocks is in Table 1, p. 57, (see 'R.') and notes a sixfold tackle by which the 18th-century English ship to which the table applies was hove down.

In more recent documentation, a tackle is identified by the number of folds (turns of the fall around a sheave) in each block; for example, a "threefold" tackle, has a mechanical advantage of either 6 or 7 depending on how it is rigged (Ashley, 1944: 526). In earlier times, however, a "sixfold" tackle may have referred to the cumulative number of folds around the blocks making up the tackle, since the careening block illustrated in Fig. 35, p. 56, certainly did not contain six sheaves.

It is axiomatic that the larger the number of sheaves in a block, the less efficient it is. The "nautical rule

of subtraction" as stated by Ashley for natural fiber rope postulated a loss of power from friction of between 5% and 8% per sheave for a tackle (1944: 532). A pair of six-sheave blocks making up a purchase would consume 60% of the available power at the lower figure and 96% at the higher figure.

The careening tackles on both Danish vessels, if the Hvalfisken did in fact use sixfold careening blocks, most likely utilized wire rope for their falls rove over roller-bearing sheaves. This would have involved much less loss of power from friction than fiber rope of the same strength rove over older style sheaves. Otherwise, the blocks would have been inefficient to the point of being almost useless.

Careening tackle used aboard the Hamburg vessel

The arrangement of the careening tackles used aboard the German barge in Fig. 10, p. 27, and Fig. 46, p. 83, was unique and is well worth describing in detail. References to the illustrations should be helpful in understanding the description below.

A threefold running block was lashed just below the trestletrees of each of the three masts used to careen the ship. Each tackle, as rigged, gave a mechanical advantage of 6, unadjusted for friction.

Mounted on the after centerline of the barge's deck was a threefold knighthead which served as the mizzenmast careening tackle's fixed block. The standing part of the fall was secured to a ringbolt mounted through the deck immediately to port. After passing under the final sheave of the knighthead, the hauling part of the fall was brought forward between the posts of a bitt to a fourfold knighthead positioned directly under the aft head of a hammerheaded arrangement mounted on the top of the barge's mast. Three sheaves were incorporated into either hammer.

Led under the first sheave of the knighthead, the fall was rove through the knighthead's sheaves and those of the aft hammer. After the fall passed under the final sheave of the knighthead, it was brought to a capstan slightly aft and to port of the knighthead. The fall was then secured to the after bitt between whose posts it had originally passed.

The standard threefold fixed, or standing, block of the mainmast careening tackle was lashed to a through-deck ringbolt placed slightly starboard of centerline and somewhat aft of the barge's mast. The standing part of the fall was secured to the same ring. After the fall had been rove under the third sheave of the standing block, its hauling part was brought forward to a fourfold block lashed to another ringbolt directly to starboard of the barge's mast.

Passing under the first sheave of that block, the fall was taken aloft to a threefold block lashed to the side of the barge's masthead just below the hammers and rove through and through. After making a final turn under the fourth sheave of the lower block, the hauling part was run to the aftermost capstan and then secured to a bitt mounted just forward of the capstan.

The foremast careening tackle utilized a standard threefold, fixed block fastened to a through-hull ringbolt like the one to which the mainmast standing block was fastened; this block was mounted far forward along the barge's centerline. The use of ringbolts which could be moved gave some flexibility to the positioning of the two forward tackles thus permitting different-size ships to be accomodated.

In other respects, the foremast arrangement was identical to that used for the mizzenmast, employing a fourfold knighthead mounted on the deck directly under the forward mastcap hammer. The capstan and bitt used to secure the hauling part of the fall were forward of the mast in this instance.

No definitive answer can be given to the question of why the hauling parts of the falls were so torturously routed through the barge's mastcap sheaves and the multiplicity of blocks and knightheads clustered below. None of those components moved, so no mechanical advantage

could have been gained. From a negative standpoint, friction build up would seem to nullify a substantial portion of the mechanical advantage gained by the careening tackles.

Members of the Plasma Physics Laboratory at Dartmouth College theorized that the hammerhead mastcap served to dampen any pitching motion along the longitudinal axis of the ship being careened.²⁷ This could be caused by wave action, or more likely, as the ship was presumably careened in calm water, by an uneven operation of the fore- and mizzenmast capstans. It was speculated that the arms of the hammerhead mastcap, acting as levers, converted the barge's mast into a kind of bow, bending it slightly forwards or backwards to absorb unequal forces.

If the falls used in the careening tackles consisted of wire rope, which was probable during the period in which the careening seems to have occurred (perhaps as late as the turn of the present century), their lack of elasticity would make the design described above even more practicable. Wire rope would also have minimized the effect of friction; as already noted, wire-rope falls are less conducive to friction than falls made from natural fiber. Until this theory can be substantiated, however, the reason for the hammerhead mastcap must remain open to conjecture.

Dismasted Vessel

Occasionally the vessel to be hove down had been dismasted. This required another careening technique which should be mentioned, although it was not nearly as common as pulling a vessel down by its masts,

To compensate for the lack of masts, vertical timbers with which to pull the vessel over were rigged to the ship's side as in Fig. 65(A). Instead of the vessel

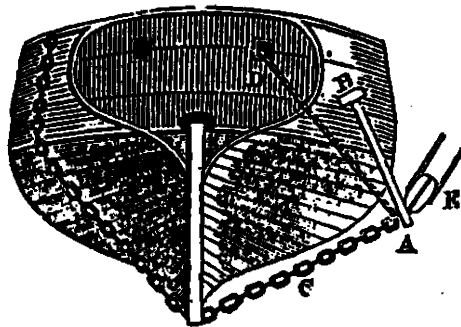


Figure 65. Careening a dismasted ship. From Walker (1902: 415).

illustrated being hove down, it could be said that it was hove up on the weather side, since the tackle, of which only the running block is shown, pulled upwards rather than downwards, tilting the ship away from the tackle. The timber is stepped in a shoe (Fig. 65 [B]) bolted to the ship's side. It is prevented from being lifted by the pull of the tackle by a chain cable (Fig. 65 [C]) fastened to

its end and run under the keel of the ship and then secured inboard of the port side. Fore and aft guys, of which the after guy (Fig. 65 [D]) is shown, prevent lateral movement of the timber.

Two timbers and their associated tackle were installed, the shoe for the after one bolted abaft the main chains, that for the forward one bolted abaft the fore chains. It was by this means that HMS Success was careened keel out in 1829 (Walker, 1902: 414-15; Boyd, 1860: 472).

With the aforementioned arrangement, the longer the timber, the greater was the leverage that could be applied by a given tackle. Boyd in fact showed a longer timber which would have helped considerably (Fig. 66).

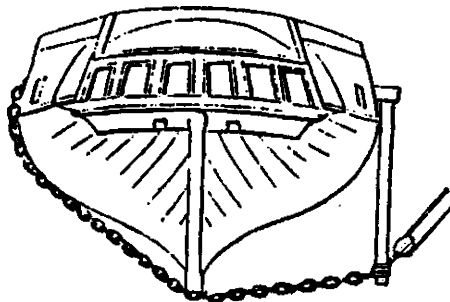


Figure 66. Using a longer careening timber to heel a listmasted ship. From Boyd (1860: 472, fig. 229).

The Success was careened utilizing capstans aboard an adjacent vessel. The fixed blocks were probably placed on the assisting vessel's side nearest the Success and its opposite side ballasted to prevent excessive heel when force was exerted by the tackle. The hauling parts of the falls would, reasonably, have been led directly from the moving blocks lashed to the timbers. Due to the angles at which they must have come aboard the assisting vessel, more than ordinary care would have been taken to avoid chafing the falls. As the falls came through the ports, they were probably led over saddles with rollers built into them.

CAREENING PITS

The fixed blocks of careening tackles were fastened in careening pits and, alternatively, to careening posts, either of which could be installed on shore or on a floating entity. Since the upward pull exerted by a vessel's masts in its attempt to right itself was concentrated at these points, careening pits and posts had to be substantially constructed.

Shore Installations

Some shore installations utilized large, horizontal timbers extended through the bottom sections of especially designed careening pits. The fixed careening blocks were lashed to these timbers with many turns of strong rope. Heavy items could then be laid across them to prevent the timbers from breaking, bowing upwards, or otherwise lifting. The accounts of the 1803 careening of the Constitution and the later careening of the Brandywine both mention that the ships' guns were used to help hold down the wharves (Bass and Bass, 1981: 4; Luce, 1884: 586), and ordnance may have been used for the same purpose in similar installations.

Fig. 67 shows careening pits along the edge of the wharf in a 1745 plan of the careening wharf at English

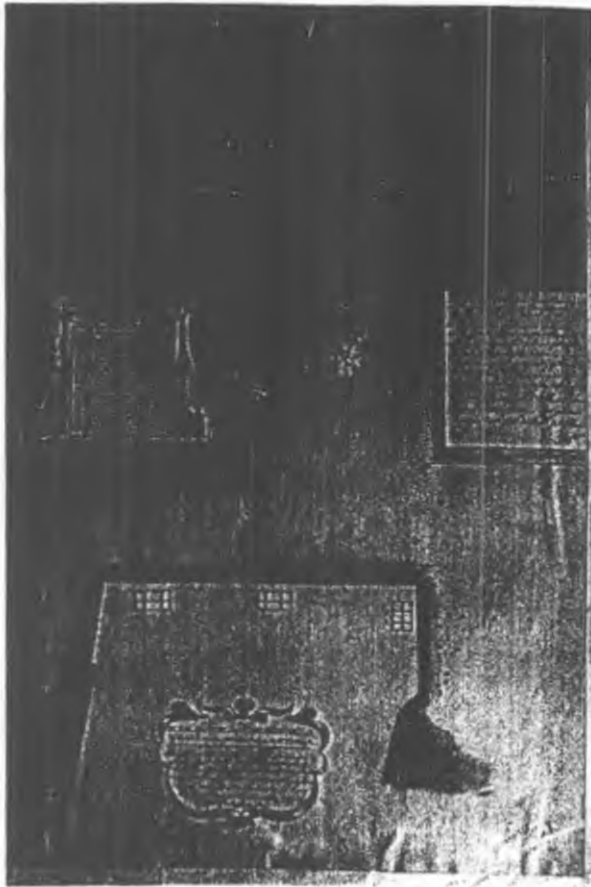


Figure 67. "Plan & View of the Carreening Wharf at English Harbour, Antigua." Hand-colored drawing, 1745, no signature. No. V2 10/54 in the Naval Historical Library, London. M. Goelet.

Harbor, Antigua (see also Fig. 58, p. 118).

The Åland vessel (Fig. 33, p. 54) was hove down alongside a series of three quays (rock-filled wooden cribs) extending from the shoreline, with the fixed block of each purchase once again lashed to a timber or iron bar incorporated into the body of each structure. This appears

to have been a common technique used in Åland, as a reliable source reported viewing the remains of many similar structures along the coast of the main island.²⁸

The Swedish vessel in Fig. 17, p. 32, was careened against a floating dock with three sections cut out of its deck, each of which served as a careening pit. A heavy timber ranging longitudinally below its deck was brought across the centers of the openings and, where exposed, was the point of attachment for each of the fixed blocks of the careening tackles. The dock was apparently of a weight sufficient to permit the ship to be careened against it without it being lifted clear of the water, or it was ballasted in some way below the decking to prevent that from happening.

The Brandywine used a like arrangement, the lower blocks of the tackle being toggled to a spar running through the careening pits in the wharf (Luce, 1884: 586).

A similar concept was employed by the crew of the Artemise in Tahiti (Figs. 55 and 59, pp. 104, 124). In that instance, two platforms, one for both the mainmast and the foremast careening tackles, were constructed of logs laid along the edge of the beach. Space was left in the center of each platform for a spar, probably the main- and foremast lower yards, which paralleled the logs and extended well beyond the end of either platform. The logs were fastened together by shorter timbers laid crossways

at the proper interval to support the ship's guns. The platforms and ordnance together counterweighted the upward force generated by the careening tackle.

Space was left clear in the center of either platform to lash the standing and lead blocks of the three careening tackles used for either mast. To prevent the platforms from being dragged seaward by the pull of the careening tackle and also to keep the ordnance in place, chain cables were brought under their ends and looped back over the guns. The forward and after chains in either case were fastened respectively to a piling and a ship's anchor set inshore parallel to the platform ends. As an added precaution against the platforms being pulled to sea, pilings were driven vertically into the water between the two outer logs. The earlier diorama (Figs. 22 and 60, pp. 41, 124) shows the arrangement of the cannon on the platforms more clearly but lacks some of the details described above.

Another method of securing the fixed block of a careening tackle was to lash its strap to a heaving-down post secured firmly to the major structural timbers of a wharf or dock or implanted in the ground. Fig. 68, a stern-on view of the ship in Fig. 31, p. 52, shows a British warship heaved down against careening posts. Fig. 69 illustrates the design of posts commonly used to careen mid- to late-19th-century American whaling ships.

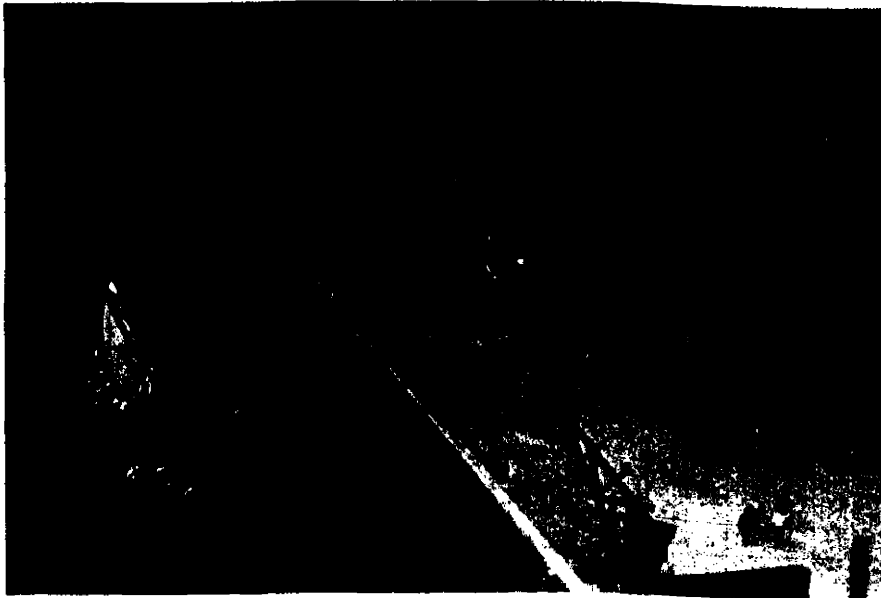


Figure 68. Stern view of diorama representing mid-18th-century British warship careened. In the Science Museum, London. M. Goelet.

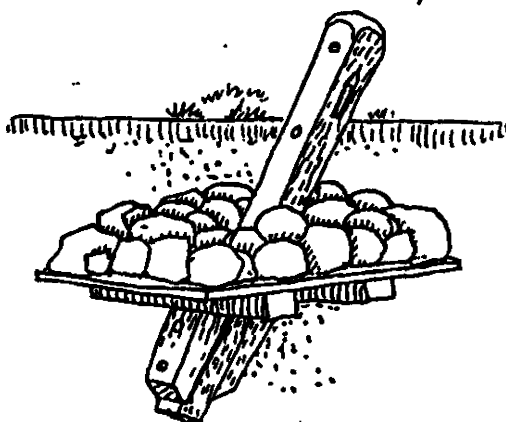


Figure 69. "A Careening Post at Merrill's Wharf, New Bedford." From Ashley (1944: 328, fig. 2016).

Brady illustrated a frigate hove down to a dock or wharf into the core of which stone blocks or timbers with ringbolts fastened through them were set (Fig. 70). Heavy chains were shackled to the rings and led to other stone blocks or timbers placed vertically above. The fixed blocks of the careening tackles were secured to those latter elements.

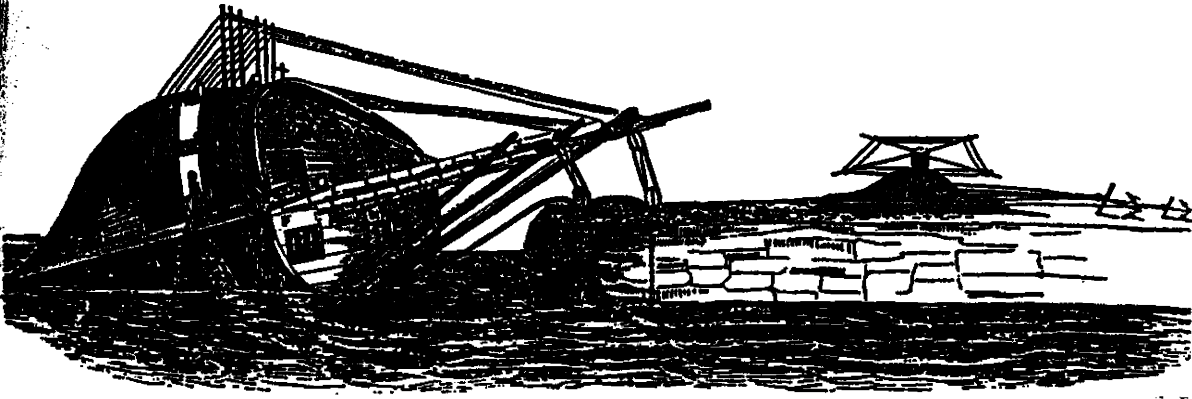


Figure 70. An American frigate hove down to a wharf. From Brady (1857: facing 261).

Floating Installations

Ships which were heaved down against barges and hulks, or a companion vessel during a cruise, had the fixed blocks of their careening tackles fastened to the hull of that vessel.

Barges

The careening barge shown in Fig. 11, p. 27, had heavy ropes at either end spliced to form continuous bands which passed completely around its hull. As they came aboard after passing beneath the hull, they were led between two of a series of bollards mounted fore and aft along either side of the barge at the gunwales. About one quarter of the way in from either side, the rope bands were brought through ringbolts secured to the deck. The bollards prevented the rope bands from slipping off the ends of the barge, and the ringbolts created compact lifting bridles. Cat blocks, serving as the fixed blocks of the two careening tackles, one extended from the foremast, the other from the mainmast, were hooked to the bridles.²⁹

As described earlier, the German careening barge of approximately the same era (Figs. 10 and 46, pp. 27, 83) utilized fore and aft heaving-down posts, with sheaves incorporated into their heads; these doubled as the fore- and mizzenmast lower careening blocks. They have been previously described as knightheads because, essentially, they had the same form as the knightheads which served as the lower jear blocks on early ships (Burney, 1974: 212). Those on the deck of the Swedish warship Vasa (Fig. 71)

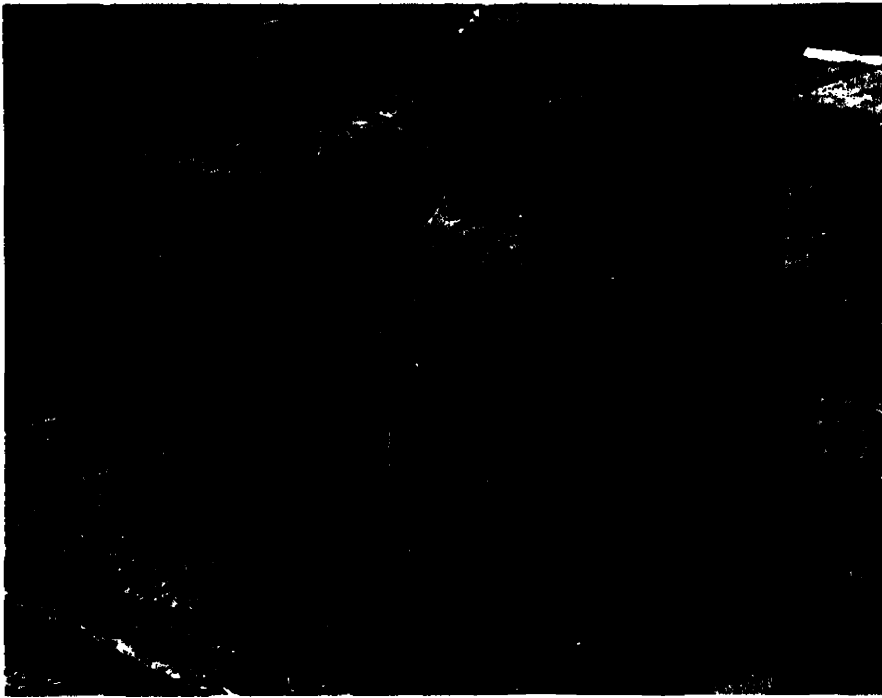


Figure 71. Several examples of knightheads aboard the Swedish warship Vasa. The foremost served as the lower main gear block. Note those to the rear serving as the vertical members of the bitts. M. Goelet.

are good examples of knightheads, and illustrate why they were so-named.

Hulks

Hulks were old ships unfit for sea duty which were utilized in a manner that no longer required their movement. As need dictated, they served as floating storehouses, temporary quarters for seamen awaiting sea orders, housing for quarantine purposes, and, in later

years, prisons (Kemp, 1976: 406). They were also fitted with mast cranes to step masts in other ships and were then called sheerhulks (Fig. 72); when used to careen

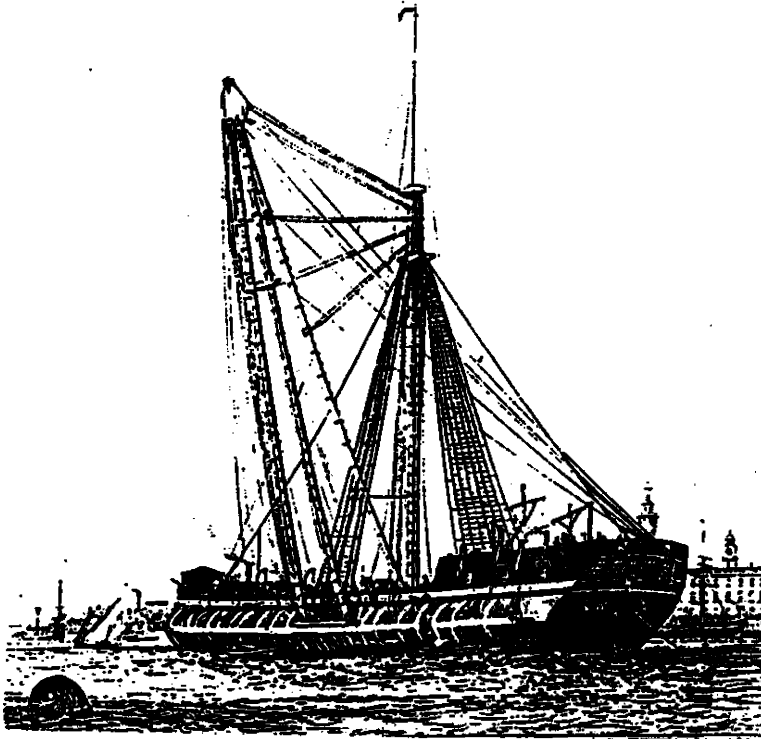


Figure 72. An early-19th-century sheerhulk. Etching by Cooke. From Fifty Plates of Shipping And Craft Drawn And Etched By E.W. Cooke, London, 1829.

ships, they were called careening hulks. Burney in defining sheerhulks made no mention of their being used to careen other vessels (1974: 452-3), and most other definitions specify either one use or the other. The masting configuration with which sheerhulks are commonly represented, however, could have easily been modified to

support the type of setting-up tackle which was attached to a vertical pole or sheers, which would have made sheerhulks eminently suitable for use as careening hulks.

An unusual reference described hulks as "generally old ships cut down to the Gun Deck, and fitted with a large Wheel for Men to go in when Careening," not mentioning their being used for masting (Blanckley, 1750: 148). The accompanying drawings (Fig. 73) illustrate a vessel too similar to the somewhat later sheerhulk in Fig. 72 to be anything else. The only exceptional difference



Figure 73. Sheerhulk with careening wheel (left) being used to heave down a ship (right). From Blanckley (1750: 29,148).

between the two is that the vessel shown in Fig. 73 was mounted with a device much like an enormous version of the tiny treadmills used to exercise mice, while Fig. 72 does not show a careening wheel. Apparently, the wheel was

geared to turn the capstans and took the place of capstan bars.

Presumably most, if not all, sheerhulks were fitted with capstans to provide the power required to lift the weight of a large ship's lower mainmast, which, in the case of an early-19th-century 80-gun English warship, was 20 tons (20.32 metric tons) (Edey, 1832: 32). These capstans could equally well have supplied the power needed to careen a ship. Based on Fig. 32, p. 53, and its inscription in the upper left hand corner which specifically denotes the hulk's dual use, Blanckley's drawing, and an earlier (1691) out-of-scale sketch of a Swedish sheer-hulk being used as a careening-hulk (Fig. 74a), it can be postulated that sheerhulks did, at least occasionally through the mid-1700s, serve a twofold purpose. The French careening barge in Fig. 12, p. 28, also fitted with a mast crane and capstans, tends to substantiate this.

No determination can be made as to whether careening wheels were commonly mounted on sheerhulks, as the inclusion of Blanckley's description and illustration of a sheerhulk with careening wheel in his encyclopedia implies. Similar documentation has not been found elsewhere and the phenomenon may have been restricted to that period in British naval history during which he wrote.

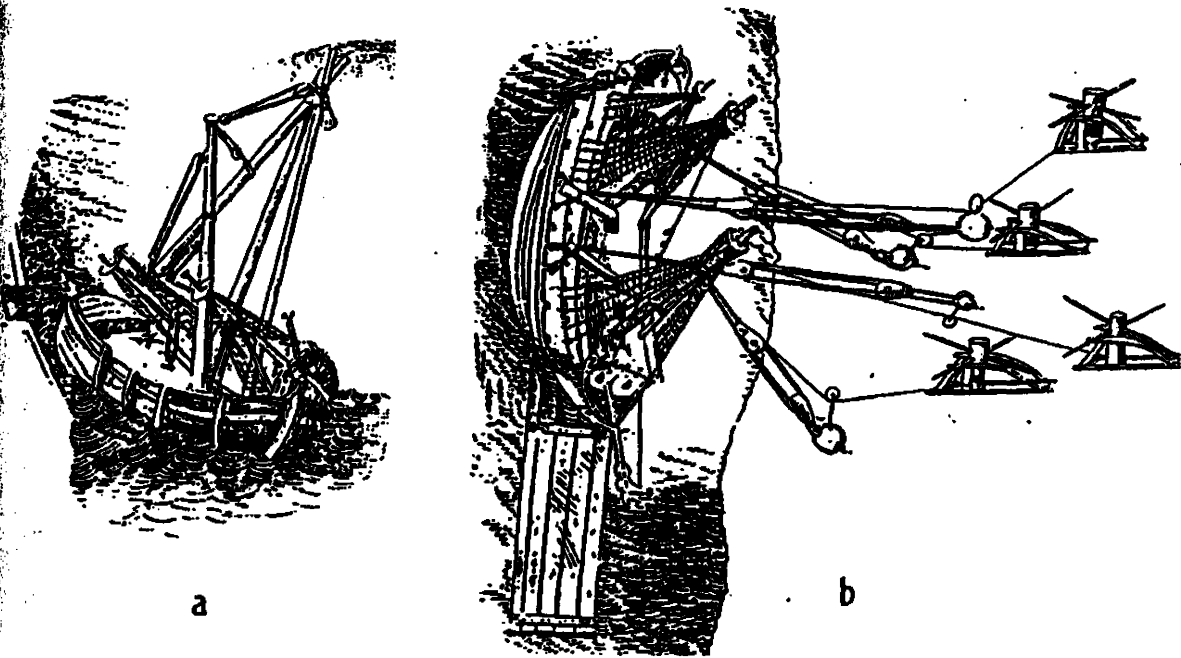


Figure 74. Swedish vessels careened against a hulk a and the shore b. Drawings by A.C. Raalamb, 1691. Seen in Halldin (1963: 57, figs. 6 and 7).

Careening against another ship

When it was necessary for a ship to be careened against another ship which had not been modified formally for that purpose, great care had to be taken that the structural timbers of the latter vessel were not needlessly strained. The Melville, for example, was careened against another ship in her squadron, the Rattlesnake, during a cruise. The method by which the lower careening blocks were attached to the Rattlesnake is

a good example of the care which was taken to prevent damage to that vessel.

Strong, hard-wood spars running longitudinally across the after hatchway between the main- and mizzenmast were fastened under the Rattlesnake's lower-deck beams. Five shores were run diagonally from the coamings alongside the hatchway to the shelf pieces on either side of the ship, and ballast was placed over their heels where they butted the coamings. The shores were then themselves braced with additional shoring running to the main deck beams above, which helped to distribute the strain laterally. Additional ballast was placed around the coaming fore and aft and to the sides.

Two more spars were positioned on the main deck, again extending fore and aft over the after hatchway. Two tillers were placed across the hatchway (probably resting on the spars and running athwartship).³⁰ These were to support the standing block of the careening tackle. Several more tons of ballast were placed around the upper hatchway's coaming.

The block strap had two parts, both of equal length. One end of either part was made into an eye which cinched the block; the other end, the tail, also ended in an eye. The two tails were led under the two spars beneath the lower deck, one under either spar. After crisscrossing each other between decks, they were brought over the two

spars placed on the main deck, one over either spar, and their eyes were lashed together. The space between the hatchways was then ballasted as solidly as possible. Fig. 75 shows how the arrangement may have looked.³¹

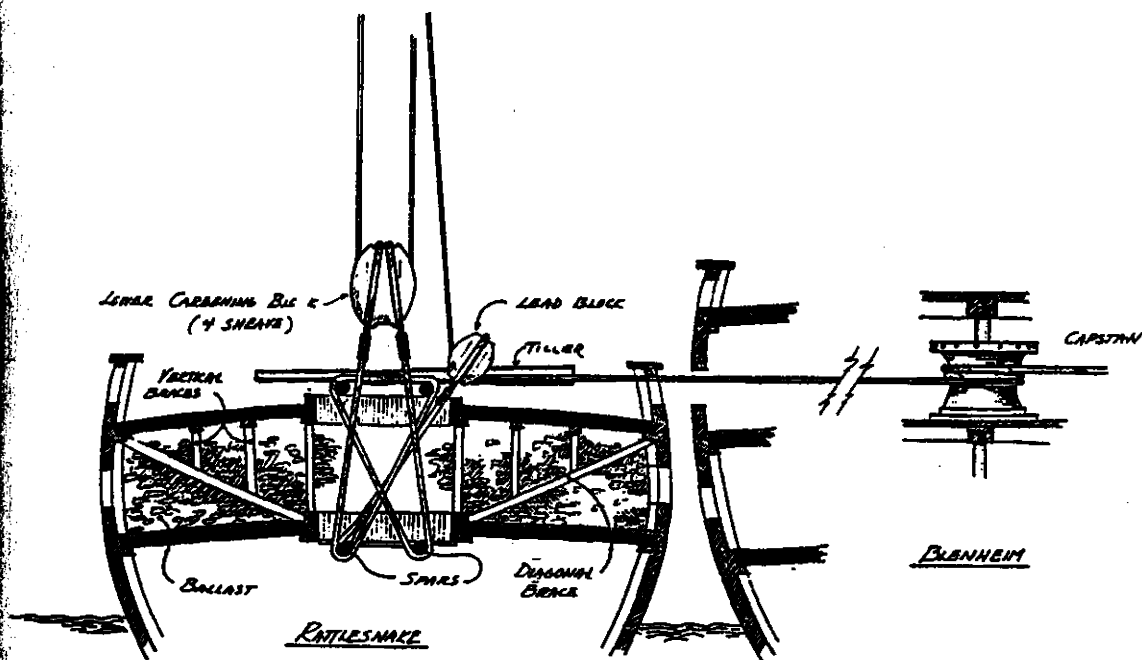


Figure 75. The arrangement aboard the Rattlesnake for the careening of the Melville. Interpretive drawing by J. Taylor.

The Rattlesnake was chosen to heave down against because its deck configuration was the most suitable of the ships available even though its capstans were not strong enough to supply the force necessary to heave down the Melville. Accordingly, a third vessel, the Blenheim, a larger ship with stronger capstans, was positioned

parallel to the Rattlesnake to supply the careening power (Harris, 1841: 15; see Fig. 24, p. 43).

A nine-part tackle was rigged as in Figs. 62 and 64, pp. 134, 140, and the hauling part of the fall was brought through the Rattlesnake's and Blenheim's ports to the latter's main capstan.

The standing block of the foremast careening tackle was lashed over the Rattlesnake's bowsprit, the lashings passing through its hawse holes below. The hauling part of the fall was led through one of the Blenheim's ports to her fore capstan. Several tons of ballast were placed on the forward part of the Rattlesnake's deck to help offset the pull of the Melville's foremast careening tackle.

CAREENING CAPSTANS

Shipboard Capstans

Capstans mounted aboard ship during the late 15th through the early 17th centuries were rather crude wooden devices, initially constructed with narrow, multi-faceted heads, later with round heads. They were mounted on the main deck, their spindles extending to the deck below. Capstan bars extended completely through the head and therefore did so at two or sometimes three different levels, depending on how many bars the capstan employed.

To prevent the capstan from backing up, a pawl, to be kicked into place behind the whelps by the nearest crew member, was socketed into a structural timber running athwartship behind the capstan (Stevens, 1949: 32-35; Howard, 1979: 113).

Fig. 76 illustrates the two-level, round-headed capstan and the pawl arrangement on the Vasa. An empty socket can be seen alongside the one in which the pawl is fitted. It appears that either the same pawl, pivoting around a shaft, was moved to the other position when the capstan was reversed, or another pawl, now missing, was permanently mounted there.

By the last part of the 17th century, capstans with deeply-socketed drumheads able to accommodate all the bars

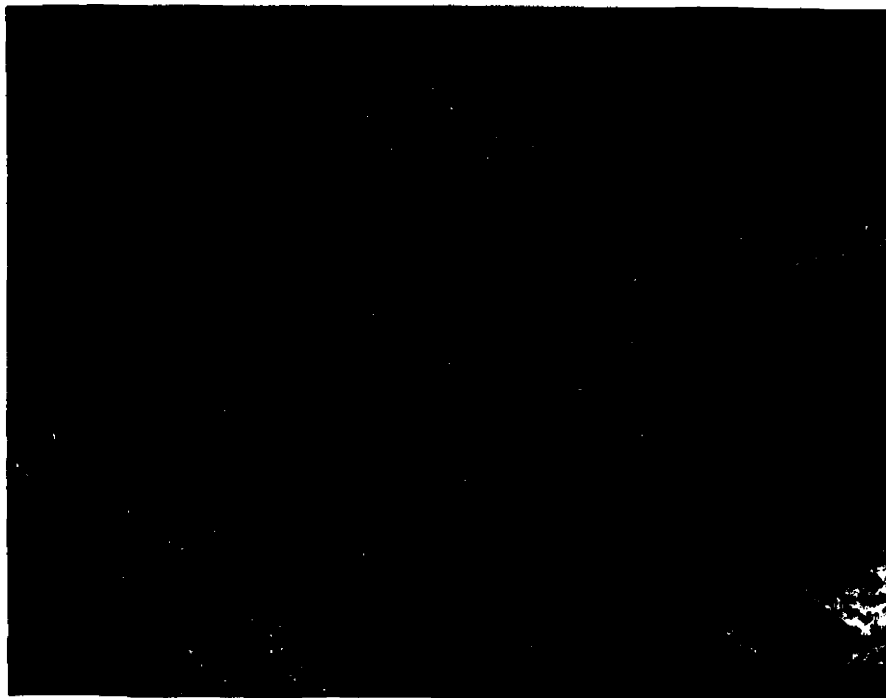


Figure 76. A capstan on the main deck of the Vasa conserved in the Statens Sjöhistoriska Museum. Note the capstan bars extending through the head at different levels and the pawl arrangement. M. Goelet.

on a single level had been developed and, by the end of the 18th century, they had become quite sophisticated. Instead of the pawl design depicted in Fig. 76, several iron pawls were affixed to pawl rims that were integrated into the base of the capstan. These were designed to drop into the ridges of an iron plate called the iron pawl rim permanently fastened to the deck of the ship (Stevens, 1949:36; Burney, 1815: 72 and pl. 7; see Fig. 77).

The capstans mounted on careening barges and hulks tended to reflect the contemporaneous state of the art.

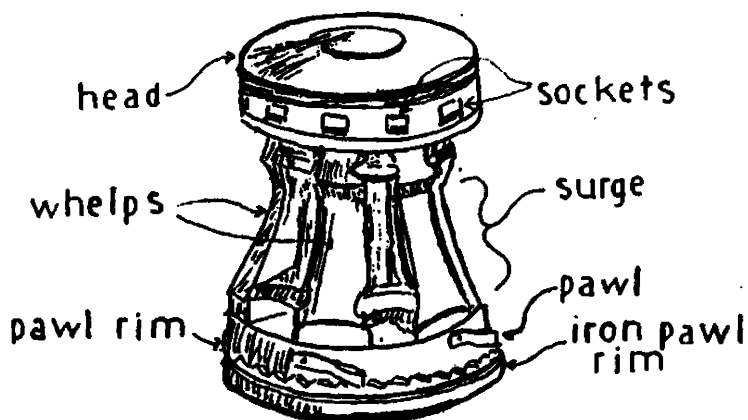


Figure 77. An 18th- to early 19th-century capstan. After Stevens (1949: 36).

Shore-mounted Capstans

Shore-mounted capstans, if not installed at a formal careening facility, were portable and rather makeshift affairs compared to those used on board ship, somewhat similar to the pre-1700 design previously described. The shafts or barrels normally turned on a timber support extending between two runners which, with a framework above, formed a kind of sled. To prevent the capstan from being drawn towards the ship, the runners could be lashed to posts dug into the ground, as were those of the capstans used in the careening of the Artemise.

Alternatively a capstan might have been braced by posts butting against cross-timbers at its base, as in the mid-19th-century sketch of a Danish capstan shown in Fig. 78.

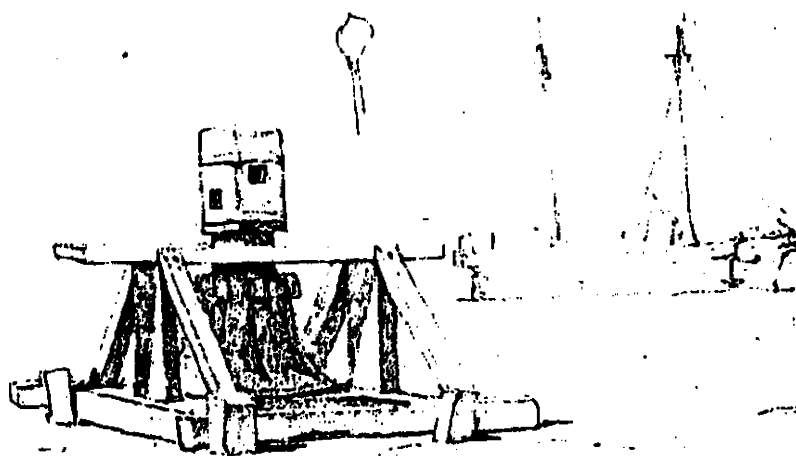


Figure 78. A portable mid-19th-century Danish capstan. Pencil drawing from a sketch book by C.F. Sørensen (1847-50: pl. 60). Courtesy of Handels-Og Sofartsmuseet Pa Kronborg, H&S 176:66.

The bow-shaped apparatuses seen in the center and left foreground of Botticelli's painting (Fig. 36, p. 61) seem to be portable capstans similar to the one being operated in Carpaccio's painting (Fig. 51, p. 93), but with their barrels removed. Note their resemblance to the capstans in the 1691 Swedish sketch (Fig. 74b, p. 164).

The Artemise was careened using at least six capstans; the earlier diorama (Fig. 22, p. 41) shows a seventh capstan used for the righting cable. It seems unlikely that these were carried on board as a contingency for the heaving down which did in fact occur; they were probably constructed on the spot. Depending upon whether the original model (Fig. 22, p. 41) or that now displayed (Fig. 55, 104) is correct, either fourteen or eight bars

were fitted to each capstan. In either case, their primitiveness is demonstrated by the fact that 600 men were required to careen the Artemise, while only 73 men manned the two obviously more efficient capstans at the Charleston Navy yard when the Constitution was careened more than 30 years earlier (Boudriot, 1981: 38; Bass and Bass, 1981: 4).

None of the portable capstans which I observed used pawls; they all required that a constant force be maintained against the bars until the fall was secured and stoppers installed.

It was not always manpower that turned the barrels of capstans. Fig. 79 shows horse-powered capstans being employed in 1901 to heave down the Lucille, said to be the last vessel careened in San Francisco (Kemble, 1957: 129).

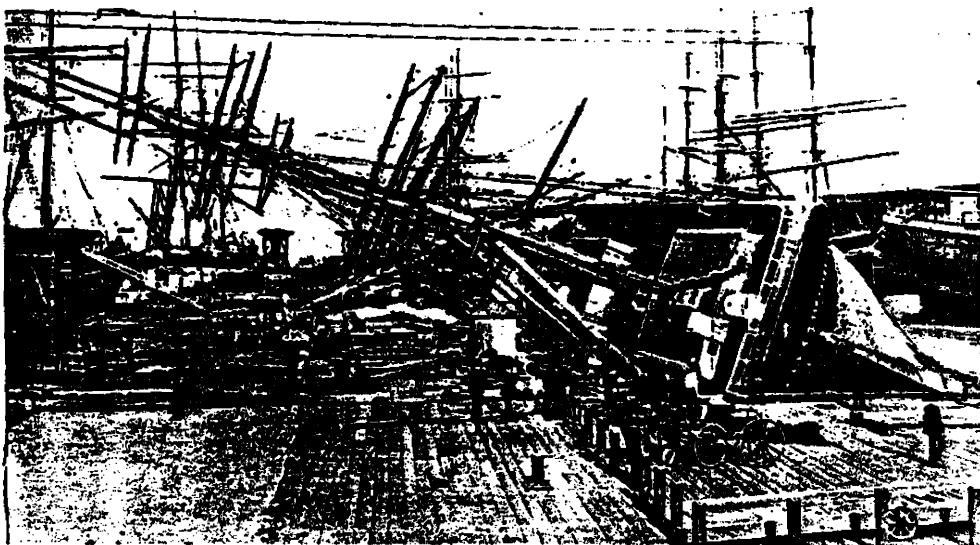


Figure 79. The Lucille careened by horse-powered capstan in San Francisco, 1901. Courtesy of the National Maritime Museum, San Francisco.

HEMPEN CABLES AND HAWSERS

Classification And Description

The various hempen ropes used on board ships were classified as being either cable-laid or hawser-laid rope; the latter type was alternatively called plain-laid rope.

Cable-laid rope was nine-stranded, left-handed rope. It consisted of three separate ropes each made of three strands laid to the right. The three ropes so constructed were then laid to the left forming the cable.

Hawser-laid rope was three-stranded rope with a right-handed lay. Ropes used for the standing rigging were hawser-laid ropes with a fourth strand and a center filler called the heart. These were called shroud-hawser ropes (Burney, C., 1871: 126-29; Anon, Lords Commissioners of the Admiralty, 1891: 143-47). Fig. 80a illustrates cable-laid; Fig. 80b, hawser-laid; and Fig. 80c, shroud-hawser-laid rope.

The different ropes had different characteristics, and it was important for seamen to know them so that the proper rope could be used for a specific job. For example, the prime requisite for rope used for the fall of a careening tackle was strength, with minimal stretch being another important requirement.

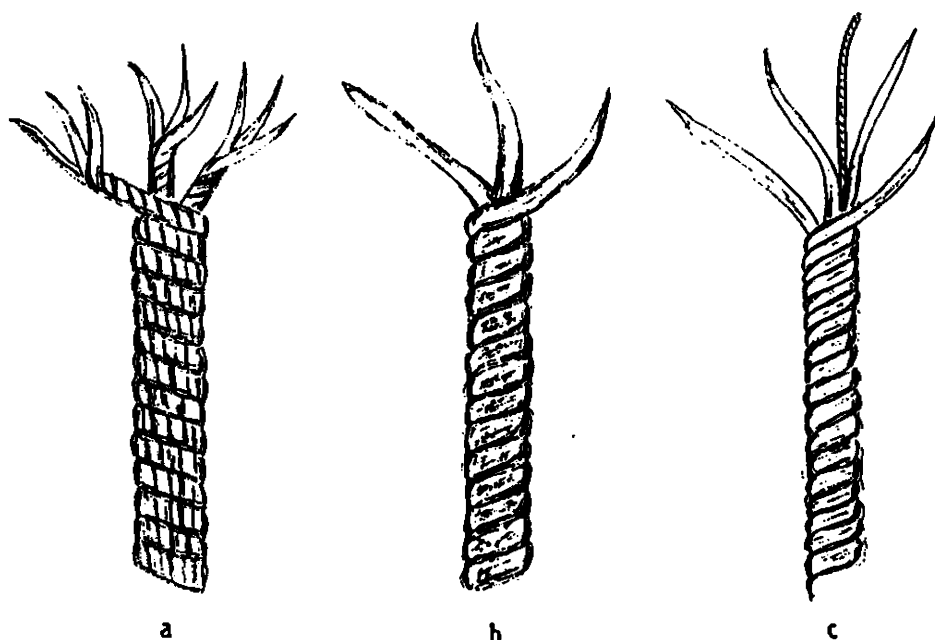


Figure 80. From left to right, cable-laid, hawser-laid, and shroud-hawser-laid rope.

Comparative Strengths

In 1844-45, Nicholas Tinmouth, as part of a revision of the British Navy's Establishment of Anchors and Cables, undertook a series of experiments to determine the strengths of hempen cables, hawsers, and chain cable, since no definitive information existed at that time (Tinmouth, 1845: 2). From his experiments, the maximum, minimum, and mean breaking strains of hempen ropes of various dimensions were determined. The results are contained in Tables 4 and 5 (Tinmouth, 1845: 6, 8).³²

Table 4. For ascertaining the strength of hempen cables.

FOR ASCERTAINING THE STRENGTH OF HEMPEN CABLES.

Size, Inches.	No. of Turns.	Weight 100 Fath. lbs.	BREAKING WEIGHT IN TONS.							Mean.	Calculated from * weight.	
			Main Strain	Intermediate Strains.					Main Strain			
26	3528	14112	122.2							105.9	111.6	101.5
25½	3393	13572	117.5							101.9	107.3	97.6
25	3267	13068	113.	107.	106.5	102.	101.5	99.	99.	98.	103.2	93.8
24½	3122	12488	114.4							94.4	102.5	90.1
24	3006	12024	115.7							91.	101.9	86.5
23½	2880	11520	117.							87.6	101.3	82.9
23	2763	11052	118.3							84.2	100.7	79.4
22½	2646	10584	119.5	109.5	101.7	99.5	99.	96.5	94.	81.	100.1	76.
22	2529	10116	111.4							77.9	96.	72.6
21½	2412	9648	103.5							74.9	90.1	69.4
21	2304	9216	95.8							72.	86.3	66.2
20½	2196	8784	88.3							69.2	80.6	63.1
20	2088	8352	81.	78.5	78.2	78.	77.	75.5	74.2	66.5	76.1	60.
19½	1980	7920	76.7							62.1	71.3	57.1
19	1881	7524	72.6							57.9	66.6	54.2
18½	1782	7128	68.6							53.8	62.1	51.4
18	1692	6768	64.7							49.8	57.7	48.6
17½	1597	6388	61.	59.7	54.7	54.5	52.	50.	49.2	46.*	53.4	46.*
17	1512	6048	57.3							44.9	51.	43.4
16½	1422	5688	53.9							43.8	48.7	40.8
16	1332	5328	50.5							42.8	46.5	38.4
15½	1251	5004	47.3							41.9	44.3	36.
15	1179	4716	44.2	43.	42.7	42.5	42.	41.7	41.5	41.	42.3	33.7
14½	1098	4392	41.6							38.4	39.9	31.5
14	1026	4104	39.1							36.	37.6	29.4
13½	954	3816	36.7							33.6	35.4	27.3
13	882	3528	34.4							31.3	33.3	25.3
12½	810	3240	32.2	32.2	32.	32.	31.2	31.2	31.	29.2	31.3	23.4
12	756	3024	29.8							26.6	28.6	21.6
11½	693	2772	27.6							24.2	26.1	19.8
11	630	2520	25.5							21.8	23.7	18.1
10½	576	2304	23.4							19.6	21.4	16.5
10	522	2088	21.5	21.	19.7	17.7	17.7	—	—	17.5	19.2	15.
9½	468	1872	19.							15.7	17.1	13.5
9	432	1728	16.7							14.	15.2	12.1
8½	396	1584	14.6							12.4	13.4	10.8
8	315	1260	12.6							10.9	11.7	9.6
7½	288	1152	10.7	10.5	10.5	10.3	10.3	10.3	10.	9.5	10.2	8.4
7	252	1008	9.3							8.2	8.8	7.3
6½	216	864	8.1							7.	7.5	6.3
6	189	756	7.							5.8	6.3	5.4
5½	162	648	5.9							4.8	5.3	4.5
5	135	540	5.	4.9	4.6	4.2	4.	4.	4.	3.9	4.3	3.7
4½	108	432	4.							3.1	3.4	3.
4	90	360	3.2							2.5	2.7	2.4
3½	69	276	2.4							1.9	2.1	1.8
3	54	216	1.8							1.4	1.5	1.3

(From N. Tinmouth, An Inquiry Relative to Various Important Points of Seamanship, Considered to be a Branch of Practical Science. London, 1845.)

Table 5. For ascertaining the strength of hawser-laid rope.

Size.	No. of Yarns.	Weight 100 Yards, lbs.	STRAIN IN TONS.			Mean.	
			Maxi- mum.	Intermediate Strains.	Mini- mum.		
12	1173	2940	45.5	40.5	39.	35.	40.
11½	1077		41.7			32.	36.7
11	987		38.2			29.3	33.6
10½	900		34.9			26.7	30.7
10	816	2136	31.7			24.2	27.9
9½	738		28.6			21.8	25.2
9	660	1712	25.7			19.6	22.6
8½	591		23.			17.5	20.2
8	522	1379	20.4			15.5	18.
7½	459		18.			13.6	15.8
7	399		15.8			11.8	13.8
6½	345		13.7			10.2	12.
6	294	834	11½	10½	10.	8.7	10.3
5½	240	712	9.8			7.3	8.7
5	204		8.2		7.	6.1	7.2
4½	168	413	6.7		5.	5.	5.9
4	132		5.3			4.	4.7
3½	102		4.1			3.2	3.7
3	75	203	3.1		2.5	2.4	2.8
2½	54		2.2			1.8	2.1
2	33		1.5		1.7	1.3	1.4
1½	27		1.28	1.28	1.23	1.13	1.23
1¼	21		.90	.89	.88	.86	.88
1½	15		.60	.56	.55	.53	.56
1	12		.58	.51	.49	.46	.51
¾	9		.51	.46	.46	.2	.46
½	6		.28	.28	.28	.28	.28

(From N. Timmouth, An Inquiry Relative to Various Important Points of Seamanship, Considered to be a Branch of Practical Science. London, 1845.)

A rapid comparison of the tables will quickly reveal the salient fact that hawser-laid rope is substantially stronger than cable-laid rope of a similar dimension.

Several other interesting pieces of information were revealed as corollaries of Timmouth's experiments. Four-strand rope, of which shroud-hawser is an example, was found to be 20% weaker than three-strand rope.³³ White rope (untarred rope) was stronger than tarred rope. It also emerged that any rope strained well beyond the limit of permanent elasticity was "permanently and irretrievably weakened," and Timmouth cautioned that he personally "should at all times use with extreme caution, any rope which has been subjected to a great strain" (1845: 10-13).

It was noted that, in several accounts and descriptions of specific careenings, an explicit reference was made to the use of white and new rope (Bass and Bass, 1981: 5; Luce, 1884: 585; Brady, 1857: 263). Bearing Timmouth's experiments in mind, the reason for such mention becomes readily understandable.

Comparisons Of Tackle Falls

A comparison of the strengths of the falls used to careen some of the vessels that have been mentioned, using Tables 4 and 5, pp. 175-76, as references, is revealing.

The 6-in (0.152 m) falls of the Courageux were unique

would have been rove through 28-in (0.711 m) jear blocks (Gill, 1932: 243, Table of the Dimensions of Rigging, etc.), the foremast fall would have had a mean breaking strain of 14.4 tons (14.63 metric tons). The combined mean breaking strain of the two tackles would have been 41.28 tons (41.94 metric tons).

The Formidable, the largest of the vessels, employed new 10 1/2-in (0.267 m) hawser-laid rope for the falls of both the primary mainmast and the foremast careening tackles, and a new 9-in (0.229 m) hawser-laid fall for the secondary mainmast tackle (Walker, 1902: 414). Referring again to Table 5, each of the two 10 1/2-in (0.267 m) falls and the 9-in (0.229 m) fall had a mean breaking strain of 30.7 tons (31.19 metric tons) and 22.6 tons (22.96 metric tons), respectively, for a combined mean breaking strain of 84.0 tons (85.34 metric tons).

From the above, it can be seen that the Melville utilized tackle with the lowest aggregate breaking strength of the four vessels under consideration. Although she was larger than the Constitution, about the same size as the Courageux, and smaller only than the Formidable, the Melville used falls that had a combined strength of less than one half that of the larger English ship.

Perhaps this can be explained by Harris's scientific turn of mind, illustrated by his documentation of the careening of the Melville and his analysis of some of the

forces involved. He seems to have been one of the first seamen to have gone to that trouble. In view of his obvious interest in the subject, Harris may have accumulated a store of information prior to the Melville's heaving down that enabled him to minimize the tackles used yet still keep them within the bounds of safety, something others with less knowledge than he would not have dared to attempt.

AN ESTIMATION OF THE FORCE REQUIRED
TO CAREEN THE MELVILLE

Limitations

Unquestionably, the heaving-down weight assumed by the Melville's mainmast careening tackle was greater than that handled by its foremast tackle; but since we do not know the proportion allotted to each, it is impossible to determine what part of the force required to heave the ship down was contributed by either tackle or capstan.

Although recognizing this and other limitations, I nevertheless have considered it worthwhile to use the Melville to illustrate more thoroughly some of the forces involved when a large vessel was careened. To accomplish this, I have utilized all available information. Estimates based on comparables were used to supply data which was unavailable for the Melville itself. To simplify the illustration, only forces relative to the mainmast careening tackle are dealt with. Similar calculations could be used to determine those forces which related to the foremast tackle.

Preliminary experimentation

Among the various details of the heaving-down process

Harris recorded was the height in inches that the Rattlesnake rose as a result of the lift exerted by the Melville's careening tackles. Through reference to Edye's calculations (1832: 58), and Harris's own observations and calculations, he was able to approximate the maximum weight lifted by the tackle, finding it to be about 80 tons (81.28 metric tons) with the ship over on her port side, and 65 tons (66.04 metric tons) when down on her starboard side.³⁶

Harris knew from practical experience that, due to friction, the nine parts of the main-tackle fall did not bear an equal strain. Using the 80 ton figure for his calculations, he undertook an experiment utilizing a nine-part fall in a small fourfold tackle to find what the tension would be on the hauling part of a nine-part fall required to lift 80 tons (81.28 metric tons). Harris assumed for the sake of simplification that the mainmast tackle was to act alone. The results determined that a weight of 50 lbs (22.68 kg) on the first part, or hauling part, of the fall gave 12 lbs (5.44 kg) on the ninth part, 28 lbs (12.70 kg) on the seventh part, 32 lbs (14.52 kg) on the fifth part, and 38 lbs (17.24 kg) on the third part, approximately. By setting up a mathematical proportion, he computed that the hauling part of the fall of a nine-part tackle subject to 80 tons (81.28 metric tons) of force would have a tension of 25 tons (25.40

metric tons) (Harris, 1841: 12).³⁷

Formulas

As Timmouth's treatise on the strengths of rope was yet to be published, Harris used the following formula, apparently in common use at the time, to approximate the necessary circumference of a shroud-hawser fall used in a tackle required to lift a given weight:

$MA \times C^2 \div 5 = W$, where MA = mechanical
advantage

C = circumference of shroud-hawser in inches,

and

W = bearing weight of tackle in tons (Harris,
1841:12).

By experimentation, the true mechanical advantage had been found to be 3.2 ($80 \div 25 = 3.2$). If the mechanical advantage was 3.2 and the weight was 80 tons, solving the equation would have given a shroud-hawser circumference of 11 9/50 in (0.284 m). Harris rounded this off to 11 in (0.279 m), the nearest size manufactured, although logically, he should have rounded it off to 11 1/2 in (0.292 m), the next larger size.

The above formula incorporates another basic formula

used during that period to roughly estimate the weight a rope would bear:

$C^2 \times 5 = W$, where C = circumference of shroud-hawser in inches, and W = breaking strain of shroud-hawser in tons (Harris, 1841: 12).

Application to the Melville

Applying the formula to 11-in (0.279 m) shroud-hawser:

$$11^2 = 121 \div 5 = 24.2 \text{ tons (24.59 metric tons).}$$

Burney advanced the same formula but considered it to provide a slightly higher figure than the actual weight the rope would bear, although it was easy to remember and "not far from the truth" (1974: 416). Applying it to a known weight of 25 tons, the weight the ninth part of the fall had to support, the formula again yields a shroud-hawser size of approximately 11 9/50 in (0.284 m).

If the number derived by formula, 24.2 tons (24.59 metric tons) is compared to Tinmouth's mean breaking strain for an 11-in (0.279 m) shroud-hawser, calculated to be 26.88 tons (27.31 metric tons), it is in fact found to be slightly less, rather than more, than the weight it

would actually bear, but still "not far from the truth," if that term can be applied to the figures in Tinmouth's Table 5, p. 176. If, however, Tinmouth's figure for the minimum, rather than the mean, breaking strain for an 11-in hawser were incorporated into the formula, with a 20% reduction in strength for a shroud-hawser, the result would be 23.44 tons (23.82 metric tons), and it would have been safer to use 11 1/2-in, rather than 11-in, shroud hawser to support the requisite 25 tons (25.4 metric tons). Also, Burney would then have been correct in his assessment that the formula gave a slightly higher figure than the "truth."

A similarly close relationship can be found to exist between the formula given by Harris and Burney and Tinmouth's tests for any size shroud-hawser falling within the limits of Table 5, p. 176.

Analysis

If it is assumed that the maximum 25-ton (25.40 metric tons) theoretical force necessary to careen the Melville with a single nine-part tackle was divided between the main- and foremast careening tackles so that the strain on each fall was the same percentage of their respective mean breaking strains, thereby limiting the possibility of either one being overstrained, it can be

computed that the maximum strain or tension on the hauling part of the mainmast careening tackle fall was 16.28 tons (16.54 metric tons).³⁸

The primary force used to careen the ship was, in the vast majority of cases, manpower applied to the capstan bars. Each bar, acting as a lever, transferred a moment to the center of the capstan equal to the sum of all the forces applied at various points along its length by members of the careening crew, each force multiplied by its distance from the center of the capstan. The total moment at the capstan's center was equal to the sum of the moments imparted by its bars.

An opposite moment, also acting at the center of the capstan was created by the lifting force exerted against the lower careening block as the vessel attempted to right itself. The lifting force divided by the true mechanical advantage (the theoretical mechanical advantage less a percentage loss from friction) equaled the tension on the hauling part of the fall. The tension multiplied by the radius of the capstan barrel where the hauling part of the fall encircled it gave the moment. For the hauling part of the fall to be in equilibrium (motionless) while still under tension, the moments generated by the capstan bars and by the vessel's attempts to right itself had to be equal.

To heave a ship down, the moment produced by the

capstan bars had to exceed the opposing moment. The excess was used to overcome friction, rotate the capstan barrel and thus careen the vessel.

At the point of heaviest resistance, when a full 80 tons (81.28 metric tons) of lifting force was exerted by the Melville's attempt to right herself, Harris mentioned that "there were not less than 370 men exerting their full power" at the two capstans, nine men to each bar, five to each part of the swiftners (Harris, 1841: 17).

If we estimate that the capstans on the Blenheim had barrels whose diameters, including the whelps, were 32 in (0.813 m) where the fall passed around the surge, then the moment arm of the fall was one half that distance or 16 in (0.406 m).³⁹ The moment exerted at the center of the capstan by the hauling part of the fall was thus the product of 16.28 long tons times 16 in. This figure, 21.71 foot-tons or 48,630 foot-pounds (65,930 newton-meters), was also the moment that had to be provided by the men at the main capstan bars to keep the hauling part of the fall in equilibrium.

Three-deck vessels, of which the Blenheim was most probably an example, during that general period had capstans with 14 bars, each bar 14 ft (4.267 m) in length (Fincham, 1821: 197). It is reasonable to suppose that the main capstan, which was destined to do most of the work, would have been manned to its physical capacity of nine

men per bar and five men for each of the 14 parts of its swifters. This would make a total of 196 men, 126 at the bars and 70 at the swifters.

I have estimated that the man closest to the capstan exerted force 3 ft (0.914 m) from its center and the furthest man out on each bar applied force 15 ft (4.572 m) from its center. I further assumed that the head of the capstan had a diameter of 4 ft (1.219 m), and that each bar was set 1 ft (0.305 m) into the head sockets.

Harris mentioned that the average force applied by each outer man on the capstan bars was above 40 lbs. (18.14 kg) at the point at which the righting moment of the ship was the greatest (1841: 22). This was undoubtedly more force than was exerted at any of the other positions along the bars. Since the outside man walked a relatively straight path around the capstan, compared, for example, to the man closest to the barrel, he could push more evenly. He could also take a much higher percentage of uninterrupted steps during each circuit before being required to step over the hauling part of the fall. Each time this happened, it meant an adjustment of footing with a commensurate loss of applied power for at least the steps immediately before, during, and after crossing the fall.

In the computations which follow, I estimated that the men at the ends of the bars exerted twice the force of

those closest to the capstan. It was further assumed that each of the seven other men applied force in direct proportion to his position along the 12-ft (3.66 m) length of the bar between the innermost man, who applied the least force, and the man furthest out, who supplied the most force. The men at the swifters, pulling or pushing on the ropes awkwardly, also were considered to have contributed one half the force of the men at the ends of the bars.

Force applied at the capstan

The force applied by each man at a capstan bar can be expressed as a proportion of force F , the force applied by the man at the end of the bar. Fig. 81 represents this diagrammatically. The position of each man is represented at the top of the diagram by a dark dot along a 12-ft (3.658 m) section of the capstan bar. An extension of this section of the bar surmounted by a right triangle (represented by diagonal lines) with its apex $0 F$ and its base $1/2 F$ is shown at the bottom of the diagram. The numbers in the middle of the diagram are measurements taken from the base of the rectangle to the hypotenuse of the triangle and represent the proportion of F at each position. The sum of these proportions ($6.75 F$) is the total force applied along each capstan bar.

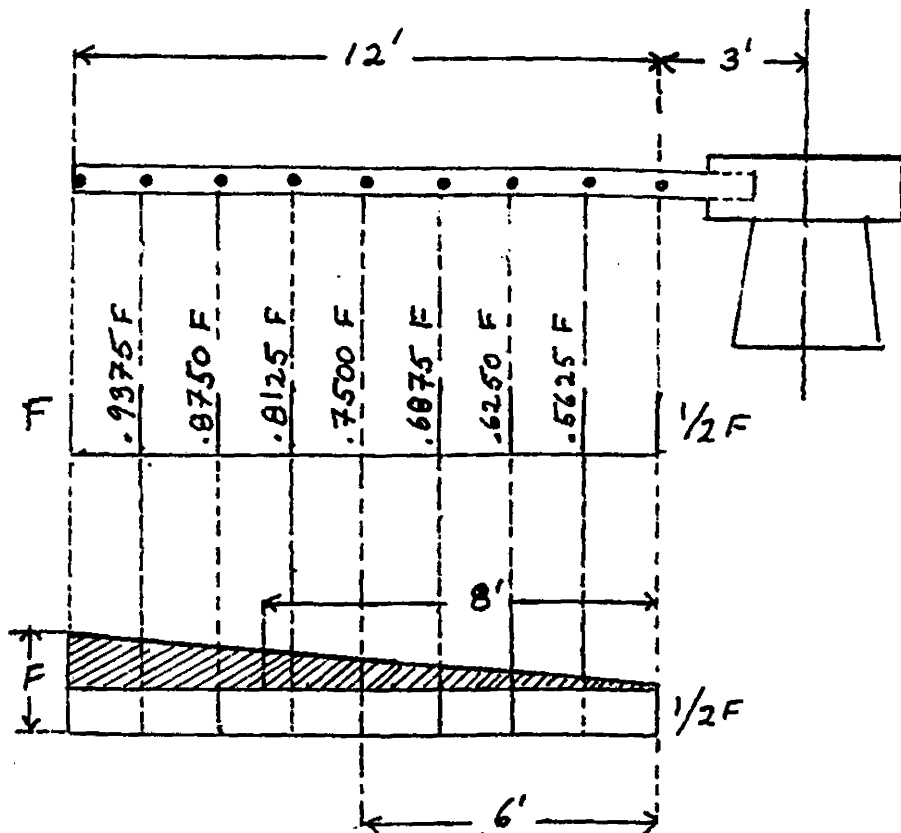


Figure 81. Diagram of moment arms and forces on one of the Blenheim's main capstan bars during the careening of the Melville. After a sketch by Prof. C. Long.

The same result can be achieved mathematically. The resultant of the forces operating on the rectangular portion falls at one half its length, or 6 ft (1.829 m). The resultant of those operating on the triangular section falls at two thirds the distance from the apex to the base, or 8 ft (2.438 m). The nine separate forces on the rectangular section have a resultant of $4.5 F$ ($9 \times .5 F$),

and the triangular section, one half the area of the rectangle, has a resultant of 2.25 F. Their sum is thus 6.75 F, as was obtained previously.

The total moment provided by the capstan bars can be calculated by multiplying the resultants of the forces by the lengths of their arms measured from the center of the capstan, their products multiplied by 14, the number of bars. The 70 men at the swifterns, each contributing a force of $1/2 F$, 15 ft (4.57 m) from the capstan's centerline, add another moment $35F \times 15$. Thus the total moment, M, at the center of the capstan can be calculated:

$$M = 35F \times 15 + 14(2.25 F \times 11 + 4.5 F \times 9) = 1438.5 F$$

Since this was the moment required to keep the hauling part of the fall in equilibrium:

$$1438.5 F = 48630 \text{ ft-lbs, and } F = 33.8 \text{ lbs.}^{40}$$

This means that an estimated 33.8 lbs (15.33 kg) force was required of the outer men at the capstan bars. The forces applied by those at other points can be calculated as a proportion of that figure. The 40-plus lbs (18.14 plus kg) that Harris stated was exerted by the men at the ends of the bars can be explained by the extra energy that was

required to overcome the friction of the three or four turns of the hauling part of the fall around the capstan barrel and the need for a certain amount of force to keep the capstan barrel turning in order to continue heaving down the ship.

Distance traversed by outside men

The 30-ft (9.144 m) diameter of the circle traversed by the outer men on the capstan bars would have required them to walk 94 ft 3 in (28.7274 m) for each 360° revolution of the capstan barrel. Each complete turn of the barrel would gain 8 ft 4 17/25 in (2.557 m) of the fall, if we assign the capstan barrel a diameter of 32 in (0.813 m) and ignore the stretch in the fall.

For each 1 ft (0.305 m) that the two blocks of the careening tackle were drawn closer together, 9 ft (2.743 m) of the hauling part of the fall was required. Taking into consideration that the running block described an arc as the mast to which it was attached descended, we find that each turn of the capstan drew the two blocks very slightly less than 11 4/25 in (0.284 m) closer together.⁴¹

Harris stated that the outer men on the bars walked 6 1/2 miles (10.4605 km) during the course of careening the Melville to an angle of 73.5° (1841: 22). This would seem excessive but for the fact that the Blenheim was anchored

about 2 1/4 ship lengths distant when the heaving down began, but, in their final positions, the vessels had been drawn to within slightly more than 1 ship length of each other (see Fig. 60, p. 124). Obviously, 6 1/2 miles (10.4605 km) is a greater distance than the outside man would have walked had the ship been careened against a wharf or a hulk equipped with capstans.

Six and one half miles or 34,320 feet (10,460.5 m) would have required the outside men to circle the capstan 364 times. During this time slightly more than 338 feet (103.0224 m) of the hauling part of the fall would have passed around the capstan's barrel, a number that does not seem inconsistent with Fig. 60, p. 124.

Conclusions

Given the possibility of errors in one or more of the estimations used in the calculations above, the example nevertheless demonstrates how variables such as the mechanical advantage produced by the careening tackles, the diameter of the barrel of the capstan, the number and lengths of its bars, and the number of men employed on them can affect the forces expended.

It also emphasizes the critical necessity of ballasting a vessel properly prior to careening so that the moment exerted at the capstan's center created by the

ship's tendency to right itself was minimized but, at the same time, stable equilibrium was maintained throughout the heaving-down range. Additionally, the importance of setting up the support rigging properly and balancing the vessel correctly prior to careening to avoid overstraining one or another of the careening tackles becomes evident.

In view of the above analysis of the forces involved in careening the Melville, the earlier comparisons of the minimal tackle used to heave down the Melville to the tackle used on the other vessels take on additional implications. In particular, the continued use of Table 3, p. 137, by the British Naval establishment at Malta is somewhat startling. The table's continued use may, in part, be explained by the strength of tradition in the British Navy and the fact that little time had passed between the date of Harris's publication and the careening of the Formidable in 1845, at which time Table 3 was apparently still in use.

It seems that prior to the publication of at least three critical documents, Edye's analysis of the draught versus displacement of various-sized vessels (1832), Harris's analysis of the forces to be dealt with (1841), and Timmouth's scientific experiments relative to the strengths of cables and hawsers (1845), the ingredients necessary to properly assess the tackles required to careen a given ship were not available. The sometimes

gross oversizing of the careening tackles employed in heaving down large vessels may have been a reflection of this.

Taking advantage of the increased safety offered by oversized tackles was a precaution that would have been hard to fault by a naval Board of Inquiry. On the other hand, damage incurred during careening which resulted from undersized gear would not have been viewed kindly. From a more charitable viewpoint, excesses in the sizes or quantities of tackles used for careening may simply have been evidence of a healthy respect for what Harris regarded as "one of the most arduous and critical manoeuvres that we are ever called upon to execute" (1841: 15).

STABILITY

No discussion of careening can be complete without considering the important subjects of transverse and longitudinal stability, the first concerned with rolling motion about a horizontal fore-and-aft axis, the second with pitching motion about a horizontal axis running athwartships.

Concomitant with stability was the fundamental consideration of safety. The captain contemplating careening his vessel needed to have at least a basic familiarity with the factors affecting a ship's stability in order to know how to ballast his vessel, to be able to supervise the installation of auxiliary rigging, and to take the proper precautions to prevent the ship from capsizing.

An abbreviated description of the terms used in the physics of ship stability combined with an analysis of the changes which occurred when a ship was careened should give the reader a better understanding of the forces acting on it and the reasons for some of the procedures described earlier.

Terminology

A floating vessel displaces a weight of water equal

to its own weight. The weight of water moved aside is termed the ship's displacement or displacement tonnage. If weight, ballast for example, is added to a ship, its hull sinks deeper into the water, thus displacing an additional weight of water equal to the weight added.

The depth to which a vessel sinks in the water until it floats is its draught, a figure which always changes with the addition or subtraction of weight, and, depending upon the vessel's underwater configuration, very often changes with its degree of heel.

The center of buoyancy (B) of a vessel is the single point at which the resultant of all the forces of the displaced water can be construed to act vertically upwards with reference to the surface. Its position changes with modifications to the underwater shape of the vessel as it is heeled.

A vessel's center of gravity (G) refers to the center point of the vessel's mass at which the whole weight of the ship and its contents are conceived to act vertically downwards with relation to the surface of the water. Its position remains constant within a vessel's hull as the vessel is heeled but shifts as changes are made to its mass; for example, its position can be changed by the addition or subtraction of ballast or a shifting of ballast to a different position on board the ship.

Changes Which Occur When A Ship Is Heeled

With a ship resting in an upright position, G and B are equal and opposite forces acting along the same vertical line (Fig. 82). When a ship is heeled (careened), not only does the submerged area of its hull change shape, but a wedge-shaped portion, initially below the waterline when it was upright, emerges. Concomitantly, a wedge of corresponding volume on the other side of the hull which initially lay above the waterline is submerged. These portions of the ship's hull are called the wedge of emersion and the wedge of immersion (Fig. 83).

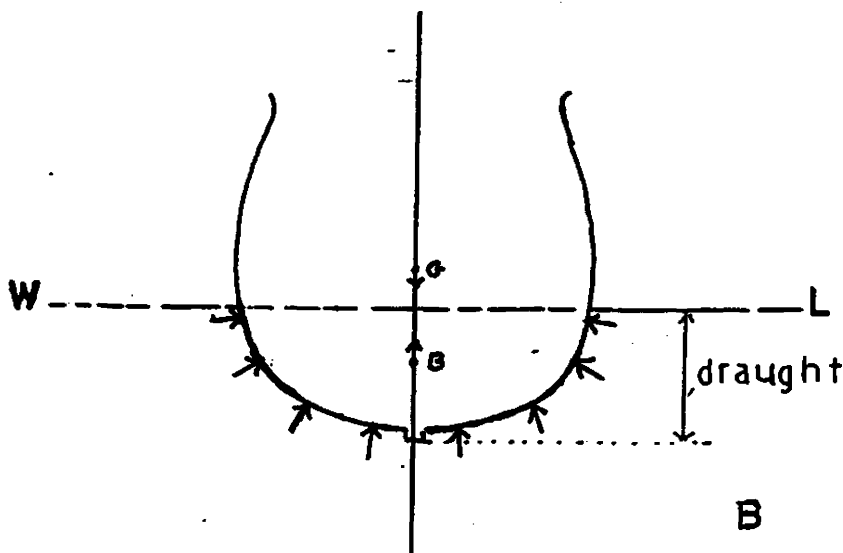


Figure 82. The centers of gravity and buoyancy and the forces acting through them. Arrows along the ship's bottom show water forces acting to push the vessel upwards, consolidated at B. M. Goelet.

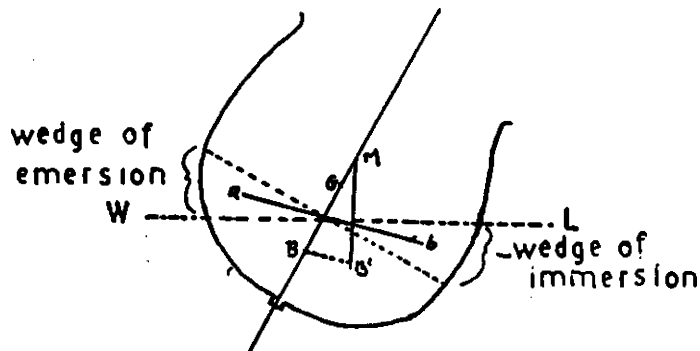


Figure 83. Wedges of emersion and immersion. M. Goelet.

As a vessel heels, B moves parallel to the line which would join the center of gravity a of the wedge of emersion and the center of gravity b of the wedge of immersion (Taylor, 1977: 9). A line extended vertically through the new center of buoyancy (B^1) intersects the vessel's vertical centerline at a point called the metacenter (M).

Equilibrium

A ship can be in one of three states of equilibrium.

Stable equilibrium

If, after the removal of a heeling force, such as was

exerted by careening tackles when a ship was being heaved down, the vessel returns to an upright position, it is considered to be in a state of stable equilibrium (Fig. 84a). Note that the two vertical forces (see arrows) through G and B^1 , called a couple, would tend to right the vessel illustrated. Note also the position of M above G ; the distance between them is the metacentric height.

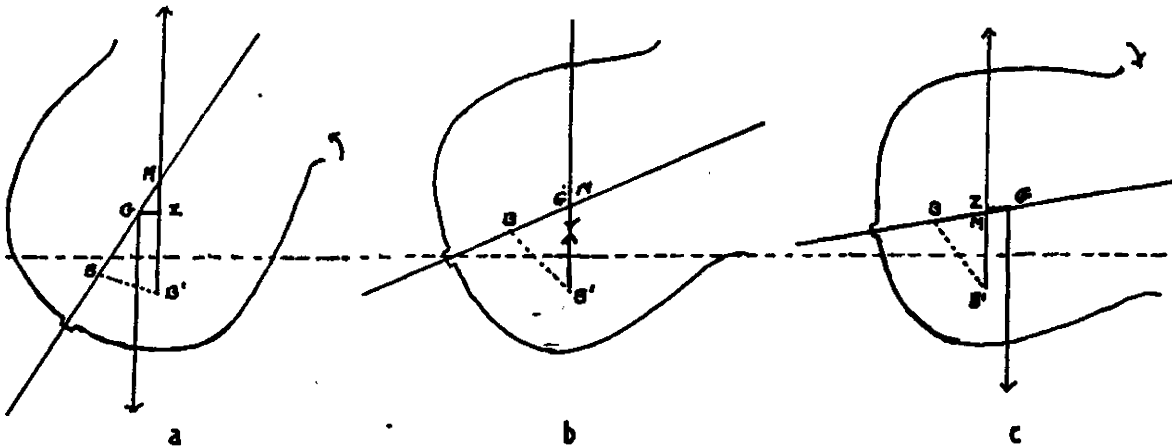


Figure 84. The three states of equilibrium. From left to right: stable, neutral, and unstable equilibrium. M. Goelet.

Neutral equilibrium

In a condition of neutral equilibrium the vessel remains static after being relieved of the heeling force, tending neither to right itself nor heel further. It is in

a state of delicate balance which, in practice, cannot be maintained. Fig. 84b, p. 200, shows the vessel heeled to an angle at which the line of force through B^1 perpendicular to the waterline intersects the ship's vertical centerline at G. In this situation there is no moment arm and therefore no righting or heeling tendency.

Unstable equilibrium

Fig. 84c, p. 200, illustrates the ship heeled to an angle at which B^1 has shifted to a position where the perpendicular line of force through it intersects the vessel's centerline at a point at which M is below G. In this situation the couple acts in a direction tending to overturn the vessel, and without adequate restraining gear it would probably capsize. A ship in this state is said to be in unstable equilibrium.

Note that in all three illustrations G's position has remained constant and the state of equilibrium is purely a function of the location of B^1 .

Righting Moment

The horizontal distance between G and B^1 , shown as GZ in Fig. 84a, p. 200 and ZG in Fig. 84c, p. 200, is the arm of a moment which, dependent upon the direction of

rotation of its couple, either tends to right the vessel or overturn it. The moments for either condition can be determined by multiplying the length of the arm GZ (or ZG) by the upward force acting through B^1 , the weight of the ship plus, in the case of a ship being careened, the component of tackle force acting vertically downwards with reference to the water's surface (Waterhouse, 1984).⁴²

With the weight of a ship and the position of its ballast constant, G's position remains the same. It can be seen in Fig. 84a-c, p. 200, however, that as a vessel heels, B^1 shifts position changing the length of GZ and thus determining the magnitude of the righting or, in a case of unstable equilibrium, the capsizing moment.

Curve Of Stability

The length of GZ at any angle of heel can be visually represented by a graph called a curve of stability (see example in Fig. 85). By drawing a line from any point on the curve perpendicular to the vertical scale at the left, the length of GZ can be determined for any angle of heel (the example shows 1.7 m at a heel of 40°). The maximum righting moment occurs at the angle of heel, coinciding with the apex of the curve (approximately 52°).

For practical purposes, the curve normally includes only those angles of heel which lie within a vessel's

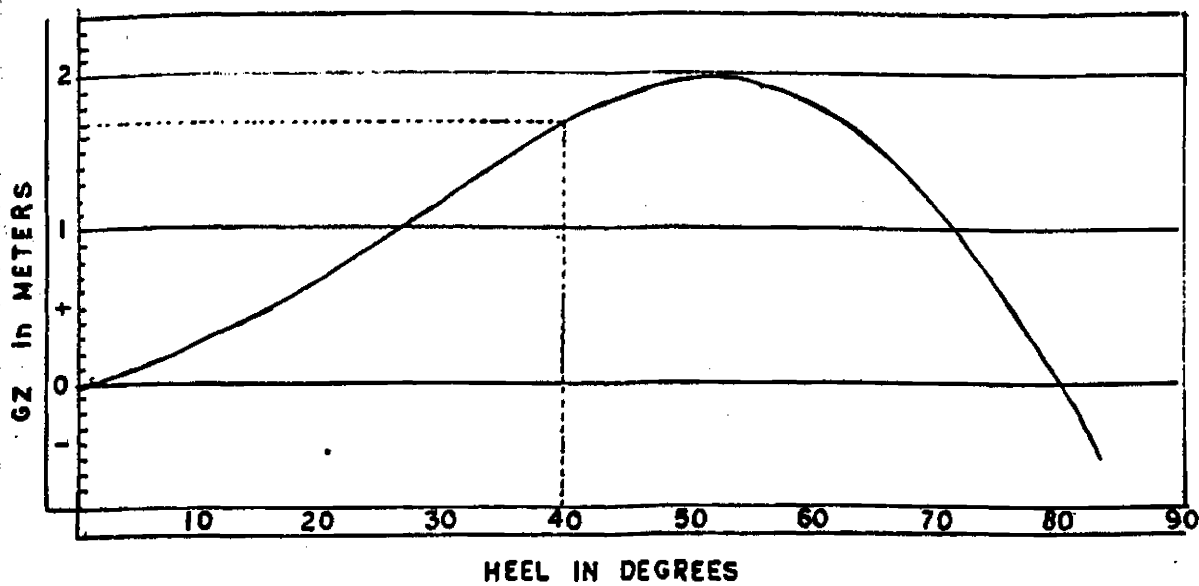


Figure 85. An example of a curve of stability. M. Goelet.

range of stable equilibrium (from 0° to about 81° in the illustration) when in a specific configuration. It could, however, be extended into the range of unstable equilibrium to visualize the moment necessary to prevent the ship from heeling further.

Upsetting Moment

When a ship is careened, the upsetting moment is that component of force applied by a careening tackle which acts perpendicularly to the mast multiplied by the

distance between the tackle's attachment point on the mast and B^1 (Waterhouse, 1984). Of course, with more than one careening tackle, the moments are cumulated.

Referring to Fig. 86, it can be seen that (with the ship's angle of heel represented as \underline{a} and the angle at which the tackle force is exerted against the mast represented as $\underline{a} + \underline{b}$) the tackle force perpendicular to

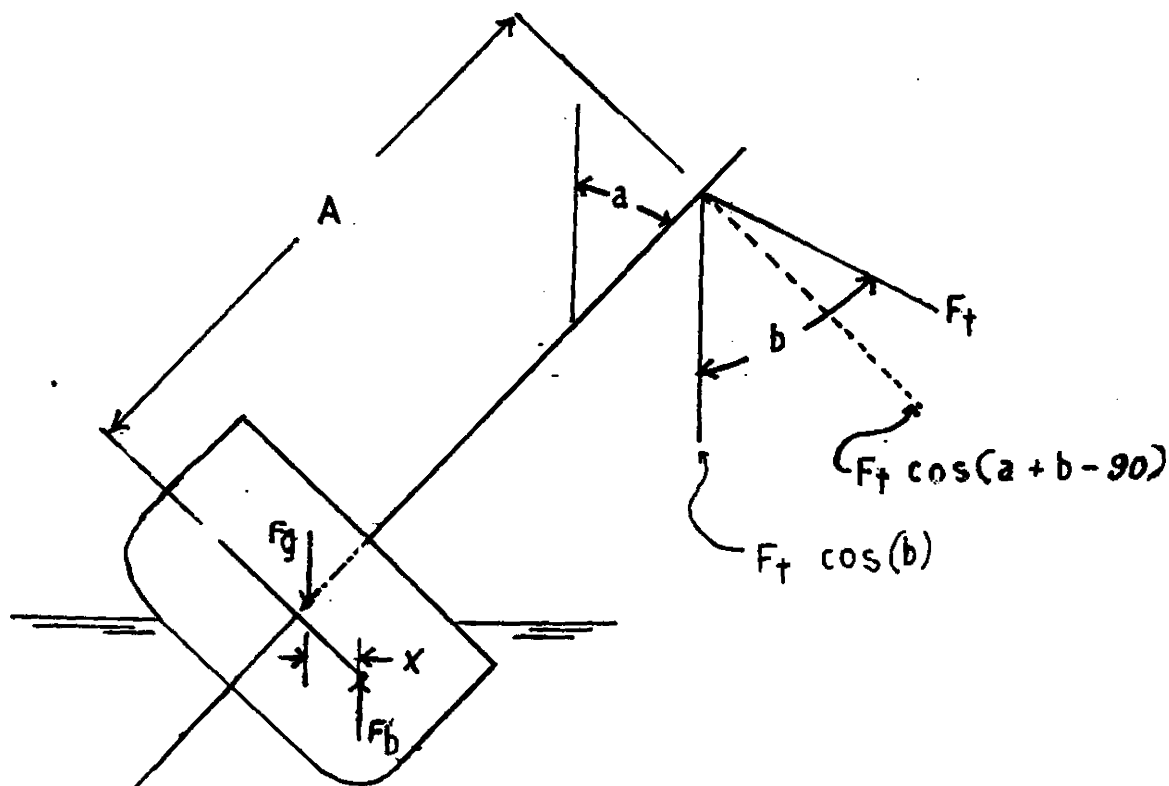


Figure 86. Forces and distances determining upsetting and righting moments. F_t stands for tackle force. X is the horizontal distance between perpendiculars through F_b and F_g . After a sketch by J. Waterhouse.

the mast is

$$F_t \cos(a + b - 90)$$

and the result multiplied by A, the height of the attachment point of the moving block above B¹, is the upsetting moment.

For the vessel to be in equilibrium, the righting moment must equal the upsetting moment. Therefore,

$$F_b(x) = F_t \cos(a + b - 90)A,$$

where F_t is the hypotenuse of a right triangle.

Bouyancy force (F_b) must not only equal the weight of the ship, expressed as a downwards force (F_g) but also the component of the tackle force acting vertically downwards with reference to the surface of the water. Thus, in Fig. 86,

$$F_b = F_g + F_t \cos(b).^{43}$$

A Discussion Of Moment And Force Using The Melville As An Example

Since we have more basic information about the careening of the Melville than for any other ship studied,

its example can also be used to obtain a clearer picture of the various moments and forces involved. Having actually been careened, it serves as a realistic illustration of the relationships that existed between the elements described above. Estimates based on comparables have been used for some of the calculations where concise information is lacking. For that reason, while the underlying principles used to obtain the results are presumed correct, the results obtained should not be considered definitive.

Upsetting moment

The upsetting moment provided by a careening tackle, it should be recalled, is the distance between the attachment point of its running block to the mast and the ship's center of bouyancy multiplied by the force perpendicular to the mast exerted by the tackle. For purposes of this example, the proportion of the force supplied by the mainmast and the foremast tackle to the total force of 80 tons (81.28 metric tons), required at 72° angle of heel, is the same as that used in the earlier discussion of the strains on the careening tackle falls.

Of the 25 tons (25.4 metric tons) force generated by the hauling parts of the falls, I have estimated that 16.28 tons (16.54 metric tons) was applied by the mainmast

fall. Having established the relationship

$$16.28 \div 25 = F_t \div 80,$$

I calculate F_t , the force exerted by the main-mast tackle, to be 52.1 tons (52.93 metric tons), leaving the remaining 27.9 tons (28.35 metric tons) to be supplied by the foremast tackle.

To determine the tackle forces perpendicular to the masts (F_p) with the ship inclined 72° , I assumed for simplification (and it would have been normal at that heel) that the Melville and the Rattlesnake were positioned relative to each other so that a line extended through the moving and fixed blocks of the careening tackles was vertical to the water (Fig. 87). It was then only necessary to solve the equation

$$F_p = F_t \cos 18,$$

where F_p is the force perpendicular to the masts and F_t (the hypotenuse of a right triangle) is the force applied by each tackle. Solutions give an F_p of 49.55 tons (50.34 metric tons) against the mainmast and 26.53 tons (26.95 metric tons) against the foremast.

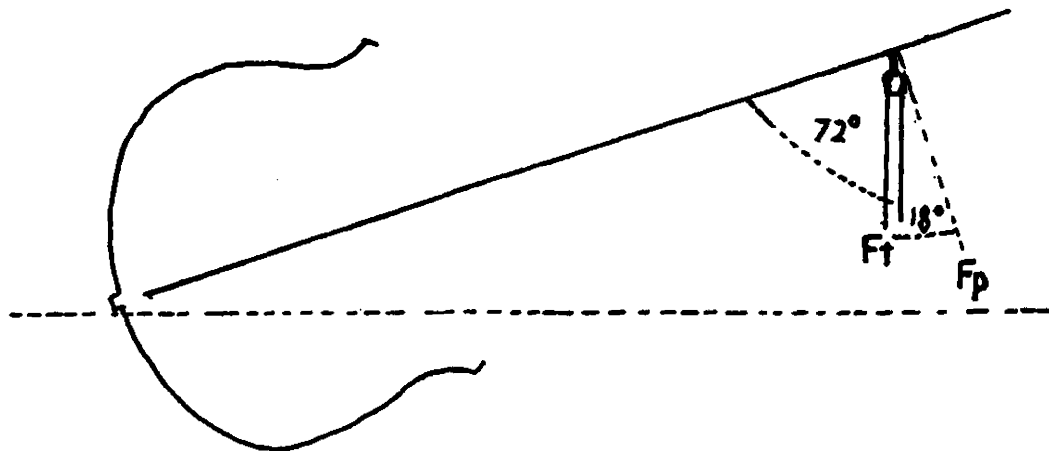


Figure 87. Determination of the forces acting perpendicular to the Melville's main- and foremast with the ship careened to a 72° angle of heel. M. Goelet.

To complete the upsetting moment equation, the distances between the tackles' attachment points on the masts and the ship's new center of bouyancy must be estimated, but this can be done with what is probably a reasonable degree of accuracy.

Fig. 88 is a simplified and reduced copy of Harris's Table 2 (1841), representing the Melville careened to various degrees of inclination. The two lines shown cutting vertically through the waterlines with the ship at inclinations of 28° and 74° have passed though the respective centers of bouyancy and intersected the ship's vertical centerline at the metacenters for those angles of heel. M is the metacenter with the ship careened 74° , and G is the ship's center of gravity. The short dotted line,

GZ, vertical to that passing through my approximation of the center of bouyancy, B (added to Harris's original drawing), and parallel to the waterline with the ship heeled to a 74° inclination, represents the horizontal distance between B and G, i.e., the moment arm (corresponding, for example, to the moment arm GZ in Fig. 84a, p. 200).

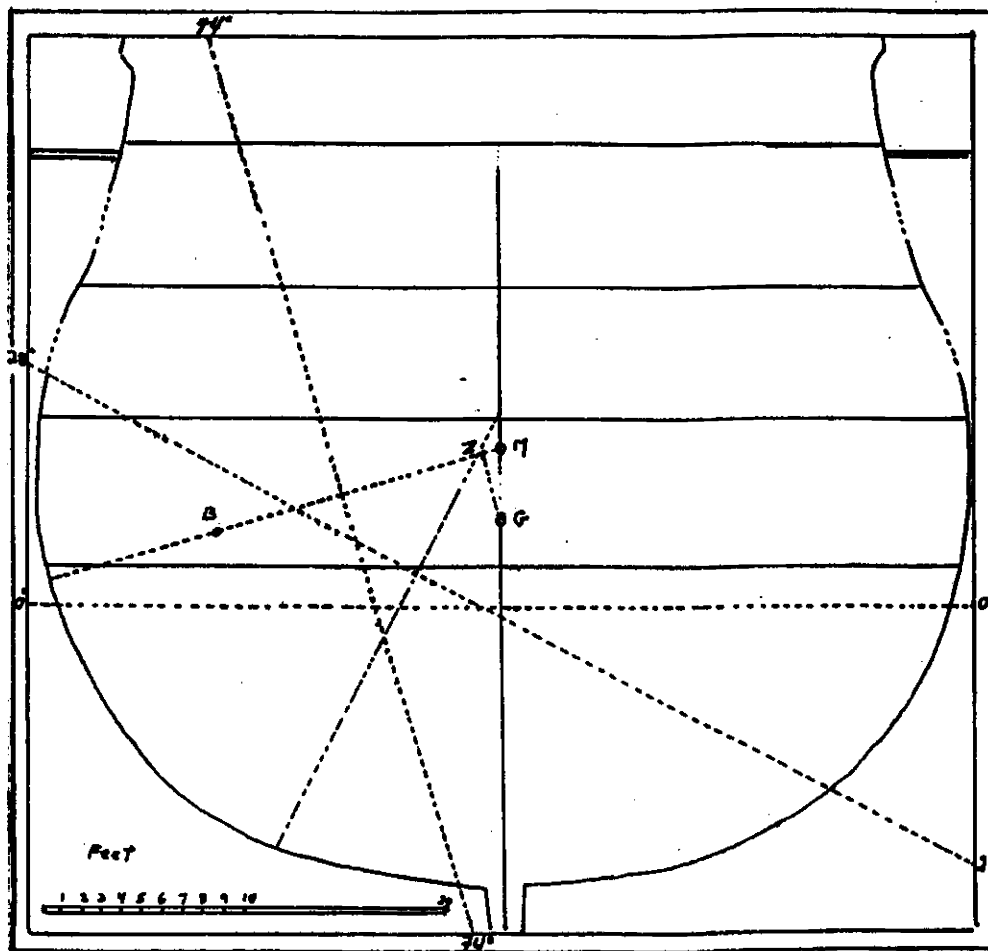


Figure 88. The Melville careened to 28° and 74° inclination. After Harris (1841: pl. 2).

Harris calculated that G was about 2 ft 2 in (0.660 m) above the orlop deck and 3 ft 6 in (1.067 m) below M (1841: 21); both figures are confirmed by measurements taken using the scale in Fig. 88, p. 209. The scale can also be used to determine that the orlop deck lay about 16 ft (4.876 m) above the keel, a distance corroborated by Rees (1970: pl. IV). With the Melville careened to an inclination of 72° , the center of bouyancy would be about 5 in (0.127 m) below the center of gravity, or 1 ft 9 in (0.533 m) above the orlop deck, as reference to Fig. 88, p. 209, will confirm.⁴⁴

The heights of the main- and foremasts of an English warship of the Melville's vintage and size were 111 ft (33.833 m) and 98 ft 6 in (30.023 m) respectively (Burney, 1974: 266; Rees, 1970: 104). On a ship of the Melville's class, the heel of the mainmast was supported in the mast step about 4 ft (1.219 m) above the keel, while that of the foremast, due to the rise of the bow section, was about 2 ft (0.610 m) higher (Burney, 1974: 503, pl XVI; Rees, 1970: pl IV).

Lees states that from 1773 to 1850 the lengths of the mastheads of both fore- and mainmasts on English warships were 5 in (0.127 m) for each 3 ft (0.914 m) of the mast's total length (1984: 2-3). The Melville's masthead with a mainmast length of 111 ft thus had a length of

$111 \text{ ft} \div 3 \text{ ft} \times 5 \text{ in} = 15 \text{ ft } 5 \text{ in} (4.611 \text{ m}),$

and the foremasthead, a length of

$98 \text{ ft } 6 \text{ in} \div 3 \text{ ft} \times 5 \text{ in} = 13 \text{ ft } 8 \text{ in} (4.166 \text{ m}).$

Since the masthead was considered to extend between the tops of the trestletrees and the mast peaks, the masthead lengths represent the lowest points below the peaks at which the Melville's careening tackles could have been attached.

If we assume that the careening tackles were attached to the mastheads directly above the trestletrees and that, due to the method of attachment, pressure was exerted 6 in (0.152 m) higher than the mainmast trestletrees and 5 in (0.127 m) higher than the foremast trestletrees, it is possible to estimate the distances between the points of attachment of the main- and foremast careening tackles to the masts and the center of buoyancy. The calculated distance between the point of attachment of the mainmast tackle and the center of buoyancy is:

mast length (111 ft) - masthead length (15 ft 5 in)
 + attachment distance above trestletrees (6 in)
 - distance from heel of mast to top of orlop deck
 (12 ft) - distance from top of orlop deck to center
 of bouyancy (1 ft 9 in) = 82 ft 3 in (25.070 m).

Similarly, the corresponding distance at the foremast is:

mast length (98 ft 6 in) - masthead length
 (13 ft 8 in) + attachment point above trestletrees
 (5 in) - distance from heel of mast (stepped 2 ft
 higher than mainmast) to top of orlop deck (10 ft)
 - distance from top of orlop deck to center of
 bouyancy (1 ft 9 in) = 73 ft 6 in (22.403 m).

Multiplying these distances by the forces vertical to
 the masts generated by each of the careening tackles and
 using long tons, we get for the mainmast:

49.55 tons X 82 ft 3 in = 4075 foot-tons
 (12,376,770 newton-meters)

and the foremast:

26.53 tons X 73 ft 6 in = 1950 foot-tons
(5,921,781 newton-meters),

the total calculated upsetting moment being approximately
6025 foot-tons (18,298,551 newton-meters).

Righting moment

Since, for the ship to be in static equilibrium, the righting and upsetting moments must be equal, the righting moment for the Melville to be in that state must also have been approximately 6025 foot-tons.

A measurement of the arm GZ, using the scale in Fig. 88, p. 209, yields an approximate length of 3 ft 4 in (1.016 m). By dividing the upsetting moment by this length, we get a vertical righting force through the center of bouyancy of 1807.52 tons (1836.44 metric tons). This figure, it must be remembered, equals the force acting vertically downward through the center of gravity (the ship's weight) plus the downward force generated by the careening tackles of 80 tons (81.28 metric-tons). The Melville can thus be estimated to have weighed approximately 1727.52 tons (1755.16 metric tons) when careened.

Edge (1832: 14) gives the hull displacement of an English "74" as approximately 1617 tons (1642.87 metric

tons) when launched, with an additional 1359 tons (1380.74 metric tons) received on board for a fully-provisioned displacement of 2976 tons (3023.61 metric tons). The average difference in tonnage between a 74-gun British warship in 1835 and a 72-gun ship in 1840, the category into which the Melville would fit, was less than 1 ton burthen, 1756.13 tons versus 1755.25 tons respectively (Fincham, 1979: 401). Presumably, their displacement tonnage was also comparable. It does not seem unreasonable, then, that either a "74" or the Melville would have displaced about 1727.52 tons (1755.16 metric tons) when lightened for careening.

The importance of the location of the center of bouyancy during careening

It should be noted that if, for example, the tackles had been attached 1 ft (0.305 m) lower down on either mast, with the same careening force exerted, the total upsetting moment would have been reduced to 5949 foot-tons. This is found by multiplying the reduced distances between the tackle attachment points by the previously-calculated forces acting perpendicularly to each mast. Thus the mainmast tackle in this case would provide a moment of

81 ft 3 in X 49.55 tons = 4026 foot-tons

and the foremast tackle, a moment of

72 ft 6 in X 26.53 tons = 1923 foot-tons,

for a total upsetting moment of 5949 foot-tons (18,066,404 newton-meters).

Since, with the ship in equilibrium, that moment equaled the righting moment, the new moment arm can be found by dividing this figure by the bouyancy force, which was previously calculated to be 1807.52 tons (1836.44 metric tons). Thus, the adjusted moment arm would be

$5949 \text{ foot-tons} \div 1807.52 \text{ tons} = 3 \text{ ft } 3 \frac{1}{2} \text{ in.}$

This demonstrates that a 1 ft (0.305 m) reduction in the attachment point of the careening tackle could be offset by a 1/2 in (0.013 m) movement of the center of bouyancy closer to the center of gravity. It can be inferred from this how much more important the location of the center of bouyancy was than the attachment points of the careening tackles when careening a ship of a given displacement.

The Relationship Of Stability To Careening Preparations

Of the common preparations for heaving down, only relieving gear was capable of bringing a ship back should it be heeled beyond safe limits. Other preparations, subtler and more passive in their function, helped to ensure that the vessel did not exceed its range of stable equilibrium.

Free-surface effect

The care taken to ensure that pumps were designed to reach and discharge bilge water with the ship careened evidenced concern over what is known today as free-surface effect. This term, applied to careening, refers to the water that entered a ship's hull during the procedure which, if left unattended, could increase to a point at which it could compromise the vessel's stability.

Fig. 89a shows a vessel in an upright position with water in its bilge represented by diagonal lines. The center of gravity of the water, g , is on the ship's centerline, and the center of gravity of the ship is represented by G .

In Fig. 89b, the same vessel is careened and the center of gravity of the bilge water has shifted to the down side. A line passing through g vertical to the

waterline intersects the ship's centerline at point gv , known as the virtual center of gravity of the bilge water. G and gv combine to determine a new center of gravity for the ship, Gv , above the original ship's center of gravity. The result is a lessening of the metacentric height (the distance between the ship's center of gravity and its metacenter), resulting in a shortening of the arm GZ (refer to Fig. 84a) and a diminution of the righting moment in the couple created by GZ and the weight of the ship.

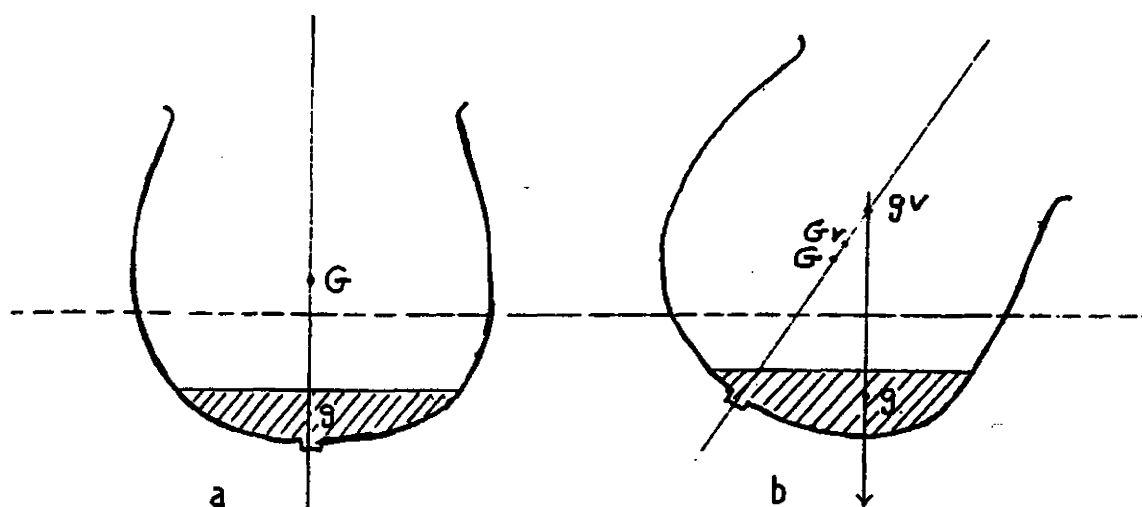


Figure 89. Free-surface effect. M. Goelet.

If enough water leaked into the vessel during careening, there was a possibility that the center of gravity might be raised to a point where it coincided with

the metacenter, resulting in a loss of stable equilibrium.

Wedges of immersion and emersion

With reference to wedges of immersion and emersion (Fig. 83, p. 199), once a ship was heeled to a point at which its leeward waist became submerged, a portion of the wedge of immersion was destroyed and the center of gravity of the wedge shifted towards the center of the ship. Since the center of bouyancy of the vessel moved parallel to a line drawn between the centers of gravity of the wedges of immersion and emersion and was influenced by the distance between them, a shift in the center of gravity of the wedge of immersion towards the vertical centerline was met with a corresponding movement of the vessel's center of bouyancy inwards toward its vertical centerline (Taylor, 1977: 9 and 54-56).

This shift had the effect of lowering the metacenter and reducing the horizontal distance between the centers of bouyancy and gravity, again shortening the righting arm, thereby reducing the righting moment.

Concomitantly, with the loss of part of the bouyancy supplied by the wedge of immersion as its leeward waist submerged, the ship would compensate by sinking deeper into the water, eliminating still more of the bouyant area within the wedge and exacerbating the situation. If the

metacentric height was minimal before a portion of the leeward waist was submerged, a rapid decrease in the righting moment caused by its submergence could impose the immediate danger of the ship's capsizing.

The planking added to the gangway of the Courageux, a "French built, and consequently wall-sided" ship, as King described her (1802: 310), was designed to mitigate that possibility. Its construction effectively gave the ship the tumblehome it lacked. By preserving the wedge of immersion and the bouyancy thus provided through a greater range of inclination than if it had not been installed, the planking maintained the value of the righting arm.

Ships with a more substantial tumble-home than that of the Courageux, such as exhibited by British warships of the same period, kept their leeward waists dry through a greater range of inclination and so would not have required such an installation. For example, in Fig. 90 the section drawing of the inner vessel a demonstrates how tumble-home preserves the bouyancy within its wedge of immersion at the angle of heel shown. The superimposed section drawing of vessel b demonstrates that this vessel, without the addition of planking along the gangway, would lose a portion of the bouyancy within the wedge of immersion indicated by the diagonal lines.

A quite similar arrangement is shown in Fig. 40(B), p. 70. This representation of a portion of the main deck

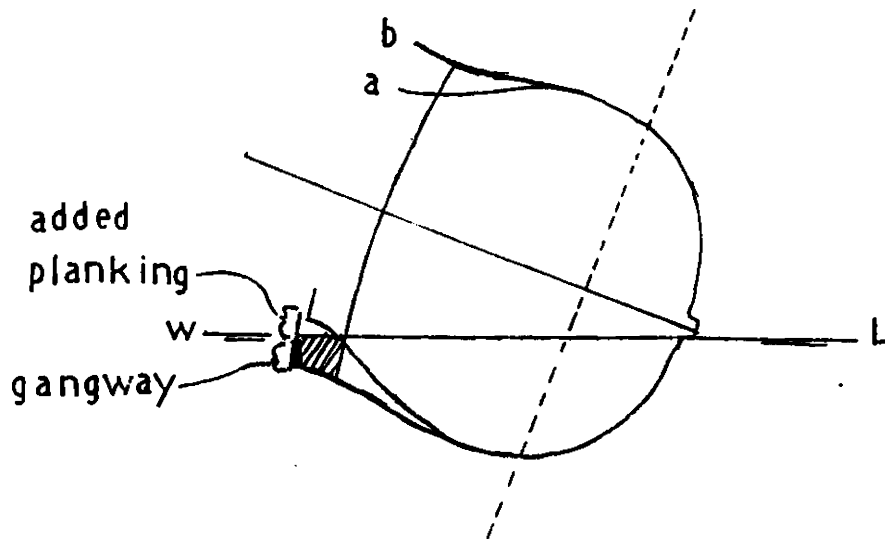


Figure 90. Preservation of bouyancy on a wall-sided vessel by the addition of planking to the lee gangway. M. Goelet.

area of an early-19th-century Danish warship, another rather wall-sided vessel, shows a vertical timber, one of a series extending the length of the ship's waist, butted and secured to the deck fg inboard of the bulwark. Secured to their upper ends, beams extend to the bulwark railing. Planks ab are run fore and aft and caulked in between forming a false deck. This added the volume encompassed by adfg to the bouyancy of the ship when it has been careened to the new waterline df, again maintaining the value of the righting arm.

Athwartships bulkheads

The athwartships bulkheads extending to the midships

of the Formidable and Melville mentioned by Walker and Harris were able to regulate the water's effect on the ships' stability by containing it in a specific area. Harris commented that, at the angle of inclination required to bring the Melville's keel free of the water, the metacenter could never have been in danger of passing through the center of gravity thus making the ship unsafe, an analysis that can be easily verified from Fig. 88, p. 209. In the Melville's case, the water in question, contrary to its being detrimental to the ship's stability, performed a service by reducing the load on the careening tackle.

Casks and barrels

A tender vessel, where M was not far above G initially, would sometimes have casks or barrels strapped along its lee waterline to shift the vessel's center of bouyancy to the lee side. Funch (1976: 7) mentioned their use on 19th-century Danish ships as an alternative to the false decking in Fig. 40(B), p. 70, described above. Apparently, this was a long-standing practice; note the barrels strapped along the leeward side of the late-15th-century carrack in Fig. 51, p. 93. A carrack was top-heavy to begin with and would have been even more so with ballast removed. By strapping empty barrels along its lee

side, the center of bouyancy would have been shifted further to that side, increasing the moment arm and thus the righting moment.

Not only would the barrels have increased the stiffness of an erstwhile tender vessel, putting the careening under more positive control, but, by keeping the lee waist above the water at high angles of heel, the barrels also would have minimized the problem caused by the free surface effect of the water which would inevitably have found its way through the deck to the bilge. Furthermore, if the waist was kept above water, the bouyancy of the wedge of immersion was maintained.

The carrack in the slightly earlier Botticelli fresco (Fig. 36, p. 61) is so positioned against a wharf that it is impossible to determine whether or not barrels were also strapped along its side. As these two examples were the only ones noted of carracks being careened, it is premature to comment on whether or not barrels were commonly strapped alongside that kind of vessel as part of the heaving-down procedure.

Effects Of Configuration And Ballasting

Fig. 91 shows sections at the main frame of mid-18th-century vessels of different nationalities, illustrating the variations in hull shape, tumblehome, and draft.

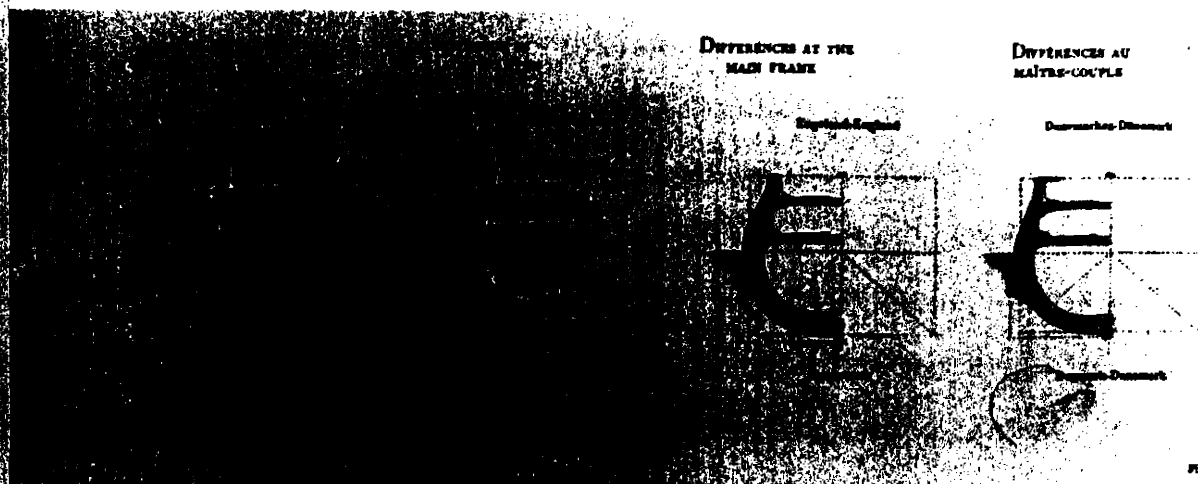


Figure 91. Differences at the main frame of mid-18th-century ships of various nationalities. From Van Konijnenburg (1895-1905 vol. III, 8, fig. 13).

The Dutch warship displays a shallower draught, a higher freeboard, a noticeably fuller section, and a greater beam-to-depth ratio than the other vessels. Its shallower draft and greater freeboard would make its center of gravity as well as its center of buoyancy somewhat higher than those of the other vessels shown, relative to each ship's waterline. Still, with all the vessels upright, the metacentric heights of each would remain proportional. If, however, they all were careened to the same high angle, because of the Dutch ship's fuller section, its center of buoyancy would shift further to leeward than would the centers of buoyancy of the other

ships. The result would be that the Dutch vessel would have a proportionately longer righting arm and an increased metacentric height compared to the other ships, with a correspondingly greater righting moment.

Additionally, the Dutch vessel's greater freeboard, which tended to preserve the bouyancy within its wedge of immersion through higher angles of heel (although this last feature would be modified by a somewhat wall-sided section compared to the other ships), would make the Dutch ship more difficult to careen than its counterparts. The aforementioned review of the Dutch vessel's heeling characteristics sheds some light on Sir Henry Manwaring's comment, albeit made a century earlier, that Flemish vessels were hard to bring down and easy to right, even without internal ballast (Mainwaring & Perrin, 1822: 118).

Not only were different vessels of the same displacement heaved down with varying degrees of difficulty, the same vessel often was not careened as easily to one side as to the other. For example, the maximum tackle load when the Melville was hove down on her port side was approximately 80 tons (81.28 metric tons) but was only about 65 tons (66.04 metric tons) when she was hove down on her starboard side (Harris, 1841: 20).

Harris ascribed the difference in the careening forces required to additional weight to starboard when the vessel was heaved down on that side: 16 tons (16.26 metric

tons) of water in kegs and 1.75 tons of chain "on the mainmast." Harris calculated that this meant that 2.05 tons (2.08 metric tons) less force was required at the masthead. He attributed the remaining approximately 13-ton (13.21 metric tons) difference in the force required to "the chain cables being on the lower side, when the strain was least." He did, however, speculate that since the port side of the ship's planking was 4 in (0.102 m) thicker than that of the starboard side, the "stability" (i.e., bouyancy) on that side may have been increased in some measure (Harris, 1841: 20-21).

The Melville's bouyancy may in fact have been increased on the port side as a result of its thicker planking, but the shift in the relative lengths of the moment arm from port to starboard, the only variable that apparently changed, would have been substantial to have made much of a difference in the force required at the mastheads. For example, if the length of moment arm GZ in Fig. 88, p. 209, were diminished 1 in (0.025 m), from 3 ft 4 in (1.016 m) to 3 ft 3 in (0.991 m) because of a shift in the relative positions of the centers of gravity and bouyancy, with the Melville careened to starboard, the forces required at the mastheads to careen the ship would have totaled only 2.66 tons (2.71 metric tons) less.⁴⁵

Similar discrepancies in the force required to heave down vessels on one side as compared to the other were

remarked by both King, with reference to the Courageux, and the sailing master of the Constitution in his account of the careening of that vessel (King, 1802: 312; Bass and Bass, 1981: 5). Neither was able to explain why the careening forces were unequal. It can be presumed, however, that using the same tackles and points of attachment of the moving blocks to the masts, the differences in the careening forces resulted from either uneven ballasting or substantial variations in the hull configuration of the port and starboard sides of the ships in question. Both instances would have affected the relative positions of the centers of gravity and bouyancy, and thus the length of the moment arm in the righting moment formula (refer to pp. 201, 202).

Longitudinal Stability

The discussion above has centered on lateral stability, but longitudinal stability, a less obvious matter of concern, was also important. The terminology and forces involved in both lateral and longitudinal stability are similar. Their relevance to careening, however, differed.

The dominant issue with regard to longitudinal stability was not to prevent a vessel from capsizing, since longitudinal stability could hardly have been a

determinative factor, but to bring the ship down with a proper keel angle relative to the waterline in order to minimize strain on any particular element of the ship's rigging or hull by ensuring that all components assumed their fair share of the load. If one of a pair of careening tackles, for example, was to fail as the result of an uneven strain and the vessel spun out while attempting to regain an upright position, its masting and rigging, as well as the facility to which it was hove down, would have been at great risk, as would personnel working in the immediate vicinity.

The importance of proper ballasting

Proper ballasting was important in ensuring proper longitudinal balance and avoiding undue strain. The Melville, for example, was initially ballasted for careening with the view of trimming her down by the head. To this end, 15 tons (15.24 metric tons) of ballast was placed forward in the gunner's storeroom which, added to 10.5 tons (10.67 metric tons) of ballast inadvertently left in the chain locker, gave the ship a draft of 17 ft 1 in (5.206 m) forward, and 17 ft. 2 in (5.233 m) aft. This was an abnormal position for the vessel, since the normal draft of a British "74" of comparable tonnage when in a light condition was 17 ft 6 in (5.334 m) aft and only 13

ft. 5 in (4.089 m) forward (Edye, 1832 :2). The result was an extraordinary strain on the foremast careening tackle culminating in the parting of two of the strands of its fall.

Fortunately, the mainmast tackle was able to take the increased strain until the damage to the foremast fall could be repaired. The ship was righted and then lightened. All the forward ballast was removed, as was the mizzenmast and all remaining removable weight in an effort to reduce the righting moment and thus the required upsetting moment.

Before the ship was heaved down again, the draft was remeasured and found to be 17 ft 6 in (5.334 m) aft and 16 ft 6 in (5.029 m) forward (Harris, 1841: 14, 16-17). Although still substantially, and inexplicably, down by the head with reference to Edye's calculations, the adjusted longitudinal balance must have proved satisfactory as no further difficulty with the careening tackles or rigging is mentioned.

Kegs to conserve weight

For the sake of minimizing weight, rather than adding internal ballast at one end of a vessel to raise its other end, empty kegs occasionally were lashed to a vessel's lee side at the end to be raised. To make the keel of the

Formidable "parallel" to the water when she was hove out, a number of butts were lashed under her fore chains.⁴⁶

Harris, in his abbreviated discussion of the careening of another English warship, the Medina, in 1824, mentioned that several water casks were lashed under its bow on the side to be hove down. As an indication how ballast and bouyancy devices were often used together to achieve a proper longitudinal trim before heaving down, the casks were used in conjunction with 2 tons (2.032 metric tons) of ballast positioned under the poop in the stern, the only ballast that remained aboard (1841: 25).

Balancing of careening forces

It might be thought that the force exerted on individual capstans could have been regulated to allow a vessel to be careened with the proper fore-and-aft trim, but that does not seem to have been the case. King, observing the careening of the Courageux, remarked that "the main-purchase tackles acted almost independently of the fore ones, which sufficiently accounts for the ship being keel out of the water aft, almost as soon as forward" (1802: 311).

This supports the theory that the hammerhead mastcap on the careening barge in the Hamburg diorama (Fig. 10, p. 27) was used to modify excessive strains on tackle and

rigging caused by non-uniform forces applied to the masts of the ship which was being careened, a condition which would have been exacerbated had the vessel not been in proper longitudinal trim before heeling commenced.

Stoppers

Once careened, a properly-trimmed and ballasted vessel normally maintained a state of stable equilibrium, thereby imposing a continuous strain on the careening tackle falls, which tended to stretch or possibly break them. To relieve the falls it was common to stopper the tackles. Stoppers for the careening tackles of an English "72" consisted of pairs of 11- or 13-in (0.279 or 0.330 m) ropes of sufficient length to permit their being fastened to each masthead and secured to the straps of the lower blocks of the careening tackles (Harris, 1841: 13). It was then possible to ease off on the capstans, allowing the stoppers to assume the tension.

BASIC MAINTENANCE AFTER CAREENING

After a ship had been careened to the proper inclination and the tackles stoppered, the falls could be reversed on the capstans in anticipation of righting the ship after work had been completed. The job at hand would progress at a rapid pace, as it was recommended that, if possible, a ship be righted every day to avoid unnecessary strain on its hull and rigging. Harris emphasized this, warning, for example, that if a leak was to be repaired, "the carpenters must be careful not to increase the leak, by undertaking more than they are able to perform, and as a general rule make all as tight as possible before you think of easing up" (Harris, 1841: 14).

In some situations, righting a ship every day was impossible due to the extent of the repairs. The Courageux, for instance, required the installation of a new keel, and for that to be accomplished, the ship remained hove down keel out on its larboard side 18 days without being righted.

Commenting on this, King remarked that the Courageux was hove down in a tideless basin, which lessened the tendency of the fore- and mainmast careening tackle falls to stretch at different rates. This consequently made a difference in the number of adjustments necessary,

although the falls still required monitoring (1802: 312).

A vessel might have been hove down for any of a number of reasons, but having gone to all the trouble attending that event, with the need evident and time permitting, it was an improvident captain that did not have at least basic maintenance performed on the hull. This merely might have been cleaning the bottom of marine growth, then regravings it, or it might have involved the more complicated process of recaulking leaking seams, which first would have required the removal of any existing sheathing in the area to be treated.

The opportunity might have been taken also to try to rid the ship of vermin. For example, when Captain Porter careened the American frigate Essex in the Marquesas in 1813, he had charcoal fires lit in the holds whereby some 1500 rats were asphyxiated. Relief, however, was only temporary, as shortly thereafter the ship was reinfested with local cockroaches (Gruppe, 1979: 119).

Sheathing

Wood

From the 1500s until copper sheathing became commonplace, the most common method of preserving ships' bottoms from the ravages of "the Worm," as the teredo worm

was somewhat apprehensively called, was to use auxiliary wood sheathing as an expendable line of first resistance.

Wood sheathing usually consisted of thin boards seldom more than 1 1/2 in thick, fir and elm being the two most commonly-mentioned woods used on English vessels. It was the practice after 1600 to smear the inside of the boards thickly with tar followed by a layer of hair (probably horse hair) of a similar thickness before the boards were nailed to the ship's hull. Sometimes, in place of tar and hair, brown paper dipped in tar and oil was used (Fincham, 1821: 297).

The addition of the tar and hair is said to have been initiated by Sir Richard Hawkins, who believed that "when the worm passed through the outer board, the hair and the tar so involve him that he is choked therewith" and credited his father, Sir John Hawkins, with the original idea (Chatterton, 1926: 85-86, 93). Sir John may actually have invented the procedure, but its elements were used similarly much earlier. Chatterton himself mentions the use of tarred sailcloth between the lead sheathing and planking on ancient Greek vessels (1913: 30) and the hair of a wild animal followed by an application of tar to caulk the seams of the Broesen ship, a clinker-built Viking vessel found near Danzig in the 1870s (1914: 117).

Lead

Lead was sporadically used as a sheathing material over the centuries. A certain Moschion, who gave an account of the building of a vessel which was supervised by the mathematician Archimedes, described "lead sheets" for sheathing, and Casson remarked that there have been a number of early wrecks yielding evidence of lead sheathing over a layer of pitch-impregnated fabric (1971: 194-95). Physical evidence of the early use of lead sheathing is provided by the late-4th-century BC Greek merchant ship excavated at Kyrenia, Cyprus. That vessel bore a lead sheathing of apparently uniform thickness (1 mm) over the entire preserved portion of its hull. The sheathing was affixed to the hull with copper tacks and underlaid with simply-woven agave leaves which had been saturated in a red-brown resinous pitch (Steffy, 1985: 83-84).

The first use of lead sheathing in modern naval history was by the Spaniards in 1514, according to Navarrete, while the first English ships to use it were fitted out in 1553 and sent under the command of Sir Hugh Willoughby to discover a north-east passage to China (Creuze, 1846: xiii). In 1519 Magellan carried 2100 lbs (952.56 kg) of lead on his circumnavigation, although the expressed reason for bringing it was not for use as a full sheathing but to make it into strips to be run along the

seams so the caulking would be prevented from falling out as the ship worked. Towards the close of the 16th century, mention was made by Sarmiento de Gamboa of covering the entire bottom of a vessel with "metal plates," probably lead (Meigs, 1924: 350).

After an apparent period of disuse, a temporary revival occurred in the late-1600s with the invention of milled lead, said by its promoters to cost very little more than "a good 'streights' sheathing and not above half so much as an 'East-India' sheathing" (Howard and Watson, 1691: 69).⁴⁷ A slightly later publication, further extolling its virtues, held that it was also of a more uniform thickness than cast lead and consequently stronger (Hale, 1695). The constant thickness of the lead sheathing recovered from the Kyrenia wreck must, however, cast some doubt on that claim.

The first application of milled lead was to HMS Phoenix in 1670, and by 1691, 20 ships had been sheathed with the material, which was fastened to the bottom with copper nails (Fincham, 1979: 94). Corrosion of iron bolts and the rudder gudgeons and pintles, however, caused high ranking naval officers to call for the discontinuation of the use of milled lead.

By the end of the 17th century, the practice, for English vessels making a long voyage, was to sheath the underwater body with boards over the paying stuff and to

cover only the keel and the lower part of the rudder with lead. This was usually applied in the form of large-headed nails driven well into the timbers, but a strip of lead was occasionally employed along the waterline (Roome, 1984: personal correspondence). Full lead sheathing was, however, still used intermittently for almost another 100 years until, in 1770, one of the last ships to be sheathed with milled lead, the Marlborough, was examined. Her sheathing was found to be almost completely gone, and the determination finally was made that the metal was too soft for the purpose for which it was engaged, and its use was discontinued (Fincham, 1979: 95).

Copper

Copper sheathing was a relatively late arrival in the era of large sailing ships. It was first used on HMS Alarm in 1761 on Admiral Anson's direct orders (Walter, 1928: xxi), doubtless the result of earlier experiences on his cruise around the world. But it was not until 1783, when the replacement of iron hull bolts with mixed-metal bolts was mandated by the Admiralty in all ships of 44 guns and less, and later in the same year extended to all classes of warships, that the problem of corrosion caused by electrolysis was eliminated and copper sheathing gained general acceptance (Fincham, 1979: 97; Roome, 1984:

personal correspondence). Mixed-metal was the term given to an alloy of copper and tin (Abell, 1962: 97), the two primary elements in bronze.

Copper sheathing was made in several different sizes and weights which were applied to different parts of the ship. Large, early-19th-century English ships had sheets 14 in (0.356 m) by 4 ft (1.219 m), weighing 32 oz (0.907 kg) per square ft (0.093 square meters), tacked along their waterline and bows, while sheets of the same size, but weighing 28 oz (0.794 kg) per square ft (0.093 square meters), were used in other areas. Smaller vessels used copper sheets 20 in (0.508 m) by 4 ft (1.219 m), weighing 18 oz (0.510 kg) per square ft (0.093 square meters), throughout (Fincham, 1821: 297).

The sheets were installed with small copper nails so that the after end of one sheet overlapped the fore-end of another and the edge of an upper sheet overlapped the edge of a lower one.

The acceptance of copper sheathing was by no means universal; at least one seaman, who preferred to remain anonymous, expressed his views in a pamphlet which he had published. In it he observed that "the coppering of ships is become so pernicious in its consequences, that nothing but a total suppression of so ruinious an application can possibly restore the navy to its original strength and safety...". The writer contended that the seams of a

vessel were the places where leakage generally occurred and that the caulking used was both water-soaked and rotten. He further argued that, during the period when otherwise fit vessels had their iron bolts removed and replaced with bronze preparatory to sheathing them with copper, their bottoms were not properly inspected nor could they be once the copper was in place (Stockdale, 1795: 9-20).

While the criticisms of the anonymous author above may have been justifiable, copper sheathing remained the standard on British warships until sometime after the invention of Muntz metal in 1832. Muntz metal consisted of a 60%:40% alloy of copper and zinc respectively (Cubberly, 1979: 467), the two essential ingredients of brass, and was applied to the hull in sheet form in a manner similar to copper. It was tougher than pure copper and apparently somewhat cheaper, since it received the sobriquet "poor-mans sheathing" (Steffy, 1986).

Breaming

Whether sheathed or not, if a ship had been in the water for a considerable time since its last overhaul, and a scrubbing device such as those in Figs. 6 and 7, pp. 17, 18, had not been used, its hull would have required at least the removal of the weed and barnacles which would

have substantially diminished the speed of the ship. This was especially true if the vessel had spent any length of time in tropical waters. On vessels whose bottoms were sheathed with wood, this was ordinarily accomplished by the process of breaming.

Techniques used

Breaming involved heating the residual bottom coating of the hull to loosen it and then scraping it off along with the marine growth clinging to it. Before coppering ships' bottoms became common, it was "a necessary and frequent operation" (Kemp, 1976: 107), to be accomplished each time a vessel needing regravings. Wood sheathing could be expected to last between three and four years before needing replacement, and regravings might be required once or twice each year according to Mr. Hale (1695: 3). Hale's figures should be approached cautiously, however, as they were used in his comparison of the expense of milled lead to that of wood sheathing. In view of his motive for quoting them, they might be expected to be somewhat less than the actual figures.

In any event, the longevity of both wood sheathing and graves would have varied with the area within which the ship habitually sailed. Those ships spending most of their time in tropical waters could be expected to suffer

a much more rapid build-up of marine growth than vessels normally operated in northern waters.

Small, beached vessels could be breamed by using brush-fires lit on shore beneath the exposed portion of the hull (Kemp, 1976: 106; see Fig. 92). Similarly, when breaming larger ships, fires were sometimes lit directly on the work floats beneath the exposed portion of the

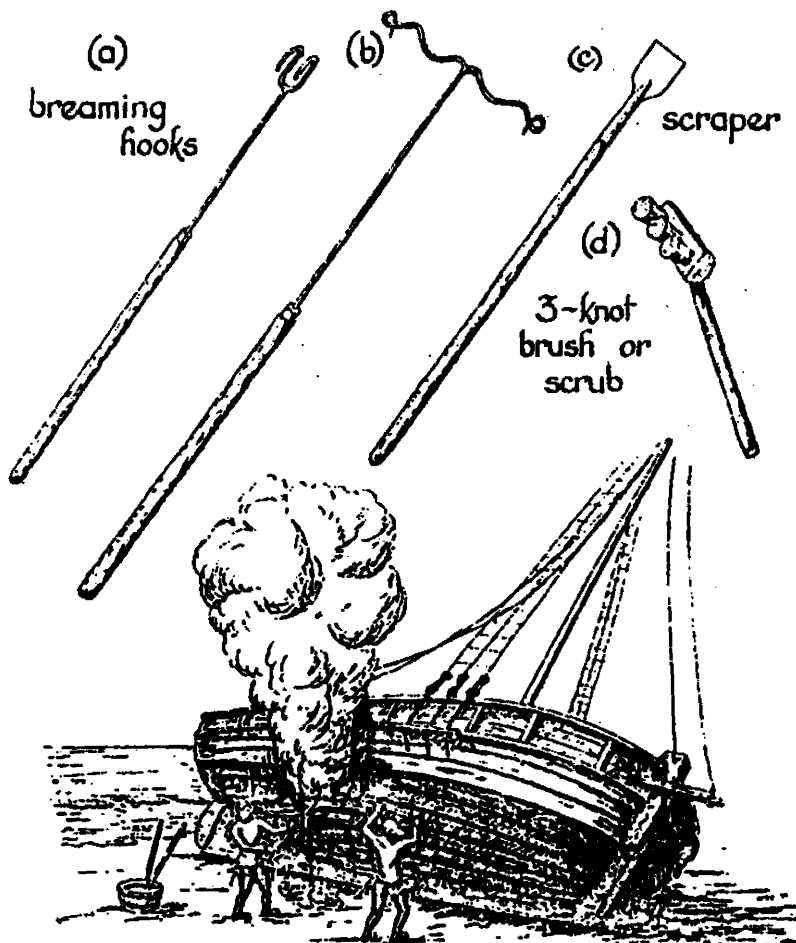


Figure 92. "Breaming a small sailing vessel before graving or re-tarring." Note the fire beneath the vessel's hull. From Horsely (1978, fig. 40).

hull. Fig. 93, shows men building low tepees of reeds, straw, or broom--a European shrub from which the term "breaming" was derived--on the float along the length of the ship's hull preparatory to being lit as the work progressed.



Figure 93. Breaming an early-18th-century Dutch ship. Etching by R. Nooms, c. 1630-40. Courtesy of the Rijksmuseum. Photograph No. 22,176.

Obviously breaming, at least as shown in Fig. 92, p. 240, and Fig. 93, was "an operation not unattended by danger, and many a wooden ship in olden days has been set on fire and destroyed by breaming" (Kemp, 1976: 106). At

the very least, some charring of the hull could have been expected.

Alternatively, fires would be lit in iron containers, an approach that had at least two obvious advantages over the first method. It was considerably safer than lighting a fire under the hull, since the flame used to ignite the broom could be kept clear of the hull thereby minimizing the danger. Fires in iron containers were more efficient as well, because the fire could be easily moved to where heat was required.

Whether the fire was contained or not, the procedure called for men to hold lit bundles of broom in order to apply heat locally while others scraped away the residue of the marine growth and softened bottom coating.

Tools

Fig. 92, p. 240, illustrates some of the tools employed to bream vessels during the 19th century. The first man holds a breaming hook (a) or (b) on which is entwined burning reed or broom. The second man uses a scraper (c) to remove most of the old graving. He would then use the scrub (d) to remove the remainder so that the new graving would adhere better (Manwaring and Perrin, 1922: 109). In earlier times, a bundle of broom simply would be tightly tied and held from the end instead of

fastening the loose material to a breaming hook (see Fig. 93, p. 241).

Fig. 93, p. 241, which shows the breaming of an early-17th-century Dutch vessel, was used as the first of two plates in a somewhat later publication (Mortier, 1719: 92-3, pl. XXV). The associated text included a statement that Noom's etching does not support, namely that the fire was contained in several pots and was fueled with small pieces of wood. In other matters, including a notation that the heat was not to be spared, the description seemed to be accurate.

The two small structures on the float at the bow of the ship were said to have contained tar which was used to impregnate wood and rope to protect against wind, water, and sun. Similar structures can be seen on the float at the left of Fig. 15, p. 30.

Precautions

Since the essence of breaming was the application of an open flame to the combustible part of the substance with which the bottom had been graved, and since the flammability of the substance could vary according to its composition, there was always the possibility that a fire could erupt and quickly get out of control no matter how carefully the operation proceeded.

As a precaution against the spread of fire to the interior of the ship, the ports, scuttles, scuppers and any other openings above the waterline on the side of the ship to be worked on would be stopped up and the joints sealed with clay or some other nonflammable agent before breaming began (Fincham, 1821: 218).

A careening at Brest (Fig. 94) shows fire pumps being employed from two small boats. Each boat contains a pyramidal-shaped, double-handled pump in its center and four men to man the pump, two men at either end. A hose



Figure 94. Detail of a French ship being breamed from "Vue Du Port De Brest En 1776." Courtesy of the Musée De La Marine, Photograph No. 44,266.

leads from either pump and is held by two men standing on the float just to the left of the billow of smoke. Fig. 95 shows a slightly earlier breaming taking place in front of the King in mid-18th-century France. Note the pump employed to prevent the ship from catching on fire and to

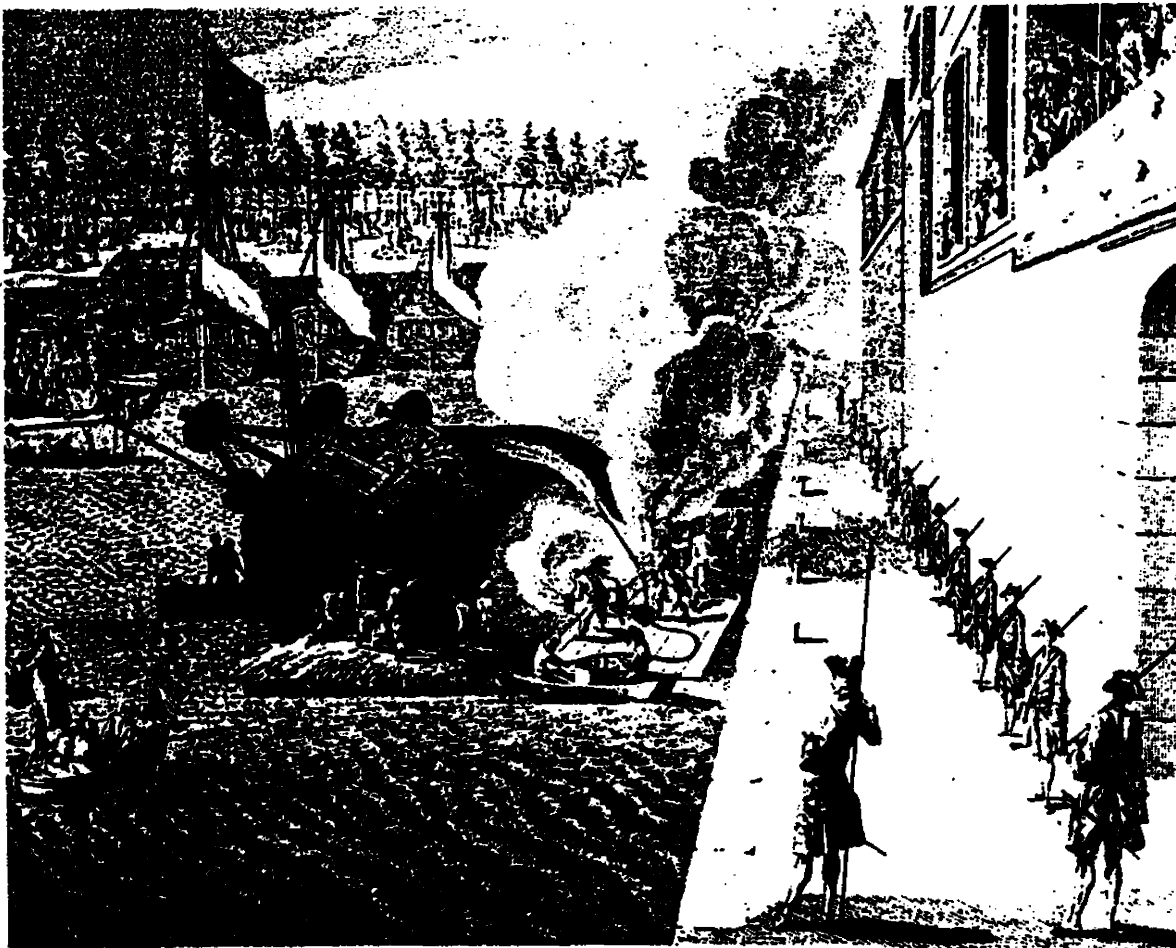


Figure 95. French ship being breamed in view of the King at Havre, France. Engraving by Jacques Phillippe Le Bas, 1752, after a painting by Descamps, 1749. Courtesy of the Mariners' Museum, Newport.

keep the upper works wet down. These two illustrations of French ships were the only ones which showed fire-pumps being utilized during breaming, although it seems inconceivable that such an elemental precaution would not have been commonly taken.

Graving

Ships that were unsheathed or sheathed with wood had a protective application of graving material applied to their hulls or sheathing.

In the past, the term graving was used interchangeably with breaming (Burney, 1974: 168; Kemp, 1976: 350; Manwayring, 1972: 46), but actually it was a separate process: the application of a semi-viscous coating, known as graves, to the hull or wood sheathing as a final protection against marine organisms and to make the bottom "smooth and slippery, so as to divide the fluid more readily" (Burney, 1974: 56-57). Unquestionably, the slipperiness of the hull was a by-product of the reduction in marine growth and not a function of the graves itself.

Composition

Graves could be made of different products, although it all came to be classified under the general description

of tar. Henry Manwayring, in 1644, mentioned the use of tallow alone, tallow and soap together, and train oil, rosin and brimstone boiled together, as three possible mixtures. He preferred the latter mixture as he thought the former two "will quickly grow foul" (Mainwaring, 1972: 46; Manwayring and Perrin, 1922, vol. 2: 157).

In 1668, reference was made to a kettle of rosin and tallow melted together for use in graving the Monmouth's bottom in the context of remarks made about the frigate's near loss to fire when the mixture boiled over onto the deck (Lubbock, 1934: 161).

In 1711, the English ship designer William Sutherland gave two formulas for the graves for a 1000-ton ship. The first consisted of 11 cwt. of tallow mixed with blacking made up of six barrels of pitch and three barrels each of blacking and tar. The second formula used 19 cwt. of resin mixed with 2 1/2 cwt. of brimstone (sulfur) and 25 gallons of oil (Abell, 1962: 91, 206).⁴⁸ Blanckley (1750: 117) called for a mixture of tallow, pitch, rosin, and brimstone boiled together.

From the foregoing, the prime requirements for the ingredients of graves, within a compositional spectrum including sulfur, soap, pitch, and/or tar, seem to have been availability, an ability to adhere to the bottom of a ship for a long time, and a high degree of offensiveness to marine organisms. The substance was applied hot and,

depending on its viscosity, was swabbed or troweled onto the hull.

Demise of graving and breaming

Following the advent of copper sheathing, the practices of graving and breaming gradually became obsolete. Fig. 49, p. 86, shows men applying hot pitch to the hull of the American whaleship Sunbeam. This, however could not be considered graving in the true sense of the term, since the tarring was not applied as a line of first resistance. Techniques had apparently changed by that time since, after the Sunbeam was recaulked, the pitch was applied and then overlaid by a felt base. One-inch (0.025 m) pine sheathing was then nailed over the felt and covered with copper sheathing (Church, 1938: 25).

Coppered ships' bottoms still had to be cleaned, but that could usually be accomplished by vigorous scraping. The bottom of the Essex, for example, following her careening in the South Pacific, was cleaned by islanders wielding coconut shells (Gruppe, 1979: 119).

Recaulking

If a ship's sheathing needed replacement or if its seams had been found to be leaking (most easily determined

from inside the hull before careening) and recaulking was required, the old sheathing was removed. For those vessels sheathed with wood, the practice credited to Hawkins of smearing the inside face of the sheathing boards with tar, then adding a thick layer of hair so that the hair lay against the hull of the ship, probably eliminated the need to bream again once the planks were removed.

Recaulking required several steps and a variety of tools. Among the ones most commonly used are those illustrated in Fig. 96.

After removing the necessary sheathing, the first step in recaulking a vessel was the removal of the old caulking. This was done with a tool called a rake or hoe (s). Jerry or clearing irons (k and l) were then used to clear any remaining material from the seams. The irons were about 1 ft (0.305 m) long and were tapered from front to back to avoid jamming as they were driven along the seams. If the oakum was too hard to be removed with a clearing iron, a sharp-bladed iron (c) would be used to cut it out. Where treenails had to be replaced, a treenail (trunnel) iron (a) would be used to split the end of the new treenail after it had been installed to firm it in place. A spike iron (b) was used to caulk the treenail where it had been split.

After the seams had been cleared they were then opened with reaming (raming) irons to receive new

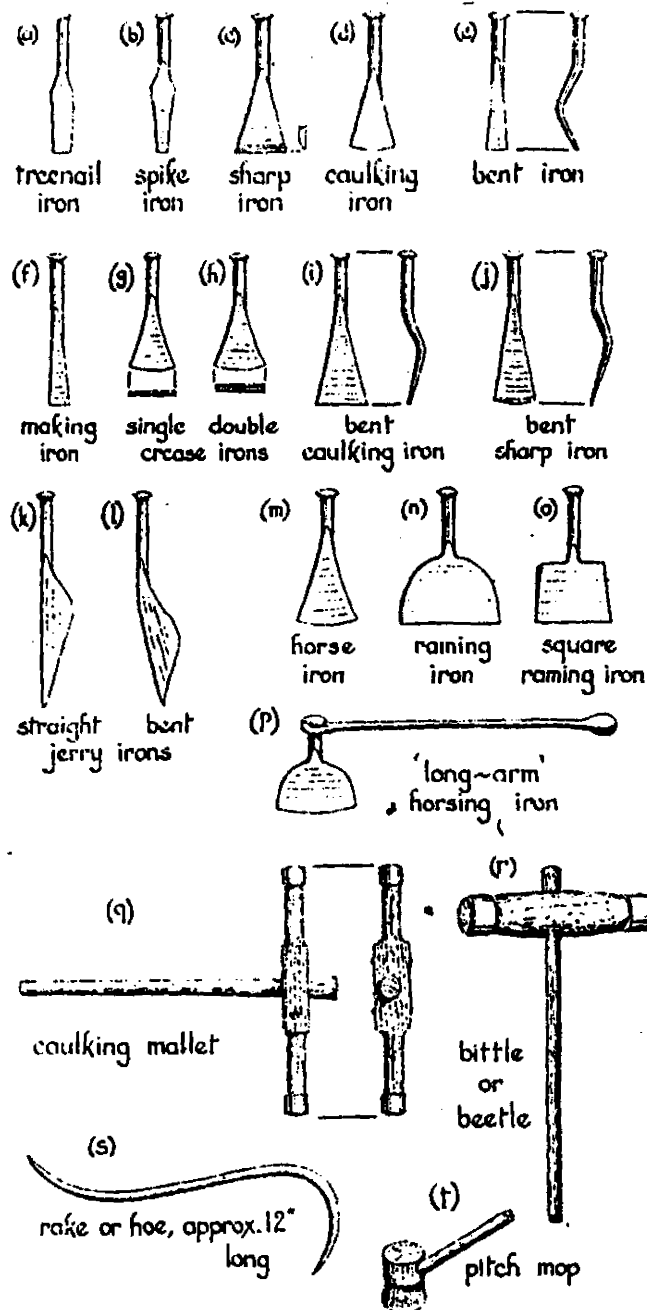


Figure 96. Caulking tools. From Horsely (1978: fig. 39 I, II).

caulking. These irons were either curved (n) or square (o) in style and had a blade length of about 9 in (0.229 m).

Once the seams were opened, teams of caulkers, swinging their mallets in rhythm, would drive oakum into the seams with caulking irons (d). Special caulking irons (e and i) were used in awkward areas. Oakum was customarily driven in from left to right.

When the oakum was in place, it would be hardened down with making irons (f, g, and h). Horsing irons, (m and p), were enlarged versions of making irons. The first was used for thicker than normal planking, while the second, called a long-arm horsing iron, employed two men, one to hold the iron, the other to swing a large, heavy beetle or hammer which was applied to its head.

Two different versions of long-arm horsing irons are seen in Fig. 97a. Fig. 97b, the upper of the two shows the square portion of the shank directly above the blade. The upper half of the shank was rounded, allowing the blade to be rotated in the iron handle within an opening conforming to the square portion of the shank below. The blade could be positioned in the seam in a way that enabled the man holding the iron to keep to one side and out of the way of the man wielding the hammer, yet still permit him to hold the blade firmly in position. The bottom iron in Fig. 97a shows an iron in striking position.

Care had to be taken not to make the seam too

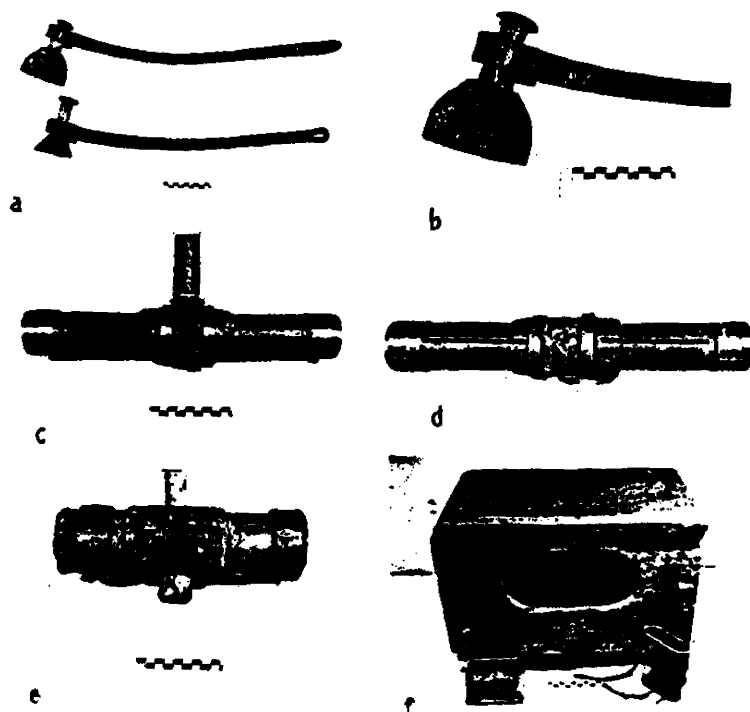


Figure 97. Late-19th-century caulking paraphernalia in the Bath Maritime Museum, Maine. Scale in centimeters. M. Goelet.

tight, or it could spring the plank or even shear off fastenings. On the other hand, if the seam was not made tight enough, it could leak. Making was normally accomplished by working from right to left.

After the oakum had been hardened down, the seams would be payed with hot pitch applied with a pitch mop (Fig. 96t, p. 250).

Fig. 97c is an example of a caulking mallet with a

handle about 15 in (0.381 m) long. Both ends of the hammer are bound with metal to prevent them from flaying with use and were used alternately to ensure even wear. They were built of a hard, tough wood such as *lignum vitae*, black mesquite, beech, or live oak (Horsely, 1978: 125; Story, 1964: 24-25). English and American examples dating from the 19th century, and perhaps examples from other countries and periods as well, had slots extending completely through their heads from one side to the other (figs. 96q and 97d, pp. 250, 252). Although the reason for the slots has been obscured by time, Mr. Dana Story (1985), who wrote a book about the shipyards of Essex (1964), much of it based upon personal recollection, suggested that they were cut to provide the proper resiliency to the mallet.

Horsely remarked that the slots usually had one or more round holes through their centers (fig. 96q, p. 250), although this is not evident in Fig. 97d, p. 252, and that the number and size of the holes and the lengths of the slots were used to tune the mallets, each one producing a distinctive musical note. He further noted the theory that without the slots and holes to tune each mallet differently, the noise made by a crew of caulkers would have soon deafened them (Horsely, 1978: 125).

Caulking mallet heads recovered from the French frigate Machault (Fig. 98) (which sank in Quebec province

in 1760 [Ross, 1981]), when viewed from the side, have a different shape than the examples in Figs. 96q and 97c, pp. 250, 252. They also show a curvature, absent in the others, which is probably not wholly attributable to their

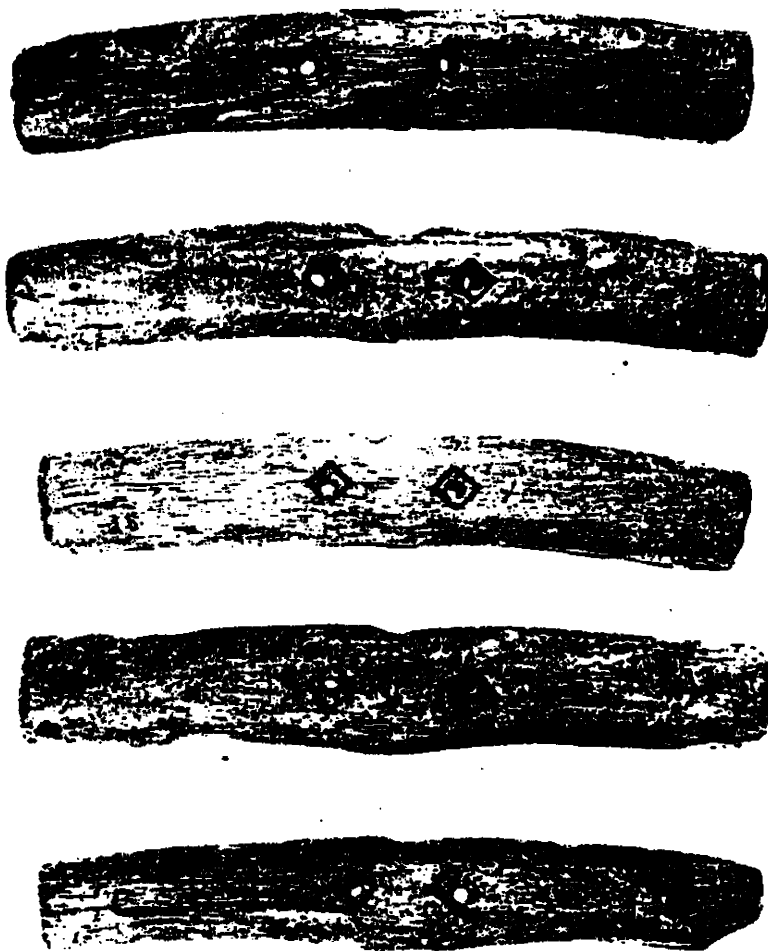


Figure 98. Caulking mallet heads from Le Machault.
From Ross (1981: 66, fig. 7).

long period of submersion. It is likely that the two holes through the sides of the mallets in Fig. 98, p. 254, were used to reinforce the handles in some way; perhaps they accomodated bolts which may have extended through wood or metal collars similar to the collar around the mid-section of the one in Fig. 97c-d, p. 252.

It cannot be seen from Fig. 98, p. 254, whether or not the mallet heads found aboard the Machault had slots. This would be valuable information, since an item displaying specific design elements, if found in a datable context and a context which makes the item's place of manufacture probable, can help identify future sites.

The tool in Fig. 97e, p. 252, is an example of a beetle or caulking hammer used for heavy work. Sometimes these were made from caulking mallets whose ends had worn to a point where they were no longer serviceable. The one shown, however, seems to have always been a beetle, since it appears too heavy to have ever been used as a caulking mallet. It may, for instance, have been used to drive clearing irons. Heavier versions used with long armed horsing irons sometimes weighed over 12 lb (5.44 kg) and had handles approximately 39 in (0.991 m) in length. The ends of their heads, like those of caulking mallets, were also bound with metal to prevent splitting.

Fig. 97f, p. 252, is an example of a caulker's tool box. It contained his caulking mallet and irons, which

were often identified with the owner's name or initials. In front of the tool box are tins filled with beeswax into which he would dip his caulking irons to prevent them from sticking to the tar-covered oakum. The top of the box consists of a piece of tautly-stretched leather fastened to the sides with copper tacks. This formed a seat where, in inclement weather, he might spend his days laboriously picking apart old rope and spinning oakum from the hemp fiber by rolling it across his leather-aproned knees. A minor example of the artistic self-expression that was so common among those connected with the sea is the brass heart which adorns the box just below the opening.

Final Procedures

After recaulking, the ship's hull was often resheathed. If the sheathing was of wood, it was payed over with graves. When the graving was completed, the stoppers were removed, the careening-tackle falls having been reversed on the capstans earlier. If necessary, the relieving tackle would be manned to help start the vessel upright. Slowly and steadily, care being taken to avoid surging of the falls, the capstans were backed and the ship eased upright in preparation for the reballasting, rerigging, and restowing of all the paraphernalia necessary to make the vessel once again seaworthy.

SUMMARY

Each of the general procedures undertaken during the careening of a ship can be characterised as having been universal rather than endemic to a particular nation or geographic area. The preliminary steps of ballast removal, the patching over and caulking of openings on the leeward side, and the concepts of heaving a ship down by its masts and supporting the rigging while this was being done were fundamental and constant. From the 1500s to the 20th century, changes in careening techniques, which had more potential for variety, were in the nature of modifications of extant practices rather than sharp divergencies from them.

Overall complexity, as judged by the variety of procedures and techniques employed and the dimensions and numbers of the paraphernalia used in careening a single vessel, reached a peak between roughly the 1740s and 1840s. It resulted more from the general increase in the size of ships and their greater stability than from the introduction of new equipment or novel careening methods.

This is not meant to suggest that techniques and careening equipage did not improve after that period. Advances born of the industrial revolution permitted increases in the lightness and strength of both a vessel's

hull and rigging; changes which permitted it to be more easily and safely careened. Examples of these improvements are the invention of wire rope, which replaced fiber rope in a ship's standing rigging, and composite hull construction. Service vessels also took advantage of new technology, exemplified by the sophisticated hammerhead mastcap and the complicated arrangement of the careening tackle falls on the Hamburg barge (Fig. 46, p. 83). As suggested earlier, it is unlikely that the system could have operated had wire rope not been used for the tackle falls.

But the industrial revolution, while it permitted a general simplification of the careening process, also wrote its obituary. Inventions, such as the steam engine, presaged the demise of large sailing ships and permitted in any case the use of methods other than careening for bottom maintenance.

Some careening techniques were more common to one area than another. In Denmark and Sweden there was a predilection toward A-frame shores to bracket the masts, and the practice favored by Dutch seamen through the centuries was to heave down their vessels against barges, often two of them, rather than against the land or a wharf. But there seems to be no case where a specific technique was uniquely applied to ships of a particular nationality. Mast shores were ubiquitous, as was the use

of floating craft to careen against. In conditions where no other method of careening was available, nations which normally refrained from using floating craft (such as the United States) would have been forced to do so. The lack of uniqueness in careening techniques can probably be explained by the rapidity with which improvements in any of the myriad aspects of seamanship could be transmitted and added to the fund of general knowledge among the seafaring fraternity.

Since I observed no substantial variations in careening technology among the nations whose ships I studied, it is reasonable to suppose that the kinds of carpentry and caulking tools used also did not vary greatly, although, over time, they may well have changed in physical detail (as in the shapes of the heads and/or wood composition of caulking mallets, as seen from Figs. 96q, 97c-d, and 98, pp. 250, 252, 254).

Innovations having to do with careening, while not rare, were applied selectively, most often when the more common solution to a problem was, for some reason, found to be non-viable. Such innovations, however, were not used with enough frequency to become incorporated into ordinary usage. The still-puzzling weather-mast shores that were apparently used on the Brandywine are a case in point.

CONCLUSIONS

The general universality of careening procedures makes it relatively easy to understand how vessels of the various nationalities included in this study were heaved down. Conversely, the same phenomenon would make it difficult for an archaeologist to use his knowledge of careening procedures to answer specific questions such as whether or not a certain ship was heaved down at a particular careenage. Since the procedures themselves were of a transitory nature in any event, little or no physical evidence of the use of a specific method would have survived. The advantage to an archaeologist of understanding the general techniques used in heaving down ships lies more in his potential ability to recognize artifacts that were commonly associated with the careening operation, and thus be able to identify a site as having been used as a careenage.

In areas where formal careenages were non-existent, a site that was commonly used may not have been documented and, through time and disuse, its exact location could have become lost. Evidence of discarded careening implements, perhaps an exceptionally long span bolt, or parts of one or more very large blocks built especially for a specific careening, then discarded, could

reestablish its location. Items such as maintenance tools or elements of discarded sheathing found in context with a site that met the conditions favored for a careenage would be strong indicators of its past usage. Supporting evidence such as the debris associated with a temporary encampment also would help identify the site.

Other than the evidence supplied by the recovery of personal-type artifacts, it remains for the surviving careening paraphernalia itself, by sophisticated comparisons to similar elements previously documented, to date a careenage, and to identify the nationality of the ship or ships which predominantly used it. These comparisons might be of such diverse elements as the design and material composition of blocks, and the types and designs of maintenance tools used by various nations at different times. Hole-punch patterns in metal sheathing where it was tacked to the hull seem to have varied among nations and might also help determine when the careening occurred, as might a thorough analysis of the composition of the sheathing. If detailed studies of such careening and maintenance equipage do not now exist, it is highly recommended that they be initiated.

NOTES

[1] The conversation took place in St. Thomas, U.S. Virgin Islands, in 1985.

[2] An exception to this phenomenon is Burney's 1815 enlargement of Falconer's original dictionary (1974).

[3] Boottopping, a later shortened terminology for boot-hose topping, was the application of graving material such as tallow, or mixtures of tallow, sulphur, resin, etc., to those strakes of a ship's hull at and immediately below the waterline, after scraping them clear of grass, slime, and shells (Knight, 1939: 237-38). Burney (1974: 52) did not limit his definition to the three strakes below the waterline, stating that the process involved heeling the ship first to one side, then the other, as far as safety permitted.

[4] This was a major concern of Anson's when he was forced to careen his British flagship, the Centurion, in the Philippines during his voyage around the world in the early 1740s. He was afraid the Spanish would take the opportunity to destroy her. His fear was justified as the Spanish Council in Manila had considered contracting with the captain of another vessel to burn the Centurion while she was careened, payment receivable upon completion of the job. The Manila merchants who were to put up the money, suspecting a plot to bilk them, balked and the plan was dropped. But for the merchants' perceived cupidity of the Governor and his Council, probably justified by past experience, the Centurion would have been in great danger (Walter, 1928: 346-47).

[5] The docks Mainwaring referred to were probably drydocks. Graving places, in context, probably referred to places a ship could be sewed (run aground) at high tide and graved on the ebb. No indication is given as to the size of the ships to which he referred, and they may well have been small compared to some of the larger ships of his day.

[6] The Brandywine was a 44-gun frigate launched in 1825 and burnt in Norfolk in 1861 at the outbreak of the Civil War (Chapelle, 1949: 534). Therefore, the careening

described by Admiral Luce took place between those years. Both the Brooklyn Navy Yard and the Charleston Navy yard in Boston (at least through 1825) incorporated formal heaving-down facilities complete with permanent careening pits similar to those shown in the diagram of the British West Indian careenage at English Harbor, Antigua (Fig. 67, p. 154).

[7] On one occasion, while the Melville was being careened, 268 tons (272.29 mt) of water leaked into the ship in 96 minutes, even though nine hand pumps and five engines were at work during that time. When righted, it took 210 minutes, at the rate of 1.25 tons (1.27 metric tons) per minute to free her of water (Harris, 1841: 19). The term ton in this thesis means the long ton of 2240 lbs. (1.016 metric tons).

[8] The lower and orlop decks of the Melville were scuttled to allow the pumps to be set at the required angle of about 37° above the horizon, with their ends a little below the orlop wing gratings (Harris, 1841: 10). One of the upper pumps of the two pairs illustrated in Fig. 25, p. 44, is shown positioned so as not to require the lower deck to be scuttled.

[9] See Burney (1974: 263, pl. XVI, no. 4) and Gill (1932, pl. II-IV) for a description and illustrations of built-up masts and side and front fishes.

[10] Howard (1979: Fig. 241) illustrates a painting which, at first glance, appears identical to Fig. 36, p. 61, but, on close examination, varies in some of its details. It quite clearly shows mast shores. Howard states that the painting is by Botticelli but does not document it in his List of Illustrations, and it is possible that the painting is a later copy of the original fresco in the Sistine Chapel.

[11] King (1802: 308) refers to the Courageux as a ship of the line. A ship of the line was a ship of one of the first three rates, by British standards. Even if the Courageux fell within the lowest or third-rate category, a ship of her vintage carried between 70 and 84 guns compared to the Brandywine's 44 guns (Kemp, 1976: 692 and 788; Chappelle, 1935: 114 and 127). King (1802: 310) gives the length of the longer mast shore

used for the Courageux as 50 French feet, and the proportion between French and English feet as 13 to 14, yielding for the shore a length of approximately 54 English feet (16.46 m).

[12] Van Konijnburg describes a kof as a merchant vessel ranging in tonnage from 70-150 lasts at the end of the nineteenth century (1895-1905, Vol.I: 81-82). He defines a last as 2.2 tons (1895-1905: 46).

A Swedish frigate of the period was not necessarily a warship, and, as evidenced by Fig. 44, p. 81, neither were Dutch fregats. In the late 1700s, the burdens of various Swedish merchant frigates ranged from 532 lasts for a first-class, ship-rigged vessel to 29 lasts for the smallest sloop-rigged craft (Chapman, 1979: 11-17, pl. I-VII and pl. LXII). Chapman defines a Swedish "heavy last" as a measurement of burden equal to 2.4 long tons (1979, 5).

[13] The term "to set up the rigging," as defined by Burney (1974: 448), is to extend the rigging more firmly than before, by mechanical means, in order to secure the masts. Probably a tackle of some nature or possibly a Spanish windlass was employed for the purpose.

[14] Measurement courtesy of William Bayreuther, curator of the Constitution Museum.

[15] Wire rope was originally used in the Hartz Mountains for mining operations about 1831, and by 1857, three quarters of the ships rigged in Liverpool used wire rope for their standing rigging. It was cheaper, lighter, less bulky, and lasted longer than fiber rope of similar strength (Luce, 1863: 51).

[16] Mr. Joseph Roome is curator of the Water Transportation Department, Kensington Science Museum, London. He gives a date of about 1851 for the first use of composite construction.

[17] Forelocks were thin wedges of iron driven through a hole in the end of a bolt to prevent it from being drawn (Burney, 1974: 157). They served the same purpose as modern-day cotter pins, but differed from cotter pins in that they did not splay at their ends.

[18] A span was the equivalent of 9 in (0.229 m). The bolts Harris described were, therefore, 90 in (2.29 m) long.

[19] Edey (1832: 2) gives the breadth for tonnage of an 80-gun English warship of the period as 51 ft 5 1/4 in (15.68 m). According to Fincham's list (1979: 401), only one English "84" was built in 1825, the date Moore (1926: pl. 55) gives for the launching of the Melville. Its tonnage of 2285 (Moore gives it at 2289) was slightly more than 200 tons greater than that of an 80-gun ship at that time (2082), so its beam must have been at least that given by Edey (Fincham, 1979: 401; Moore, 1926: 56). Boudriot (1976: 33) gives the breadth measurement of the Artemise as 43 ft 2 in (13.16 m).

Using the formula, tons burden (in long tons) = keel length x breadth x 1/2 breadth divided by 94, recommended by Steffy (n.d.) for 19th-century ships, I calculate a burden of 2279 long tons (2315.46 metric tons) for an 80-gun English ship. Applying the same formula to the dimensions of the Artemise given by Boudriot, I obtain a tonnage of 1692 (1719.07 metric tons).

See Taylor (1977: 44-61) for a thorough discussion of the effects of increased beam and freeboard on a vessel's stability.

[20] Fincham (1979: 256, 267-72), consolidating the results of a commission appointed in 1833 by the French minister of marine to compare French and English warships, provides tables establishing that French vessels were generally narrower, taller-masted, and carried more ballast than English vessels of comparable fire-power.

[21] In 1697, Paul Hoste, a professor of mathematics at the royal seminary in Toulon, France, published his Theorie de la Construction des Vaisseaux, a work concerned with the theory of naval architecture. Fincham considered it to be the first attempt "at bringing the construction of ships under the ruling power of mathematical science." Hoste discussed, among other subjects, ballasting, center of gravity, transverse and longitudinal stability, and the wind/sail-generated forces acting upon the masts to incline a ship (Fincham, 1979: xv-xix). Hoste was primarily interested in the effects of these themes on the sailing characteristics of vessels, but their applicability to the concerns of stability during careening is obvious.

Van Konijnenburg states that drawing was used in

connection with shipbuilding at the middle of the 18th century (1895-1905: vol. 1: 54-55), although Howard (1979: 132 and 134) illustrates original lines drawings of the Royal Louis said to date from 1692. Ship plans of an earlier date can be found (see c. 1586 plans of an English ship by Matthew Baker, in Rule, 1983: 108), but these did not incorporate lines drawings as we now understand them.

[22] Edye (1832: 2) gave the burthen of an English 74-gun ship as 1741 tons (1832: 2). I calculate from a table provided by Fincham (1979: 401) that the average displacement of each of the eight British "72s" extant in 1840 was 1755 tons (1783 metric tons).

[23] Jeer blocks were part of the tackle used to raise and lower a yard. Through the 1700s, in the British navy, the upper blocks were strapped in pairs to the lower masthead. By 1815, pairs of upper jeer blocks had been replaced on large British naval vessels with one hanging block, "with a long and a short leg round the mast-head," (Burney, 1974: 202). These were treble blocks (Lees, 1984: 65) and almost certainly the blocks to which Harris was referring.

[24] Burney (1974: 41-42) stated that the pin should be the thickness of the sheave, which, in turn, was to be 10% larger than the diameter of the fall. The diameter of a 10-in (0.254 m) fall is 3 9/50 in (0.081 m) which, increased by 10%, equals 3 1/2 in (0.089 m) approximately. Pins could be made of a hard wood such as lignum vitae or greenheart, but, according to Burney, the best blocks had iron pins.

[25] Hounds were wooden projections fastened to either side of a ship's masts. Their shoulders helped to support the trestletrees and the framing of the tops (Burney, W., 1815: 199; Rees, 1819-20: pl. 8). Considering that the Courageux was a ship of the line, and, therefore, carried at least 74 guns, the head of her mainmast was at least 16 ft (4.877 m) long and the head of her foremast was almost 15 ft (4.572 m) in length (Fincham, 1979: 268). Lees (1984: 2-3) notes that the length of the hounds on English warships during all periods between 1625 to 1860 was two thirds the length of the masthead, although this disagrees with Steel who uses a ratio of 7/15 the length of the masthead on a late-18th-century British "74" (Gill, 1932: pl. III), making the hounds on ships of that class

just under 8 feet (2.438 m) in length.

Using Lees' figures, the hounds on the Courageux's mainmast were at least $10 \frac{2}{3}$ ft (3.252 m), and those on her foremast, about 10 ft (3.048 m) long.

As noted earlier, French ships of the period were somewhat taller masted than their English counterparts, so that even though Steel and Lees were referring to English ships, while the ratios of masthead to overall mast length may have been different on French ships, the hounds were probably at least as long as the ones on comparable English ships.

[26] Boudriot in his article on the careening of the Artemise stated that three "apparatus" (tackles) were employed, one for each mast, and that each consisted of a double block fastened to the "working stocks" (in the careening pits) and a treble block fastened to the masthead. The standing part of the fall, in his description, was fastened to the body of the double block (1981: 38). This would have provided six parts to the fall. As Boudriot used the photograph of the earlier diorama (Fig. 60, p. 124) in his article, which shows the tackles as he describes them, he obviously used that diorama as a source of information (1981: 38). He was, however, incorrect in stating (1981:38) that the running blocks were fastened to the mastheads in view of his inclusion of the photograph reproduced by my Fig. 22, p. 41, which clearly shows them fastened well below the tops. He was also in error in stating that only one tackle was used on each of the masts. Both misstatements may well derive from a faulty translation.

[27] Michael Mross and Richard Cook.

[28] Gote Sundberg is director of the Ålands Sjöfartsmuseum in Marienhamm.

[29] Taunt (1893:150) defined a cat block as a heavy threefold, iron-strapped block, with a large hook fitted to the strap by a link. This precisely fits the description of the blocks used. They were used aboard ship to cat the anchor.

[30] Tillers on British 74-gun warships of that era were timbers 11 in (0.278 m) square at the rudderhead and the final 2 feet 3 inches (0.686 m) of their after end, gradually tapering to 7 in (0.179 m) square at their

forward end. They were 26 ft (7.92 m) long, or short enough to "pass freely by the mizzen-mast" (Norie, 1822: 138, 300).

[31] A 74-gun British ship at the beginning of the 19th century carried 80 tons (81.28 metric tons) of iron ballast, covered by 270 tons (274.32 metric tons) of shingle. Steel (1807: 12) stated that the iron ballast was of two sizes, 7 and 21 pigs to the long ton. The larger were 3 ft (0.914 m) by 6 in (0.152 m) by 5 in (0.127 m), while the smaller were 1 ft 6 in (0.457 m) by 5 in (0.127 m) by 4 in (0.102 m).

[32] The size of rope is always described in terms of its circumference.

[33] Luce (1863: 50) referred to experiments which seemed to contradict Timmouth's concerning the strength of shroud-laid rope. These experiments showed that when under 5 in (0.127 m), it was weaker than plain-laid rope; when from 5 to 8 in (0.127-0.203 m), the difference in strength was "trifling," and when above 8 in (0.203 m), the ropes had equal strength if well made. Unfortunately, Luce did not name the author of the experiments, so they are not available for comparison with Timmouth's. For this reason, and for the sake of consistency, Timmouth's results will be used exclusively, with the caution that they may be somewhat in error.

[34] For the sake of standardization and, in view of an absence of evidence to the contrary, tonnages quoted in Tables 4 and 5, pp. 175, 176, are assumed, as elsewhere in this thesis, to be long tons of 2240 lbs. (1.016 metric tons).

[35] For these computations as well as those that follow, Timmouth's mean breaking strains have been used. From Table 5, p. 176, the mean breaking strain for 10-in hawser is 27.9 tons. Since shroud-hawser is 20% weaker, its breaking strain equals $27.9 - .2(27.9) = 22.32$ tons. Therefore, the combined breaking strain of two falls equals $2 \times 22.32 = 44.64$ tons (45.35 metric tons). Calculations to determine the mean breaking strain of an 11-in (0.279 m) shroud-hawser are similar.

[36] Harris obviously used Edye's figures for the displacement per inch of draught at the load line of a 28-gun ship, since his figures for the Rattlesnake coincide with Edye's for a vessel of that size.

Harris (1841: 20), using Edye's figures, calculated that 80 tons (81.28 metric tons) of force was exerted against the fixed blocks when the Rattlesnake's draught was decreased by 10 3/4 in (0.273 m).

At the load line of a 28-gun ship, each inch (0.025 m) of draught equaled 7 tons 9 cwt or 7.45 long tons (Edye, 1832: 58). $10.75 \times 7.45 = 80.09$. Edye's calculations were for a ship with a displacement of roughly 780 tons (792.48 metric tons) at the load line.

[37] The proportion is $12 + 28 + 32 + 38 + 50 = 160$ lbs, as $6 + 14 + 16 + 19 + 25 = 80$ tons.

[38] This is calculated by solving an equation wherein the mean breaking strain of an 11-in (0.279 m) shroud-hawser divided by the combined mean breaking strain of an 11-in (0.279 m) and an 8-in (0.203 m) shroud-hawser equals the maximum strain on the 11-in (0.279 m) shroud-hawser divided by the maximum strain the two shroud-hawsers were called upon to support in combination: 25 tons (25.4 metric tons). Referring to Table 5, $26.88 \div 41.28 = X \div 25$, and $X = 16.28$ tons (16.54 metric tons).

[39] I was not able to find the exact dimensions of the Blenheim's capstans, but early practical rules pertaining to the dimensions of capstans gave a rule of thumb of 5 times the diameter of the largest cable used aboard for the diameter of a capstan's barrel, "though some will have it as big as the mainmast in the partners" (Stevens, 1949: 107). The largest cable used aboard a 70-gun vessel in 1815, somewhat earlier than when the Melville was careened, was 20 1/2 in (0.521 m) or about 6 1/2 inches (0.165 m) in diameter (Burney, 1974: 64). Multiplied by 5, that figure would give an estimated barrel diameter of 32 1/2 in (0.826 m).

Fincham (1979: 270) states that the mainmast of a 74-gun English ship of a slightly later period had a mainmast diameter of 36 in (0.914 m).

The average diameter of the surge of the main capstan on a British 74-gun ship, according to Rees's Naval Architecture (1970: pl. IV), is slightly more than 36 in (0.914 m) which seems slightly high. At approximately the same period, Norie (1822: 310) gives the barrel diameter of the main capstan of a 74-gun vessel as 28 1/2 inches

(0.724 m), a figure which is probably more accurate but may not include the whelps. Taking all other information into consideration, including an appreciation that the smaller the barrel of a capstan, the smaller the moment on the hauling part of the fall to be overcome, it would probably be not far wrong to assume a diameter of 32 in (0.813 m) for the Blenheim's capstans. Fore and main capstans on ships of that period were interchangeable in case of damage to one (Burney, 1974: 72), thus the barrel diameters would have been the same.

[40] These formulas were generated through consultations with Professor Carl Long, Thayer School of Engineering, Dartmouth College, 1985.

[41] Since 9 ft (2.743 m) of fall were needed to bring the careening blocks 1 ft (0.305 m) closer to each other in a nine-part fall, each turn of the capstan, requiring 8 ft 4 17/25 in (2.557 m) of the fall, would bring the careening tackle blocks 8 ft 4 17/25 in (2.557 m) divided by 9, or 11 4/25 in (0.284 m) closer together.

[42] John Waterhouse is a marine architect and past curator of the Hart Nautical Collections, Massachusetts Institute of Technology.

[43] Formulas and sketch, courtesy of Mr. Waterhouse.

[44] The difference in the position of the center of bouyancy and of the length of the arm GZ with the ship careened to 72° instead of 74° can be seen to be negligible and was not considered for the purposes of this example.

[45] The upward vertical force of 1807.52 tons through the center of bouyancy, adjusted for the 15 tons less vertical force required of the careening tackles (65 tons instead of 80 tons) equals 1792.52 tons (1821.2 metric tons). Diminishing the moment arm 1 in to 3 ft 3 in and multiplying that figure by 1792.52 tons results in a righting force of 5825.69 foot-tons. Subtracting 5825.69 foot-tons from the previously-established righting moment of 6025 foot-tons leaves an equivalent reduction of approximately 199.31 foot-tons (605,281 newton-meters) in the required upsetting moment. We have already estimated

that the mainmast tackle assumed $16.28 \div 25$ of the force required. By setting up the mathematical relationship $16.28 \div 25 =$ the reduction of the upsetting moment required at the mainmast $\div 199.31$, the result can be calculated to be 129.71 foot-tons (393,914 newton-meters). The difference between 199.31 foot-tons and 129.71 foot-tons, 69.60 foot-tons (21,367 newton-meters), is the reduction in the upsetting moment required of the foremast careening tackle.

By dividing each of these moments by the distances of the careening tackles' attachment points from the vessel's center of bouyancy, 82 ft 3 in (25.070 m) and 73 ft 6 in (22.403 m) respectively, the forces acting perpendicular to the masts, 1.58 tons (15,742 newtons or 1.61 metric tons) and 0.95 tons (9,465 newtons or 0.97 metric tons), can be determined. These forces must be converted to forces acting vertically downwards; this is accomplished by the formula $F_v = F_p \cos 18^\circ$ (see earlier discussion of upsetting moment^P and Fig. 87).

The resultant calculations show vertical forces of 1.66 tons (1.69 metric tons) on the mainmast and 1.00 tons (1.02 metric tons) on the foremast, for a total decrease of the force applied at the mastheads of 2.66 tons (2.71 metric tons).

[46] A butt equals 108 imperial gallons or 129.7 U.S. gallons (490.95 l). Since 1 cu ft (0.0283 cu m) equals approximately 7.5 U.S. gallons, each butt displaced approximately 17.3 cu ft (0.4896 cu m) of water. Since 1 cu ft (0.0283 cu m) of water weighs approximately 64 lbs (28 kg), each butt displaced about 1107 lbs (484.31 kg). Walker and Boyd disagree as to how many butts were used, Walker (1902: 414) stating that 30 butts were employed, while Boyd (1860: 471) gives the figure of 80.

[47] "Streights" was a specific British reference, at first to the Gibraltar station and later to the entire Mediterranean station (Steffy, 1986). In context, a streights sheathing was probably a standard wood sheathing. An East-India sheathing in later years was a copper sheathing (Burney, 1974: 452); during the late 1600s, an East India sheathing probably referred to an extra-thick version of a streights sheathing, perhaps two layers of wood sheathing.

The manufacturers are saying that their milled lead sheathing cost very little more than an existing Mediterranean wood sheathing and not more than half as much as the thicker East-India version.

[48] Abell referenced Sutherland's The Shipbuilders Assistant, or some Essays towards compleating the Art of Marine Architecture, which was published in London in 1711.

GLOSSARY

Abaft. Towards the stern of a vessel.

Abreast (abeam). Directly to the side of an object; the position at a right angle to the fore and aft line of the ship.

Air port. An opening in a vessel's side or deck for ventilation..

Athwartships. Reaching across the ship, from one side to the other.

Belly lashing. A horizontal lashing between a mast and a mast shore.

Belly shore. A timber strut fastened horizontally between a mast and a shore to unitize them.

Bitt. A heavy post to which cables and lines are made fast; usually in pairs, strengthened by cross-members.

Bollard. A vertical post of iron or timber, set into a vessel or wharf to secure mooring lines.

Bolster. A piece of wood placed to prevent chafing. On sailing ships, they were pieces of soft wood covered with canvas which were placed above the trestletrees to protect them from the rigging.

Breeching. A strong rope used to prevent a piece of ordnance from recoiling too far in time of battle.

Breeching bolts. Ringbolts on either side of the gunports used to secure the breeching.

Built-up mast. A mast constructed of several timbers rather than a single tree trunk.

Bulwark. The sides above the upper deck which prevent the sea from entering.

Burthen. The cargo capacity of a vessel; also, tonnage. Also called burden.

Burton. A tackle used to set up the topmast shrouds or to support the topsail yards.

Cap, mast. A thick piece of hard, shaped wood fitted to the upper end of a lower mast with a hole cut in it to bring through the lower part of an upper mast and so act as a support.

Catharpings. Short horizontal lines under the tops used to pull the shrouds closer to the mast, permitting the yards to be braced further around, thus allowing the ship to sail closer to the wind.

Cathead. A heavy timber, roughly horizontal to the water and angling slightly forward, projecting from a vessel's bow on each side. Sheaves were inserted into its outer end as part of a tackle used to draw the anchor into a position clear of the topsides before stowing it or letting it go.

Chains (chain plates). The chain links or, in some cases, iron rods or plates secured to through-hull bolts (chain bolts) beneath the channels and extended through them to secure the lower of the two deadeyes which tensioned the shrouds.

Channel. Derived from chainwale. A broad, thick plank projecting horizontally from the hull abreast each mast. Its purpose was to extend the shrouds outboard to lend the mast greater support, and to permit the shrouds to clear the bulwarks and remain clear of each other.

Chesstree. A vertical timber bolted abaft the fore-channels on either side of a square-rigged vessel with a hole or a sheave set into its upper end. The bowlines used to haul in the main course tacks were led through the holes or sheaves in this timber.

Clinch (a rope). To fasten a rope back on to its own part by means of a half hitch followed by a seizing of the two parts.

Cock-bill. To angle a yard towards the deck. When a ship was careened, the lower yards, if kept on board, were cock-billed so that they angled down towards the weather side to keep them clear of the careening tackle.

Decks, locations. The names given to the decks of a warship from top to bottom (excluding quarter and forecastle decks) are: spar (U.S.), main or upper deck; middle, gun, or upper gundeck; lower gun, spar (Br.) or berth deck (U.S.); orlop deck.

Displacement. The weight of water a vessel moves aside when afloat; the physical weight of the ship.

Dolphin. A pile or group of piles serving as a mooring post for ships.

Fathom. A distance measure equal to six English feet.

Folds (in a block). The term used to describe the number of sheaves contained in the block; thus a twofold block has two sheaves. It may also be called a double block. A double tackle is one consisting of two double blocks.

Frap. To bind two or more ropes together to increase their tension.

Hounds. A mast projection used to support the trestletrees.

Hulk. A large vessel no longer fit for sea duty, used for utility purposes. Hulks used for careening other ships were heavily ballasted and strengthened to accommodate the lower blocks of the careening tackles.

Jacob's ladder. A ladder made of rope.

Larboard. An old term for the port side of a ship.

Leeward. The direction away from the wind. With reference to careening, it was the down side of the ship, as if it had been heeled by the wind.

Masthead. The portion of a lower mast above the hounds.

Mast partner. A framework of heavy timbers surrounding the hole in the deck through which a mast passes, designed to strengthen the deck in that area.

Mast step. A hardwood fitting or structure which was mounted on the keelson and was morticed to receive the heel of the mast.

Parcel (rope or chain). To wrap a strip of tarred canvas around a rope or chain. It was normally done after worming and before serving, and was designed to make the rope watertight. Chains were parcelled to prevent them from marring surfaces.

Pendant. A length of rope with an eye spliced in one end to attach a tackle. It was used to transmit the power of the tackle to a distant point.

Port. The left side of a vessel as one faces the bow. Also, an opening in a vessel's side or deck.

Preventer shroud. An additional shroud used to support others when they were subjected to unusual strains. Although preventers were often of a permanent nature, preventer shrouds, in the context of careening, were temporary.

Rigging. The ropes, chains, and wires used for the support or manipulation of a vessel's spars and sails.

Runner. A rope which, when connected to a tackle, transmits the tackle's effort as if the tackle was the entire length of the rope.

Running rigging. The movable parts of the rigging, used to manipulate the sails and yards.

Scuttle. A small hatch or hole cut in a ship's hull or deck.

Seizing. Binding two ropes together or the end of a single rope back on to itself to form an eye, by means of small rope or cord.

Set up (a tackle). To tension the tackle.

Sew. A word used to describe a ship run aground. The difference between the level of the water and the normal floatation level of the ship was the distance the ship was sewed.

Sheers. Two or more spars raised and lashed together at the points where they intersect; used for lifting or supporting heavy weights, often in conjunction with a tackle.

Shelf piece. A heavy piece of timber upon which the ends of the deck beams rested (Paasch, 1977: 22).

Shingle. Coarse, rounded alluvial stone used for ballasting, differing from ordinary gravel only in its larger size.

Shrouds. The standing rigging which supports a mast laterally.

Sill. The upper and lower framing lining a port cut through a ship's side.

Skids. Compassing timbers conforming to the hull shape from the main wale to the top of the sides. They were usually located amidships, and were intended to protect the side of a ship where heavy objects moved over them.

Spar. A rounded wooden member, such as a mast, yard, or boom.

Spirketting. The strakes between the waterways and the lower sills of the the gunports.

Spring (a mast). To crack the mast.

Standing rigging. The stationary ropes and wires which support the masts and yards.

Starboard. The right side of a vessel when facing the bow.

Surge. The area on the barrel of a capstan which encompassed the vertical travel limits of the fall. The term also described the slipping (surging) of the fall on the tapered whelps, something to be avoided during careening as it severely strained masts and rigging.

Swifter. A rope passed around slots in the ends of capstan bars to allow additional men to seize hold and thus increase the power.

Tackle. A system of two or more blocks with a rope rove through them to multiply the power exerted on the rope when it is hauled upon.

Tonnage. See burthen.

Top, mast. A platform which rested on the trestletrees and crosstrees. It was used to extend the topmast shrouds and to provide a fighting station on warships.

Train bolt. A ringbolt affixed to the deck behind a gun. A tackle was fastened between it and the gun to prevent the latter from running outboard while being loaded.

Treenail (trunnel). A cylindrical wooden pin used to fasten the planks and timbers.

Triatic stay, main. A stay running in a horizontal direction from the mainmasthead cap to the foremasthead cap.

Tumblehome. The inward curve of a vessel's sides above the point of maximum breadth of its hull.

Trestletrees. Strong pieces of wood on either side of a mast, running in a fore and aft direction, used to support a top or the crosstrees of an upper mast.

Waist. The center part of a ship, between the quarter deck and forecastle.

Wall sided. A reference to a vessel with relatively straight sides and little tumblehome.

Waterway. A curb along the side of a deck, channeled to carry water from the deck to the scuppers.

Weather, to. Towards the wind. In careening, the upper side of a ship when it has been heeled.

Whelps. Tapered pieces of wood extended from the barrel of a capstan in the surge area. They decreased friction and increased the barrel diameter for handling large cables.

REFERENCES

- Abell, W., 1962, The Shipwright's Trade. London.
- Ashley, C., 1944, The Ashley Book Of Knots. New York.
- Bass, W. and E. Bass, 1981, Constitution: Super Frigate of Many Faces. In Shipsresearch. Melbourne, Florida.
- Blanckley, T.R., 1750, A Naval Expositor, Shewing and Explaining the Words and Terms of Art belonging to the Parts, Qualities, and Proportions of Building, Rigging, Furnishing, & Fitting a Ship for Sea. London.
- Bonnefoux, P.M.J. Baron de, n.d., Dictionnaire de Marine (2d. ed.). Paris.
- Boudriot, J., 1981, The Frigate L'Artemise And Its Careening At Tahiti In 1839. In Nautical Research Journal, 27 (1): 32-38.
- Boyd, Capt. J., 1860, A Manual For Navel Cadets. London.
- Brady, W., 1857, The Kedge-Anchor; or, Young Sailor's Assistant. New York.
- Burney, C., 1871, The Boy's Manual of Seamanship & Gunnery for the use of Training Ships of the Royal Navy. Greenwich.
- Burney, W., 1974, Falconer's Marine Dictionary (modernized and enlarged by Dr. William Burney, reprint of 1815 edition). London.
- Cairo, R., 1976, Shipyard and Service Craft: A Portfolio of Plans - Part III. In Nautical Research Journal, 22 (2): 83-91.

Casson, L., 1964, Illustrated History Of Ships And Boats. New York.

Casson, L., 1971, Ships And Seamanship In The Ancient World. Princeton, New Jersey.

Chapelle, H., 1935, American Sailing Ships. New York.

Chapelle, H., 1949, The History Of The American Sailing Navy. New York.

Chapman, F., 1979, Architectura Navalis Mercatoria. Facsimile reprint. Adlard Coles, Ltd., eds. and pubs. London.

Chatterton, E., 1914, Sailing Ships And Their Story. London.

Chatterton, E., 1913, Ships And Ways Of Other Days. London.

Chatterton, E., 1926, The Ship Under Sail. Philadelphia.

Clark, A., 1910, The Clipper Ship Era. New York and London.

Church, A., 1938, Whale Ships And Whaling. New York.

Cook, R., 1985, personal correspondence.

Cooke, E.W., 1829, Fifty Plates of Shipping And Craft Drawn And Etched By E.W. Cooke. London.

Creuze, A.F.B., 1846, Treatise on the Theory And Practice of Naval Architecture: Being The Article "Ship-Building" in the Encyclopaedia Britannica, Seventh Edition. Edinburgh.

- Cubberly, W.H., (Dir. of Pubs.), 1979, Metals Handbook Ninth Edition. Properties and Selection: Nonferrous Alloys and Pure Metals (Vol. 2). Metals Park, Ohio.
- De Groot, I., and R. Vorstman, (Eds.), 1980, Sailing Ships, Prints by the Dutch Masters from the Sixteenth to the Nineteenth Century. New York.
- De Lorenzo, D., et al., 1864, Diccionario Maritimo Español. Madrid.
- Edye, J., 1832, Calculations Relating To The Equipment, Displacement, Etc. Of Ships And Vessels Of War. London.
- Et Skib kølhales, 1939. In Vikingen, 14: 10.
- Fincham, J., 1979, A History of Naval Architecture. Scolar Press Limited reprint of 1851 edition, J. Leather, ed. London.
- Fincham, J., 1821, An Introductory Outline Of The Practice Of Shipbuilding, &c. &c. Portsea, England.
- Funch, D., 1976, Dansk Marine-Ordbog. Photographic copy of 1846 First Part and 1852 Second Part by Høst & Son's (Pubs.). Copenhagen, Denmark.
- Gaunt, W., 1975, Marine Painting: An Historical Survey. London.
- Gill, C., (Ed.), 1932, Steel's Elements Of Mastmaking, Sailmaking And Rigging (From the 1794 Edition). London.
- Goldenberg, J., 1976, Shipbuilding in Colonial America. University of Virginia.
- Greenhill, B. and Giffard, A., 1970, The Merchant Sailing Ship, New York.

- Gruppe, H.E., 1979, The Frigates. The Seafarers, (Time-Life series). Alexandria, Virginia.
- Gulliver, L., 1939, One Hundred Brass Guns. In U.S. Naval Institute Proceedings, 65: 74-79.
- Hale, (Pub.), 1695, Mill'd Lead, Demonstrated To be a better and more durable Covering for Buildings &c. and above 20 per Cent cheaper than Cast-Lead can be; supposing that to be 16s. and this but 13s. a Hundred. And Also for Sheathing Ships against the Worm, better, and above Cent. per Cent. cheaper than the ordinariest Wood-sheathing can be. London.
- Halldin, G., (Ed.), 1963, Svensk Skeppsbyggeri. Malmo, Sweden.
- Hammersley, L. R. & Co., (Pub.), 1884, A Naval Encyclopedia; Comprising a Dictionary of Nautical Words and Phrases, Biographical Notices, and Records of Naval Officers; Special Articles of Naval Art and Science... together with Descriptions of the Principal Naval Stations and Seaports of the World. Philadelphia.
- Harris, Com. R., 1841, Remarks On Heaving Down A Seventy-two Gun Ship, Shewing The Strain To Be Resisted, And In What Manner The Established Allowance Of Stores May Be Rendered Available; With An Abridged Account Of The Method Pursued By Her Majesty's Ship Melville, In Chusan Harbour; To Which Is Added A Short Account of The Heaving Down Of H.M.S. Medina, In Port Leone, And a few Remarks on other Subjects connected with the Naval Profession. Portsea, England.
- Henningsen, H., 1959 Et Gammelt Traeskibsvaerft. In Arbog (Danish Maritime Museum Annual Yearbook): 23-43. Helsingør, Denmark.
- Horsely, J.E., 1978, Tools of the Maritime Trades. Camden, Maine.

- Howard, F., 1979, Sailing Ships Of War 1400-1860.
Greenwich and New York.
- Howard, P. and F. Watson, 1691, The New Invention Of Milled Lead, For Sheathing of Ships against the Worm, better for Sailing, and Cheaper above Cent. per Cent. than the old way with Boards. Pamphlet. London.
- Hutchinson, W., 1777, A Treatise On Practical Seamanship.
Liverpool, England.
- Kemble, J.H., 1957, San Francisco Bay A Pictorial Maritime History. Cambridge, Maryland.
- Kemp, P. (Ed.), 1976, The Oxford Companion To Ships & The Sea. Oxford University.
- King, Lt. W., 1802, Account of the preparations and process of careening his Majesty's late Ship the Courageux, in the arsenal of Toulon, October 1793; with observations. In Naval Chronical For 1802: containing a General and Biographical History of The Royal Navy of the United Kingdom; with a Variety of Original Papers on Nautical Subjects. Vol. VIII: 308-312. London.
- Knight, C., 1939, "Queries." In The Mariner's Mirror vol. XXV, 2.
- Lees, J., 1984, The Mastng and Rigging of English Ships of War 1625-1860. London.
- Liardet, Capt. F., 1849, Points Of Seamanship, Discipline, &c., Portsea, England.
- Long, C, 1985, personal correspondence.
- Lords Commissioners of the Admiralty, 1891, Manual of Seamanship for Boy's Training Ships of the Royal Navy.
London.

- Lubbock, B., 1934, Barlow's Journal, Volume I 1659-1677. London.
- Luce, S., 1863, Text-Book of Seamanship. Newport, Rhode Island.
- Luce, S., 1884, Text-Book Of Seamanship. Edited by A. Ward. New York.
- Magoun, A., 1928, The Frigate Constitution And Other Historic Ships. Salem, Massachussetts.
- Manwaring, G. and Perrin, W., (Eds.), 1922, The Life and Works of Sir Henry Mainwaring, Vol. II (printed for the Navy Records Society). England.
- Manwayring, H., 1972, The Seamans Dictionary 1644 (Scolar Press Limited reprint, R. Alston, ed.). Menston, England.
- McKee, A., 1972, The influence of British naval strategy on ship design: 1400-1850. In Bass, G., ed., A History Of Seafaring based on Underwater Archaeology. London and New York.
- Meigs, J.F., 1924, The Story of the Seaman, Vol. I. Philadelphia.
- Meyer, J., 1976, Vom Moor Zum Meer, Papenburger Schifffahrt in 3 Jahrhunderten. Norderstedt, West Germany.
- Moore, A., 1926, Sailing Ships Of War 1800-1860. London.
- Mortier, D. (Pub.), 1719, L'Art de Batir les Vaisseau, et d'en perfectionner la Construction; de les garnir de leurs appareils, les mettre en funin, les manoeuver, &c. Amsterdam.
- Mross, M., 1985, personal correspondence.

- Norie, J.W., 1822, The Shipwright's Vade-Mecum: A Clear and Familiar Introduction to the Principles and Practice of Ship-Building. London.
- Paasch, Capt. H., 1977, Illustrated Marine Encyclopedia 1890 (Argus Books Ltd. facsimile reprint). Watford, Herts, England.
- Phillips, W., 1863, Cleaning Ship's Bottoms (patent letters submitted to Office of the Commissioners of Patents, A.D. 1863, 2nd April. No. 845). London.
- Pyle, D., 1981, Clean Sweet Wind. Preston, Maryland.
- Rees, A., 1970, Rees's Naval Architecture (1819-20): A selection from The Cyclopaedia; or Universal Dictionary of Arts, Sciences and Literature by Abraham Rees. United States Naval Institute, Annapolis, Maryland.
- Rees, A., (Ed.), 1819-20, The Cyclopaedia; or Universal Dictionary of Arts, Sciences and Literature. London.
- Roome, J., 1984, personal correspondence.
- Ross, L., 1981, Eighteenth-Century French Naval Duties as Reflected in the Tools Recovered from the Fifth-Rate Frigate Le Machault Sunk in Chaleur Bay, Quebec, A.D. 1760. In In The Realms of Gold: The Proceedings of the Tenth Conference on Underwater Archaeology. Fathom Eight Special Pub., W.A. Cockrell, ed. 1: 56-75. San Marino, California.
- Rule, M., 1983, The Mary Rose. Leicester, England
- Salvini, R., 1965, All the Paintings of Botticelli, Part 2 (1445-1484). New York.
- Sørensen, C., 1847-50, Blyantstegning Af C. Frederik Sørensen. Pencil sketchbook in Handels-Og Sofartsmuseet Pa Kronborg. Helsingør, Denmark.

Steel, D., 1807, Seamanship; Both In Theory And Practice.
London.

Steffy, J.R., 1985 The Kyrenia Ship: An Interim Report on
its Hull Construction. In American Journal of
Archaeology 89: 71-101.

Steffy, J.R., n.d., Tonnage Calculations In The Research
Of Shipwrecks. Notes from an unpublished article.

Steffy, J.R., 1986, personal correspondence.

Stevens, J.R., 1949, An Account of the Construction, and
Embellishment of Old Time Ships. Toronto.

Stockdale, J. (Pub.), 1785, Strictures upon Naval
Departments, &c. &c. &c. with a Recommendation to
abolish the Coppering of Ships' Bottoms on the state of
ordinary, and to discontinue the Caulking Of The King's
Ships with rotten, water-soaken oakum, &c. &c. &c.
also a Proposition to appropriate the Royal Academy in
Portsmouth Dock-Yard, instead of building the Intended
Expensive Magnificent Dwelling House, for the residence
of the Resident Commissioner. London.

Story, D., 1964, Frame-Up! The Story of Essex, Its
Shipyards and Its People. Barre, Massachusetts.

Story, D., 1985, personal correspondence.

Sundberg, G., 1984, personal correspondence.

Taillemite, E., 1967, Royal Glories, in J. Jobe, ed., The
Great Age of Sail, Lausanne, Switzerland.

Taunt, Lt. E.H., 1893, Young Sailor's Assistant in
Practical Seamanship. Washington.

- Taylor, Capt. L., 1977, The Principles Of Ship Stability Including Modern Applications. Glasgow.
- Tinmouth, N., 1845, An Inquiry Relative to Various Important Points Of Seamanship, Considered as a Branch of Practical Science. London.
- Todd, J. and Whall, W., 1911, Practical Seamanship for use in the Merchant Service: Including All Ordinary Subjects; Also Steam Seamanship, Wreck Lifting, Avoiding Collisions, Wire Splicing, Displacement, and Everything Necessary to be Known by Seamen of the Present Day. New York.
- U.S. Secretary of the Navy, 1825, Report Of The Secretary Of The Navy, In Relation To The Construction Of A Dry Dock. Senate Doc. 10 (Jan 5, 1825).
- Van Konijnenburg, E., 1895-1905, Shipbuilding From Its Beginnings, Vols. I-III. Brussels.
- Velazquez, M., 1875, Seoane's Neuman and Baretti's Spanish Pronouncing Dictionary. New York.
- Villiers, A., 1937, Cruise of the Conrad. New York.
- Walker, T., (Ed.), 1902, Captain Alston's Seamanship. Portsmouth, England.
- Walter, R., 1928, Anson's Voyage Round The World. London and Boston.
- Waterhouse, J., 1984, personal correspondence.
- Wright, R., 1936, Secretary's Notes. In U.S. Naval Institute Proceedings, 62: 1369-70.

APPENDIX I
LETTERS OF PERMISSION



The MIT Museum 265 Massachusetts Avenue, Cambridge, Massachusetts 02139, Telephone 617-253-4444
Hart Nautical Collections 617-253-5942

28 December 1985

Mr. Michael P. Goelet
P.O. Box 862
Norwich, VT 05055

Dear Mr. Goelet:

Permission is hereby granted you to use copies of the following
Hart Nautical Collections print:

Clark Collection #F 58 showing a ship in a canal in
Amsterdam harbor, 1792

for use in your thesis, The Careening and Bottom Maintenance of
Wooden Sailing Vessels. A credit line for the "Hart Nautical
Collections, MIT Museum" is mandatory. Further permission may
be granted in a separate agreement for publication of the above-
named print in books or journals for a nominal fee. Correspon-
dence for such permission must be sent to the Curator of the Hart
Nautical Collections at the above address. Permission is granted
in the present case for unpublished use of the print. This includes
making copies of the thesis for internal use of the educational
institution for which the thesis was written plus a limited
number of copies for the private, non-commercial use of the author.

Sincerely,

John G. Arrison
Curator
Hart Nautical Collections

Sistine Chapel Art Museum
 Decio Redig de Caspos
 Vatican

Michael P. Golet
 P.O. Box 862
 Norwich, Vermont 05055
 U.S.A.

Dear Sir:

Permission is hereby granted you to use copies of a detail
 from a painting for which we control the rights in your thesis
The Careening and Bottom Maintenance of Wooden Sailing
Vessels.

"The Punishment of Korah," by Botticelli. Detail of
 the sailing vessels.

Signature(s)

Date



Michael P. Golet

March 12, 1986

→ Do you need a print of the photograph?

Fathom Eight
P.O. Box 8505
San Marino, California 91108

Michael P. Golet
P.O. Box 862
Norwich, Vermont 05055

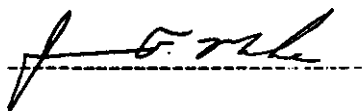
Dear Sir:

Permission is hereby granted you to use copies of the following illustration in a book published by us, in your thesis The Careening and Bottom Maintenance of Wooden Sailing Vessels.

Ross, L., 1981, Eighteenth-Century French Naval Duties as Reflected in the Tools Recovered from the Fifth-Rate Frigate Le Machault Sunk in Chaleur Bay, Quebec, A.D. 1760. In In The Realm of Gold: The Proceedings of the Tenth Conference on Underwater Archaeology. Fathom Eight Special Publication # 1, w.H. Cockrell, ed., pp. 66, fig. 7, consisting of wooden caulking hammer heads recovered from Le Machault.

Signature(s)

Date:



1/7/86

Permanent International Association
of Navigation Congresses
Rue de la Loi 153
B-1040 Bruxelles
Belgium

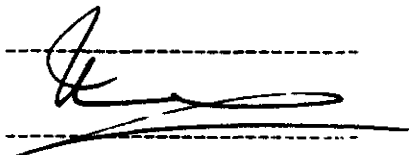
Michael P. Goelet
P.O. Box 862
Norwich, Vermont 05055
U.S.A.

Dear Sir: provided that you mention the source of the information
Permission is hereby granted you to use copies of the
following illustration in a book published by us in your
thesis, The Careening and Bottom Maintenance of Wooden Sailing
Vessels.

Van Konijnenburg, E., 1895-1905, Shippulging from
its Beginnings. Vol. III, pp. 8, fig. 13, depicting
sections of mid-18th century ships at the main frames.

Signature(s)

Date: 21 January 1986

A handwritten signature in black ink, appearing to be 'M. P. Goelet', is written over a set of three horizontal dashed lines. The signature is fluid and cursive.

STATENS
SJÖHISTORISKA MUSEUM
Wasavarvet

1985-04-11

Dnr 799/85

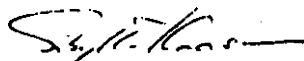
Pablo Wiking-Faria/ BC

Michael P Golet
P O Box 862
Norwich, Vermont 05055
USA

Identification and reproduction of photographs.

You are asking for information about Fo 47.406. It is painted by Carl Bennet about 1840 and called "Careenage at the Southern mountains". You may gladly reproduce the photographs in your thesis, but in that case please send us a copy for our library.

STATENS SJÖHISTORISKA MUSEUM



Sibylla Haasum

Pablo Wiking-Faria



NATIONAL MARITIME MUSEUM

MM 22

APPLICATION TO REPRODUCE PHOTOGRAPHS

INSTRUCTIONS

1. Two copies of this form are to be forwarded to the applicant who is to complete and return BOTH to: The Director, National Maritime Museum, Greenwich, SE10 9NF.
2. If the application is approved, authorization will be completed on both copies, of which one will be returned to the applicant with an invoice, the second being retained in the Museum for record purposes.
3. No receipt will be sent unless requested.

Permission is requested by Mr. M. P. Golet.(Address) P.O. Box 862, Norwich, Vermont 05055, U.S.A.

Tel. No. _____

Ext. _____

to reproduce the undermentioned photographs in the publication/~~television~~entitled STUDENT THESIS

Artist or Reference	Subject
2461 Artist Gaspar Van Wittel cl703	View of Naples B 5177/30 Careening. B.5178/19 Careening PLEASE NOTE: THIS PERMISSION IS GRANTED FOR USE IN YOUR THESIS ONLY ANY FURTHER PUBLICATION MUST BE REFERRED TO THE NATIONAL MARITIME MUSEUM FOR PERMISSION AND A FEE WILL BE CHARGED..

ACKNOWLEDGMENTS: NATIONAL MARITIME MUSEUM LONDON

The photograph entitled _____

is to be used on the cover and/or dust jacket.

FOR OFFICIAL USE

Permission granted.

Signed M. Golet Date 5.3.85Type of Publication ~~EXHIBITION~~ STUDENT THESISCharge & NO FEE Invoice

THESIS



DAVID & CHARLES
publishers

BRUNEL HOUSE NEWTON ABBOT DEVON TQ12 4PU Telephone: 0626 61121 Telex: 42904

JL/AK

2 July 1985

Mr M. P. Goslet
P.O. Box 862
Norwich
Vermont 05055
USA

Dear Mr Goslet,

RE: TOOLS OF THE MARITIME TRADERS

Thank you for your letter requesting permission to reproduce two illustrations from the above title. As these illustrations are for use in your thesis we gladly give you permission and will not charge for it.

However, if your thesis is published, you must re-apply to us for permission to reproduce them.

Yours sincerely,

Jenny Loasby
Subsidiary Rights

THE MARINERS' MUSEUM

NEWPORT NEWS, VIRGINIA 23606

804 305-0768

PERMISSION TO REPRODUCE PHOTOGRAPHS OF MATERIAL FROM THE COLLECTIONS OF THE MARINERS' MUSEUM

The Mariners' Museum hereby grants to Michael P. Coelet

P.O. Box 862; Norwich, Vermont 05055

permission for a single publication or reproduction in black & white of the
following item(s): Careening a Ship in the harbor of La Havre

by Descamps (LE 672)

This permission is conditionnal upon full payment of the stipulated reproduction fee of waived and is granted with the understanding that this item is to be used for: one-time use in a master's thesis, The Careening and Bottom Maintenance of Wooden Sailing Vessels to be submitted to Texas A & M in 1986.

The Museum should be credited as follows: "Courtesy of The Mariners' Museum, Newport News, Virginia."

(signature) _____

Lois Oglesby

(typed name) _____

Lois Oglesby

(position) _____

Curatorial Assistant

(date) _____

December 30, 1985

Handels-Og Søfartsmuseet
PA Kronborg
DK-3000 Helsingør
Denmark

Michael P. Golet
P.O. Box 862
Norwich, Vermont 05053
U.S.A.

Dear Sir:

Permission is hereby granted you to use copies of the following museum photographs in your thesis, The Careening and Bottom Maintenance of Wooden Sailing Vessels.

682:56

Nos. Sx: 675:56 / Sx: ., showing the Hvalfisken being careened in the diorama of Rasmus Moller's shipyard as it appeared in the 1870s.

Signature(s)

Date: *January 9th 1986*

K. Golet

Mr. Alan Francis, E.O.
Naval Historical Library
Room 2502
Empress State Building
Lillie Road
Fulham
London SW6 1TR
England

Michael P. Goelet
P.O. Box 862
Norwich, Vermont 05055
U.S.A.

Dear Sir:

Permission is hereby granted you to use copies of the following items in your thesis The Careening and Bottom Maintenance of Wooden Sailing Vessels.

H 13, consisting of two drawings of a ship being careened by Philip Gilbert, dated 1740; V2 10/54, consisting of a plan of the careening wharf at English Harbour, Antigua, dated 1745.

Signature(s)

Date: 2 January 1986

A. J. Francis

Marjolaine Matikhine
Chef du Service d'Etudes et de Documentation
Musée De La Marine
Palais De Chaillot
75116 Paris
France

Michael P. Golet
P.O. Box 862
Norwich, Vermont 05055
U.S.A.

Dear Sir:

Permission is hereby granted you to use copies of the following museum photographs in your thesis The Careening and Bottom Maintenance of Wooden Sailing Vessels.

Nos. 3135 (ref: 13 PA 28); 9234, 9235, and 9236 of the diorama of L'Artemise careened in Tahiti (ref: 13 PA 32); and 44266 "Vue Du Port De Brest En 1776."

Signature(s)

Date: 3 janvier 86.

Michael P. Golet

Ms. Kathy Flynn
Photography Department
Peabody Museum
East India Square
Salem, Massachusetts 01970

Michael P. Golet
P.O. Box 862
Norwich, Vermont 05055
U.S.A.

Dear Sirs:

Permission is hereby granted you to use copies of the following museum photograph(s), or illustration(s) ~~in books published by our company~~, in your thesis The Careening and Bottom Maintenance of Wooden Sailing Vessels.

Neg. Nos. 9346, 9347, and 16443, of the whalers Josephine, Sunbeam, and James Arnold have down.

Signature(s)

Date:

Kathy M. Flynn

16 December 1985

One time North American English language rights is granted; reproduction fee is waived. A copy of your publication should be sent to our research library.

Rijksmuseum
Stadhouderskade 42
1071 ZD Amsterdam
Netherlands

Michael P. Goelet
P.O. Box 862
Norwich, Vermont 05055
U.S.A.

Dear Sir:

Permission is hereby granted you to use copies of the following museum photographs in your thesis The Careening and Bottom Maintenance of Wooden Sailing Vessels.

Nos. 22176, 22177, 22180, 22181, and 29540 (ref: B 109, B 113, B 117, W 170, and B 44, respectively, all etchings by R. Nooms; 39538, and 39539 [ref: 301-F-31, (g) 6, 7], by G. Groenewegen

Signature(s)

Date:



3. January 1986

(B. Stekhuyzen)

(with thanks for your letter
dd. 20. December 1985!)

(phot. dept.)

40 West 23rd Street
 New York, NY 10010-5201
 Telephone: (212) 907-7300
 Telex: 253770

Viking Penguin Inc.

March 14, 1986

Michael P. Golet
 P.O. Box 862
 Norwich, Vermont 05055

Dear Mr. Golet:

We have no objection to your use of material from our publication(s)


SAILING SHIPS, PRINTS BY THE DUTCH MASTER FROM THE SIXTEENTH TO THE NINETEENTH CENTURY, edited by Irene De Groot and Robert Vorstman.

in your dissertation, as requested in your letter of subject to the following conditions:

1. Such material shall be reproduced exactly as it appears in our publication;
2. Full acknowledgment of the author, title, copyright and Viking Penguin Inc. is given;
3. If you ever wish to publish your dissertation, you must reapply for permission.

Best wishes for the success of your paper.

Sincerely,


 Jacqueline A. McCornick
 Permissions Department

Please use the following credit line: From SAILING SHIPS, PRINTS BY THE DUTCH MASTERS FROM THE SIXTEENTH TO THE NINETEENTH CENTURY, edited by Irene De Groot and Robert Vorstman. Copyright (c) Uitgeverij Gary Schwartz, 1980. Reprinted by permission of Viking Penguin, Inc.



Penguin • Puffin • Stephen Greene Press • Frederick Warne • Viking Kestrel • Elisabeth Sifton Books • Viking



VITA

Michael Peter Goelet was born in New York City on July 17, 1937. He received a BA degree in Art History from Dartmouth College in June, 1958.

Upon his graduation from college, he enlisted in the U.S. Marine Corps and served as a pilot before leaving the service in 1962 with the rank of captain. For the next two years, he worked in the real estate and construction fields in New York City.

Mr. Goelet then moved to St. Croix, U.S. Virgin Islands, and, among other real estate ventures, built a hotel which was operated under his ownership until 1977.

Returning to the mainland in 1974, he settled in Vermont and practiced real estate there as well as in New York, Florida, and the Virgin Islands.

In 1982, he applied for admission to Texas A&M University seeking to consolidate his interest in art and history, his longtime hobby of sport diving, and his business experience through a study of nautical archaeology.

Future plans include two projects in Belize; the first, a survey of historically-important shipwreck sites, the second, a study of Mayan water-borne commerce from the classical period to Spanish contact.

Mr. Goelet has been married since 1970 and lives with his wife and two sons on Main Street in Norwich, Vermont.