ROPE AND THE ART OF KNOT-TYING IN THE SEAFARING
OF THE ANCIENT EASTERN MEDITERRANEAN

A Thesis
by
WILLIAM HARRISON CHARLTON, JUNIOR

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements
for the degree of
MASTER OF ARTS

NAUTICAL ARCHAEOLOGY

August 1996

Major Subject: Anthropology
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August 1996

Major Subject: Anthropology
ABSTRACT


William Harrison Charlton, Junior,
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Fibers woven into cords or ropes and tied together with knots form one of mankind's earliest tools. When he first went out onto the water on anything more sophisticated than a simple paddle-driven dugout canoe he had to have done so with the assistance of some type of cordage. He may have needed a line tied around a stone that would serve as an anchor, a line to retrieve his fishing spear, and a line to moor his craft on the beach. And soon he would need lines to hold a mast erect so he could raise a sail. In fact, no waterborne vessel, in ancient times, as today, could function without rope.

As ships got larger and more complicated, the requirement for many different types and sizes of cordage became increasingly important. Depictions of seagoing vessels from the ancient eastern Mediterranean -- Egyptian, Greek, Phoenician, or Roman -- give some idea of the great quantities of cordage that would have been
required to keep these ships at sea. Yet, when rope has been found on ancient shipwrecks, or in other nautical contexts, those examples have received comparatively little attention. Likewise, the overall subjects of the making of rope and the art of knot-tying in the ancient world, both without which ships could not have set sail, have received little attention.

Evidence from antiquity that can open these subjects up to the modern world does exist. The Greek and Roman writers reveal a great deal about rope, and the materials used in its manufacture, although they are less open about knots. Ancient artists were less revealing with specific detail on rope and knots, but there is some information there. Archaeological remains of ancient rope are found on many shipwrecks and, while it occurs less often, a few knots have also been found on ancient sites.

This thesis is a review of this material from the ancient world. It will provide insight into an important, but little known subject, and will add to our understanding of seafaring in the Mediterranean area during antiquity.
DEDICATION

To the memory of my mother
SYLVIA LEONA CARRINGTON CHARLTON
and my father
WILLIAM HARRISON CHARLTON

And to my wife
BARBARA BURNICE WHITE CHARLTON
and my sons
WILLIAM HARRISON CHARLTON, III
&
DAVID ALEXANDER CHARLTON
ACKNOWLEDGMENTS

My appreciation is extended to Drs. George F. Bass, L. Roy Cornwell, and Shelley Wachsmann for serving on my thesis committee, and doubly to Dr. Wachsmann for prodding me into accepting "rope and knots" as my thesis topic.

Many thanks to Miss Noreen Doyle for her help with "things" ancient Egyptian, and to James Coggeshall and Sam Mark for their help with ancient Greek and Latin.
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Rust.  De Re Rustica (On Farming), Varro
Stat.  Statius
Supp.  The Suppliant Maidens, Aeschylus
Tro.  Trojan Women, Euripides
Vol.  Volume
INTRODUCTION

A tool, as defined in The Scribner-Bantam English Dictionary, is "any instrument or implement used in doing work, especially one that is hand held" (s.v. "tool"). Rope is without doubt an implement of work, and there are few instances in which a rope is not manipulated by the human hand to accomplish its intended purpose. We must realize initially, however, that rope alone is useless; what makes rope a usable tool is the art of knot tying.

Fibers woven into cords or ropes and tied together with knots form one of man's earliest tools, possibly having their beginnings hundreds of thousands of years in the past (Day, 1947: 1). The gorillas of western Africa are known to use knots in the construction of their jungle nests, and it is difficult to believe that early humans did not have at least the same capabilities as the animals that shared their world. The naturalist Ivan T. Sanderson, on an expedition into southeastern Nigeria in 1937, observed gorilla nests in which large saplings were bent down to the ground and tied there with creepers and smaller saplings. He counted more than two dozen.

This thesis follows the style and format of the International Journal of Nautical Archaeology.
complete knots: "most were 'grannies', but there were three 'reef' knots, which had undoubtedly resulted only by chance" (Sanderson, 1937: 187).¹

Whether African gorillas used knots in making their nests, or not, it is an undisputed fact that early humans fabricated rope in many areas of the world in very remote times. Prehistoric Japanese were making rope as far back as 8000 B.C. (Hurley, 1979: v), and the peoples of Çatal Hüyük, Turkey, were weaving and twisting flaxen fibers as early as 6000 B.C. (Ryder, 1965: 175-176). Neolithic lake dwellers in Switzerland made rope and nets out of flax (Munro, 1890: 114), and neolithic Britons twisted rope out of heather, grass, and nettle-fibers (Burl, 1979: 144). Chalcolithic peoples in Israel, c. 3500 B.C., were weaving fine linen materials and twisting ropes out of straw (Bar-Adon, 1980: 197 & 230); the peoples of Mesoamerica had a thriving cordage and textile industry by 1500 B.C. (Hurley, 1979: 3). One of the earliest specimens of rope recorded in Egypt was made of linen fibers and dates from the predynastic period, c. fourth millennium B.C. (Brunton & Caton-Thompson, 1928: 67). And to put all this rope to good use, early man must have known and used more than just a few knots.

When man first went out onto the water on anything more sophisticated than a simple paddle-driven dugout
canoe he had to have done so with the assistance of some type of cordage, made either of animal or vegetable fibers. We know that man discovered early on the use of vegetable fibers for making rope. We also have evidence from the Middle Kingdom Egyptian Coffin Texts (Faulkner, 1977: 49) and tomb paintings (Davies, 1944: 50) that ropes made from animal hides were in common use. In fact, one Coffin Text excerpt [Spell 404] refers to the use of animal skins and sinews in the making of lacings and halyards for a boat.

The requirement for many different types of cordage is of paramount importance to the operation of any ship. In fact, no waterborne vessel, in ancient times, as today, could function without rope. Sail could not have been raised, nor could anchors have been deployed without the aid of rope. Indeed, a sail could not even have been fabricated without the use of some type of cordage. One can imagine dozens of uses for rope on the sailing vessels of the ancient Egyptian seagoing fleets (Fig. 1), as well as all sailing vessels since, yet, when rope has been found on ancient shipwrecks, or in other nautical contexts, in the Mediterranean area, those examples have received comparatively little attention.

Evidence from the ancient world that reveals this subject to us is quite varied, and includes textual,
Figure 1. Egyptian Sailing Ship, c. 1500 B.C.
(After Landström, 1978: fig. 36).
iconographic, and archaeological examples. Yet, there are by no means sufficient of any of these to provide a complete and unquestionable picture of how rope was made or what knots were used in seafaring, or in any other segment of any of the ancient societies, for that matter.

The objective of this thesis is a comprehensive study of the available evidence, from the paleolithic era through the end of the Roman Empire, on the manufacture and use of rope and knotwork in the seafaring of the ancient eastern Mediterranean. By investigating this crucial, but little studied material, I hope to add to our understanding of seafaring in the Mediterranean area during ancient times.
1. Many modern treatises on knots relate, to some extent, Sanderson's observations of African gorillas having used knots in the fabrication of their nests. This story is refuted, however, by G.B. Schaller's observations from his gorilla research, stating that there was "...no interlacing, weaving, knot-tying, or other involved manipulation..." in any of the nests he and his wife examined in 1959-1961 (Schaller, 1963: 188). Likewise, Paul A. Zahl says that he found no knots in the several central African gorilla nests that he examined during this same period (Zahl, 1960: 126).

Based on Schaller's observations, C.L. Day says that Sanderson was "...probably pulling his reader's legs..." (Day, 1967: 98, n. 6). Yet a more complete explanation of how Sanderson came to see the knots lends truthfulness to his story. It begins with a description of his native guides, and goes like this: "these tribemen had never had contact with any white men, and are noted for their veracity in matters of animal behavior. They further insisted that the gorilla was not a superior form of monkey like the Chimpanzee but a debased form of wild man.... As one proof of the contention that they are almost men, these natives showed the author sleeping platforms constructed by gorillas a few feet off the ground in gnarled dwarf trees made by bending down branches and anchoring them with true knots with a double over-and-under twist - both 'grannies' and 'reef knots'" (Sanderson, 1958: 102).
ROPE

INTRODUCTION

"Rope is probably the most remarkable product known to mankind. It is a simple thing, just a handful of fibers intertwined, its origin lost in the misty beginnings of history" (H.G. Smith, 1971: 1).

Basic ropemaking is actually a rather simple procedure that has changed little over the millennia. Materials from which cordage can be made are available almost anywhere. Any fibrous material of reasonable length, and of moderate strength and flexibility, can be used. Fibers from many common grasses, reeds, vines, barks, and palms have these traits. One has but to select a plant that meets these requirements, gather the raw material, separate out the desired fibers, and twist them into rope. In fact, descriptions of ropemaking in a modern guidebook on wilderness survival (Graves, 1978: 2-14), or a modern book on old-time crafts (Seymour, 1984: 116-117), probably differ little from instructions given by a master ropemaker to his apprentice five thousand years ago.

This study of the manufacture of rope and its use in seafaring in the ancient Mediterranean will cover the
available evidence from the ancient world, including
textual, iconographic, and archaeological. While we do
have iconographic and textual evidence for the use of
animal fiber rope in ancient Egypt, we have never found
evidence of animal fiber rope on any excavated shipwreck
in the Mediterranean Sea. This thesis, therefore, is
limited to the study of vegetable fiber cordage.

It is imperative that the study of any new subject
begin with a knowledge of the basic terminology of the
subject. While an extensive glossary of rope and
knotwork terminology is provided with this thesis
[Appendix B], it is proper to begin with some of the
basic terminology of the making and use of rope, as well
as to provide illustrations to aid in the understanding
of this terminology.

TERMINOLOGY

The basic raw material component of any type of
plant-based cordage is the fiber. Vegetable fibers fall
into three categories, depending on the part of the plant
from which they are taken. Soft or bast fibers are
flexible elongated strands obtained from the inner bark
of the stems of plants. Hard or leaf fibers are
comparatively stiff strands from leaves and leaf stems.
Seed fibers come from a plant's seed pods, although the
only fiber commonly used in the manufacture of cordage that falls into this category is cotton (*Gossypium sp.*) (D. & C. Osborne, 1954: 1095). [Crude, but serviceable, rope can also be made from strips of pliable bark from some plants, but none of this type of rope has been discovered on shipwrecks.]

Preparation of fibers for the rope-making process requires that they be removed from their natural state, i.e., from the stalk or the leaf, so that they can be handled individually. An initial concern when dealing with the flax plant (*Linum usitatissimum*), not present with other plants, are the flax seeds, since they are also a usable product. The first step after flax plants are harvested is called *rippling*; this removes the seed heads from the stalks. The flax seeds may then be crushed for their oil [linseed], or used for food. The stalks are then submerged in water in a step called *retting* [from the word rot]. This causes the gum that holds the flax fibers together to decompose, and rots away the inner core of the stalk. Once the stems begin to crack open, the retting is complete. [Since flax fibers can also be used in the weaving of fine linen cloth, the time spent in retting is very important. The quality of the fibers depends largely on the correct retting time, as well as the “ripeness” of the plant. A
later harvest gives more seeds, while earlier gives a finer stalk. The stalks are then washed in clean water and allowed to dry. They are then scutched, or beaten. This breaks and crushes the woody pith in the fibers so it can be removed. What remains are the true linen fibers. The fibers are then hackled, or drawn through a hackling comb, often simply a large bed of nails. This removes the shorter fibers, known as tow. Although too short for either spinning for cloth or twisting into rope, tow serves well for caulking [as oakum], stuffing mattresses, making small cord, and many other uses (Seymour, 1984: 177-179).

Once the individual fibers have been prepared, they are formed into rope in a process called laying or laying up. Natural vegetable fibers are covered with irregularities along their lengths. When spun together these irregularities are pressed against each other, causing a binding that prevents them from slipping apart when pulled from each end. The fibers are twisted, or spun, into yarns. This is accomplished by hand, by thigh rolling, by spindle, and, in the modern world, by machine. The separate yarns are then twisted into strands, and the strands are twisted to form the finished rope (Fig. 2).
Figure 2. A Length of Rope Showing Separate Strand, Yarns, and Fibers. (Drawing: W.H. Charlton).
Examination of a length of common three-strand rope will show that the fibers were twisted in one direction to form the yarns, the yarns were then twisted together in the opposite direction to form the strands, and the strands were again twisted in the original direction to form the finished product. This alternate twisting is the key principal in the manufacture of rope; it is this that creates the tension that holds the rope together and gives it strength (H.G. Smith, 1953: 2). As a final step, the completed length of rope is often passed through fire to burn off remaining loose ends and fibers. This gives the finished product a smooth and professional look and feel (Graves, 1978: 13).

Certain technical terms are used to describe the properties of finished cordage. The direction of twist, and the various terms used to describe it, can be an interesting study in itself. Basically, a finished rope, as well as its component yarns and strands, can only be twisted in one of two directions, to the right or to the left. However, the variety of terms used to describe these directions, and the interpretations of these terms by modern writers and sailors, has lent only confusion to the subject.

A yarn, strand, or rope which has been twisted to the left, or counterclockwise, has been interpreted by
some as *laying to the right*, or having a *right lay*, since, when one sights along its length, it appears to spiral off to the right. Conversely, a right, or clockwise twisted rope, can be said to have a *left lay*. Then there are those who use the terms *laid* and *twisted* synonymously ("...rope: laid, or twisted, to the left...," Frost, 1981: 94 & fig. 43).

As far back as 1930 Charles Amsden, writing in *American Anthropologist*, addressed this problem in a short note entitled "What is Clockwise?" He rightfully concludes that any written description of cordage using these terms must be accompanied by illustrations to assure understanding, but his recommendation that "the use of the terms left spiral and right spiral would avoid the possibility of misinterpretation and help to establish a uniform practice" (Amsden, 1930: 579-580) was not accepted. In 1952 the American Society for Testing Materials [ASTM] adopted the terms that are now standard references to direction of twist in cordage (D. & C. Osborne, 1954: 1098). These are "Z Twist" and "S Twist." Despite this clarification, however, writers and seafarers continue to use a confusing combination of these terms, most likely based on the traditions from which they come. Again, the only way of assuring understanding is by use of accompanying illustrations.
Modern scientific criterion, under the ASTM system just noted, dictates that cordage made with a left-hand, or counterclockwise twist, and whose angle of spiral matches that of the middle segment of the letter "Z," has a Z Twist. Conversely, cordage whose angle of spiral matches that of the mid-section of the letter "S," which was made with a right-hand, or clockwise twist, has an S Twist. The terms which will be used to describe direction of twist in this thesis are left, or Z-twist, and right, or S-twist (Fig. 3).

Rope is measured across its cross-section. If a piece of three-strand rope is cut straight across, in the end view three circles are seen, each one laying against the other two. Measuring the diameter, or the longest distance across the rope, will basically be across the diameters of two of the strands, the sum of which is equal to twice the diameter of one strand (Fig. 4).

EVIDENCE FROM THE PAST

We will most likely never have a complete understanding of the history of rope. We do know, though, from some of the ancient writers, what materials were used to make rope, and in some cases, which materials were preferred for particular applications. There is no description from the ancient world of the
**Figure 3.** "Z" and "S" Twists. (Drawings: W.H. Charlton).

**Figure 4.** Cross-Sectional Measurements. (Drawings: W.H. Charlton).
rope manufacturing process, but by piecing together various bits of evidence from the Egyptian tomb paintings and inscriptions, we can establish a reasonable understanding of that process. And, although scraps of rope excavated from ancient shipwrecks seldom give hints of their original use, they do tell us, in most cases, what materials were used in their manufacture, and are physical verification of the ancient writers' references to the use of these materials.

The Textual Evidence

What do ancient writers tell us about specific plants that were used in the manufacture of rope during their time? Where do these plants come from? And how was the finished product, the rope itself, acquired from its sources?¹

The ancient writers who provide this information fall into a variety of categories. There are epic poets, historians, playwrights, scientists, and even a geographer and a lawyer.²

¹ All translations of classical works cited in this thesis are from the Loeb Classical Library editions, unless otherwise noted.

² Names and dates are from The Oxford Classical Dictionary (Hammond & Scullard, 1970), unless otherwise noted.
The earliest of these was Homer. His life has been placed variously between the time of the Trojan War, about which he wrote, and some five hundred years after that [or approximately 1200-700 B.C.]. In the *Odyssey* he writes: "Now there lay beneath the portico the cable of a curved ship, made of the byblus plant..." (Od. 21. 390-391).

Byblus was the common name for Egyptian papyrus *[Cyperus papyrus] (LSJ 333, s.v. βυβλος). An alternative translation of this passage reads: "A coil of deck-rope of papyrus fiber lay in the gateway..." (Fitzgerald, 1961: 403). Not only do we have here the earliest textual reference by a Greek writer to rope made from a specific plant, but also the fact that the reference places that rope in a nautical context.

In Book II of his *History*, the fifth century B.C. historian Herodotus provides the following description of the building of an Egyptian boat: "The boats in which they carry cargo are made of the acacia, which is in form most like to the lotus of Cyrene, and its sap is gum. Of this tree they cut logs of two cubits length and lay them like courses of bricks, and build the boat by making these two-cubit logs fast to long and close-set stakes; and having so built they set crossbeams athwart and on the logs. They use no ribs. They caulk the seams within
with byblus. There is one rudder, passing through a hole in the boat's keel. The mast is of acacia-wood and the sails of byblus" (Hdt. 2.96). This passage includes two references to the use of papyrus, one for caulking and one for the making of sails.

The phrase "They caulk the seams within with byblus" has long been taken as evidence of caulking of the inside of the hull to prevent leakage. A convincing argument for an alternative translation, however, is presented by Haldane and Shelmerdine, i.e., "They bind in the seams from within with papyrus" (Haldane & Shelmerdine, 1990: 535-539). This refers to sewing, or lashing, as the method of binding the boat's external planking together, the same procedure used in the design and construction of the Cheops Vessel (Lipke, 1984: 20-21, fig. 11, item 'h'). [Casson (1992b: 557, n. 17) does not agree with this new translation.] If this new translation is correct, as seems probable, we have a second reference to the use of papyrus in the manufacture of rope in ancient Egypt. I refer to papyrus being used in rope in this instance, rather than in any other form, i.e., as a withey, because the papyrus plant is similar to a rush in its construction and does not have the strength of structure to be used as a ligature. Pliny the Elder describes strips of bark and flexible shoots from the willow tree
that are used as withies (NH 16.67.174), but never does he describe papyrus being used in such a manner.

In 480 B.C. Xerxes, the King of Persia, attempted to conquer Greece in an effort to avenge the defeat of his father Darius by the Greeks at the battle of Marathon ten years earlier (Radice, 1973: 252). In three passages Herodotus recounts the building of bridges by Xerxes for the crossing of the Hellespont during this campaign: “Thus did Xerxes accomplish this work; and for the bridges he charged the Phoenicians and Egyptians with the making of ropes of papyrus and white flax....” (Hdt. 7.25.1). “Beginning then from Abydos they whose business it was made bridges across to that headland, the Phoenicians one of flaxen cable, and the Egyptians the second, which was of papyrus” (Hdt. 7.34.1). “Having so done, they stretched the cables from the land, twisting them taut with wooden windlasses; and they did not as before keep the two kinds apart, but assigned for each bridge two cables of flax and four of papyrus. All these were of the same thickness and fair appearance, but the flaxen were heavier in their proportion, a cubit thereof weighing a talent” (Hdt. 7.36.3). It has been estimated that each of these ropes would have been a mile long, some seven inches in diameter, and would have weighed up to fifty pounds per foot of length (Macan, 1895: 53-54).
The Athenian tragic dramatist, Aeschylus [524/5–456 B.C.], tells in his play *The Suppliant Maidens* of a ship in which rope made of flax is used. He writes "Our oars, indeed, and our timbered barque, girdled with flaxen cordage to withstand the sea, sped me on by help of favouring gales, unharmed of all tempests..." (*Supp.* ll. 134-136). Herbert Weir Smith's translator's note to the "girdled with flaxen cordage" passage refers to it as "undergirdling ropes (ὑποξωματα [upozomata]) to brace a ship's sides" (*Supp.* l. 135, n. 1). This has been interpreted as referring to lacing, or sewing, the ship's planking as a method of binding it together (Mark, 1991: 442).

In another passage from the same play Aeschylus' King concludes that he must go to war, that there is no way out. Aeschylus compares the finality of the King's position as follows: "There is no escape - 'tis as firmly fixed as a ship's hull drawn tight by windlasses" (*Supp.* ll. 439-441). It seems that Aeschylus believed this method of binding a ship's hull planking was well enough known to his audience that the comparison would be readily understood by all.

In his play *Trojan Women*, the Athenian dramatist Euripides [c. 485–c. 406 B.C.] mentions the use of flaxen ropes. In the story of the people of Troy bringing the
Trojan Horse into their city, he writes: "The whole race of Trojans rushed to the gates to give to the goddess the mountain pinewood, polished ambush of the Argives which was to be the destruction of Troy. It was a gift to the virgin goddess of the immortal steeds. They brought it like the dark hull of a ship, with encircling ropes of spun flax, to the stone floor of the temple of the goddess Pallas. It was death to our country" (Tro. 11. 532-540). Also, in the play Iphigenia in Tauris (IT 1. 1043), Euripides tells of a ship moored with "flaxen bridles" (Casson, 1971: 231, n. 27).

Theophrastus [c. 370-288/5 B.C.], an early botanist, wrote about, among other things, plant life in Egypt during the fourth century B.C. In his Inquiry into Plants, he makes the following references to papyrus: "The papyrus does not grow in deep water, but only in a depth of about two cubits, and sometimes shallower" (IP 4.8.2). "The papyrus itself [the stalk] is useful for many purposes; for they make boats from it, and from the rind they weave sails, mats, a kind of raiment, coverlets, ropes, and many other things," and "Such is the papyrus and such its uses. It grows also in Syria about the lake in which grows also sweetflag; and Antigonus made of it the cables for his ships" (both IP 4.8.4).
Varro [116-27 B.C.] wrote about the raising of crops in his treatise on Roman farm management, *On Farming*. He recommended the growing of hemp (*Cannabis sativa*), flax, rushes, and esparto grass (*Stipa tenacissima*) "...for weaving shoes for the oxen and making string, cords, and ropes" (*Rust.* 1.23.6).

In an interesting contrast to the writings of Euripides, the Roman poet Virgil [70-19 B.C.] also writes about the Trojan War, but from a different perspective, and from a time some four hundred years more distant from the original event. Recounting the story of the Trojan Horse in *The Aeneid*, Virgil's passage reads: "We cut through our walls and threw our defenses open. All set to work with zest. Rollers for smooth running were placed under the horse's feet and hempen ropes tied round its neck. That engine of doom, pregnant with armed men, mounted our walls" (*Aen.* 2.234-238). Why the difference in the type of ropes mentioned by Euripides and by Virgil? Might it be that each author was simply presenting the name for rope which he thought would be most familiar to his audience? And might this be a clue that the most common material used to make rope in Euripides' fifth century B.C. Greece and Virgil's first century B.C. Rome was different, i.e., flax and hemp, respectively?
The Roman historian Livy [59 B.C.- A.D. 17 or 64 B.C.-A.D. 12], writing about the Punic Wars between Rome and Carthage during the third century B.C., relates how a Roman fleet "...sailed to Longuntica, where they found a great quantity of esparto grass, which Hasdrubal [the Carthaginian general] had got together for the use of his ships. Of this they took what they needed and burned the rest" (Livy 22.20.6). This passage illustrates the importance to both sides during these wars of this raw material used for the manufacture of rope, as well as a common military tactic in a raid such as this, take as much as you can carry and destroy the rest, leaving nothing usable for your enemy.

In Fasti, the Roman poet Ovid [43 B.C.-A.D. 17] writes: "...and while they made ready to furl the sails with the ropes..." (Fasti 3.587-588). Lionel Casson translates the original Latin torto lino in this passage as "ropes of twisted flax" (Casson, 1971: 231).

The Roman satiric poet Persius [34-62 A.D.] includes a passage in his fifth Satire that is suggestive of rope. Telling of a man at mealtime aboard ship, he writes: "Thou, on coiled hemp couched, take dinner...." (Satire V: 146-147). Because of his use of the term "coiled," it is my opinion that Persius intended the man in this passage to be seated on a coil of hemp rope, rather than on hemp
in any other form. A bundle of raw hempen fibers, for instance, would not have been "coiled," and a coil of rope was likely a common commodity aboard ship.

Pliny the Elder [A.D. 23/24-79], in his exhaustive study of his world, *Natural History*, refers to the use of many different plants in the manufacture of rope and other seafaring-related goods. In Book XIII, he notes that the Date Palm [*Phoenix dactylifera*] is used for rope (*NH 13.7.30*), and that in Egypt papyrus is "...plaited to make boats, and the inner bark is woven into sail-cloth and matting, and also cloth, as well as blankets and ropes" (*NH 13.22.72*). In 19.56.174 he emphasizes that hemp is "...exceedingly useful for ropes."

In Book XIX, Pliny praises the flax plant for its part in linking the widely separated areas of the Roman Empire, because sails are made from it (*NH 19.1.3*). Continuing, he states: "Moreover as early as the Trojan war linen already held a place of honour - for why should it not be present even in battles as it is in shipwrecks? Homer testifies that warriors, though only a few, fought in linen corslets. This material was also used for rigging ships, according to the same author as interpreted by the more learned scholars..." (*NH 19.6.25*). In a marginal note one of Pliny's translators, H. Rackham, indicates that he refers here to the passage
in The Iliad in which Agamemnon laments: "Already have nine years of great Zeus gone by, and lo, our ships' timbers are rotted, and the tackling loosed..." (Il. 2.135).

In two passages Pliny tells of specific applications for ropes made of three different plant species, two of which are of particular interest to the subject of seafaring. Mentioning both esparto grass and hemp in the same sentence, he says esparto "...is of unrivaled utility, especially for use in water and in the sea, though on dry land they prefer ropes made of hemp" (NH 19.8.29). And "we have said that in the east palm-leaves [date palm] are used for making strong ropes, and that these are made specially serviceable for use in water" (NH 16.37.89). Continuing with his praise of esparto, Pliny says "...one who wishes to understand the value of this marvelous plant must realize how much it is employed in all countries for the rigging of ships..." (NH 19.8.30).

Again in Book XIX, Pliny names another plant which the Greeks had long used for their cordage. This is genista [Spartum junceum] (NH 19.2.15). In NH 24.40.65 he wonders "...whether this is the plant that Greek writers have called sparton...," since "it is certain that the Spanish or African esparto grass was not yet in
use..." Morton interprets these passages as follows: "Pliny distinguished two plants used for making ropes which bore the name spartum (NH, XIX.26; XXIV.65). One with 'yellow flowers and seeds in pods' is correctly identified by him as genista, the plant known to the Greeks as sparton (broom, Spartum junceum), and used from earliest times for ropes. The other spartum, cultivated by the Carthaginians in Spain, is said by Pliny to be a rush-like plant (iuncus) of arid ground, and is clearly the esparto grass (Stipa tenecissima), of which he describes the cultivation, technology and economic importance" (Morton, 1986: 91).

The Roman lawyer and man of letters, Aulus Gellius [c. A.D. 130-c. 180], in his Attic Nights, relates a story concerning the Homeric word σπάρτα [sparta]. Quoting from the twenty-fifth book of Marcus Varro's Human Antiquities (a document which we know today only from a fragment; AN 17.3.4, n. 1), Gellius gives us Varro's opinion on the availability of esparto during the Homeric period, plus some enlightening information on other plants used for rope, as well as a comment on ship building methods of the time. The passage reads: "I believe that σπάρτα in Homer does not mean sparta, or "Spanish broom," but rather σπάρτοι (spartoi), a kind of broom which is said to grow in the Theban territory [the
Grecian Thebes]. In Greece there has only recently been a supply of spartum, imported from Spain. The Liburnians did not make use of that material either, but as a rule fastened their ships together with thongs, while the Greeks made more use of hemp, tow, and other cultivated plants (sativis), from which ropes got their name of sparta" (AN 17.3.4).

Athenaeus [fl. c. A.D. 200], in The Deipnosophists, writes the following about the superfreighter, Syracusia, built by Hiero II (306-215 B.C.): "I cannot refrain from mentioning the ship built by Hiero of Syracuse, the one supervised by Archimedes the mathematician... Hiero, ...eager to gain a reputation in the field of shipbuilding, had a number of grain-carriers built, the construction of one of which I shall describe. For the materials, he collected...; for cordage, esparto from Spain and hemp and pitch from the Rhone Valley...." (Ath. 5.206 d-f, from translation of G. Kaibel's 1887 text by Casson, 1971: 191-194).

There are a great many more references to rope in the writings of the ancient authors, especially of rope in nautical contexts, but those just quoted were selected because they have answered my first question. They have told us specifically of seven different plants from which rope was made during antiquity: papyrus, flax, esparto
grass, hemp, date palm, genista, and the rush *Scirpus holoschoenus*. Of these, esparto, hemp, date palm, and the rush have been substantiated by archaeological finds.

My second question asked if any of the ancient writers would tell us specifically where the plants used in the manufacture of rope came from. Some of them do. Theophrastus, the fourth century B.C. botanist, tells us that papyrus grows in Egypt, and also in Syria (*IP* 4.8.2-4).

Pliny also refers specifically to Egyptian and Syrian papyrus (*NH* 13.22.73). He states: "King Antiochus would only allow ropes made from this Syrian papyrus to be used in his navy..." In this same passage he adds that papyrus grows in the Euphrates near Babylon.

In Book XIX, Pliny first mentions Egypt, and then takes his readers on a tour of western Europe in his listing of the areas where flax was grown during his time. Included are various regions of Spain, Gaul, Germany, and Italy (*NH* 19.2.7-11).

In *NH* 19.7 Pliny provides information on esparto. He states that the use of esparto did not begin until the Carthaginians' first invasion of Spain in 237 B.C. He continues: "Esparto also is a plant, which is self-sown and cannot be grown from seed; strictly it is a rush, belonging to a dry soil, and all the blame for it
attaches to the earth, for it is a curse of the land, and nothing else can be grown or can spring up there. In Africa it makes a small growth and is of no use. In the Cartagena section of Hither Spain...even the mountains are covered with esparto grass" (NH 19.7.27). And "...a sufficient quantity...will be found to exist in a district on the coast of Cartagena that extends less than 100 miles along the shore and is less than 30 miles wide. The cost of carriage prohibits its being transported any considerable distance" (NH 19.8.30-31). Here Pliny must refer only to esparto in its raw, unprocessed form, for finished esparto rope could be, and assuredly was, transported far and wide in the rope lockers of ships.

B.O. Foster's translator's note to the section in Livy which relates how the Roman navy looted Carthaginian stores of esparto reads: "Longuntica, otherwise unknown, was probably not far from New Carthage [Cartagena] for the Spartarius Campus (so named from a kind of rush-grass, still called esparto, which was used for twisting into rope) lay inland from the latter town" (Livy 22.10.7, n. 3).

Pliny also names a variety of other locales where the plants from which rope is made abound. Reeds and papyrus grow in the river Niger (NH 5.8.44); date palms grow around the Judean town of Jericho (NH 5.15.70), on
the western side of the Dead Sea \((NH\ 5.15.73)\), and near Great Leptis in North Africa \((NH\ 18.50.188)\). Both papyrus and date palms grow in the Canary Islands \((NH\ 6.37.205)\), genista grows in Italy \((NH\ 17.30.136\ & 18.65.240)\), the rush \([\text{Scirpus Holoschoenus}]\) grows in Greece \((NH\ 21.68.113)\), and hemp grows in Mylasa and in Rosea in the Sabine territory of Italy \((NH\ 19.56.174)\). Hemp is also imported from the Rhone Valley \((\text{Ath.}\ 5.206\ d-f,\ \text{from Casson,}\ 1971:\ 191-194)\).

Towards the end of his *Natural History*, Pliny states: "For now that I have completed my survey of Nature's works, it is right that I should make a critical assessment of her products, as well as the lands that produce them. This then I declare: in the whole world, wherever the vault of heaven turns, there is no land so well adorned with all that wins Nature's crown as Italy.... Nowhere are the things that man is entitled to expect more excellent - flax.... Next to Italy I would place Spain...for here we find esparto grass...." \((NH\ 37.76.202-203)\). It seems meaningful that Pliny should name, among all that he believes are Nature's greatest products, two that are well known for use in the manufacture of rope, an indication of rope's importance to all of mankind during those times.
Now, can we determine how the finished product, the rope itself, was acquired from its sources? Yes.

There are three sources that provide us with specific information. First, Varro, writing during the first century B.C., as quoted by Gellius, stated that spartum [esparto] was only recently imported into Greece from Spain (AN 17.3.4). The second is the Greek geographer Strabo [64/3 B.C.-c. A.D. 21 at least]. It is Strabo's style to travel through an area and describe places and events he passes on his way. In Geography 3.4.9 he is traveling on "...the road from Italy to what is called Farther Iberia" in Spain. Past the city of Setabis the road "...gradually departs from the sea and joins what is called the Spartarian - or, as we should say, Rush Plain. This plain is large and has no water, but produces the kind of spart [sic] that is suitable for twisting into ropes, and is therefore exported to all regions, and particularly to Italy."

The third bit of information on how the finished rope got from the source to the user is contained in the Achilleid of the Roman poet Statius [c. A.D. 45-96]. Section 1.413-422 catalogs the contributions of various Greek towns to Agamemnon's expedition against Troy. Each item of equipment was appropriate to its place of origin, with but one exception. The contribution of Mycenean
Pylos was not clear, yet it had long been interpreted as being either siege engines, or timber for siege engines, although Pylos was not known as a source of quality timber. The decipherment of Linear B, however, provided insights which allowed clarification. This reinterpretation revealed that Pylos had a flourishing flax industry, and was known as a center of rope manufacture. This knowledge allowed the much more believable interpretation that Pylos supplied rope to be used with the war machines (Williams, 1986: 280-283). Since Pylos was a center for rope manufacture, it certainly seems within the realm of possibility that its rope would have been procured in quantity by the quartermasters for all manner of requirements, not just for use with siege engines. One can imagine flaxen rope from Pylos having been used by the Achaeans at Troy to replace their "loosed tackling."

There are two subjects which I believe require correction, or clarification. First is the matter of the material used to make the ropes that the Phoenicians provided for the bridges on which Xerxes' armies would cross the Hellespont. Once in Hdt. 7.25.1, once in 7.34.1, and twice in 7.36.3 Herodotus names the specific material used to make these ropes. Three times he uses the term λευκόλίνον [leukolínon], and once the term λίνεα
[ linea]. These translate literally as "white flax" (LSJ 1041, s.v. λευκόλινον) and "flaxen," respectively. Yet A.D. Godley, the translator of the Loeb Classical Library edition of Herodotus printed in 1920, attached the following note to his translation: "λευκόλινον is apparently not really flax but 'Esparto Grass,' imported from Spain by the Phoenicians" (Hdt. 7.25.1, n. 1). No other comment is provided in the form of a reason, or explanation for this change.

Λίνον [linon] is defined as "anything made of flax" (LSJ 1051, s.v. λίνον). Interestingly, the references given for λευκόλινον [leukolinion], or white flax, in the Greek-English Lexicon (LSJ 1041, s.v. λίνον) are to these very passages in Herodotus (7.25, 34, and 36), as well as a passage from On The Characteristics Of Animals [De Natura Animalium] by the Roman writer Aelian [c. A.D. 170-235]. This passage, a fantastic story of a monstrous worm found in the Indus River, reads: "The following means have been devised for hunting and capturing them. Men let down a stout, strong hook attached to an iron chain, and to this they fasten a rope of white flax [λευκόλινον] weighing a talent, and they wrap wool round both chain and rope to prevent the worm biting through them" (NA 5.3).
Beside the fact that Herodotus named quite specifically the material from which the Phoenician's ropes were made, I believe there is other evidence from the ancient writers which will prove the translator's change was not correct. Two of the Roman-period writers state that esparto grass did not come into Greece until much later than the time Herodotus was writing about, c. 480 B.C. Marcus Varro in his Human Antiquities [written during the first century B.C.], as quoted by Aulus Gellius (AN 17.3.4), states that "in Greece there has only recently been a supply of spartum, imported from Spain." And in Natural History, Pliny the Elder states: "As a matter of fact the employment of esparto began many generations later, and not before the first invasion of Spain by the Carthaginians" (NH 19.7.26). I believe that, given the evidence which I have presented, and until more convincing evidence is provided to the contrary, we should consider that Herodotus' references to the Phoenician's ropes having been made of flax should be taken literally.

The other subject I wish to address concerns the use of the term "rigging" by Pliny the Elder in two passages in his Natural History. Our late-twentieth-century understanding and use of the term "rigging," in relation to seafaring, pertains rather strictly to components of a
vessel's standing and running rigging. Pliny states in NH 19.6.25 that linen was "used for rigging ships" [navium armamenta] during the Trojan War, and in NH 19.8.30, in praise of esparto grass, he says that, among other uses, "...it is employed in all countries for the rigging of ships [navium armamentis]..."

In a recent reinterpretation of Odysseus' boat-building passage in the Odyssey (Od. 5.234-253), Mark (1991: 441-445; 1996: 46-48) proposes that the hull planks of the boat Odysseus builds would have been sewn, or laced, together, rather than having been joined by the heretofore accepted pegged mortice-and-tenon method. [Casson (1992a: 73-74) disagrees with Mark's reinterpretation.] In his argument, Mark cites Pliny's reference in Natural History 24.40.65, where Pliny discusses the possibility that Homer's sparta refers to a ship's "loosed cords," rather than to esparto grass, because esparto was not yet available in Greece during Homeric times. He then states matter-of-factly: "Though ships were made with sewed seams, yet it was with flax that they were sewed and never with esparto." W.H.S. Jones' translator's note to this passage states, in part, "Pliny, as Varro in Aulus Gellius XVII.3, takes σπάρτα (sparta) to be the cords with which the planks of a ship
were bound together, and not the rigging" (*NH* 24.40.65, n. 5).

I submit that not only is this not the case, but possibly exactly the opposite. *Cassell's New Latin Dictionary* defines *armamenta* as "implements, tackle; especially of a ship" (Simpson, 1958: 58, s.v. *armamenta*). Casson interprets Pliny's statement in *NH* 19.8.30 to mean "for ship's cordage," and not specifically for rigging (1971: 231, n. 28). I believe that Pliny used the term in a much more general sense than we would today, i.e., that he was neither referring specifically to a ship's standing or running rigging, nor only to the plank lacings. If so, his understanding and use of the term included all manner of ways in which cordage would have been used in a ship's operation, from anchor rodes, to stays and shrouds, to halyards and sheets, to plank lacings. This meaning would make perfect sense, and would fit in both cases where Pliny uses the term.

The Iconographic Evidence

When we look to the iconography of the Greeks and Romans for clues to the rope manufacturing process, we find little. This is not true of ancient Egyptian society, however. Ancient Egyptian tomb paintings and inscriptions are a rich source of information on the
subject, and most of these actually come from periods much earlier than Homer, the earliest of the Greek writers.

In addition to Egyptian tomb paintings and inscriptions, there are also references to the use of rope for shipbuilding in the Coffin Texts. These were spells intended to aid the departed in the after-life (Mueller, 1972: 99), and were written in ink on the inside walls of the wooden coffins used for the burial of wealthy Egyptians during the Middle Kingdom period [c. 2150-1800 B.C.] (Faulkner, 1973 I, vii). The references to boat-building are simple statements, but they emphasize the importance of boats in ancient Egyptian society. In Spell 189 the deceased says: "I have tied up the bark to the land... Its papyrus stems are cut, its lacings (?) are twisted, its hull is frapped. A way to the sky is made for me..." (Faulkner, 1973 I: 158).

In other words, the deceased has prepared his papyrus reed canoe, his preferred mode of transportation, for his trip to the after-life. Spell 195 contains similar references to preparation of the reed canoe (Faulkner, 1973 I: 161).

While there is no single site, or tomb, that relates the entire rope-making story, there are enough depictions available that we are able to assemble the entire puzzle.
E. Teeter (1987) studied the Egyptian rope-making scenes previously identified by Vandier (1969), and was able to add several scenes to Vandier's list. Teeter lists eleven scenes from ten different Egyptian tombs, and on one loose block in the Cairo Museum, as depicting the manufacture of cordage (1987: 71). Of these, one scene is so badly damaged that it cannot actually be made out (Teeter, 1987: 71, n. 1).

Although most rope-making scenes in the tomb paintings are from the period of the Old Kingdom [c. 2800-2175 B.C.], there is also a scene from the Middle kingdom, as well as two scenes from the New Kingdom [c. 1570-1085 B.C.]. The majority of the scenes appear together with either boat-building or agricultural scenes, but they are conspicuously absent from any of the many depictions of arts and crafts. This likely indicates that rope-making was considered a more common, or menial, function, and was not afforded the higher status of an art or a craft (Teeter, 1987: 75).

The tombs from the Old Kingdom that have rope-making scenes are those of Akhtihotep (Vandier, 1969: pl. xxix, fig. 197), Iymery (Ergänzungsband, 1913: pl. vi), Kaemnofret (Dunham, 1935: 300-309), Kahif (Junker, 1943: 68-69, fog. 43, pls. xiva, xxiib), Nefer (Junker, 1943: fig. 17), Nyankhnesut (Nelson-Atkins Museum of Art,
Kansas City. PM III\(^2\), 695), and Ptahhetep (Davies, 1900 vol. I: pls. xxii, xxv). The loose block in the Cairo Museum, also from the Old Kingdom, is CG 1697 (Borchardt, 1899: 141). The New Kingdom tombs of Khaemwaset (Mackay, 1916: pl. xv) and Rekh-mi-Re' (Davies, 1944: pl. LII) have rope-making scenes. Several of the scenes are accompanied by inscriptions which describe, at least in part, the activity depicted in the scene.

In addition to the scenes described by Teeter, and Vandier before her, I have identified two additional scenes, from the Old Kingdom tomb of Anta at Deshasheh (Petrie, 1898: pl. v) and the Middle Kingdom tomb of Tehuti-Hetep at El Bersheh (Newberry, n.d., pl. XXVI).

Taken together the scenes illustrate the four basic functions required for the manufacture of rope, i.e., collection of the raw materials, sorting or removing the fibers, twisting fibers into yarns, and twisting the yarns together to form the finished product. [In her discussion of the subject, Teeter does not address the realities of the rope-making process, i.e., that small yarns are twisted into larger strands that are then twisted into rope.]

The most complete depiction of the process of rope-making is from the Old Kingdom tomb of Kaemnofret (Fig. 5). The top register shows three men gathering the raw
Figure 5. Rope Scene from Tomb of Kaemnofret. (After Dunham, 1935: fig. 1).
materials. One man is shown pulling a papyrus stalk, while two others are already loaded down with bundles of papyrus. Directly below, two men sit facing each other sorting fibers and placing them in a stack at their feet. A coil of rope is shown at the right. The inscription between these two men reads "pulling out papyrus-fibre" (Dunham, 1935: 304). In the third register the seated man feeds in separate fibers as his partner twists them into a yarn, but part of this picture is missing. Borchardt's (1899: 141) recording of the Cairo CG 1697 block (Fig. 6) clearly shows the same scene as the Kaemnofret third register. Here a weight is shown attached to the yarn in front of the standing man. This weight would have been spun around by the standing man helping him to put the twist into the yarn. He would have walked backwards as his partner continued to feed fibers into the twisting yarn and the yarn grew in length. Ropewalk is the modern term for the specific area where long ropes are made. It is so called because, in this case, the man putting the twist into the rope, strand, or yarn by spinning the weighted tool would have walked backwards as the rope grew in length. Another coiled rope is shown to the left in the Kaemnofret scene, and the inscription between the men reads "twisting papyrus-fibre" (Dunham, 1935: 305). In the completion of
Figure 6. Rope Scene from Cairo CG-1697. (After Borchardt, 1899: 141).
this series of scenes, Dunham states this rope would be used to bind papyrus stalks into a boat (1935: 305).

In addition to the tomb of Kaemnofret and the Cairo CG 1697 scenes, those of Akhtihotep, Iymery, Khaemwaset, and Ptahhotep show workers near swamps, probably all gathering papyrus. The scenes from the tomb of Ptahhetep (Fig. 7) include rope-making in the top register and binding of papyrus boats across the bottom. Griffith describes the inscriptions accompanying these scenes as follows: "An old man and a boy are 'twisting ropes of boat-building,' as the inscriptions says." And of the bottom right-hand section of the boat-building scene, "A man says to a boy 'O strong youth, bring me ropes;' the boy replies 'O my father, here is the rope for you,' offering him two coils" (Griffith, 1900: 10).

The rope-making scenes from the tombs of Kahif (Fig. 8) and Nefer (Fig. 9) accompany agricultural scenes, indicating the gathering and use of a fiber other than papyrus, although the type of fiber is not identified. [Ancient ropes of halfa grass and doum palm have also been found in Egypt. See below - The Archaeological Evidence.]

One of the additional scenes I have identified, from the tomb of Anta (Fig. 10), again features the gathering of papyrus, rope-making, and boat-building. Petrie
Figure 7. Rope and Boat Scene from Tomb of Ptahhetep. (After Davies, 1900: plate XXI).

Figure 8. Rope Scene from Tomb of Kahif. (After Junker, 1943: abb. 43).
Figure 9. Rope Scene from Tomb of Nefer. (After Junker, 1943: abb. 17).

Figure 10. Rope and Boat Scene from Tomb of Anta. (After Petrie, 1898: plate V).
describes this register as showing "...the pulling of papyrus in the marshes, carrying the bundles of it, and building the papyrus boats. Coils of papyrus rope have been twisted by the boy sitting below the boat, and are lying about on the ground behind the boat" (Petrie, 1898: 7). Given that there are a number of missing or destroyed parts of this scene, and based on information from all scenes so-far reviewed, indicating that this particular segment of the rope-making task is a two-man function, I believe that a part of this scene is also missing. Since the seated (A) boy's rope extends toward the standing (B) boy in front of him, and there appears to be a part of the standing boy's arm missing, it appears that the standing boy should also be included in the rope-making scene as the person who actually puts the twist into the rope.

All scenes so far reviewed from the Old Kingdom show the function of the twisting of the fibers into rope in a very rudimentary form. The artists either wanted, or were forced, to simplify their presentations by showing what is a three-step operation, i.e., twisting fibers into yarns, twisting yarns into strands, and finally twisting the strands into rope, in a single scene.

The second additional scene dates to the Middle Kingdom (Newberry, n.d., vii) and is quite different
(Fig. 11). It appears to illustrate a much more automated rope-making enterprise. Newberry identifies this segment of the scene as "rope-making...no doubt with palm fiber. At the top are some looped ropes, pegged out, it may be to dry. A woman, bending over, has a rope passed around her knees; the fracture [a break in the painting] has carried away the rest of the group, which probably showed another figure forcibly twisting the rope" (Newberry, n.d.: 36).

A different interpretation of the entire scene, however, is presented by E. Barber (1991: 90). The scene is unique, in that women are doing the work, as compared to other rope-making scenes in which only men are depicted. Barber identifies this scene as depicting the manufacture of textiles, i.e., weaving.

The two scenes we have from the New Kingdom show the traditional rope-making functions in somewhat more detail. The scene from the tomb of Rekh-mi-Re' at Thebes (Fig. 12) is understood as showing rope being made from thin leather thongs. Davies says of this scene: "On the extreme left an experienced cutter has taken the greater part of a hide and, by going round and round it with the knife, is producing a continuous thong so fine that it can be used like rope to form a cable of triple strands" (Davies, 1944: 50). Of interest here is the weight.
Figure 11. Rope Scene from Tomb of Tehuti-Hetep. 
(After Newberry, n.d.: plate XXVI).

Figure 12. Rope Scene from Tomb of Rekh-mi-Re'.
(After Davies, 1944: plate LII).
This is the same tool that was used for rope-making during the Old Kingdom, but shown in greater detail here. According to Davies, "for this purpose the same instrument is used as in ropemaking - a small clip of stout reed with a heavy stone lashed to it. The weighted clip is swung round and round by an assistant and, as it is attached loosely to a belt passing round his body, weight can be thrown upon the rope and prevent it from curling up under the tension" (Davies, 1944: 50). This "curling up" would have been prevented as a natural consequence of the standing man's backing up as the rope's length increased.

We have seen so far depictions of three of the four functions required for rope-making, collection of the raw materials, sorting or removing the fibers, and twisting the fibers into yarn. The one remaining painting, from the New Kingdom tomb of Khaemwaset (Fig. 13), appears to illustrate the final stage in the process, that of twisting the yarns together to form the finished rope.

Three men are making rope in, or near, a papyrus swamp. The man at the right holds a weighted tool in each hand to which are attached already-prepared, twisted strands. He would spin these strands, with the aid of the weighted tools, imparting the required twist, i.e., in the opposite direction of the twist of the strands.
Figure 13. Rope Scene from Tomb 260 at Thebes (Khaemwaset). (After Mackay, 1916: plate XV).
The seated man would be holding a vertical bar between the two strands ensuring an even twisting together of the strands [although the scene is damaged, this vertical bar can be seen in front of the man's legs]. The man to the left would have the end of the rope attached to a bar, or stick, and would put the final twist into the rope (Mackay, 1916: 126).

Pictured above this scene are four coils of finished rope, a tied bundle of papyrus stems ready to be made into rope, and the rope-making tools. Mackay describes the tools as: "...a marline-spike used in splicing and also to put between two strands when they are being twisted together. Below is a mallet used for beating the papyrus stems, after they had been soaked in water, to make them sufficiently pliable to be twisted. Next to these are two tools for twisting the separate strands of rope.... To the right of these is another marline-spike somewhat similar to, but smaller than, the first, and lastly a knife which was probably used for cutting down the reeds" (Mackay, 1916: 126).

As a comparison to the rope-making scene he has reported from the tomb painting, Mackay describes witnessing "...present-day Egyptian fellahín at work making a rope, from which it will be seen that the ancient and the modern methods are almost identical." In
Mackay’s illustration the *fellâh* in the middle position, comparable to the man in the middle of the ancient drawing, has a bar of iron stuck vertically in the ground and uses a piece of wood passed horizontally between the two strands that are in the process of being twisted together. He continues that the only differences in the ancient and modern rope-making techniques are that where the tomb painting shows one man spinning the weighted tools to place the twist in the rope, the modern Egyptians use one man to twist each strand, i.e., two men for two-strand rope, and the modern tools used to place the twist in the rope are of a much different design than those pictured in the tomb paintings (Mackay, 1916: 126).

The Egyptian tomb paintings provide a great deal of insight into the ancient art of rope-making, and one important aspect of ancient technology. They tell of at least one specific fiber that was used for making rope, and they illustrate the four main steps of the rope-making process. Yet there are some critical details not presented, and which we may never know. How was the weighted tool made and used? How was it used, and by how many people, when rope of more than two strands was made? And last, but certainly not least, how were longer lengths of rope made, i.e., what was the ancient Egyptian version of a ropewalk?
In addition to the tomb paintings and inscriptions, there are a few written sources from the period that provide amplifying information on Egyptian rope-making. We know from documents of the times that the ancient Egyptians did make ropes of great length. Entries in Nile ship's logs dated to the year 1239 B.C., during the reign of Pharaoh Ramses II (Janssen, 1961: 4), list ropes 500 and 1000 cubits in length. The Egyptian royal cubit measured 52.3 centimeters, making these ropes 261 ½ and 523 meters in length, respectively (Janssen, 1961: 87). Less precisely dated, but still from the Ramessid Period, are lists of prices for various commodities. One specific list includes ropes in lengths of 1400, 1200, and 1000 cubits ordered "...for the royal bark" (Janssen, 1975: 438-439). These were 732.2, 627.6, and 523 meters in length, respectively.

All of these ropes are from nautical contexts, and while we know their lengths, we do not know their diameters. Turning landward, however, we do find some information on sizes. In 1942 seven thick ropes were found buried in an old stone quarry at Tura. They were of papyrus and were made up of three strands, each of which had about forty yarns, and each yarn had about seven fibers. The diameter of these ropes was about two and one half inches [6.35 cm] and their circumference was
about eight inches [20.32 cm]. Two years later another papyrus rope was found in a nearby cave, this one about half the size of the others. Being of papyrus, these ropes are not modern, but they have not been dated (Lucas, 1948: 161). Arnold, however, states that these ropes are believed to be of Ptolemaic or Roman date (Arnold, 1991: 268). He also mentions a "mammoth piece of cordage" from the Nineteenth Dynasty at Deir-el-Bahari that had a diameter of 6.8 cm, as well as the modern calculations of the size of the ropes used to lower the obelisk of Thutmosis III in front of Pylon VIII at Karnak. These ropes would have to have been 85 to 90 meters long, with a circumference of 18 cm and a diameter of 5.7 cm, and they would have to have had a working strength of 6 to 7 tons and a breaking resistance of 20 tons (Arnold, 1991: 269).

One additional text specifically names another fiber used for rope-making in ancient Egypt. In Zenon Papyrus #59438 a farmer orders two hundred bundles of palm fiber so he can make ropes to bind his plow together (Edgar, 1971: 165).

This review of the rope-making scenes from the Egyptian tomb paintings, as well as their associated inscriptions and some supplemental textual evidence, provides insight into the process of rope-making in
antiquity. All of this information taken together indicates that the ancient Egyptians had developed an efficient, advanced, and productive rope-making industry.

Given the reputations of Egypt's seafaring neighbors around the ancient Mediterranean -- the Greeks, Romans, and Phoenicians -- it is unlikely that they were inferior to the Egyptians in their rope-making abilities. Detailed evidence from these cultures, however, is lacking.

The Archaeological Evidence

All of the information so far reviewed, from the Greek and Roman writers, as well as from a few even older Egyptian texts and tomb paintings, not withstanding, the most significant information on what types of ropes were used on the ships that plied the ancient Mediterranean, and the materials that were used to make these ropes, will come from the ships themselves. Rope remains have been found on a variety of ancient shipwrecks all across the Mediterranean. Interestingly, though, the oldest evidence we have does not come from a shipwreck at all.

The Royal Ship of Cheops

In 1954 Egyptian authorities opened a sealed pit located adjacent to the Great Pyramid of Giza, the burial
place of the Pharaoh Cheops (more properly Khufu, in Egyptian) dated to approximately 2500 B.C. There they discovered the dismantled timbers of a 43-meter-long funerary vessel, stacked just as they had been some 4500 years earlier (Lipke, 1984: ix & 1). Preservation, in general, was very good, especially for most of the large quantity of cordage discovered with the vessel.

Ropes were found throughout the pit. A collection of five two-strand ropes was found passing through a hole in a wooden block, indicating that some of the ropes had served to lash parts of the boat together (Nour et al., 1960: 44 & plate XXXVIII-B). This can also be seen in plates XLI-A and LXIII-A where large sections of hull timbers are still lashed together in their original positions (Nour et al., 1960: 45, 48, 49, 68).

Some ropes were found draped over large timbers (Nour et al., 1960: 43 & plate XXXII-B), and thrown between the layers of timbers (Nour et al., 1960: 68 & plate LXIII-B). Others had been used to tie together large collections of various sizes of wooden pieces in the bottom of the pit (Nour et al., 1960: 69 & plates LXV-A & B), and still others had been dumped in a large pile in the bottom of the pit (Nour et al., 1960: 68 & plate LXIV).
All of the rope buried with the Cheops vessel was made from the leaves and stems of *Desmostachya bipinnata*, commonly called halfa grass (Nour et al., 1960: 42). Halfa has been used for rope-making in Egypt since the Neolithic Period (Nour et al., 1960: 44).

Three different sizes of rope were recorded, the diameters being 1.0 cm, 1.5 cm, and 2.0 cm (Nour et al., 1960: 68), but, "no attempt was made to calculate the total...length of the cordage. Neither was their arrangement recorded in any detail other than in the initial composite photograph" (Lipke, 1984: 17). This is unfortunate. A series of five reconstructions proved that all the pieces fit, and that what had been placed in the pit, as far as the wooden components were concerned, was like a 'kit' (Lipke, 1984: 88). Had measurement of rope length and placement calculations been made, it might have been possible to determine whether the rope that was buried with the vessel was, in fact, part of the 'kit,' i.e., all the ropes, in specific sizes and lengths, that were required to reassemble the vessel.

The chief ship reconstructor noted that the three-strand halfa grass rope was laid left-to-right and was "...beautifully clean of stray ends and broken fibres, much better than the rope made today" (Lipke, 1984: 17). These are meaningful comments on the quality of rope made
in Egypt 4500 years ago, and an example of confusing terminology on the lay of the rope. [However, I cannot fault this terminology, as it may be the standard method of reference used in Egypt.] Examination of all rope photographs in both Nour et al. (1960) and Lipke (1984) indicates that the rope was made with a Z twist, i.e., twisted to the left, or counterclockwise.

Lisht

Alongside the Middle Kingdom pyramid of Pharaoh Senwosret I near Lisht, Egypt large timbers had been buried as foundations for roads and platforms. These timbers were discovered to be the dismantled remains of large wooden boats. They had once been edge-joined by both mortise-and-tenon joints and hull-plank lashing. When the timbers were discovered, their lashing mortises still contained well-preserved remains of the material that had originally held them together. This was discovered to be wide, flat straps, not twisted ropes, of Halfa Grass, Desmostachya bipinnata (Haldane, 1990: 135-136).

The Bronze Age Shipwreck at Cape Gelidonya, Turkey

During the summer of 1960 a team led by George F. Bass excavated a Bronze Age shipwreck off of Cape
Gelidonya on the Mediterranean coast of Turkey for the University Museum of the University of Pennsylvania. This shipwreck has been dated to approximately 1200 B.C.

Four fragments of rope were found on the shipwreck. Identification of this material was difficult, however, due to the advanced stages of decomposition of the specimens.

1 - Item BM 4 (du Plat Taylor, 1967: fig. 159). A fragment of twined matting consisting of two wefts of two-ply S-twisted grass rope twined around bundles of three grass rope warps. The material is tentatively identified as halfa grass (*Desmostachya bipinnata*), but other fragments exist that may be from *Phragmites* sp., another grass (du Plat Taylor, 1967: 160-161). Both species are common along the southeastern Mediterranean coast (du Plat Taylor, 1967: 162).

2 - Item BM 5 (du Plat Taylor, 1967: 160). A fragment of loosely twisted two-strand S-twisted rope measuring 0.9 - 1.0 cm in diameter. Each strand was Z-twisted, formed of approximately 7 grass stems, and measured 0.5 - 0.57 cm in diameter. The material is not identified (du Plat Taylor, 1967: 160).

3 - Item BM 6 (No figure provided.). Two fragments of two-strand Z-twisted rope approximately 6 cm in length. Each strand was S-twisted. Two different
materials were used in making this rope, a grass and palm leaf fibers. Early identification pointed to Esparto \textit{[Stipa tenacissima]} as the grass, but this is not at all certain. The palm leaf fibers are from the genus \textit{Hyphaene}. The most likely species from this genus, based on geographical considerations, would be the doum palm, \textit{H. thebaica}. This palm was commonly used in Ancient Egypt as a source of leaf fibers (du Plat Taylor, 1967: 160-162).

The combination of esparto grass and doum palm fibers having been used to make the same piece of rope is troublesome. As mentioned above, Pliny the Elder reported that esparto grass grew only in Spain and western North Africa, and was not available in the eastern Mediterranean before the third century B.C. (\textit{NH} 19.7.26). Du Plat Taylor's sources agree that esparto does not occur around the eastern Mediterranean, and that doum palm, likewise, does not occur on the Mediterranean coast, but only in Sinai and inland in Egypt and around the oases of the Libyan Desert (du Plat Taylor, 1967: 162). It seems a serious stretch of the imagination to believe that ancient seafarers would have transported raw materials from these widely separated geographical areas for the purpose of making rope. The one possibility it seems, if in the final analysis these species
identifications are correct, is that this particular rope was obtained somewhere along the central North African coast where the growing areas of these two plants might have overlapped in antiquity.

4 - Item BM 7 (No figure provided). A piece of rope approximately 1.50 meters in length was recovered from this site in 1959. It was wrapped around the handle of a stirrup jar, and had been preserved beneath the sand. This rope was made from twisted grass stems, possibly of Phragmites communis var. isiacus, but this identification is not at all certain (du Plat Taylor, 1967: 160-161). No other details are provided.

Ezion-Geber

Ezion-Geber [on the Gulf of Aqaba near the modern city of Elath, Israel] was established as a trading port in a joint venture between the Hebrew King Solomon and the Phoenician ruler Hiram of Tyre sometime in the tenth century B.C. Excavations at this site between 1938 and 1940 found evidence of maritime activity in levels dating from the eighth to the fourth centuries B.C. An assortment of ropes excavated from these levels are pictured in DeVries & Katzov, 1972: fig. 1. The smallest fragment appears to be a single strand made with an S-twist. The two medium-sized fragments are both three-
strand with a Z-twist. The largest fragment is also three-strand with a Z-twist. No size or material details are provided (DeVries & Katzev, 1972: 38).

Ma'agan Michael

Between 1987 and 1989 a fourth century B.C. shipwreck was excavated from the shallow waters of the Mediterranean coastline adjacent to the modern Israeli kibbutz of Ma'agan Michael. The rope recovered from this shipwreck was examined and cataloged by this writer in 1994 (see also Charlton [In press]).

A large quantity of rope was discovered on this shipwreck. No fewer than ten different sizes of cordage were identified, from small, two-strand string, 2 mm in diameter, to large, three strand rope, 3.8 cm in diameter. And remarkably, two complete knots were also identified.

Personal discussions with two of the excavation participants revealed that most of the rope was found in two general areas on the shipwreck. The first, still attached to the shank of the ship's one-armed anchor (Roslof, 1991: 223), and the second, coils of rope in what might have been the "rope locker" [the ship's rope storage area] located amidships [from Mr. Danny Siyon]. Uncovered also, were the remains of an eye-splice, but it
was so fragile that the joining of the ropes had disintegrated by the time it was lifted out of the water [from Mr. Ya'akov Kahanov]. [Mr. Kahanov is now the conservator in charge of the wood remains from this shipwreck.]

Ten different sizes of cordage were identified.

1 - Two-strand S-twist; overall diameter: 2 mm.
Each strand Z-twist; diameter: 1 mm. One piece; total length: 6 cm. This piece has been conserved with polyethylene glycol [PEG] and is on display in the Hecht Museum, University of Haifa, Israel.

2 - Two-strand S-twist; overall diameter: 4 mm.
Each strand Z-twist; diameter: 2 mm. One piece; total length: 5 cm. The fibers of this piece have a different appearance than the fibers of all the other cordage found on this shipwreck. They are more rounded, and are of a distinctly different color, a dark reddish hue, compared to the brownish-black of the rest of the rope. Samples of this fiber have been submitted for identification, but the results are not yet available.

3 - Three-strand S-twist; overall diameter: 5 mm.
Each strand Z-twist; diameter: 2.5 mm. Five pieces: total length: 46 cm. Two pieces totaling 20 cm in length include a small square [reef] knot.
4 - Three-strand S-twist; overall diameter: 8 mm. Each strand Z-twist; diameter: 4 mm. Five pieces; total length: 40 cm.

5 - Three-strand Z-twist; overall diameter: 10 mm. Each strand S-twist; diameter: 5 mm. Eight pieces; total length: 1.34 meters. Two pieces of this size rope were found with the 2.6 cm/1.3 cm rope and may have been associated with the eye-splice referred to earlier.

6 - Three-strand Z-twist; overall diameter: 1.2 cm. Each strand S-twist; diameter: 6 mm. Two pieces; total length: 33 cm.

7 - Three-strand Z-twist; overall diameter: 1.5 cm. Each strand S-twist; diameter: 8 mm. Ten pieces; total length: 1.425 meters. Two pieces totaling 17.5 cm in length have been conserved with PEG and are on display in the Hecht Museum. Three pieces make up the large square [reef] knot also on display in the Hecht Museum.

8 - Three-strand Z-twist; overall diameter: 2.0 cm. Each strand S-twist; diameter: 1.0 cm. Two pieces; total length: 19 cm.

9 - Three-strand Z-twist; overall diameter: 2.6 cm. Each strand S-twist; diameter: 1.3 cm. Nineteen pieces; total length: 7.68 meters. One piece 55 cm in length was identified as originally having been part of the eye-splice referred to earlier.
10 - Three-strand Z-twist; overall diameter: 3.8 cm. Each strand S-twist; diameter: 1.8 cm. Six pieces; total length: 3.93 meters.

Identification of the rope's material was made at the completion of the excavation in 1989. The main fiber identified, with the exception of item 2, above, was *Scirpus holoschoenus* of the Cyperaceae family (Shimony et al. [In press]). This plant commonly grows in damp areas along the Mediterranean coast of Europe, and up into the European hinterland (Tutin et al., 1980: 279). It is described as a "...cluster-headed clubrush, ...common in damp places from Lebanon and Coelesyria, through Palestine, to Sinai" (Moldenke & Moldenke, 1952: 121), and grows around fresh-water springs on Gebel Musa [the Mountain of Moses] in Sinai (Zahran, 1992: 296).

In the majority of cases in which rope is discovered on sunken shipwrecks from ancient times, only small bits survive, providing only hints of the types of rope that may have been carried aboard that particular ship. The extraordinarily high degree of preservation of the Ma'agan Michael shipwreck, and the cordage she carried, however, provides a more realistic view of the wide variety of ropes and strings that would commonly have been carried and used on a ship that plied the Mediterranean during the fourth century B.C.
Marsala

Large quantities of cordage were also discovered on the mid-third century B.C. Punic shipwreck excavated near Marsala, Sicily. Reported sizes ranged from rope 5.5 cm diameter to string 4 mm diameter, but no lengths are indicated in the final report. In addition to the twisted ropes, three sizes of small plaited [braided] cords were also reported.

The quantity of cordage excavated was apparently so large that it could not all be included in the excavation report, but a representative sampling is presented, identifying eight different sizes (Frost, 1981: 93-94).

1 - Three-strand plaited; overall diameter: 4 mm.
   Each strand, diameter: 2 mm.

2 - Three-strand plaited; overall diameter: 6 mm.
   Each strand, diameter: 4 mm.

3 - Three-strand plaited; overall diameter: 1.25 cm.
   Each strand, diameter: 7.5 mm.

4 - Two-strand S-twist; overall diameter: 80mm. Each strand [twist not listed]; diameter: 24mm. Although these are the sizes published in the final report (Frost, 1981: 94), I believe the entries to be typographical errors that should actually be read as 8.0 mm and 2.4 mm, respectively.
5 - Two-strand S-twist; overall diameter: 1.0 cm. Each strand [twist not listed]; diameter: 5 mm.

6 - Three-strand S-twist; overall diameter: 1.0 cm. Each strand [twist not listed]; diameter: 5 mm.

7 - Three-strand Z-twist; overall diameter: 3.0 cm. Each strand [twist not listed]; diameter: 2.0 cm.

8 - Three-strand Z-twist; overall diameter: 5.5 cm. Each strand [twist not listed]; diameter: 3.0 cm.

All of the cordage found on this shipwreck was made of esparto grass, *Stipa tenacissima* (Frost, 1981: 93), indicating the possibility that she had been outfitted in the western Mediterranean, although that interpretation was not made by the excavator. Most of the rope was found in the “kitchen area,” which was also the main storage area; every type in the typology was represented there (Frost, 1981: 96).

Long stretches of the 3-cm-rope had been trapped beneath the hull (Frost, 1981: 94). This, plus grooves on the length of the wale, suggest the use of *hypozomata*, or undergirdling, on this ship (Frost, 1981: 96). The only other statement of use in the report is that the 5.5-cm-rope would have borne the weight of an anchor (Frost, 1981: 97).
The Dead Sea

Three stone anchors dating to the third century B.C. were found at the edge of the Dead Sea near 'En Gedi, Israel, in 1989. Located approximately 40 meters from the shore, they were exposed due to a drop in sea level in recent years. These anchors were made from "...Upper Cretaceous dolomite boulders, which may have originated from the cliffs above" (Hadas, 1992: 55).

Associated with these anchors were two lengths of thick rope and a piece of small binding cord. Their descriptions follow (Shimony et al., 1992: 58):

1 - Three-strand Z-twist; overall diameter: 5.3 - 5.6 cm. Each strand S-twist; diameter: 2.5 - 3.0 cm.

2 - Two-strand Z-twist; overall diameter: 3.5 - 4.0 cm. Each strand S-twist; diameter: 2.0 cm.

3 - Two-strand S-twist; overall diameter: 3.5 - 3.8 mm. Each strand Z-twist; diameter: 2 mm.

Item 1 was 20 cm long, and was C-14 dated to 210 ± 80 BCE. Item 2 was 1.6 meters long, and was C-14 dated to 230 ± 120 BCE (Hadas, 1992: 55).

Item 3, a thin cord, was binding a fold of Item 2, near the anchor hole (Shimony et al., 1992: 58). Hadas states that Item 2 was still tied to its anchor (Hadas, 1992: 55), but does not provide a photograph or drawing of either of these bindings.
All three of these ropes were made from leaflets of the date palm, *Phoenix dactylifera* (Shimony *et al*., 1992: 58). Date palm fronds have been used in this area since early times for ropes and bags (Yadin, 1966: 140 & 144). Pliny the Elder also notes that date palms grew on the western side of the Dead Sea (*NH* 5.15.73), most likely exactly where the materials for these ropes originated. These finds are yet another in a series of discoveries verifies shipping activity on the Dead Sea during Hellenistic/Hasmonean times (Hadas, 1992: 56).

**Comacchio**

On this first century A.D. shipwreck in Italy plaited rope of esparto grass was used to bind floor timbers to the bottom of the vessel (Bonino, 1985: 91-93; Berti, 1990: 154-156 & figs. 10 & 11).

**Lake Nemi**

Two huge barges dated to the first century A.D. were found in Lake Nemi, Italy. A large hawser, approximately 10 cm in diameter, and made of esparto grass [*Stipa tenacissima*] was still attached to a large wooden anchor associated with the barges. Other ropes of esparto and hemp [*Cannabis sativa*] were found on the barges (Ucelli,
1950: 243 & fig. 275; 245 & fig. 278; 268; 431, #440; 442, #589).

The British Museum Collections

In 1987 Ryan and Hansen published their study of sixteen ancient Egyptian cordage items held in the collections of the British Museum. These specimens span time from the Middle Kingdom to the Greco-Roman period and come from a variety of locations, from the Tura quarries near Cairo to the Theban area in Upper Egypt. While these ropes do not come from nautical contexts, they do add to our knowledge of what plants the ancient Egyptians were using to make their ropes.

Six of the samples were made of papyrus [Cyperus papyrus], and the final twist was Z. Nine were made of halfa grass [Desmostachya bipinnata], the same material used to make the ropes discovered with the Cheops Vessel; eight were Z-twisted, and only one, a piece only 9 mm in diameter was S-twisted. One was of doum palm [Hyphaene thebaica], and was Z-twisted. Two of the fragments of papyrus rope are from the same Tura limestone quarries hoard reported by Lucas (1948).

During the planning for this study, Ryan and Hansen anticipated finding samples of the four fibers reputed to have been used for rope in ancient Egypt - papyrus, halfa
grass, doum palm, and date palm \(\textit{Phoenix dactylifera}\). They were surprised not to have found any date palm specimens, however (Ryan & Hansen, 1987: 7). They were also surprised to find examples of three different types of simple knots in the collection (Ryan & Hansen, 1987: 8).

**SUMMARY**

Examples of cordage have been found on other shipwrecks in the Mediterranean, but these were mainly small specimens without any specific context. They tell little more than that rope made of a particular fiber was carried on that ship. The archaeological evidence just cited provides specific information in each case about use of particular fibers in the manufacture of rope in particular areas, and may even point to specific geographical areas as ports-of-call, and even home ports of shipwrecks.

All of the evidence considered so far, textual, iconographic, and archaeological provides a great deal of information, as well as a better understanding of the use of specific plant fibers for the making of cordage around the Mediterranean. But with rope, we have only the tool. Rope alone serves no purpose; we must be able to
manipulate this tool to gain benefit from it. To do this, we must learn to tie knots.
KNOTS

INTRODUCTION

The seafarers who plied the Mediterranean in antiquity must have known and used a variety of knots, due to the simple fact that certain knots are effective in certain applications, and not in others. Some knots work best only when the rope is dry, and there are a few that are equally effective when the rope is either wet or dry. Some will hold with or without tension on the knot, while others will come loose without tension to hold them tight. And, there are some knots that are decidedly unsuited for use at sea; when they get wet they jam so tightly that they cannot be untied.

This study of the art of knot-tying in the ancient world will examine the available evidence, from the writers, the artists, and the knot-tiers themselves. As with the study of rope, this chapter will begin with a review of some of the basic terminology of the ancient art of knot-tying.

TERMINOLOGY [Or when is a knot not a knot?]

The word knot is generally applied to any manipulation of a rope, line, or cord that results in its
being attached to something else, such as another piece of rope, a sail, an anchor, or a mooring cleat or bitt. In seafaring vernacular, however, knots are broken down into four different groups: knots, hitches, bends, and splices. An understanding of the working parts of a rope is required before beginning.

In forming any type of knot, a rope is considered to have three main parts (Fig. 14). The end, working end, or bitter end is the end of the line into which the knot will be tied. The bight is a curve or loop in the rope between the ends. The standing part is the inactive, non-working part of the line.

There are two kinds of knots: knob knots and loop knots. A knob knot forms a knob in the rope to prevent unlaying or fraying, to provide a handhold, or to stop the rope from passing through something, such as slipping through a pulley block. A knot for this last specific function is called a stopper knot. A loop knot forms a loop at the end, or anywhere along the length of a piece of line.

A hitch is a knot used to bend [attach] a rope to another object, such as a spar, ring, or other line. A

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3 Knotting terminology is taken from the following sources: Ashley, 1944; Budworth, 1985; Day, 1953; Jarman, 1986; Rosenow, 1990; and H.G. Smith, 1953.
Figure 14. Rope Terminology.
(Drawing: W.H. Charlton).
**bend** is a knot used to tie the ends of two free lines together or to tie a line to a fixed object [often using a hitch]. A bend is also used to secure a sail to a boom or a stay ready for hoisting.

*Splices* are used to bend two lengths of line together permanently, to form an eye, or loop, in the end of a rope, and to make *grommets* (Fig. 15). *Short splices* and *long splices* are accomplished by interweaving the separated strands of two lengths of line together. The short splice is used most often, unless the resulting line must pass through a block, since the short splice doubles the diameter of the rope at the splice, in which case the long splice is used.

An eye splice is made by interweaving the separated strands of the end of the rope back into its own strands at a point far enough back along its length that an eye, or loop, of the desired size is permanently formed. Grommets are formed by a single rope strand laid up continuously about itself to form a ring.

**EVIDENCE FROM THE PAST**

Evidence of only a few of the knots from antiquity has survived to the present day. The ancient writers who, when taken together, passed on a surprisingly large amount of information about the rope used during their
a. Eye Splice.

b. Short Splice.

c. Grommet.

Figure 15. Splices. (After H.G. Smith, 1953: 44, 49, 54).
times did not feel the need to pass on the same level of
detail about the knots used to manipulate their ropes.
When they did wish to give the idea of tying or binding,
it was most often done in just those terms, to tie, or to
bind, with no further explanation.

In the iconography of the ancient world specific
representations of utilitarian knots are similarly rare.
Archaeological evidence, likewise, is scant. Many
examples of rope have been found on ancient shipwrecks in
the Mediterranean, but only a few knots have come to us
from that sea.

The Textual Evidence

It has already been noted that the ancient authors
did not record details about specific knots in their
writings. When the subject is explored deeper, the
reason for this lack of detail becomes apparent, and
certainly more understandable. "Primitive and
unsophisticated people everywhere and in every age have
believed in the magic power, for good and evil, of knots"
and Symbols of Ancient Egypt, "the knot was closely
connected with the magic of binding and releasing. The
knot held magic power fast" (Lurker, 1974: 75).
A story containing what Day (1967: 44) believes to be the earliest literary example of a wind knot, i.e. a knot used to control the winds, appears in the *Odyssey* (Od. 10.18.49). Aeolos, Lord of the winds, gives Odysseus a bag that contains all the winds, save the west wind that would carry him homeward. But while Odysseus is sleeping, his crew, believing the bag contains treasure from Troy, opens it and all the winds escape, blowing their ship back to the island of Aeolia.

The belief in love knots was common among the Romans during the time of Virgil. In his *Second Eclogue*, Virgil relates the story of a Roman maiden trying to win back the love of her sweetheart with a waxen image, colored cords of wool, and a spoken spell that included the mystical number three and charmed knots (Day, 1967: 74).

While we in the late twentieth century may not consider the Greeks and Romans to have been primitive and unsophisticated, there was a fine line between their concept of religion and magic. The lines just quoted indicate that among the Greeks and Romans there was strong belief in the power of knots. It is entirely possible that these ancient writers, these scientists and historians, these poets and playwrights, did not feel the need to provide specific details about knots in their writings, but might it not also be possible that they
were content in not addressing what might have been, in their minds, an uncomfortable subject?

Pliny the Elder, in his accounts of ancient folk medicine, records several magical remedies that include the tying of knots. "If the big toe is tied to the one next to it, swellings in the groin are relieved; if the two middle fingers of the right hand are lightly tied together with a linen thread, catarrhs and opthalmia are kept away" (NH 28.9.42). "Some treat affections of the groin by tying with nine or seven knots a thread taken from a web, at each knot naming some widow, and so attach it to the groin as an amulet" (NH 28.12.47-48). "The groin also swells because of sores; the remedy is to tie within the sore three horse hairs with three knots" (NH 28.61.218). "They tie a thread three times round a caterpillar in a linen cloth, and with three knots, the ministering attendant saying with each knot the reason for so doing" (NH 30.30.101). These are all amulets for the cure of disease or injury. Pliny's final listing is said to make the capture of a hyaena easier: "If the hunter tie his girdle with seven knots, and seven in the whip with which he controls his horse" (NH 28.27.94). Pliny does, however, reveal his own opinions on this subject. He calls the people who advise these methods Magi [magicians], and fraudulent charlatans (NH
28.27.94), and says: "And by Heaven!, well deserved is the disappointment if these remedies prove to no avail" (NH 28.1.5).

An actual amulet, similar in idea to these just described by Pliny, was discovered during excavations at Deir el-Medineh, Egypt, in 1950. This was a small cord with seven overhand knots tied into it, three on one side and four on the other side of a curious binding in the center. Upon investigation the binding was discovered to be a piece of papyrus rolled up and tied to the cord. The papyrus contained a written spell which directed a person suffering from a common cold to tie the knotted cord, with the written spell bound to it, around the neck and the cold would be driven away (Sauneron, 1970: 8).

Amidst the silence on the subject of knots from the Greek and Roman writers heard from so far, was one individual who took it upon himself to record in writing the knots he knew and used. The single textual reference to specific knots from the ancient world comes to us in a work entitled Medical Collections, written by Oribasius of Pergamum toward the end of the fourth century A.D. In this, Oribasius recorded the work of an obscure Greek physician named Heraklas who lived during the first century A.D. Heraklas described how to tie eighteen surgical "slings" which "...Greek physicians made use of
to apply traction when reducing dislocations and setting
broken bones, and to hold the bodies of patients in
position when performing surgical operations" (Day, 1967: 86).

There have been many attempts over the years to
identify Heraklas' slings, listed below, but his
instructions are difficult to follow without the aid of
illustrations. Many of them consist of complicated and
convoluted descriptions of tying a cord around a patient's
body to place the patient in position for a particular
procedure, or to reduce the strain of a dislocation. The
initial problem was not the inability to identify a
particular sling [or knot] from the descriptions, but in
actually being able to understand and follow the
directions themselves. In 1944 a Boston patent lawyer
who specialized in the patented knot-tying machines used
in the textile industry was able to correctly follow all
of Heraklas' directions, and create illustrations for them
(Day, 1967: 87). Only then was it possible to compare
the ancient descriptions with known constructions and try
to identify them. Not too surprisingly, thirteen of the
eighteen were found to match knots known in the modern
world, although four of these are variations of others.
A number of the common knots known today have thus been
around for two thousand years, and possibly quite a lot longer.

Heraklas' work was divided into eighteen "chapters," as follows.¹ Those configurations identifiable as knots are illustrated in figure 16.

1. *Ertos Brokhos* - 'Continuous Noose.' The Lark's Head Knot (Fig. 16a). This noose was used to support an injured limb, or to secure a patient's hands during surgery.

2. *Nautikos Brokhos* - 'Nautical Noose.' The Clove Hitch (Fig. 16b). This noose was used to secure splints on an injured limb and as a sling to support an injured forearm.

3. *Chiestos Brokhos* - 'Crossed Noose.' The Overhand Slip Knot, or Overhand Running Knot (Fig. 16c).

4. *Sandalios* or *Bouikolikos Brokhos* - 'Sandal' or 'Pastoral Noose.' Unidentifiable as a knot. Actually a sling said by Heraklas to be used to treat an injured ankle.

5. *Drakon Brokhos* - 'Serpent Noose.' A sling to treat an injured ankle.

6. *Haploun Hamma Brokhos* - 'Single Knot Noose.' The Overhand Knot (Fig. 16d).

¹ Translations and explanations are from Day, 1967: Appendix B.
a. Lark's Head.

b. Clove Hitch

c. Overhand Slip Knot

d. Overhand Knot.

e. Hercules, Square, or Reef Knot

f. True Lover's Knot.

g. Jug Sling

h. Cat's Cradle.

i. Tom Fool Knot

7. *Lykos Brokhos* - 'Wolf Noose.' Structurally identical to the Square Knot, but formed from the bights [loops] of two cords, instead of the ends.

8. *Herakleotikon Hamma* - 'Hercules Knot.' The Square, or Reef Knot (Fig. 16e).

9. *Haplous Karkhesios* - 'Single Karkhesios.' The True Lover's Knot (Fig. 16f).

10, 11, & 12. *Diplous Karkhesios* - 'Double Karkhesios.' These chapters describe three different ways to tie the Jug Sling (Fig. 16g). This same construction is also used to form a temporary rope bridle, called a hackamore, in the western United States.

13. *Plinthios* - A four-loop noose. The Cat's Cradle, from the children's string game (Fig. 16h), was used in setting fractures of the chin.

14. *Epankylotos Brokhos* - 'Interlooped Noose.' The Tom Fool Knot (Fig. 16i), was used to secure a patient's hands during surgery.

15. *Ota Brokhos* - 'Ears Noose.' A sling to treat a dislocated jaw.

16. *Diankylos Brokhos* - 'Two-Looped Noose.' Heraklas' description indicates this noose is used to secure a patient's hands during treatment.

17. *Ankhon Brokhos* - 'Strangler Noose.' This is the same as the True Lover's Knot, 9. (Fig. 16f), but
with the two loops more widely separated. It was used to secure a patient's hands during treatment.

18. Hyperbatos Brokhos - 'Transposed Noose.' This is the same as the Clove Hitch, 2., above (Fig. 16b), but with the two hitches more widely separated. It was used to secure splints on an injured limb and as a sling to support an injured forearm.

Heraklas' descriptions of how to form many of his "slings" [numbers 3, 6, 7, 8, 9, 10, 11, and 12] do not include statements of their use. Day surmises that the original manuscripts must have included illustrations showing the use of each one. The oldest existing manuscript of Oribasius' Medical Collections was made in the tenth century by the Byzantine physician Nicetas. While parts of this document are accompanied by colored miniatures, unfortunately that part attributed to Heraklas is not (Day, 1967: 103).

Now, knowing that these knots included in Heraklas' list were used by the medical community, it seems a natural assumption that they were not known only to that group, but would have been known and used throughout society. Those that have applications in seafaring would surely have been known by sailors.
Five of Heraklas' knots are used by sailors today, as they likely were during his time. The Overhand Knot is used often, but never on its own. Two overhand knots are used to form the Hercules, or Square, or Reef Knot. The square knot is used to join two ropes of the same size, but should not be used with lines under load. The True Lover's Knot is not used with a single line as in Heraklas' description, but to join two thin lines of the same size, such as fishing line. The Jug Sling can be used to lift heavy items, as well it might have been used in Heraklas' day for lifting heavy wine jars with a crane from the dock onto a ship. Last, but not least, the Clove Hitch is also much-used among modern sailors.

The Iconographic Evidence

In the iconography of the ancient world, presentations of specific knots are also rare. "Greek and Roman artists had little occasion to depict any [utilitarian] knots.... Egyptian artists did, and yet they deliberately refrained from doing so. When they represented a knot in an otherwise realistic scene...on the wall of a mastaba or tomb, they avoided realism and resorted to meaningless and conventionalized curves" (Day, 1967: 54). "As the Egyptian artists, in both the Old and Middle Kingdom, were accurate in detail, we can
only suppose that these subterfuges were intentional, and were due not to incapacity on the part of the artist to represent so small an object but to some religious or superstitious feeling in representing a knot that could never be untied" (Murray, 1922: 14-19).

The numbers of scenes in the Egyptian tomb paintings in which knots are depicted are innumerable, yet, as Murray (1922) states, the vast majority are deliberately not shown in detail. A scene from the Old Kingdom tomb of Urarna (Fig. 17), one of the Rock Tombs of Sheikh Saïd, includes two such depictions (Davies, 1901: pl. XVI). The rope by which the oxen are pulling the plow, connected to the drawbar, contains a knot that is close to being a sheet bend (Fig. 18), but is lacking just enough detail to make it questionable, although this might also be interpreted as a simple loop over a peg in the end of the drawbar. Further, there would have to have been at least one knot in the binding between the plow itself and the drawbar, yet none is shown.

A scene from the Nineteenth Dynasty (New Kingdom) Temple of the Kings at Abydos, showing the Barque of the Mummified Hawk (Fig. 19), shows that Egyptian ropemakers were masters of the technique of splicing, yet insufficient detail is available to indicate how the work might have been done (Caulfeild, 1902: pl. VI). One of
Figure 17. Scene from Tomb of Urarna. (After Davies, 1901: Plate XVI).

Figure 18. Sheet Bend. (Drawing: W.H. Charlton).

Figure 19. Scene from the Temple of the Kings at Abydos. (After Caulfeild, 1902: plate VI).
the most intriguing knot scenes in all of the tomb paintings is from the Twelfth Dynasty (Middle Kingdom) tomb at Kom el Hisn (Maspero, 1915: pl. 36). In this scene (Fig. 20) men are shown pulling a bird trap. The knot that connects the tow rope to the bird trap is a sheet bend, perfectly depicted in every detail. This knot is so well drawn, and so much out of character for its time, that Day asks if it is possible that Maspero's draftsman could have allowed his imagination to take control of his pencil" (Day, 1967: 64, n. 4). There are many, many conventionalized drawings of knots in the tomb paintings, but I feel that including more would be redundant on my part.

There was one striking exception to this lack of detail in the depictions of knots, however, in many of the cultures around the eastern Mediterranean. This was the square knot, or the Hercules Knot, so called because its invention was attributed to the god, himself (Fig. 16e). This knot was often portrayed by many of the cultures of the eastern half of the Mediterranean, from ancient Egyptian times through the Roman period. Howard Carter found two small bars of gold carved to depict square knots on Tut-Ankh-Amen's mummy, lying on each side of the upper chest parallel with the arms (Carter, 1963: 122). Three square knots carved out of wood were found
Figure 20. Scene from Tomb at Kom el Hisn. (After Maspero, 1915: plate 36).
in the excavation rubble outside the tomb of Queen Hatshepsut at Deir el Bahri (Day, 1967, 53). A number of small golden clasps made in the shape of square knots have been discovered at different sites in Egypt: in the tomb of Senebtisi at Lisht (Mace & Winlock, 1916: pl. XXIII), at Lahun (Brunton, 1920: pls. 1, 2, 3, and 8), and at Dahshur (Day, 1967: 53).

Some examples of depictions of the Hercules, or square knot by the different cultures around the eastern Mediterranean follow. Figure 21 shows a gold finger ring in the shape of a Hercules knot that was inlaid with lapis lazuli. This ring was part of the treasure discovered on the island of Aegina, but may actually have come from Crete, and may be dated as early as 1700-1600 B.C. (Higgins, 1979: 21).

Figure 22 illustrates a belt knot from a stone statue at Saqqarah dated to the third or fourth Dynasty of Old Kingdom Egypt (W.S. Smith, 1981: 61). A painting on a wall in the Middle Kingdom tomb of Djehuty-Nekht depicts eight fine linen sacks bearing the saying "The King's Equipment" (Fig. 23). The sacks are tied with square knots (Terrace, 1968: pl. XIX). A hunting scene from the tomb of Menena at Thebes shows the New Kingdom noble's garment tied with a square knot (Fig. 24) (Lange & Hirmer, 1956: pl. 146).
Figure 21. Gold Finger Ring from Aegina. (After Higgins, 1979: 36).

Figure 22. Belt Knot from Saqqarah. (After W.S. Smith, 1981: 61).
Figure 23. Painting from Tomb of Djehuty-Nekht. (After Terrace, 1968: plate XIX).

Figure 24. Scene from Tomb of Menena. (After Lange & Hirmer, 1956: plate 146).
An Etruscan bronze relief, dated to c. 530 B.C., shows Hercules wearing a lion skin with the paws tied in a square knot (Fig. 25) (Sprenger & Bartoloni, 1983, pl. 109). A 5th-century B.C. statue depicts a Greek bride with her head scarf tied in a square knot (Fig. 26) (Rodenwalt, 1927: 272). The goddess Athena's belt is tied with a Hercules knot in Figure 27 (Rodenwalt, 1927: 306). And finally, the belt on one of the statues of the Roman Vestal Virgins is tied with the Hercules knot (Fig. 28) (Jordan, 1886: pate IX).

It seems evident that the peoples of most of the cultures that existed around the eastern Mediterranean, from the early Egyptians at least to the time of the Romans, held this knot in high regard. Many may have attributed amuletic power to the knot because Hercules was considered a savior and an averter of evil (Day, 1967: 54). Pliny the Elder said that "to tie up wounds with the Hercules knot makes the healing wonderfully more rapid, and even to tie daily the girdle with this knot is said to have a certain usefulness..." (NH 28.17.63-64).

Another source of information on knots comes, again, from ancient Egypt, and from yet a different art form. During the period of the Middle Kingdom, and later, it was customary for wealthy nobles to have placed in their burial tombs models that depicted scenes from their daily
Figure 25. Etruscan Bronze Relief of Hercules. (After Sprenger & Bartoloni, 1983: plate 109).

Figure 26. Statue of a Greek Bride. (After Rodenwalt, 1927: 272).
Figure 27. Statue of the Goddess Athena.
(After Rodenwaldt, 1927: 306).

Figure 28. Statue of a Vestal Virgin.
(After Jordan, 1886: Plate IX).
lives (Winlock, 1955: 12). Excavation of the tomb of Meket-Res' revealed models of boats which he had supposedly used during his lifetime.

Some of the boats include intact rigging with knots, but these should be considered with caution. A number of the models had been damaged in antiquity, e.g., Traveling Boat N had been hit by a stone that fell from the ceiling, damaging much of its rigging. It was later repaired (Winlock, 1955: 92-93), but exactly how that was done is not completely clear from Winlock's descriptions.

Figure 29 shows the rigging of the mast, sail, yard, and boom of Traveling Boat N (Winlock, 1955: pl. 71). The enlargement to the lower left shows a square knot. This apparently is meant to show a part of the lower boom, but exactly where is not certain. The illustration of the yard is interesting, as it shows the halyards (except for the second from the left) bent to the yard with what appear to be round turns and a half hitch, with the end tucked under the turns, although all the parts are not in exactly the correct positions. I suspect, however, that this is the fault of the artist, and that, if these knots are original, they are just as described above. This configuration is called a fisherman's bend, or anchor bend, in modern vernacular, and would be
Figure 29. Mast and Sail of Meket-Re's Boat.
(After Winlock, 1955: plate 71).
considered appropriate for this application by modern sailors.

Figure 30 shows in detail how the safety line is attached to the steering oar (Winlock, 1955: pl. 84R). The combination of a clove hitch at the bottom and a marling hitch a little way up the loom would be sufficient to hold should the oar's main lashings part, given that the simple overhand knot tied inside the stern did not come loose. I feel certain, however, that this would not have been the knot chosen for this purpose on the original working boat.

In 1913 G.A. Reisner published his study of Egyptian boat models in the Cairo Museum. He identified seven of the models that he determined had ropes and knots associated with them. His criteria for a knot was apparently anywhere that two ropes touched each other. Of the seven, only four can be identified as knots from a visual examination of the drawings.

Figure 31 (Model 4841. Reisner, 1913: fig. 117) shows the lower mast and boom. The formation of the ropes around the mast itself are unintelligible. The lashings on the boom seem to depict turns about the boom with half hitches securing the line. The left-most line does show a half hitch, but this would not have been secure without at least a full round turn before the
Figure 30. Steering Oar Rigging on Meket-Rē's boat. (After Winlock, 1955: Plate 84R).

Figure 31. Lower Mast and Boom of Reisner's Model 4841. (After Reisner, 1913: Fig. 117).
hitch. The second line from the left [the short one] looks as if it may have a round turn, but if it does the hitch is not in the correct position to hold. The binding at the boom for the center long line is unintelligible. The single tuck shown for the right-most long line would hold as long as the end was secured to something at the end of the boom, as it appears to be.

Figure 32 (Model 4884. Reisner, 1913: fig. 196) shows a rope placed through a hole in the rail. After the rope is placed through the hole two half hitches are placed back around its standing part. Upon close examination, we realize that when the slack is taken up by pulling the end, a perfect clove hitch is formed. [The two are identical in construction. The difference is that a clove hitch is formed around a fixed object, while two half hitches are always formed back around the standing part of the rope.] This would be a secure, but temporary, binding.

Figure 33 (Model 4910. Reisner, 1913: fig. 232) shows a lark's head knot formed, according to the description, through a hole in the rail. This is not a secure knot when tied as shown. The short end would work its way loose in short order with any load on the long end.
Figure 34 (Model 4893. Reisner, 1913: fig. 213) appears to show a rope wound through a hole in a spar and then through an eye splice in its end. Wrapping a line around a secure fixed object and then running it through its own eye splice would be an excellent method of securing one end of a line.

The last boat model available for review that has any intelligible knotting comes from the tomb of Tut-Ankh-Amen (Fig. 35) (Jones, 1990: pl. XXXIII). The lower left-hand drawing of knot 'K' in figure 36 (Jones, 1990: pl. XXXVI) is an excellent depiction of two round turns and a half hitch. This knot would have been a good way to attach the lifts to the boom on the working boat, although two half hitches would be more secure.

The artistic and iconographic evidence for knots from the ancient world of the eastern Mediterranean does not provide us with a very clear idea of what knots were known and used by the seafarers of the time. Due mainly to the strong belief in the magical power of knots, the ancient Egyptians did not record true renderings of knots in their art work. Likely for similar reasons, we also have little evidence of utilitarian knots from Greek and Roman artists.

The one exception to this, as we have seen, is the Hercules knot. This form was widely shown in a variety
Figure 32. Two Half Hitches on Reisner's Model 4884. (After Reisner, 1913: Fig. 196).

Figure 33. Lark's Head Knot on Reisner's Model 4910. (After Reisner, 1913: fig. 232).

Figure 34. Eye Splice on Reisner's Model 4893. (After Reisner, 1913: fig. 213).
Figure 35. Boat Model from Tomb of Tut-Ankh-Amen. (After Jones, 1990: Plate XXXIII).

Figure 36. Knot on Tut-Ankh-Amen's Model. (After Jones, 1990: Plate XXXVI).
of ways, likely due to the widespread belief in its positive amuletic power.

The Archaeological Evidence

What remains now in this search for knots in the ancient eastern Mediterranean is to discover what the ancient knot-tiers, themselves, can tell us. What remains of their art that we can study?

The oldest knots associated with any of the rope yet mentioned in this study are those found in the Egyptian ropes from the British Museum (Fig. 37) (Ryan & Hansen, 1987: 12-17 & tables 7 & 9). These were one overhand knot tied in 1.5-cm papyrus rope, one overhand knot tied in 1.8-cm rope made of halfa grass, and one overhand knot tied in 2.5-cm rope made of doum palm. Also, there was a doubled overhand loop tied in 4.2-cm rope made of halfa grass. There are no credible contexts for these ropes and knots listed in the Museum’s records.

Of those that do have more complete records, one is a large piece of 6.8-cm rope of halfa grass with a figure-eight knot tied in it. This item is listed as “...used as a fender for lowering weights into tombs” (Ryan & Hansen, 1987: 13). The most interesting of all is a piece of 2-cm halfa grass rope containing two overhand knots that has been radiocarbon dated to 950 ±
a. Overhand Knot.

b. Doubled Overhand Loop.

c. Figure-Eight Knot.

Figure 37. Knots from the British Museum Collection. (After Ryan & Hansen, 1987: fig. 4).
60 B.C. The Museum records on this piece state: "Rope of a rope-ladder from the tomb of Sethos I in the Valley of the Kings, Thebes. Probably not contemporary with the tomb (i.e. about 1,200 BC) but later used by robbers" (Ryan & Hansen, 1987: 15). As with the ropes in which these knots were tied, although they were not found in a nautical context, they do indicate that these specific knots were probably known and used by ancient Egyptians, landlubbers and sailors alike.

The oldest knots yet discovered in eastern Mediterranean waters were found on the fourth-century B.C. Ma'agan Michael shipwreck. According to Hervey Garrett Smith in his The Arts of the Sailor, the square knot is "...probably the most universally known and remembered of all knots... At sea it is customarily employed in lashing and seizings, and in reefing or furling sails, and for these alone it is excellent. But under no circumstances should it ever be used as a bend, to tie two ropes together" (H.G. Smith, 1953: 26). He stresses that under most circumstances, when placed under any kind of strain, this knot will come untied.

It is interesting to note, then, that the two knots found among the ropes of the Ma'agan Michael Shipwreck were both square knots, one a standard square knot, the other, a previously-unknown variation. The small square
knot was tied in light string 5 mm in diameter. The larger square knot, tied in 1.5-cm rope, is truly a rare find, in that it is tied with three ropes instead of two. Figure 38 shows how this was done with two ropes entering and leaving one side and one entering and leaving the other side (Charlton [In press]).

It is unfortunate to note that neither knot was found in a context that would indicate what its use on the ship might have been. The small knot, having been tied in light string, may have been used as a light-duty lashing. The larger, three-rope square knot is truly an enigma. To this writer's knowledge, this is the first knot of its type ever found, in or out of the water.

The remains of an eye splice were also discovered during the excavation. Unfortunately, they were so fragile that the joining of the ropes had disintegrated by the time it was lifted out of the water [Personal communication with one of the excavators, Mr. Yaakov Kahanov, in November 1994].

The ship sank in shallow water very near the coast, allowing most of the cargo to be salvaged from the wreck. Since both of these knots remained on the wreck after the salvage operation, and were ultimately covered with sand [thus the state of their preservation], they both may have been used to secure items that were not considered
Figure 38. Three-Rope Square Knot from Ma'agan Michael Shipwreck. (Drawing: W.H. Charlton).
valuable enough to try to salvage. Or, their ropes may have simply been cut away from whatever they were holding, and left on the wreck when the cargo was removed. The small knot and its line may even have been used to secure a coil of larger rope which was all left on the wreck. The large knot is an unknown. Might it have been an amulet?

The final knot to examine in this study came from the mid-third century B.C. Punic shipwreck excavated at Marsala, Sicily. This was a complete, well-preserved eye splice (Fig. 39). It was made from "...30 mm three strand rope, laid (or twisted) to the right, with certainly no more than two tucks (possibly only one), the splice is whipped with plaited string" (Frost, 1981: 96). Examination of figure 39, as well as the photograph of the splice in situ (Frost, 1981: fig. 46-a) shows that the rope was actually twisted to the left, a Z-twist.

Frost says of this eye splice: "After examining the drawings and photographs, 'two old bosuns' wrote: 'this would be very much the same as we have spliced for the last few centuries, 'except we are doubtful if it would be very strong if it only has one twist [tuck]'" (Frost, 1981: 96). As just stated, this eye splice would not be very strong if it has only one tuck, but since an eye splice almost doubles the size of the rope at the splice,
Figure 39. Eye Splice from the Marsala Shipwreck. (After Frost, 1981: Fig. 46-b).
and if the drawing depicts the splice's correct size, that may be the case. The only way to tell for sure would be to remove the whipping, but this would destroy the aesthetic value of this ancient treasure.

SUMMARY

This study of the evidence of the use of knots in the seafaring of the ancient eastern Mediterranean has revealed a number of the different knots used by the ancients. Heraklas, the first-century A.D. Greek physician, listed the overhand knot, the true lover's knot, the clove hitch, the jug sling, and the ubiquitous square knot, although not by the names we know them by today. For the knot researcher, searching for realistic knot representations in the Egyptian tomb paintings can be a frustrating experience. The one true representation of a sheet bend is of questionable authenticity, as already stated. However, it is certain that the ancients knew the sheet bend, since its construction is identical with that of the weaver's knot, which has been known in most cultures since the earliest of times.

Egyptian boat models show that the lark's head knot, the marling hitch, the eye splice, and the concept of round turns and half hitches were known, although the question of who the artisans were that built the models
arises. Were they model builders who knew nothing of real boats, model builders who studied real boats so as to make their craft more realistic, or, possibly were they actual sailors who were shaping their models based on their real-life experiences?

The collection of ropes and knots in the British Museum reveals two new knot formations not previously encountered. These are the overhand slip knot and the figure-eight knot, both basic utilitarian knots most likely used throughout society.

The most interesting source of information, although not for the information it provided, but for what it did not provide, was the sea itself. From shipwrecks come the square knot and the eye splice. It is most probable, however, that the ancient sailors knew and used many more knots.
CONCLUSIONS

Evidence from the eastern Mediterranean indicates that basic methods of rope-making have changed little over the millennia. Many thousands of years ago mankind learned to twist fibers into yarns. Yarns were then twisted together into cords, and cords were twisted together into larger, longer, and stronger ropes. The techniques of rope-making mastered in those early years have needed little improvement. Geoffrey Budworth, past president of England's International Guild of Knot Tyers, and author of The Knot Book, refers to the large papyrus ropes found in the limestone quarries of Tura, near Cairo, Egypt, as "...as well made as any manufactured today..." (Budworth, 1985: 17). The ship reconstructor of the Royal Ship of Cheops described the 4500-year-old halfa grass rope discovered with that vessel as being of much better quality than modern rope (Lipke, 1984: 17).

The ancient Greek and Roman writers have told us of seven plants used to make rope during antiquity. These are papyrus [Cyperus papyrus], flax [Linum usitatissimum], hemp [Cannabis sativa], esparto grass [Stipa tenacissima], date palm [Phoenix dactylifera], genista [Spartum junceum], and the rush [Scirpus
holoschoenus]. Pliny the Elder even comments on the preferred use of three of these. Rope made of esparto grass is well-suited for use in the water, but rope of hemp is preferred on dry land. And date palm is used for making ropes that are especially suited for use in water. Pliny also notes that esparto is widely used for the rigging of ships.

Some information is given as to the sources of some of these plants. Papyrus comes from Egypt. Flax comes from Egypt and all across western Europe, as well as from Pylos in Greece. Esparto is from Spain. Hemp comes from the Rhone Valley and from Italy, and the rush [Scirpus holoschoenus] comes from Greece.

The ancient Egyptians passed on a wealth of information in their tomb paintings and a few separate texts about the making of rope. Papyrus is the main plant used, although the use of other fibers is indicated, but these are not identified. The methods of rope-making presented in the tomb paintings provide, at the very least, a basic understanding of how this ageless art was performed in antiquity. However, Ryan and Hansen, who conducted the 1987 study of specimens of ancient Egyptian cordage in the collections of the British Museum, provide some comments that should be considered by any student of ancient Egyptian rope-making
techniques. They say: "Though providing some insight into the manufacturing techniques that likely produced the artifacts under consideration, the [rope-making] scenes...possess certain limitations in regard to their interpretive usefulness. These representations are obviously inanimate and do not depict the detailed dynamic action involved in the manufacturing process, though they do somewhat suggest it. Furthermore, it cannot be assumed that all techniques of manufacture are represented by these often redundant depictions, nor can it be assumed that any individual example of ancient cordage was produced by any one particular technique or that such techniques remained constant through time. The investigator of cordage is left, therefore, with a physical product of culture that is the static remnant of a dynamic process which the...scenes might illustrate" (Ryan & Hansen, 1987: 3).

These comments considered, there is still a great deal to be learned about rope-making in antiquity from information that comes from the ancient sources. As has been seen, Mackay considers the technique depicted in the rope-making scene from the New Kingdom Tomb of Khaemwaset to be identical with that used by a group of rope-makers he observed at work in Egypt in 1916 [with the exception of the design of some of their tools].
Archaeological evidence has confirmed the use of five of the plants mentioned by the ancient writers as having been used for rope. One of the ropes from the Cape Gelidonya shipwreck may have been made with esparto grass, but this is not certain. It is certain, though, that ropes from the Marsala shipwreck, the Comacchio shipwreck, and the Lake Nemi ships were of esparto. Hempen ropes were also found on the Lake Nemi ships.

Papyrus ropes have not been found on shipwrecks, but a number of land sites in Egypt have yielded ropes of this material. Date palm ropes were found with the stone anchors from the Dead Sea in Israel. Ropes made from the rush [*Scirpus holoschoenus*] were found on the Ma'agan Michael shipwreck, also from Israel.

While there are numerous references to ropes made of flax in the ancient texts, no flaxen rope has ever been found on a shipwreck in the Mediterranean. And while *genista* is listed as a plant used for rope, it also has never been found on a shipwreck.

Archaeological finds, however, include ropes made of three plants that were not listed by the ancient writers. All of the rope found with the Royal Ship of Cheops was made of halfla grass, as was the lashing material from the Lisht timbers, and some of the specimens from the British Museum collections. Doum palm fibers were used in one of
the rope pieces from the British Museum, and may have been used in one of the ropes from the Cape Gelidonya shipwreck. And finally, fibers from the grass or reed, Phragmites communis, var. isiacus, may have been used in another of the rope pieces from the Cape Gelidonya shipwreck.

All of this evidence, taken together, provides a fairly complete story of rope-making in the ancient Mediterranean. Many of the materials that were used to make the ropes are known, although there were likely others that were neither mentioned by the ancient writers nor found on shipwrecks. It is probable that just about any plant fiber that could be twisted into rope would have been used, especially on a local basis. Poor fishermen from a remote area, who did not have access to the better-known rope-making materials [i.e., those listed herein], would have used whatever was available to them that served their purpose. And it is possible to interpret the graphic presentations in the Egyptian tomb paintings to such a degree that, while all the details may not be known, the basic procedure is clear.

There are two specific topics which are pertinent and warrant further consideration. These are the twist with which the ancient ropes were made, and the maximum sizes of ropes used aboard ships in antiquity. As has
been discovered in this study, the vast majority of ropes from antiquity that are well enough preserved to warrant examination were formed with a Z, left-handed, or counterclockwise twist. Is there a reason for this? This is a question often asked by those who write about rope. Was this somehow a tradition? Do natural fibers 'hold' better when twisted in one direction, than the other? There are no textual references to the direction of twist in rope from the ancients. In fact, the only hard evidence from those days comes in the form of the rope itself. The fact that most of the rope so far examined was made with a Z-twist notwithstanding, until comparative analyses of Z-twisted and S-twisted ropes made of the same fibers are conducted [which has never been done], there is not sufficient evidence on which to base a positive statement, one way or the other. When Honor Frost asked a Sicilian rope-maker about the ropes found on the Marsala shipwreck, he answered "...the direction of the lay has no particular significance" (Frost, 1981: 97).

An initial objective of this research project was a study of the sizes of anchor rope holes, particularly those of stone anchors. Were the sizes of anchor holes an indication of the maximum sizes of the ropes used with them? A study of the physical properties of rope,
however, indicated the sizes of anchor holes and the maximum sizes of ropes were not related.

A single turn through an anchor hole, or ring, exerts the most wear on a piece of rope. The sharper the curve put into the rope, the greater the chance the rope will break. The most efficient use of rope, in this case, is to put a round turn, or two, through the anchor hole. By doing this, the load is gradually absorbed in the increased number of turns through the hole, rather than being taken by a single turn (Budworth, 1985: 29). An example of this particular use of rope was found on the one-armed anchor from the Ma'agan Michael shipwreck. This anchor's lifting loop is reported to have been “...four lengths of 40 mm-diameter rope passing through the 85x40 mm rectangular hole in the head of the shank” (Rosloff, 1991: 223).

A final thought on this matter concerns the physical size and weight of rope. Rope large enough to have filled the anchor hole of one of the stone anchors found in the Dead Sea, for instance (10-16 cm in diameter; Hadas, 1992: 55-56), would have been very large and bulky. J. Richard Steffy, who comments on a line of great bulk in his section on anchor design in Yassı Ada (1982: 143) states that “...its handling and storage
would have been impractical..." on many of the smaller ships used during antiquity.

Turning to the subject of knots, a topic related to the subject of ancient knots deserves a comment. This is the Minoan Sacral Knot. This knot was not addressed in the general survey of ancient knots because it is not a working knot that is also afforded some mystical power, as is the Hercules knot. This configuration (Fig. 40), called by Day: "the mysterious Minoan knot tassels found by Schliemann at Mycenae and by Evans in Crete...," is unlike any other knot rendered in the art of the ancient eastern Mediterranean. These representations were found in such great numbers and in such a variety of styles at both locations that they are believed to have possessed some ritual or magical significance. What that significance might have been, however, is not known. This knot formation, the slip knot or loop knot, is not mentioned by the ancient writers as having any specific magical power (Day, 1967: 66). If these knots did possess ritual or magical significance among the ancient Mycenaeans and Minoans, it may have been similar to that of the Hercules knot. This formation was rendered as items of gold jewelry, wall paintings, and separate pieces made of ivory and faïence, all permanent
a. From Knossos, Crete.  
b. From Mycenae, Greece.

Figure 40. Sacral Knots.  
representations that could not be erased or untied. The true meaning of these knots, however, remains a mystery.

Continuing with the subject of ancient knots, the evidence from antiquity is less revealing than it is for rope. The ancient writers, who provided a vast amount of information on rope, are virtually silent on the subject of knots. The sole written source of information on knots from the ancient world is the first century A.D. physician Heraklas who recorded eighteen binding configurations that he referred to as "surgical slings." Nine of these compare to knots known in the modern world, of which five are used by sailors today. These are the overhand knot, the square knot, the true lover's knot, the jug sling, and the clove hitch.

The one knot found in iconography throughout the eastern Mediterranean is the square knot. Called by the ancients the Hercules knot, its likeness was used in all manner of artistic renderings throughout the region, and by most cultures, from the time of the ancient Egyptians through at least the end of the Roman period. This knot was believed to have had positive amuletic power and it was, therefore, acceptable to have it graphically represented. The lack of other knot depictions in the art of the region is believed to have been due to a superstitious fear that the artist would be "bound into"
the situation in which the knot was shown, and could not be released therefrom.

A few model boats from Egyptian tombs provide some information on knots used by the ancient Egyptians. Included are the fisherman's bend, or anchor bend (which include two round turns and a half hitch), the square knot, the clove hitch and marling hitch, the lark's head knot, and the eye splice. Some of these must be viewed with caution, however, as some of the models were repaired after excavation and records indicating which components are original and which are repairs are not specific.

Archaeological remains of ancient knots are, likewise, quite limited. The Egyptian specimens from the British Museum include the overhand knot, a doubled overhand loop, and the figure-eight knot. The earliest knots from a nautical context are two from the fourth-century B.C. Ma'agan Michael shipwreck. The first is a square knot in small string. The second is also a square knot, but in larger rope, and may be a never-before-seen configuration, i.e., tied with one rope on one side and two ropes on the other side. The last knot under consideration is from the third-century B.C. Marsala shipwreck. This is an eye splice, but one that would not
have been expected to have carried much of a load because of the limited number of tucks in its splice.

Taken all together, this evidence indicates the knots used around the ancient eastern Mediterranean include: the square knot; fisherman's, or anchor bend; clove hitch; marling hitch; lark's head knot; true lover's knot; jug sling; and the eye splice (this likely includes all types of splices). The sheet bend should be added to the list. It is hinted at in the tomb paintings, and in fact, its construction is the same as the weaver's knot, which has been known by most cultures around the world for many thousands of years.

This is a well-rounded group of knots that may have served all the requirements of the ancient sailors on the Mediterranean. However, it is most likely that the list is not complete, that is, that examples of many of the knots used by the ancient sailors are yet to be found.

The purpose of this thesis has been to review the evidence that exists from the ancient world on the use of rope and the art of knot-tying in the seafaring of the ancient eastern Mediterranean. A great deal is known about the rope, and, while many of the knots used are known, there remains much to discover.
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Classical Works Cited


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APPENDIX A

PLANT SOURCES FOR

ANCIENT MEDITERRANEAN-AREA ROPE-MAKING MATERIALS

(Text = Textual References; Art = Artistic/Iconographic renderings; Find = Archaeological Finds.)

CANNABIS SATIVA - Hemp
Text-Athenaeus, The Deipnosophists: 5.206 d-f;
Aulus Gellius, Attic Nights: 17.3.4;
Persius, Satire V: 146-147;
Pliny the Elder, Natural History: 19.8.29, 19.56.174.

Find-Ropes made of Hemp were found on the first-century A.D. ships found in Lake Nemi, Italy (Ucelli, 1950: 243 & fig. 275; 245 & fig. 278; 268).

CYPERUS PAPYRUS - Papyrus
Text-Homer, The Odyssey: 21.390-391;
Herodotus: 2.96, 7.25.1, 7.34.1, 7.36.3;
Theophrastus, Inquiry Into Plants: 4.8.2-4;
Pliny the Elder, Natural History: 5.8.44, 6.37.205, 13.22.72-73;

Art -Anta (Deshasheh), Petrie, 1898: 7 & plate V;
Kaemnofret, Dunham, 1935: 304-305 & fig. 1;
Khaemwaset, Mackay, 1916: 125-126 & plate XV;
Ptahhetep, Davies, 1900: plate XXI; Griffith, 1900: 10.

Find-Papyrus ropes were found at Tura, Egypt (Lucas, 1948: 161; Arnold, 1991: 268).
Six rope specimens held in the British Museum were made of Papyrus, including two from the Tura quarries reported by Lucas (1948) (Ryan & Hansen, 1987: 8).
**DESMOSTACHYA BIPINNATA** - Halfa Grass

Find-Rope found with the Royal Ship of Cheops at Giza, Egypt was made of Halfa Grass (*The Cheops Boats*, Nour et al., 1960: 42).

Fragmentary lashing remains found with boat timbers buried at Lisht, Egypt were made from this material (Haldane, 1990: 135-136).

Nine rope fragments held in the British Museum were made of Halfa Grass (Ryan & Hansen, 1987: 7).

**HYPHAENA THEBAICA** - Doum (Dum) Palm

Find-Rope found on the Bronze Age shipwreck at Cape Gelidonya, Turkey was tentatively identified as having been made from Doum Palm fibers, mixed with Esparto Grass fibers (Du Plat Taylor, 1967: 160-162).

One specimen of ancient Egyptian rope in the British Museum was made from Doum Palm fibers (Ryan & Hansen, 1987: 7).

**LINUM USITATISSIMUM** - Flax

Text-Aelian, *On the Characteristics of Animals*: 5.3;
Euripides, *Trojan Women*: 11.532-540 &
*Iphigenia in Tauris*: 1.1043;
Herodotus: 7.25.1, 7.34.1, 7.36.3;
Ovid, *Fasti*: 3.587-588;
Pliny the Elder, *Natural History*: 19.1.3, 19.2.7-11,
19.6.25, 24.40.65, 37.76.202-203;
Statius, *The Achilleid*: 1.413-422;

**PHOENIX DACTYLIFERA** - Date Palm

Text-Pliny the Elder, *Natural History*: 5.15.70 & 73,
6.37.205, 13.7.30, 16.37.89, 18.50.188.

Zenon Papyrus #59438 contains an order from a farmer for two hundred bundles of palm fibers so he can make ropes to bind his plow together (Edgar, 1971: 165).

Find-Ropes buried with three third-century B.C. stone anchors found in the Dead Sea near 'Ein Gedi, Israel were made from this material (Hadas, 1992: 55; Shimony et al., 1992: 58).
PHRAGMITES COMMUNIS, var. ISIACUS - Grass or Reed
Find-One piece of rope from the Bronze Age shipwreck at Cape Gelidonya, Turkey was tentatively identified as having been made from this plant fiber (du Plat Taylor, 1967: 160-161).

SCIRPUS HOLOSCHOENUS - A Rush
Text-Pliny the Elder, Natural History, 21.68.113.
Find-Rope from the fourth-century B.C. shipwreck excavated near Kibbutz Ma'agan Michael, Israel was made of fibers from this plant (Charlton (In press)).

SPARTUM JUNCEUM - Genista
Text-Pliny the Elder, Natural History: 19.2.15, 24.40.65.

STIPA TENACISSIMA - Esparto Grass
Text-Athenaeus, The Deipnosophists: 5.206 d-f;
    Livy 22.20.6;
Pliny the Elder, Natural History: 19.7.26-27, 19.8.29-31, 24.40.65, 37.76.202-203;
Strabo, Geography: 3.4.9;
Varro, Human Antiquities: Book 25 &
On Farming: 1.23.6.
Find-The fibers from one piece of rope from the Bronze Age shipwreck at Cape Gelidonya, Turkey have tentatively been identified as Esparto Grass (du Plat Taylor, 1967).
All ropes found on the third-century B.C. Punic wreck at Marsala, Sicily were made of Esparto Grass (Frost, 1981: 93).
Ropes from the first-century A.D. Lake Nemi ships, were made from this material (Ucello, 1950: 243 & fig. 275; 245 & fig. 278; 268; 431, #440; 442, #589).
APPENDIX B

GLOSSARY

BACKSTAY - A line to keep a mast from leaning (raking) forward.

BAST (SOFT) FIBERS - Flexible elongated strands obtained from the inner barks of the stems of plants.

BECKET - A loop or an eye in the end of a rope or line, either tied or spliced.

BELAY, TO - To make a line temporarily fast on a cleat, pin, pair of bitts, etc.

BEND - A knot used to tie the ends of two free lines together.

BEND, TO - To tie two lines together or to tie a line to a fixed object (often using a hitch), or to secure a sail to a boom or stay ready for hoisting.

BIGHT - A curve in a rope or line. In knotting, the part of the rope or line, between the end and the standing part, on which the knot is formed.

BITT(S) - A post or pair of posts with or without a crossbar for securing heavy lines.

BITTER END - Technically the inboard end of the anchor rode. It was originally the end secured to the bitts, thus the name.

BOLLARD - A round heavy post for securing lines, usually on a pier.

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CABLE - In modern terms, three 'plain-laid,' 'hawser-laid,' or 'right-laid' ropes laid together 'left-handed.' This is called 'cable-laid,' and is actually 'right-twisted,' or 'S-twisted.' In modern times, any large line - usually used for anchoring.

CAPSIZE, TO - To turn over a coil from the position in which it was stowed so that the standing part will run free. To turn over parts of a knot for the purpose of loosening it.

CAST IN, TO - To put a knot or splice in a line.

CAST OFF, TO - To take turns off a winch or bitt. May imply hauling the line in after casting off, as is the case with docking lines.

CAST ON, TO - To put turns on a winch or bitt, etc.

CHAFING GEAR - Any device - leather, rope, etc. - used to prevent wear on lines, sails, decks, or spars.

CHOCK - Device to hold a line in place as it passes over or through the rail.

CLEAT - A fitting with two arms on which to belay a line, see horns.

CLEAT EYE - A hole in the center of some cleats for securing the bitter end of the line so that it will not come adrift (loose).

CORDAGE - A general term which includes all sizes of rope.

CROSS TURNS - Turns taken around, and perpendicular to, the turns of a seizing of lashing - Frapping turns.

END - The working end of the line, the part with which the knot is tied.

EYE SPLICE - A bight (fixed loop) formed in the end of a line by splicing the end back into its standing part.

FAIR, TO - To put the parts of a knot in their proper positions. To arrange the bights in a coil so they lie in order.
FAIRLEAD - A device - block, chock, etc. - to keep a line in a desired position so that it will not foul other gear and will not chafe.

FIBER - The basic raw material component of any plant-based cordage.

FID - A conical piece of wood (hickory or lignum vitae) used to work or undo knots and lines.

FIXED OBJECT - A ring, spar, cleat, bitt, other line, to which a line is tied.

FOOTROPE - A line stretched beneath the yards of a ship on which men stand when handling sail.

FORESTAY - A line to keep a mast from leaning backward.

FRAPPING TURNS - See Cross turns.

GASKET - A small line or strip of canvas used to secure the sail to its boom.

GRANNY - A square or reef knot incorrectly tied, the second step being reversed.

HACKLING - Combing fibers to remove those too short to be used.

HALF KNOT - The first half of a square knot; identical to an overhand knot.

HALYARD - Line used to hoist and lower a sail or flag.

HAWSER - A large rope 5 to 24 inches (12.7 - 61 cm) in circumference, for towing, etc. In modern terms, a hawser is 'plain-laid,' 'hawser-laid,' or 'right-laid;' this is 'left twisted,' or 'Z-twisted.'

HITCH - Knot used to bend a line to a spar, ring, or other line.

HORNS - The two arms or projections of a cleat.

KNOT - In general, any fastening, including bends, hitches, and splices, made by interweaving cordage. Specifically, a method of joining the ends of two cords together, or of forming a noose, a fixed loop, or a knob or stopper.
LASH, TO - To tie down moveable objects on board.

LASHING - Generally any rope or small stuff used to lash objects.

LEAF (HARD) FIBERS - Stiff strands that are obtained from leaves and leaf stems.

LAY, LAID, LAID UP - The direction in which the strands of a rope are twisted. Can also refer to the tightness of the twist (soft, medium, or hard lay).

LEECH LINE - A small line rove through the hem of the leech whose adjustment controls the shape of the sail and excessive flutter.

LIFELINES - Permanent lines rigged to keep the crew aboard in bad weather.

LIFT - Line(s) rigged from the mast to hold the yard or boom in a horizontal position, sometimes called a topping lift.

LINE - A rope used for a particular purpose.

MAKE FAST, TO - To fasten securely using a hitch or a bend.

MARLINSPIKE - A long metal cone for opening strands in splicing and multi-strand knot tying. (Also called Marline Spike, or Marlingspike.)

MONKEY FIST - A small weight covered with a rope knot, similar to a Turk's Head. Bent to a heaving line, it has enough mass when thrown to pull the line behind it.

NIP - The part or parts of the knot where the line itself or another line applies pressure to provide the friction that makes the knot hold.

OVERHAND KNOT - A simple knot which will not hold by itself.

PAINTER - A short, small line secured to the bow of a small boat for towing or making fast.

PREVENTER - A line rigged to give extra support to another line or to hold another line under strain.

PURCHASE - A tackle or device used to increase hauling power.
REEF POINTS - Small line rove through grommets set in the sail, on lines parallel to the foot and used to reef the sail.

REEVE, TO - (past tense: ROVE) To run the end of a line through a fairlead or block, or any opening.

RETTING - (To rot.) Causing the connective compounds (gums) of a plant to decompose in preparation for removing its fibers.

RIPPLING - Removing seed heads from plant stalks.

RODE - A name applied to the anchor line or cable.

ROPE - Modern usage applies this term to cordage over 1 inch (2.54 cm) in circumference (about the size of a wooden pencil).

ROUND TURN - A wrap of line around an object. The two ends of the line are parallel, and the line touches the object for 540°.

RUNNING RIGGING - All lines and gear used to set and trim sails.

S-TWIST - Twisted to the right, or clockwise. Also called 'left-laid.'

SCUTCHING - Beating plant stalks to break up the woody pith that holds the fibers together.

SECURE, TO - To stow or put in its proper place something that is no longer needed. Often used in place of 'make fast.'

SEED FIBERS - Fibers from a plant's seed pods (cotton).

SEIZING - A lashing for holding two ropes or parts of a rope together. Throat, middle, quarter, and end seizings are so named from the part of the rope where the seizing is applied.

SHEET - Any line attached to the lower, after corner of a sail for the purpose of trimming or setting it.

SHROUD - Line supporting a mast laterally.
SINGLE HITCH - A hitch made around a fixed object with the end under a standing part. It is similar to a Half Hitch which is made around its own standing part.

SMALL STUFF - Twine, cord, marline, etc. Small cordage under 1 inch (2.54 cm) in diameter.

SPlice - The interweaving of separated rope strands for the purpose of either lengthening the line, or placing an 'eye,' or loop at the end of the line.

STANDING PART - The inactive, non-working part of the line.

STANDING RIGGING - All lines and gear used to support the masts.

STAY - Rope supporting a mast fore or aft.

STOPPER - A short line used to hold another line, or to control it while paying out.

STRAND - Yarns are twisted together to form a strand. Strands are twisted together (laid up) to make rope.

TOPPING LIFT - A line rigged to support a yard or boom.

TUCK, TO - In knot tying, inserting the end of the line between two other lines or two parts of the same line. In splicing, inserting a strand between two other strands.

TURN - A single wrap of line around an object. The two ends of the line are parallel to each other, and the line touches the object for 180°.

UNLAY - To unwind the strands of a rope, usually in order to work in a splice.

WHIPPING - Round turns made with small stuff on the end of a line to prevent it unlaying.

YARN - Long fibers twisted together. Yarns are twisted together into strands.

Z-TWIST - Twisted to the left, or counterclockwise. Also called 'right-laid.'
VITA

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A.A. (General Education)
College of the Desert, Twentynine Palms, California
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1995/6-Diving Safety Officer, Institute of Nautical Archaeology.
1995---Byzantine Shipwreck Excavation-Bozburun, Turkey; Divemaster.
1994---Byzantine Shipwreck Excavation-Tantura, Israel; Divemaster.
1990/3-Bronze Age Shipwreck Excavation-Uluburun, Turkey; Divemaster.
1991/2-Built museum display model of the Kinneret Boat.
1989---Retired from the United States Marine Corps after 29 years active duty service.

CERTIFICATIONS:

U.S. Navy SCUBA Diver, U.S. Navy Emergency Medical Technician, SCUBA Diving Course Director (Instructor Trainer), Nitrox Diving Instructor, Master SCUBA Diver, Divemaster.

AWARDS: