VERNACULAR BOATS AND BOATBUILDING IN GREECE : VOL. 1

Kostas Damianidis

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VERNACULAR BOATS AND BOATBUILDING

IN GREECE

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VOLUME I

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ABSTRACT

This work presents a study of the vernacular boats of modern Greece. A new typology of boats is offered, and an account is given of tools and boatyard practice, design and construction techniques. Evidence for these subjects is drawn from field surveys, museum collections, iconographic studies, and interviews with old boatbuilders. Although most of the information presented comes from the first half of the 20th century, background information from the 18th and 19th centuries is also covered. This longer historical perspective is particularly important in making comparisons between 20th century practices and the boatbuilding techniques of the past.

There is evidence for the existence of two main periods of technical change in the industry, namely, the late 18th century, when new methods such as lofting were introduced, and the late 19th century, when changes in the wider shipbuilding industry initiated a process of decline in vernacular boatbuilding. At the same time however, a number of older techniques, for example certain moulding methods, survived at least into the first part of the 20th century.

This work offers new insights into the design methods involved in the control of hull-form during "skeleton-first" boatbuilding from the last two hundred years. It also offers an analysis of the structural integrity and strength of vernacular boats and shows how the structure of boats has evolved across time to incorporate new techniques and changes in boat function.

Declarations

I, Kostas Damianidis, hereby certify that this thesis, which is approximately 95,000 words in length, has been written by me, that it is the record of work carried out by me and that it has not been submitted in any previous application for a higher degree.

22nd December 1989

I was admitted as a research student under Ordinance No. 12 in October 1985 and as candidate for the degree of Ph.D. in October 1985; the higher degree for which this is a record was carried out in the University of St. Andrews between 1985 and 1989.

22nd December 1989

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I hereby certify that the candidate has fulfilled the conditions of the Resolution and Regulations appropriate for the degree of Ph.D. in the University of St. Andrews and that the candidate is qualified to submit this thesis in application for that degree.

22nd December 1989

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Guide to phonetic transcriptions of Greek Names and vernacular terms occuring in the text.

α	a
β	b
γ	g
δ	d
ε	e
ζ	z
η	i
θ	th
ι	i
κ	k
λ	l
μ	m
μπ	b
ν	n
ντ	d
ξ	x
ο	o
π	p
ρ	r
σ	s
τ	t
υ	y
φ	ph
χ	ch
ψ	ps
ω	o

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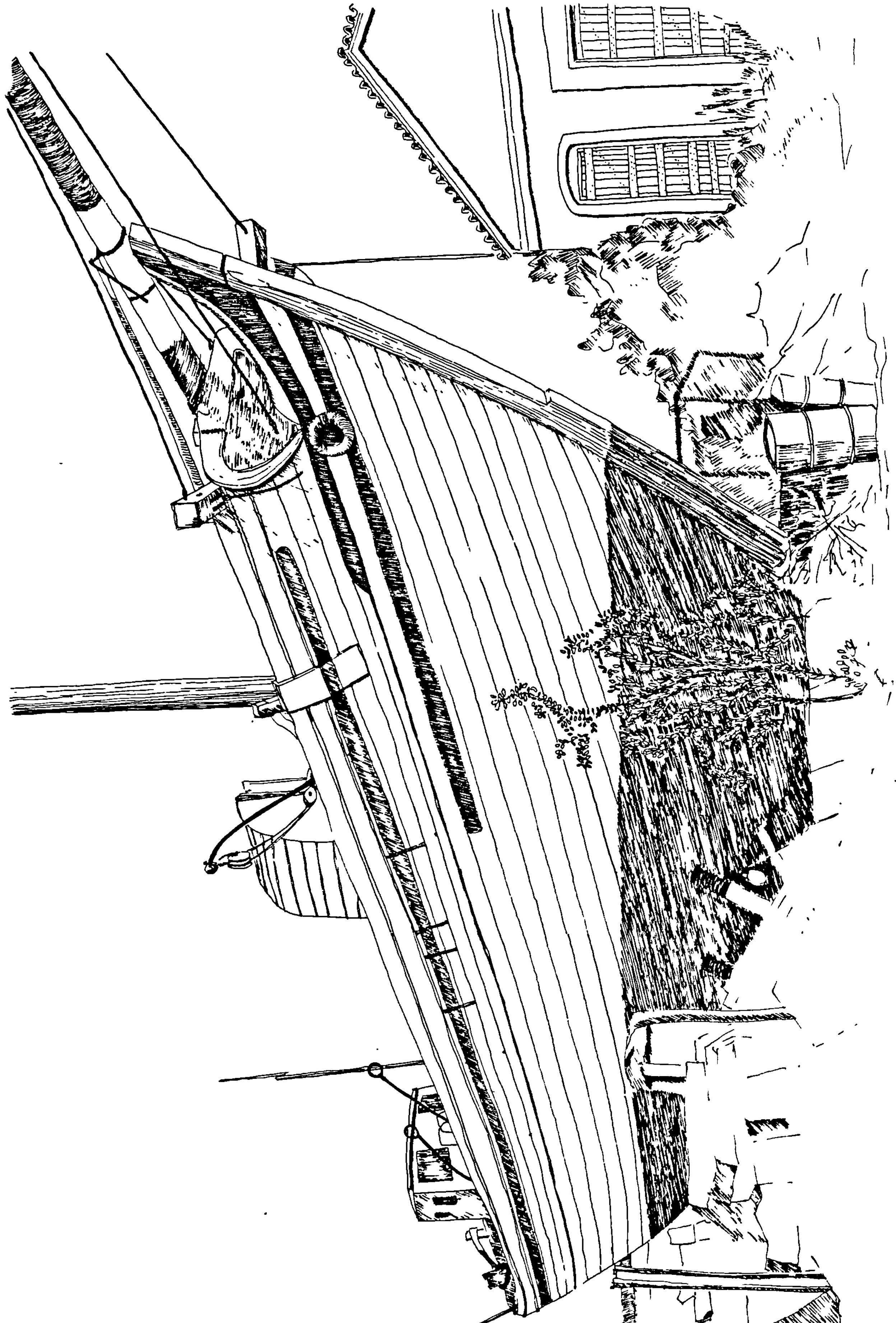

INTRODUCTION

Traditional shipbuilding in modern Greece has been studied sporadicaly by native and foreign scholars (Basch,L. (1972), Damianidis,K. & Zivas,A (1986), Denham,H.M. (1986), Heidelberg,P.K. (1985), Kladou-Bletsa (1983), Poulianos,A.I. (1977), Throckmorton,P. (1964), Tzamtzis,A.I. (1972), Vichos,I. (n.d.), Zouroudis,G.I. (1974)). A more systematic study was undertaken by Adoniou,A. (1969) for his doctoral thesis. As a naval architect, he focused on the formal properties of the traditional designs of vessels. The main intention of his work was to compare these properties with international standards of naval architecture. At the same time, he suggested a few structural improvements to meet the modern demands of boatbuilding.

By contrast, the main intention of the present work is to describe evolution of the traditional boatbuilding techniques. The last three centuries will be the period of our study although the main bulk of the technical evidence has been provided by sources from the 20th century (interviews). Our knowledge of boatbuilding techniques in the Aegean prior to the late 18th century is severely limited. Direct historical and archaeological studies tell us very little about the process of building boats.

The studies which are mentioned above provide some evidence about early techniques which have survived in Greece up to the second half of this century. Briefly, we can note here the "master frame and ribbands" method (Poulianos,A. (1977), Basch,L. (1972)), moulding with adjustable templates (Heidelberg,P.K. (1985), Damianidis,K & Zivas,A. (1986)), careening (Zouroudis,G.I. (1974, pp.169-70) and some other elements in the building process (Zouroudis,G.I. (1974), Poulianos,A. (1977)). Also, until recent times, hand tools were extensivly used in some boatyards ([10]-Binos, [12]-Kozonis, Poulianos,A.I. (1977)).

We do not know exactly how old are most of these techniques. Comparing this material with the scant historical and archaeological evidence about boatbuilding in the area from the 11th century onwards, we can certainly see some common features. But some extravagant claims have been made by scholars about the historical origin of these surviving techniques without adequate evidence (Thorckmorton,P. (1964), Denham,H.M. (1986), Vichos,I. (n.d.)). However, analysing the material in the present work we can more clearly recognize influences from modern techniques and adaptations of the old ways to modern demands. All the available sources suggest that the bulk of these changes occurred during the last three centuries.

A technical approach to the subject during this period can cast some light on the evolution of these techniques in modern Greece. And, because of our limited knowledge about most of the early boatbuilding techniques, an understanding of the evolution of this modern Greek tradition becomes particularly valuable. Part of the significance of the present study of technical methods during more recent times, is the light it casts upon some aspects of early (pre 1750) boatbuilding.

The balance of the present work is influenced by the uneven coverage in the literature. On the one hand, several aspects of this tradition, which have been previously neglected, are given lengthier treatment (classification of sails, boatbuilding tools, boatbuilding wood). On the other hand, aspects of this tradition which have been studied by other scholars are included in this work in a summarised form (historical introduction, classification of hulls, classification of early types of hulls).

Evidence from written sources is inadequate to account for several elements of this study (morphology of hulls, practical determination of boat form, the use of some tools, planking up and caulking a vessel). Extensive fieldwork was undertaken in old boatyards surviving in the Aegean. Traditional techniques were recorded on site and many old boatbuilders were interviewed (see methodology of the fieldwork and index of interviews).

The ground and the limits of this work are set in two ways. First, by the period of the last three centuries (from the late 18th up to the middle of 20th). Second, by the "skeleton first" and "carvel" building methods; only these were used in Greece and any comparison with other traditions has been made within these techniques.

The chapters of this work together with their main sources of evidence are as follows:

1.<u>HISTORICAL INTRODUCTION</u>

(bibliographical sources, preliminary survey in the boatyards of the area)

2.<u>CLASSIFICATION OF BOATS</u>

(interviews, bibliographical sources, recorded material)

3.<u>MORPHOLOGY</u>

(interviews, recorded material)

4.<u>TOOLS</u>

(interviews, recorded material, bibliographical sources)

5.<u>DESIGNING</u>

(interviews, recorded material, bibliographical sources)

6.<u>BOATBUILDING TIMBER</u>

(bibliographical sources, interviews)

7.<u>CONSTRUCTION</u>

(interviews, bibliographical sources, recorded material)

8.<u>CONCLUDING REMARKS</u>

The study of the evolution of modern Greek traditional boatbuilding techniques is central to all the chapters mentioned above. This starts from the few fragments of evidence from the late 18th century and widens in scope through the 19th and 20th century.

A second major aim of this work is the contemporary study of the "skeleton first" and "carvel" planking techniques as they survive in this area today. This is mainly undertaken in the chapters on TOOLS, DESIGNING, and CONSTRUCTION.

Historical and archaeological material has occasionally been introduced in order to study the historical roots of these techniques in the Aegean. Further comparison, with ethnological and historical material from other countries, yields a wider perspective on some aspects of the present work, epecially in the chapter on DESIGNING and occasionally in the chapters on TOOLS and CONSTRUCTION.

In the HISTORICAL INTRODUCTION there is a short review of the evidence about the history of traditional boatbuilding in modern Greece (from the 16th century until the middle of 20th century). A preliminary study of the location and the working environment of boatyards has been included in this part of the work.

In the chapter on CLASSIFICATION of boats attention is paid to the structure and formation of the different types of hull. In the same chapter, types of rigging are studied in relation to types of hull. The geographical distribution of the building of different types of hull within the Greek area provides some evidence about vernacular boatbuilding traditions.

The TOOLS of this craft have been studied more as the means of the application of traditional knowledge and experience than as static objects of a past technology. From this perspective, the study of tools has focused on their use during the boatbuilding process and also on the relationship between the boatbuilders and their tools. This part of the work looks in detail at some examples of the use of tools as an introduction to the analysis of vessel structure that is included in the following chapters.

In the chapter on DESIGNING the most abstract parts of boat formation are examined. The recently published material in this field from other countries provides comparative ground for studying the material of this work (see the method of moulding with adjustable templates). In this part, first the contribution to this field of the Aegean tradition has been studied. Later, the relationship between the design methods from different parts of the world, including Greece, and from different historical periods has been reviewed (from early 15th century until today). An overall study of these methods follows, and some suggestions are made about the links between these methods and their likely common origin. At the end of the chapter on DESIGNING we look at the requirements about boat formation which shaped the evolution of these methods in Greece from the end of the 18th century until the middle of the 20th century.

The lack of any adequate study of boatbuilding timber from the Aegean makes it necessary to include in this work the chapter on BOATBUILDING TIMBER. Here, attention is paid to the properties of the wood which are directly related to boatbuilding structure. Once again, this part of the work has been considered as an introduction to the following this chapter on CONSTRUCTION.

The study of boatbuilding tools and timber provides comprehensive support for the final chapter of this work, which is about the boatbuilding process. The order of examination of the material in this part follows the order of the construction process as studied in the fieldwork and interviews. Sometimes deviations into the different structural types of boats are included in this study. At the end of this chapter, an overall view of boat construction from this part of the world is presented. The principles of these structures are outlined together with some suggestions about the evolution of some structural elements.

In the CONCLUDING REMARKS there is a brief review of the main points resulting from each chapter. A general suggestion about the evolution of boatbuilding techniques during the last three centuries is made here. Furthermore, there are some concluding comments about the early origin of these techniques and their transmission between generations. Finally, the traditional practice in modern Greece is classified within the known pre-industrial boatbuilding techniques. No doubt, further study of the tradition surviving in Greece could provide additional knowledge on the history of boatbuilding techniques. This is to say that the field is still open and attractive for further research from similar or other approaches.

Methodology of the fieldwork

The information from the bibliography about the technique of boatbuilding in the Aegean during the last two centuries is limited. Therefore, other sources had to be studied. Relevant material from this period can be found mainly in ethnographical fieldwork, museum collections and photographic archives.

In addition to the fieldwork, other sources which provided material for this work are as follows:

1) The Pireaus Maritime Museum's collection of models and popular paintings (portraits of ships and boats, usually commissioned by the owner).

2) The Maritime Museum in Galaxidi owns a good collection of popular paintings and some old boatbuilding tools which were examined and partly recorded during this work (wooden mallet).

3) "Evaggelistria", the boat which belongs to the Aegean Maritime Museum, has been recorded during this work (fig.105a,b,c, 122a,b,... and 122i).

4) Models in the Maritime Museum in Chania are studied.

5) The Maritime museum on Santorini has a few boatbuilding tools and popular paintings relevant to this study.

6) A good collection of contemporary popular paintings of boats

belongs to the Folk Museum on Salamis.

7) The Hellenic Institute of Preservation of the Maritime Heritage owns some boatbuilding tools and some patterns some of which are recorded during this work (fig.62, 65a, 71, 108)

8) The Benaki Museum provided some old photographs of boats and boatyards.

9) Two old photographs which are included in this work (fig.7 and 135) were provided by the Archaeological Museum in Kavala.

10) The Εταιρία Ελληνικού Λογοτεχνικού και Ιστορικού Αρχείου provided this work with the photographs which appeared in the fig.35 and 42.

11) The Institute of Forest Research in Athens provided some of the rare bibliographical sources about timber from the area.

12) The Ministry of Transport provided some information about the number and the activities of boatyards in 1987 (fig.3).

12) Mr. Tzalas, president of the Hellenic Institute of Preservation of the Maritime Heritage, supplied some copies of plans of vessels studied (tables,no.28, 29, 30, 31) and partly included in this work (fig.14a,b, 17, 22a,b).

13) Two other private photographic collections provided some of the photographs which are included here (fig.34a,b, 82).

The ethnographical fieldwork which was carried out during this work consisted of two parts. The first was to record and study artifacts and techniques in the boatyards and the second to conduct interviews with old boatbuilders. The first part produced, by the end of the fieldwork, a large number of photographs, including those which appeared on the fig.19a,b, 120, 124, 127, 136, 137 and, also, most of the drawings and plans which are presented here. (Any of the drawings and plans without a source reference come from this part of the fieldwork). This part also covered the recording of the lofting floor in [1]-Mavrikos' boatyard / 1987 (see 5.3.1. The method of laying out the lines of a boat straight on the lofting floor) and the recorded lines of the boat "Phaneromeny" (fig.18a,b,c) which has been restored in [17]-Papastephanou 's boatyard.

The second part is the interviews which are considered as the main source of the new information to be studied. There is still a sufficient number of old boatbuilders (over 60 years old) who can describe their old boatbuilding techniques. An initial investigation which was undertaken a few years ago (Damianidis,K and Zivas,A. (1986)) suggested that interviews with the oldest generation of boatbuilders in the Aegean can provide us with some valuable knowledge on the subject.

This traditional technical knowledge is no longer regularly transmitted from the old to the new generation of boatbuilders, simply because for the latter this knowledge is not applicable any more. Therefore in addition to the information on boatbuilding which is provided by these interviews, the actual bodies of these interviews are some of the last documents in traditional Aegean boatbuilding.

This distinctive importance of the interviews determined the aims and the methodology of the field work in this thesis.

The informal character of the interviews was necessary in order to overcome the problems of communication. (terminology, language, knowledge, confidence).

The questionnaire method faces the problem of short and general answers and in practice turned out not to be comprehensive enough for the aims of this thesis. The previous experience of the old boatbuilders at giving standard interviews to local authorities was an additional problem to work out with our technical questionnaire. After the test of the questionnaire for the interviews we came to the decision that in order to collect as much valuable information as possible we had to introduce topics for conversation or even for demonstration.

Therefore the final form of the interviews was to introduce topics for conversation where priority was given to have interaction in sufficient detail with the boatbuilders. In some instances demonstration work was carried out in order to overcome the problem of communication (the moulding techniques, the use of the lofting floor).

The suggested topics for conversation were divided according to the chapters of this thesis. In practice these topics were some times very general and we had to manipulate or analyse them in respect to the most salient aspects of each interview (interview with caulker, sailmaker, boatbuilders with experience in moulding or in lofting techniques).

The topics divided according to the chapters are the following:

[H]-HISTORICAL INTRODUCTION

1) Identity of the boatbuilder.

2) The way that the boatbuilder learnt this technique.

3) The history of the boatyard where the boatbuilder worked.

[Tp]-TYPOLOGY

1) The types of vessels that he used to build.

2) The identity of these types.

3) Other types of traditional vessels that he has seen and whether he can identify the place where these types were usually built.

[M]-MORPHOLOGY

1) The common function of each type.

2) The advantages and disadvantages of each type of vessel in respect to their function, to their method of propulsion and their construction.

3) How the different functions influenced the form and the structure of the vessels

4) How the method of propulsion influenced the form and the structure of the vessels

[T]-TOOLS

1) Descriptions and names of hand tools which were used in boatbuilding.

2) How they used these tools?

3) How and where each tool was made

[W]-WOOD

1) The kinds of wood they used

2) The required properties of the wood for boatbuilding

3) The treatment of the timbers before they used them in the structure.

4) The required volume of wood for a boat

[D]-DESIGNING

1) What were the ratios of the fundamental dimensions of each type of vessels?

2) The description of the method they used to determine the lines of the vessels.

3) What changes have they noted in these methods during their life time

[C]-CONSTRUCTION

1) In which part of the construction process were they specialised?

2) Differences in construction in respect to different types of boats.

3) Dimensions of structural components

4) Changes in the construction of traditional boats during their lifetimes.

Most of the interviews took place in the boatyards because most of these people are still involved with boatbuilding work. One of the problems during an interview was the limited time available by the boatbuilder. This problem was solved in two ways. With most of the boatbuilders I could agree upon more than one interview ([1]-Mavrikos, [3]-Stilianou, [5]-Dardanos, [6]-Arvanitis,

[7]-Chimonas, [8]-Chalaris, [10]-Binos, [11]-Polias, [14]-Chatzinikolaou, [16]-Kritikopoulos, [17]-Papastephanou, [19]-Bilias).

With a few of them a second interview was rather difficult. In this case I decided to focus on the most interesting topics of the interview program in order to get as much information on those as possible ([15]-Vrochidis, [20]-Giamougianis).

An additional problem became the "secret" points of this technique. Some of the boatbuilders were very suspicious about the purpose of the interview, because they are still in the boatbuilding business and they believed that some of their technical details might be used in competitor boatyards ([15]-Vrochidis, [20]-Giamougianis).

The language was sometimes another problem. Even for someone who speaks Greek as a native language it was rather difficult to understand all the descriptions and the local names. So in order to solve this kind of problem additional time was spent by the boatbuilders repeating or explaining themselves. Sometimes demonstrations were undertaken to overcome this problem.

Difficulties appeared also in keeping the conversation of the interview about techniques and types of boats focused on the old times. Most of the boatbuilders tended to give information about modern techniques and they described the types of boats which they build today.

Some of the interviews were very difficult to tape-record because either the boatbuilder was not so happy with the sight of the tape recorder ([17]-Papastephanou), or the conditions in the boatyard were very noisy ([16]-Kritikopoulos).

There were some boatbuilders who refused to have any conversation at all about their work, and others who provided this work with only sporadic and unrecorded information. Both of these two groups of boatbuilders are excluded from the interview index.

In addition to the interviews which are included in this work we should mention the previous interviews which were used as preliminary material for this methodology being included in Damianidis,K and Zivas,A. (1986). These were undertaken with the following boatbuilders: Chalaris,A. (Santorini), Dimitriadis (Perama), Pezaros (Pireaus), Binos,V. (Limnos), Triandaphilos (Kalimnos)

With Mr. Chalaris,A and Mr. Binos,V. we had additional interview material during the field work of this present work.

At the end of the field work we had twenty new interviews (most of them in two or three parts) which were suitable for comparison and they are listed as an index of sources of information included in this thesis. The length of these interviews and sometimes the existence of irrelevant parts to the program of the interview determined their condensed form in the following index. However in addition to the index of the interviews the tapes on which the actual body of each interview has been recorded are also included in this thesis. The numbered order of these intervews is only related to the order that these are included in the list of the index.

This order is as follows:

[1]-Mavrikos	[11]-Polias
[2]-Kornidaris	[12]-Kozonis
[3]-Stilianou	[13]-Kontatos
[4]-Korakis	[14]-Chatzinikolaou
[5]-Dardanos	[15]-Vrochidis
[6]-Arvanitis	[16]-Kritikopoulos
[7]-Chimonas	[17]-Papastephanou
[8]-Chalaris	[18]-Kastrinos
[9]-Binos	[19]-Bilias
[10]-Binos	[20]-Giamougianis

1. HISTORICAL INTRODUCTION

Although this work does not attempt to be a strictly historical research it is obviously necessary to include a presentation of both the historical background and the references to boatbuilding activities in the Aegean during post Medieval and early modern times. The basic aim of this chapter is to provide some direct or indirect evidence about the evolution of shipbuilding techniques within the last three centuries.

At the end of this chapter there is an examination of the characteristics of the location and the working environment of boatyards.

The evidence provided in this introductory chapter comes only from historical sources and preliminary surveys in the boatyards. It does not include extensive interview material.

The historical background of the last three centuries is presented mainly in the form of tables (tables.no.1 & 2). The history of boatbuilding during this time is divided into three periods:

First Period: The growth of shipbuilding activities and the trading fleet in the Aegean Sea. This is the whole 18th century and the first three decades of the 19th century.

Second Period: The zenith of wooden shipbuilding activities. This is from the fourth decade of the 19th century until the eighth decade of the same century.

Third Period: The period of the decline of wooden shipbuilding activities and the survival of traditional boatbuilding in the production of wooden boats. This is from the eighth decade of the 19th century until today.

1.1 First period (18th century to 1830)

Before the 18th century the information which we have is not comprehensive enough to provide us with clear evidence on what kind of boatbuilding activities existed in the Aegean and Ionian Sea. From the 15th until the middle of the 17th century the available historical sources for the area are extremely rare.

In "Fragments of Ancient English Shipwrightry" (Barker,R.A.(1983)) there is an illustration of a "Greek Mould" for the midship frame of a vessel (fig.1a). The "fragments" were written in the period between 1570-1630. Most probably the author of this part of the "fragments" can be identified as Mathew Baker, who "was one of the seventy or so young men sent on a training voyage as far as Chios in the Mediterranean about 1550"(1). This is, according to the hypothesis of the author's identity, the period when this mould was recorded together with a map of the Peloponnese which is also included in this book.

Another piece of evidence which suggests boatbuilding activities almost half a century before the "Fragments" is the chronicle of Galaxidi from the period 1497-1517 (Mitropoulos,I.A. (1970, p.50).

During the 16th century there is evidence of boatbuilding in the city of Kavala (1591) (Beloy,P. (1638, pp.128-34)), on the Island of Patmos (1590- 1599) (Lane,F.C. (1933, p.20)), on the Island of Zakinthos (Antonopoulos,K. (1964, p.11)), and at Lindos on Rhodes (1590-1606) (Bekiaroglou - Exadaktylou,A. (1988, p.109)).

During the 17th century we have the first evidence that provides more information about the existence of boatbuilding before 1612. At Sphakia on Krete they built vessels of timber from the local forests of pine and cypress (Spanaki,St. (1969, p.402)). On the Island of Simi they built small vessels which were called "Simbequirs" or "Sumberchi" (1650). They were propelled by means of nine pairs of oars or some kind of sails and they were fast vessels (Slot B.J. (1977, p.220) refers to the book "Voyage du Levant du Seigneur Stochove Escuier, Seigneur de Catherine" Brussels, 1650).

The first ship was built on the Island of Hydra in 1657. Only three tools were used to built this vessel: the saw, the adze and the auger. This ship was "ugly" and "unsymmetrical" (Kriezis,G. (1860, p.18)). In 1658 two of the people from Hydra who were repatriated after capture by pirates, built the first trechadiri boat. This boat was 12-15 feet long and weighed 5 tons (Kriezis,G. (1860, p.18)).

In addition to the individual boatyards mentioned above, in the Aegean Sea there were a number of Turkish arsenals during the period of 16-18th century. The places where these arsenals were located are: Adramittion (Asia Minor), Lesvos, Lemnos, Alikarnassos (Asia Minor), Rhodes, Attalia (Asia Minor), Thasos, Alania (Asia Minor) (Bekiaroglou - Exadactylou,A. (1988, p.71)). During the Venetian occupation, arsenals existed at Methoni (Modon), Koroni, Chalkis (Negreponde). In Chane and in Candia (Iraklion) on Crete Venetian arsenals existed as long as the capture of the Island by the Turks (1669) (Bekiaroglou - Exadactylou,A. (1988, p.115).

It is clear that during the 16th and 17th century local boatbuilding activities existed in the Aegean Sea. Despite the unstable political and social situation in an endless condition of war around this area, the people of some Islands and places on the coasts continued to build some sort of vessels (fig.1b).

Moreover there is evidence that Greek shipwrights had been building ships during the 15th, 16th and 17th century in the Turkish arsenals (Bekiaroglou - Exadactylou,A. (1988, pp.129-37) and in Venice (Lane,F.C. (1934, pp.56-57) & (1943, p.25)).

What we can suggest for that period in the Aegean is that the possibly limited boatbuilding activities were not due to the lack of any boatbuilding knowledge and experience of the local population, but due to the poverty and the war conditions in the area.

In contrast to the previous period, during the middle of the 18th century the Greek population of the islands took advantage of the economical and political changes of that time and developed shipping together with shipbuilding. The Karlovich treaty (1699) and the Passarovich treaty (1718) provided some peace in the north eastern Mediterranean. The most crucial treaty though for the Greek merchant fleet was that of Kucûk - Kainartsi (1774). This allowed the merchant ships of the minorities in the Ottoman Empire to sail freely in the Black Sea. At the same time because of the Napoleonic war in the Mediterranean (end of the 18th century - beginning of the 19th century) the voyages of French and British merchant ships through the Eastern Mediterranean were limited (Leontaritis,G. (1972, pp.28-32)). This situation turned on the green light for the Greek merchant fleet and helped it to grow and to become one of the major merchant powers in the eastern Mediterranean by the end of the 18th century (Kremmidas,B. (1985, pp.143-48) & Leontaritis,G. (1972, pp.28-32)). This process had an equivalent effect on the development of shipbuilding. In relation to the limited evidence about boatbuilding in the time before the 18th century it is really difficult to suggest any hypothesis about the technical origin of the shipbuilding development in the second half of the 18th century. This is in fact one of the puzzles which we will try to study in the following chapters of this work.

At the moment let us give some evidence about the 18th century merchant shipbuilding in the Aegean. It seems that boatbuilding activities existed on quite a few of the Dodecanese Islands. On Karpathos before 1815 there were two shipyards with an estimation of about 600 people working there. The timber that they used was pine from the local woods of the Island. Timber from the same wood was used in the shipyards on the Island of Kassos (Papavasiliou - Petritsis (1936)). Shipyards also existed on the small island of Kastellorizo (Petridis,G. (1937)). At Lindos on Rhodes boatbuilding seemed to be developed by the end of the 18th century (Ephthimiou -

Chatzilakos,M. (1983, pp.189-90)). On the island of Simi there is evidence of building sponge-fishing boats at the beginning of the 18th century (Slot,B.J. (1977, p.149)) refers to Aaron Hill (1685-1750) (1709, pp. 210-212), London). Before 1820 some of the merchant ships which belonged to this island were possibly built there (Karanikola,S. (1937)).

We have evidence about the existence of boatyards from that period on the Islands of Ikaria, Samos, Lesvos (Bekiaroglou - Exadactylou,A. (1988, p.114)) while on the Island of Chios merchant ships were built at least during the first years of the 19th century (Lemos,A. (1963, p.111) & Konstadinidis,T. (1954, p.140)). Other places with shipyards by the end of the 18th century are: Kimi (Evia), Mesologgi, Zagora, Parga, Trikeri, Skiathos (Tzamtzis, A. (1976)), Sphakia (Bekiaroglou - Exadaktylou,A. (1988 p.114)). At the same period places with small scale boatyards exist on: Kalamata, Skopelos, Litochoro, Agio Oros, Ainos, Ag. Marina (Golf of Maliakos), Moutzeles (Pilion), Pilos, Paro, Mikonos, Patmos, Chalkis, Andros, Aivali and Tsesme (Asia Minor) and the Islands of Marmara (Tzamtzis,A. (1976)), Poros, Skiros, Limni (Evia), Kranidi (Bekiaroglou - Exadaktylou,A. (1988, p.114). There is evidence that in 1757 the biggest (250 tons) vessel at that time of the island of Hydra was built at Sofiko (a place close to the island on the Peloponnese coast) by shipwrights from Hydra. That was because of the timber available at that place (Kriezis,G.K. (1860, p.18)). This is one of the earliest examples of vessels which were built by travelling boatbuilders. We do not know how extensive this practice was during the 18th century but we do have evidence of travelling boatbuilders from later periods (Gourgouris,E.N. (1983, p.446), [5]-Dardanos).

According to the available historical evidence for the second half of the 18th century and especially for the first two decades of the 19th century (before the war for independence 1821-1830) the dominant merchant communities in the Aegean were those of the islands of Hydra, Spetses and Psara. These flourishing merchant activities were based on the shipping of crops from the ports of the Black Sea and Eastern Mediterranean to the Western Mediterranean ports (Kriezis,G.D. (1869)). Together with shipping, shipbuilding was developed on these islands. There is evidence that sometimes in order to build trading boats of bigger size than what they used to build, they copied the design of ships built in Italian yards (Tzamtzis,A. (1976, p.28)). On one hand evidence suggests that boatbuilding existed on the Island of Hydra before that period (Kriezis,G.D. (1880, p.28)). On the other hand we have evidence that boatbuilding started on Spetses in the first half of the 18th century, possibly by shipwrights from Hydra (Kostandinidis,T.P. (1954, p.115)). The earliest evidence for boatbuilding on Psara goes back to the second half of the 18th century by shipwrights from Chios (Nikodimos,K. (1862, pp.72-3, 157-8)).

Therefore we can suggest that by the end of the 18th century some changes occurred in boatbuilding in the Aegean. Considerable shipbuilding activity started on some islands (Spetses, Psara) based on the development of the merchant fleet and possibly new (western) designs applied in the yards (Hydra, Spetses, Psara) (Kostadinidis,T.P. (1954, p.118)).

From that period and from the Island of Psara we have the most valuable technical information about shipbuilding.

In 1862 Cap. K.Nikodimos gives the first technical report referring to the last years of the 18th century. In this reference we have evidence about the "modernization" of the boatbuilding in the last period of the 18th century. This is provided by a shipwright called Mastro-Stamatis from Chios who spent some years in a Turkish arsenal working as a carpenter. We will meet this reference again later in the technical parts of this work (5.3.1 Laying out the lines of a boat, 7.3 Framing up).

It is likely that from the last quarter of the 18th century until 1821 some sort of modernization occurred in the boatyards of some islands and this is directly related to the flourishing of the merchant fleet. We will study these technical changes in the following chapters and we will focus our attention on the evolution of boatbuilding techniques throughout the last three centuries.

We do not have enough evidence to produce any sort of classification for most of the yards on the islands during this period. However we know that there were islands where the boatyards produced mainly merchant vessels (Hydra, Spetses, Psara, Chios) and islands where the main boatbuiding activity produced fishing or sponge divers'boats (Symi). Another kind of classification can be suggested according to the names of the types of the boats. Yards on Hydra specialised in the Trechadiri hull, on Psara they specialised in the Sacoleva, on Chios they called their vessels Lephka and the yards on Symi named their boats Skaphi (2.3.3. Skaphi from Symi).

In addition to the local types of vessels other common types of that period like: Kirlangitch (Bekiaroglou _ Exadactylou (1988, p.112-3)), Martigos or Martingana (Lyman,J. (1972, p.203)) and Polacca, seem to have been built on most of the main shipbuilding islands during the second half of the 18th century (2.6.1. Square sail, 2.7. Early types). By the beginning of the 19th century the Brig was a common type built in the Aegean. Probably that was related to the modernization of the yards around the end of the 18th century as we mentioned above. The map in fig.2 shows the places where boatbuilding activities existed in the Aegean and Ionian Sea during the 18th century in the first three decades of the 19th century.

This period ended in 1821 when the war for independence started. In this decade of 1821-1830 most of the merchant-ships from the Islands were modified to be used as fighting vessels (Kriezis,G.K. (1869)).

Table.no.1

Chronological order of evidence from 16th, 17th, and 18th century

A	B[1]	
1497-1517		Chronicle of Galaxidi
	1566.	Capture of Chios by Othomans
1570-1630		"Fragments of..." Mathew Baker (?)
1590-1599		Venice bought 7 vessels from Patmos
1590-1606		Boatbuilding at Lindos (Rhodes)
1591		Boatbuilding in Kavala
1612		Boatbuilding at Sphakia (Crete)
1650		Boatbuilding on Symi
1658		The first built trehadiri on Hydra
1657		Build vessel on Hydra
	1669.	Capture of Criti by Othomans
	1699.	Treaty of Karlovich
	1700.	Settlement of Spetses Island
1714		Boatbuilders from Chios went to Turk. Arc.[2]
	1718.	Treaty of Passarovich
1745		The first built "Latinadiko" 116tons, Hydra
1745-1746		People from Mesologgi own about 50 vessels [3]
1757		250tons is the biggest vessel built on Hydra[4]
1764		Vessels built at Mesologgi, Aitoliko, etc.
	1774.	Treaty of Kucûk- Kainartzi
1786		Two big vessels built on Psara[5]
1787		People from Hydra own 79 ships & 49 boats[6]
1794		Vessel of 150tons built on Psara[7]
1797		Vessel of 254tons built on Spetses[8]
	1797.	Occupation of Ionian Isl. by the French
1801		Vessel of 440tons build on Hydra(9)
	1822.	The city of Chios destroyed by Turks
	1824.	The devastation of Psara's villages by Turks
1824		First evidence about boatbuilding on Syros(10)
	1830.	Independent Hellenike Kingdom

(1) A: Historical evidence of boatbuilding.
B: Evidence of historical background.
(2) Tzamtzis,A. (1972, p.101)
(3) Leodaritis,G. (1972, p.31) mentions that people from Mesologgi owned about 50 vessels of the types of Barco (or Gabarra), Tartana, Polaka, which were from 1.5! - 180tons.
(4) Kriezis,G.D. (1860, p.20)
(5) Bekiaroglou - Exadactylou,A. (1988, p.114)
(6) Kriezis,G.D. (1860, pp.19-20)
(7) Bekiaroglou - Exadactylou,A. (1988, p.114)
(8) Tzamtzis,A. (1976, p.28)
(9) Kriezis,G.D. (1860, pp.56-7)
(10)Kardasis,V. (1985. p.169)

1.2 Second period (1830 to 1880)

During the war for independence the three islands with the main merchant power lost most of their ships. The merchant community on the island of Psara was destroyed by the Turkish Navy (1824) and the city of Chios suffered major destruction (1822). Most of the people from these islands emigrated to other Aegean places. Under these circumstances the old merchant islands could not recover and take advantage of the independence of Greece to rebuild their fleet. By contrast, another island, without any shipbuilding tradition in the past, became the dominant site of the shipbuilding trade during the first period of the new Hellenic Kingdom. Syros thanks to the Catholic population, was virtually untouched during the war and most of the emigrants from Psara and Chios settled on this island. Some of them opened the first boatyards a few years before 1830. (Kardasis,V. (1987, p.169)).

In the decade of 1830-1840 shipbuilding on Syros grew rapidly due to the flourishing of the local merchant activities as had happened before the war in the three merchant islands (Hydra etc.). Tzamtzis,A. (1976, p.30) mentions that almost 50% of the wooden ships of that period were built on Syros.

During the independence war and the years that followed we observe significant shifts of population from one part of the country to the other. In these conditions we must expect also that boatbuilders moved from their original places to others and opened new boatyards (Gourgouris,E.N. (1983, p.448). As a result quite a few of the islands and cities on the coasts had had their own boatyards by the middle of the 19th century. Therefore it is difficult to identify all the places in the Aegean where boatyards existed. However we suggest that the maps in fig.2, 3 include most of these places.

Table 3 includes only the boatyards within the contemporary territory of the new Hellenic Kingdom in the period of 1843-1858. From this table we can see some distinctions between the boatbuilding places in H.K.

Siros was undoubtedly the main shipbuilding place. Hydra, Spetses, Piraeus, Koroni, Skiathos, Skopelos, Galaxidi and Kalamai (Kalamata) were the other more productive boatbuilding places (number of hulls). In order to study closer these nine boatbuilding places we introduce table 4, based on the figures from table.no.3. From this table we can suggest the following: Siros was undoubtedly the most productive place with an average tonnage of 147.8 tons per vessel. Among these vessels we find 57% brigs and 13% Goélets. Galaxidi had similar average tonnage figures but an 80% lower productivity (number of hulls) than Siros. Gourgouris,E.N. (1983, p.775) gives evidence that the second period of boatbuilding activities started in Galaxidi in 1829.

There was another group of places with an average tonnage between 59.5 and 78.8 tons. These are Spetses, Skiathos and Skopelos. Spetses was the second most productive place (number of hulls) but most of the vessels had a low carrying capacity while 55% of them were of the Trechadiri type. Hydra and Pireaus had an average tonnage of about 34.5 tons. Hydra appears to continue the local tradition to build trehadiri but with a low carrying capacity. Finally at the two other places Koroni and Kalamata, only small boats had been built during the period 1843-1858. Undoubtedly the main reasons for these significant differences between these places are connected with the distribution of the merchant activities in the country. The major production is focussed on building small vessels with the exception of Syros and Galaxidi (rather medium sized vessels). At the same period a variety of different types with the exception of Hydra (Trechadiri), Koroni (Trechadiri) and Kalamata (Caiques ?). However it is not clear whether the names of the types are related either to the types of hulls or to the types of rigging. In the case of Brigs and Goélet it is probable that this classification is related to the rigging rather than to the hull. And if these types had in fact the same kind of hull we can note that the yards of Şiros were specialized on this kind. It is likely that this is something similar to a Karavoskaro hull (Segditsas,P.E. (1940, pp.237-8), Adoniou, A. (1969, p.14)) (2.5.1. Karavoskaro).

Unfortunately the confused kind of classification in table no.3 can not provide us with sufficient information about the type of boats. It is clear that Brigs, Goleta, Sacoleva and Bratsera are types of rigging while Trechadiri, Tserniki, Perama and Trata are kinds of hull. In any case there are names which are difficult to identify as types of rigging or hull. These are Gavara, Bombarda and Mistico (2.7 Early types). Finally there is the name "Caiques" which was a general name for small vessels. The problem of understanding table.no.3. lies in the fact that the data were possibly taken from local authorities which seem to have used a different system to classify the types of boats.

During the same period there were a number of boatyards on those islands which were not part of the Hellenic Kingdom. In the middle of the 19th century, for example, the Dodecanese Islands seem to have produced a remarkable number of boats. In 1866, the islands of Simi and Kalimnos alone had about 370 vessels each and in 1854 a number of 100 merchant ship had been mentioned on the island of Kassos (Loukatos,S (1977, p.419)).

Therefore as already mentioned at the beginning of this section some form of boatbuilding activity existed on almost every populated island in the Aegean during the second half of the 19th century. These widely spread activities were associated with different levels of wooden boatbuilding techniques from one island to another during the same period (5.4 Comments on Designing). The differences in the amount of production of vessels between the boatbuilding places (table no.3) make clear that places with a low production of vessels (number of hulls) were rather unimportant to the boatbuilding history of the area (note : On the three islands of Syros, Hydra and Spetses, more than half of the total number of boats were built during the period 1843-1858). However for a study of the boatbuilding techniques in the area it is necessary to pay attention to all yards regardless of the number of built vessels. We suggest that in the most productive shipyards (Syros, Galaxidi, Spetses, etc.) some form of modernization had been taking place continuously in order to build competent big ships. By contrast the more familiar and less expensive traditional techniques were successfully continued in the small boatyards (5.2.2 Moulding with adjustable templates, 5.4 Comments on Designing).

It is very difficult to map these widespread boatbuilding activities in the Aegean. This is because the evidence studied for this part of the work is insufficient.

Table,no.2
Chronological order of evidence from 1829 to 1922

A	B[1]	
1829..........		People from Galaxidi call a famous shipwright from Aegena to work in Galaxidi[2]
	1830.	Independence of Hellenice Kingdom
	1834.	Athens becomes the capital of Greece
1845..........		The shipyards' area is 12.000m^2 and there are 1.500 workers / Syros[3]
1850..........		The first built steam ship / Syros[4]
1853..........		The second built steam ship / Syros[5]
	1861.	1.096.810 the population in Greece
	1862.	Installation of gas Service in Athens
	1864.	The Ionian Islands join Greece(6)
	1868.	461km. is the total length of roads in Gr.[7]
	1870.	1.457.894 population incl. Ionian Islands.
1873..........		First marine engineering shop in Piraeus[8]
1875..........		Ship of 1150tons built in Galaxidi[9]
1880..........		Ship of 1050tons built in Galaxidi[10]
	1881.	Thessali join Greece
	1882.	The construction of the first railway started outside Athens
	1890.	Crisis on the export of raisin[11]
1890-1914.....		14% of the population emigrates (350.000 of people go to North America)[12]
1892..........		Greece owns 104 steam-ships (total capacity 61.000tons) and 1739 sail-ship (total capacity 206.000tons)[13]. The total length of railway this year was 906 km.
1893..........		Launching of the first steel vessel . Syros[14]
	1896.	The first Olympic Games in Athens
1899..........		Launching of the last wooden boat in Galaxidi[15]
1901..........		Greece owns 198 steam-ships (161.000tons) and 925 sail-ships (145.000tons)[16]
	1907.	2.631.952 total population of Greece
1907..........		Greece owns 285 steam-ships (147.000tons) and 1045sail-ships (147.000tons)[17].
	1912.	War between the Balkan Countries
	1913.	Criti, Samos, Chios, Mitilini, Lemnos, Thasos and other smaller Islands join Greece
	1913.	4.732.966 total population of Greece
	1922.	Greece loses the war in Asia Minor, about 1.500.000 people migrate from Turkey to Greece.

(1)Two groups of dates like on the table,no.1
(2)(9)(10)(15)Gourgouris,E.N. (1983, p.775, 442, 787)
(3) Kardasis,V. (1985, pp.170-1)
(4)(5)(8)(14)Tzamtzis,A. (1976, p.31)
(6) The Islands were under British "protection" from 1815 until 1864
(7) Dimitrakopoulos,O. (1977, p.182)
(11) Raisin covers an average of 45% of the exported products during 1891-1900
(12)(13)(16)(17) Oikonomou,N. (1977, p.192-7)

1.3 Third Period (1880 to 1940's)

Although the decline of wooden boatbuilding started earlier than the 1880's (Tzamtzis,A. (1976, p.31)), during the last two decades of the 19th century some dramatic changes occurred.

Siros was no longer the first port of the country (Tsokopoulos,B (1984, pp.249-55) & Dimitracopoulos,O. (1977, pp.184-185)) and wooden sailing ships were by no means competitive with the steam wooden or steel ships. In 1850 and 1853 the two first steam ships were built on Siros and in 1893 the first steel ship (Tzamtzis,A. (1976, p.31)). Unfortunately these technical improvements did not provide any increase of the production of the shipyards. By contrast the number of boats were decreasing year by year. The economical and political crisis of that period had a bad effect on the Greek merchant fleet (Vergopoulos,K. (1977, p.63-5)). In Galaxidi the last wooden ship was launched in 1899 (Gourgouris,E.N. (1983, p.787)).

Pireaus became the first port of the country thanks to the financial growth of the new capital. Athens and Piraeus expanded enormously within a few decades and people from all over the country migrated to the new symbol of a capital city. The first boatyard in Pireaus appeared quite early (1845-6) (Tsokopoulos,B. (1984, p.199)). During the first twenty years of the 20th century the new suburb of Perama together with the small island of Salamis became the areas with the dominant boatbuilding activities. Boatbuilders from Asia Minor settled in the same area after the Asia Minor war (1922). Most of the grandfathers or fathers of the boatbuilders who work today in Perama came from Symi, Siros, Samos, Hydra, Spetses, Asia Minor or the other places with great boatbuilding activities during the middle of the 19th century ([3]-Stilianos, [6]-Arvanitis, [15]-Vrochidis, [16]-Kritikopoulos, [17]-Papastephanou, [19]-Bilias).

In the Admiralty Mediterranean Pilot (1918), Pireaus, Syros, Rhodes, Volos and Smyrna are mentioned as places with major ship-repair facilities in the Aegean.(2)

The decline of wooden boatbuilding seemed to have continued gradually until the second world war. However, according to boatbuilders ([3]-Stilianou, [6]-Arvanitis, [8]Chalaris, [11]-Polias, [15]-Vrochidis, [17]-Papastephanou, [19]-Bilias), it appears that this decline was associated rather with the size and the number of the vessels than with the wooden boatbuilding techniques. [6]-Arvanitis, [16]-Kritikopoulos, [17]-Papastephanou mentioned Mr. Psaros as a very capable boatbuilder in Perama during the first half of the 20th century.

By contrast, the actual decline of the techniques started mainly after the second world war ([3]-Stilianou, [6]-Arvanitis, [10]-Binos, [12]-Kozonis, [15]-Vrochidis, [17]-Papastephanou, [19]-Bilias).

At the places shown on the map of fig.3 wooden boatbuilding activities were recorded in 1987. Only very few of them are completely new firms and today a considerable number of them are involved with repair-work only. I believe that their scattered distribution reflects the existence of even more boatyards during the early 20th century.

To summarize this historical introduction we can suggest that there were two important periods during the evolution of the wooden boatbuilding technique in the Aegean in the last two centuries. The first was during the last quarter of the 18th century when some kind of modernization occurred in the most capable yards (Hydra, Spetses, Psara) together with an increase of their production. The second was the last quarter of the 19th century when together with the construction of the biggest wooden vessels of all this period (Siros, Galaxidi), the decline of this trade started.

We can suggest that during the period of these two centuries two technical levels characterized the boatyards in the Aegean. First the techniques in the yards where big merchant vessels were built. There modern techniques were used and they were influenced by foreign methods. Second in the boatyards where usually fishing or sponge divers' vessels were built, the old traditional methods were used. By the beginning of the 20th century this distinction between these two levels became less clear because a lot of boatbuilders used to go and work in different places. That had as an effect the exchange of boatbuilding techniques and knowledge among boatbuilders from all over the country. These observations will be considered as a framework for the following chapters.

Under these conditions we plan to get information about these different levels of techniques through the interviews in order to study the technical evolution of this art in the Aegean.

Table.no.3
Vessels built in Greece (1843-1858)
From Kardassis,V.A. (1985, pp.182-3)

Τόπος κατασκευής	Γαβίαραι	Βρίκια	Γολέται	Βομβάρδαι	Κότερα	Σακολέβαι	Μίστικα	Βρατσέραι	Τρεχαντήρια	Τζερνίκια	Περάματα	Καΐκια	Τράται	Λέμβοι	Τὸ ὅλον: τῶν πλοίων	Τὸ ὅλον: τῆς χωρητικότητος	Τὸ ὅλον: τῶν ναυτῶν
Ύδρα	—	48	10	7	—	—	—	5	251	—	—	—	1	11	333	11.141	1.990
Σπέτσαι	2	225	—	21	—	—	—	5	356	1	—	—	3	30	643	44.337	3.375
Πειραιεύς	—	31	6	18	—	—	—	56	98	—	—	—	—	48	257	9.112	1.291
Πόρος	—	—	—	5	—	—	—	1	12	—	—	—	—	8	26	331	97
Κορωνίς	—	1	—	—	—	—	—	—	255	—	—	—	—	—	256	2.130	880
Σύρος	7	524	123	87	—	11	8	25	—	53	16	—	4	41	909	134.318	6.685
Μύκονος	—	—	—	—	—	2	—	—	—	9	1	—	4	5	21	113	102
Θήρα	—	3	10	1	—	22	12	6	8	5	—	2	2	8	79	1.598	286
Άνδρος	—	4	1	6	—	1	—	4	1	12	24	—	7	11	71	1.210	359
Μήλος	—	—	1	—	—	1	—	8	1	—	9	—	—	—	15	75	48
Σκίαθος	—	44	34	2	1	—	8	7	23	8	—	8	—	23	153	9.098	898
Χαλκίς	—	2	5	2	1	—	—	8	14	24	—	—	5	19	80	685	325
Άμαλιάπολις	—	24	10	—	—	—	—	—	16	6	—	—	—	8	55	5.862	328
Σκόπελος	1	52	22	—	—	—	—	8	16	20	—	7	—	26	152	11.981	868
Κύμη	—	9	21	1	—	—	—	8	4	—	—	—	—	11	49	2.770	390
Μεσολόγγιον	—	—	2	—	—	1	—	7	—	26	—	—	—	24	60	749	241
Πάτραι	—	1	1	—	—	—	—	14	—	—	—	33	—	17	66	989	262
Πύλος	—	—	1	—	—	—	—	4	—	—	—	22	2	25	54	418	162
Γαλαξείδιον	—	62	28	1	—	—	—	57	—	—	—	—	—	14	162	17.982	1.000
Καλάμαι	—	—	—	2	—	1	—	15	—	—	25	90	4	8	145	772	855
Σύνολο	10	1.030	275	153	2	39	18	228	1.001	164	75	162	32	337	3.586	255.671	19.942

Πηγή: Πανδώρα, 9 (1858-1859), σ. 517-518.

Table.no.4

The nine most productive(1) boatbuilding places in Greek territory, 1843-1858(2)

Place	Total number of Vessels	Types % of total num.of Vess.(3) B(4)	G(5)	Br(6)	T(7)	C(8)	Average tonnage
Siros	909	57%	13%				147.8
Spetses	643	35%			55%		69.0
Hydra	333	14%			75%		33.5
Pereaus	257			21%	38%		35.5
Koroni	256				100%		8.3
Galaxidi	162	38%		35%			111.0
Skiathos	153	28%	22%				59.5
Skopelos	152	34%	14%				78.8
Kalamata	145					62%	5.3

(1) The number of hulls used as the indication of the productive places.

(2) Source table no.3

(3) Only the first two highest % of types from the total number of vessels are included for simplicity.

(4) Brici (Brigs)

(5) Goleta

(6) Bratsera

(7) Trechadiri

(8) Caiques

1.4 Location of boatyards

In addition to historical and economical reasons, there are other factors which were associated with the location of boatyards. The particular area on an island where a boatyard was developed was often associated with some social and natural features of the local environment. The relationship of these factors with local boatbuilding activities has often existed since the first appearance of these boatyards in the Aegean[3]. The following presentation of these factors forms a preliminary account rather than an environmental study of the boatyards' locations. Moreover, the aim of this account is to provide us with further material concerning the evolution and the distribution of boatbuilding activities in the Aegean Sea.

At places where more than one boatbuilding firm existed, it was often impossible to distinguish the different properties (Syros (fig.4), Spetses (fig.5), Symi (fig.6), Hydra, Galaxidi, Kavala (fig.7), Kalimnos, Samos).

It was very common to name the whole area as "Tarsana" or "Arsana"[4] or "Karnagio" and to identify the whole group of individual yards as "the yard" of the village. This common location of the yards reflects some sort of cooperative working environmment. This is not contradictory to the evidence of famous individual shipwrights since they were not mentioned as owners of yards but as personalities of special knowledge and building experience[5]. This boatyard of the village often covered an extensive area. In Syros this was 12.000m^2 in 1845. (Kardasis,V. (1985, p.170)) In Symi it was 7.000m^2 (Zouroudis,G.D. (1974, p.160)). The boatyard activity often dominated the local environment. For example, Gourgouris,E.N. (1983, p.453) mentions that twenty ships were under construction at the same time on the main boatbuilding area in Galaxidi.

Most of the boatyards on the islands (as well as on the mainland) are within the area of a town or a village. Even in the older examples the boatyards of the village were placed at a central and socially important position (Simi, Hydra, Spetses, Galaxidi, Kavala). This central location gave the boatyards a rather strong social character which can be better studied from the standpoint of social research into the lives of workers in the yards. Given this kind of relation between the yard and the village (fig.5, 6) we can suggest that an equivalent historical relation applied. In other words, we can expect that from the early development of these villages the boatyards were there. In this case the social history of the village community probably determined the location of the boatyards (the central position of the boatyard on the maps of the fig.5, 6, 7 can be considered as evidence for this suggestion) (Gourgouris,E.N. (1983, p.449)).

During the 19th and early 20th century, the new yards in the developing cities were located in the "industrial" areas which were by no means centrally placed (Syros (fig.4), Piraeus and later Perama and Thessaloniki).

Furthermore, we have more recent examples where the local authorities forced the old boatyards to move out of the cities, using the excuse of environmental policy (during the second half of the 20th century) (Chalkis ([5]-Dardanos, [6]-Arvanitis), Kavala, Volos, Kalimnos ([9]-Chilas)).

Gourgouris,E.N. (1983, p.451) mentions that during the last years of shipbuilding activities in Galaxidi most of the vessels were built on the beaches around the city. That was necessary since the central boatbuilding area was too busy to include all the boatbuilding activities. At the same time, these activities were no longer socially acceptable to the people of the city (Gourgouris,E.N. (1983, p.451)).

We can suppose that it was necessary for the boatbuilding area to be close to the harbour or the port facilities of the village. This is because the work on a vessel did not finish at the time of launching but continued for several days while the vessel was in the harbour (Hydra, Syros, Symi, Spetses).

There were boatyards developed at places close to woods with ship-building timber (Samos, Galaxidi, Sphakia, Spetses, Skiathos, Lesvos). There is even evidence of deforestation on small islands with a lot of boatbuilding activity in the past (Symi ([11]-Polias), Hydra, Spetses ([3]-Stilianou)).

The most common environmental feature influencing the location of boatyards was the existence of a protected sea area beside the yard. That means that the sea-shore beside the yard (the launching sea-shore) was naturally protected from the often rough sea. This was achieved by locating the boatyards at the head of small lagoons or in small and very close gulfs (Syros (fig.4), Spetses (fig.5), Hydra, Symi (fig.6), Galaxidi, Kavala (fig.7), Kilada, Lephkas, Samos, Rhodes).

The protection was particularly important against the north because northern winds are significantly strong in the Aegean Sea. In relation to this environmental factor the bed of the sea-shore had a slight-slope to allow launching activities. As an evolution of this requirement for protection from rough sea and wind we can suggest the case of the boatyards on Hydra and Siros (fig.4). Here this protection was offered by the quay of the harbour.

1.5 Aspects of the working environment

In addition to the above mentioned environmental factors we can mention some common factors of the working environment in the yards. All the boatbuilding processes took place in the open air. Even the lofting floors were unsheltered (Samos (fig.8), Perama (fig.98), Syros) (The recorded lofting floor in [1]-Mavrikos' yard was sheltered later (fig.96, 97)).

Only a small work-shop was built on a corner of the yard to be used as an office and as a storage-room for the tools. From evidence we have from more recent work-shops there was not any attention to architectural features (Syros, Samos, Spetses, Rhodes, Symi, Chalkis)(6). These were wooden huts built from second hand timbers (Gourgouris,E.N. (1983, p.459)) (fig.96, 98).

Often the boatbuilders preferred to work under shadow provided by big trees located in the yard (fig.8) or high walls from neighbouring buildings (in Hydra for example) for protection against the summer sun. The big mulberry tree in the boatyard of Symi ([11]-Polias) was famous for that reason.

In addition to the tools or the other miscellaneous timbers in the yard there were two permanent structures which can be seen as parts of the yard's space. They were both used for launching and pulling out of the water vessels.

The first was a hand capstan placed at about 10m from the sea-shore. This consisted of a vertical cylindrical pole (εργάτης) with one or two horizontal holes on the upper part and a conic end on the lower part (fig.9). Two or one handle-logs (μανέλα) were placed horizontally through the holes of the cylinder. A wooden disc (Σφοντύλιν) was located on the ground, supporting the cylinder by means of a conical hole (αφάλι). Both the cylinder and the disc were reinforced and supported by a wooden structure (κούτσες) which was firmly fixed by means of a chain to some underground "anchors". These hand capstans had a slightly different form from one place to another but the basic structure was the same (Poulianos,A.I. (1977, pp.591-93)) (fig.9a).

The small winches which have survived today (Samos, Ierissos) (fig.9b) are not parts of boatyards. The idea of the structure was very simple.

The second permanent structure was the launching grid. The version of the structure which survives today consists of a series of parallel beams (in distance about a meter from each other) supported by two other bigger beams (Perama, Siros, Trikeri, Kavala, Rhodes and most of the yard with launching activities in the Aegean today use this kind of structure). Gourgouris,E.N. (1983, p.482) suggests that the yards of Galaxidi had the same kind of launching grid in the middle of the 19th century.

The whole structure had the appearence of an enormous ladder (often more than 15m long) half submerged. During launching or pulling a vessel the upper surface of the beams were greased to provide a slipway to the launching cradles (4.4.8 Launching cradle) which were supporting the vessel. The structure was permanently fixed on the ground. As an extension to this structure farther into the land-area single beams were used (4.4.9 Single beams).

In addition to this launching structure there is evidence of an older way of launching used before the introduction of the launching cradle in the yards (late 18th century according to Nikodimos,N. (1862, pp.71-2).

However a version of this method seems to have survived until recently in the boatyards of Symi (Zouroudis,G.I. (1974, pp.170-1)). In this method there was a movable grid structure which could slide on single beams all the way from the place were the vessel was built to the sea.

In the earlier version of this practice (Nikodimos,N. (1862, pp.71-2)) it seems that they built this structure underneath each new vessel, based on some single beams. On each side of the vessel and close to the keel they placed a large block. Then beside the large blocks and at the middle part of the vessel they built a wall of bags full of sand as high as the bilge of the boat on each side. By removing the poles which supported the vessel (4.4.7 Stands for the posts and the ribs) they lowered it onto these two walls of sand bags. Then they punctured the bags which leaked slowly until the boat lay on the two large blocks on the grid structure. These two large blocks were firmly tied on the vessel and finally they launched the whole structure with the boat on it. According to Nikodimos the whole process was very dangerous and possibly damage to the hull of the vessels was not rare. In the later version (Zouroudis,G.I. (1974, pp.170-1)) the two large blocks were fastened on the supporting structure. One was lower and placed very close to the keel and the other higher and placed further away on the other side of the keel. The wall of sand bags was built only on the side of the higher block. After puncturing the sandbags the vessel tilted and settled up on the higher block. Meanwhile, the lower block prevented the keel sliding sideways as the vessel tilted. Again the whole structure with the boat was launched all together. During these methods of launching wooden wedges were used on the launching cradle providing a smooth bed for the vessel.

There is evidence for the use of some sort of similar grid structure as early as the 12th century in Byzantine yards. Koukoule, F.I. (1950, pp.290-307) mentions the use of "Φαλάγγια" which were the single launching beams and the use of "Εσχάρα" which was a launching grid during the 12th century.

There is no reference though about pulling out of the water a vessel with these systems. However we can expect that to do something like this they would need a lot of power. In order to avoid this method every time when repairing caulking damage (which was almost every year) they used another method in which the vessel was still afloat (careening). With a raft which was carrying some sort of winch, some jeer blocks, and some wires, the caulker together with the apprentices tilted the vessel until her keel appeared (fig.10) (Zouroudis,G.I. (1974, pp.169-70)). Then they start the repairs on each side, which could even include replacing of planks in the hull.

The whole work took from one to three days for each side of the vessel. It is noticeable that the vessel must be returned to the upright position each night, even if work had not finished. This was because dramatic change of weather during the night (not so rare in the Aegean Sea) could cause damage to the boats while careened(7).

Notes:

(1) Barker,R.A., who suggests Mathew Baker as the original author of the Fragments, sent me kindly a copy of the part of the text which refers to the illustration of the "Greek Mould":

F. 12 Greek mould (Screatse)

This mould is used among the Greeks for their merchannt ships which they name Screatse / The making is thus First as in all moulds these must be made a paralellogram of the breadth and depth / as a-b-c-d doth show From the groun d line a-b must be directed a perpendicular dividing the / paralleLogram in to 2 equal parts as the line e-g doth show for as much as the one half / of the mould doth serve I will take the half of the whole parallelogram / the which is the (square) e-b-c-f. for the better understanding of that I will say I will show / it as well by number as by lines therefore I name the whole breadth 40 foot first I / take the $^1/_4$ of the line e-b which line is 20 whose is 5 this I set on the line b-c / at the point h from which point I draw a line parallel to the ground line a-b again I / take the $^1/_3$ of the depth which is 10 the $^1/_3$ is $3^1/_3$ this I set from h to the point k / from which I draw a line paralell to the line a-b the which is the line k-l now is / there 2 lines to be drawn, *the first from e to h the second from e to c upon the line e-h and in the middle thereof must be directed a perpendicular which being drawn forth in / length will cross the line e-g in which crossing is the first centre of the flowar wrong / where the line e-c doth cross or cut the line k-l in the point n must be a perpendicular from the line k-l and it will also be parallel to the line e-f from the semidiameter of the second circumference I take the line e-n whose centre must always be in the line / n-o being so placed in that line so that it will make a (perese) of a circle with the first / circumference which is made of the centre g by those two centres is the flowar tymber / made the semidiameter that maketh the futtik is the line line e-c whose centre / must always be in the line b-g which line is drawn from the angle b / crossing the second centre p the centre of the posts is at point o*

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(2) The Admiralty Mediterranean Pilot.(1918) p. 133 "THE PIRAEUS Repairs, & C.- The workshops attached to the patent slip are fitted with latest plant. There are seven engineering and repairing shops established, and three of these are of importance, and capable of carrying out almost any class of marine work. There are four floating cranes, one at least capable of lifting 10 tons. Repairs to machinery and boilers of large ships can be effected by the Vulcan Engine works (Messrs. McDwall and Barbour), or at the works of Mr. Const. Basiliadis. The sheers at the Vulcan Engine works are constructed to lift 30 tons. "

p.187 " SYRA - An establishment belonging to the Forges et Chanties de Syra Company is capable of effective large repairs to hull and machinery. Vessels up to about 600 tons have been built here, but of late years this industry has considerably declined. The wood comes chiefly from Constantinople. "

p.253 " VOLOS - There are two small foundries, capable of minor repairs only, and there is a small slipway opposite Volo, suitable for small sailing vessels, lighters, &e. "

p.304 " RHODES ISLAND. Shipbuilding and repairs. -small wooden vessels for service in the Levant are built here, and uncoppered wooden vessels can be repaired; there are no facilities for repairs to iron vessels. "

p.426 " SMYRNA, repairs - There is every facility for repairs of ships and machinery. There is 10 ton steam hammer, and castings can be made up to 2 tons. The Smyrna and Aidin railway company, at their wharf, have a crane capable of lifting 10 tons. Thirty-inch cylinder can be cast and bored. "

(3) On Spetses the boatyard appeared during the same period of the inhabitation of the island (early 18th century) (Bekiaroglou - Exadaktylos, A. (1988)).

On Syros the boatyard started when the port of the island was developed (about 1824) (Kardassis,V.A. (1987, p.169)).

On Hydra the old location of the boatyard which has been studied here was in the harbour of the village. Likely this site was used for boatbuilding as early as the last period of the 17th century (Kriezis,G.D. (1860))

On Symi the older site of the boatyard was at the end of the small gulf (map.6). This site can be dated at least as early as the end of the 18th century (Karanikola,S. (1937)).

(4) From the Italian word "Arsenale". Gourgouris,E.N. (1983, p.451) mentions as well the word "Σκερα" (skera) as the name of the areas where the boatbuilders from Galaxidi used to build vessels. We can note here the similarities of this word with the unidentified Turkish type of vessel "Skyrasas" (Hakluyt,R. (1903-5)), or the Greek type of "Screatse" during the middle of the 16th century (Barker,R.A.

(1983)).

(5) Mastro-Stamatis Kofoudakis (Psara)(Nikodimos,N. (1867, p.72)).

Mastro-Giorgis (Hydra / 1801) (Kriezis,G.D. (1860)).

Papapetros,K. (Galaxidi/1876) (Gourgouris,E.N. (1983, p.442)).

Michelis (Spetses/1772) (Bekiaroglou-Exadaktylou,A. (1988, p.113)).

Kanatas,I. (Galaxidi/1880) (Gourgouris,E.N. (1983, p.442)).

Mastrothodoris (Spetses) (Bekiaroglou-Exadaktylou,A. (1988, p.113)).

Pagidas,N.I. (Syros/1832-57) (Kardasis,V.A. (1987, p.172)).

S. Leriotis (Spetses) (Bekiaroglou-Exadaktylou,A. (1988, p.113)).

G. Kantertgoglou (Kassos) (Bekiaroglou-Exadactylou,A. (1988, p.115)).

(6) The boatyard on Sandorini (Armeni) which is settled in a building which shows features of the local architecture was not originally there. Before the last earthquake on the island this building was a wine cellar ([8]-Chalaris).

(7) There are some other illustrations of the same method from earlier times and other countries: In Unger,W.R. (1978, pp. 56-7) there is an illustration of the method dated about the middle of the 17th century in Holland. In "The Great Age of Sail" (1967, pp. 76-7) there are two other similar illustrations of ship-careening from the "Album de Colbert" (Service Hydrographique de Marine in Paris).

For a further study on ship-careening see Euphimiou - Chatzilakos,M. (1983, pp.215-23).

2. CLASSIFICATION

We have already mentioned historical evidence about the evolution of boatbuilding technique in the Aegean from the second half of the 18th century until today. In this chapter we will study the different types of boats which were built during that same period. One of the main questions we are going to address in this chapter is how the evolution of the boatbuilding technique affected the types of boats.
This chapter has been studied with the intention to focus especially on vessels' properties which can be related to ship-design and shipbuilding problems. However the lack of relevant evidence limited this intention only to the latest types of boats (20th century).
We will pay attention to the variety of the types of boats in the Aegean in order to give evidence about influences from other maritime traditions and in order to realize some aspects of the framework of local technical knowledge.
In a few instances we will take advantage of this study in order to show some problems of the relationship between types of hull and types of rigging.
The main question we are going to study in this chapter is whether we have evidence to suggest any kind of evolution of boat types parallel to the evolution of shipbuilding technique.
To classify the type of vessels which have been built in the Aegean in the last two centuries is a complex task. Part of the complexity is due to the extensive use of two ways of identifying the vessels. One was with respect to the type of the hull and the other with respect to the type of rigging. Both ways were used simultaneously in a number of bibliographical sources. This situation makes any study of these sources rather difficult (table.no.3).
Furthermore, local names existed which were used to identify craft built in particular areas without having any relevance to the

technical features of the vessel. In this work we studied over 30 different names of vessels which are by no means 30 different types of boats.

In this chapter special attention has been paid to producing a convenient way of classifying these vessels in order to avoid any kind of insufficient presentation of any particular type. For this reason this chapter consists of the following sections: 1) Classification of vessels' hulls and their different versions, 2) A preliminary approach to classification based on vessels' rigging, 3) Early types (19th-early 20th century) which were abandoned in the second half of this century.

There are four different groups of sources which provide evidence for this chapter. Each one of them has been studied in different ways in order to achieve the most representative results for the classification.

1) Bibliographical sources are particularly valuable for the information about the earlier types of vessels and they are used as historical evidence.

2) Iconographic sources (old photographs, sketches, and portraits of vessels) are used to illustrate the different types and they are only used as evidence when there is sufficient accuracy and they can be cross-related to evidence from other sources.

3) Interviews with boatbuilders provide material which goes back to the last two generations of boatbuilders. In this case the types described through the interviews are those which were in use at least as early as the period between the two world wars. All the material from the interviews is examined but only the information which comes from more than one individual builder is considered as a piece of evidence.

4) Recorded material (vessels, moulds, models) is usually more accurate and therefore useful for the classification of the surviving

types. For our purpose it is occasionally used as evidence for certain features of the classification.

The basic methodology while using evidence of one group is to cross-relate them with evidence from other groups in order to have rigorous results.

The main question about the typology of the hull is which features must be examined in order to produce an accurate and comprehensive classification.

2.1 Typology of hulls

There is obviously more than one way to classify the hulls for a group of boats. Some authors have used the appearance of the form of the hull (McKee,E. (1983, pp.78-9). In Poulianos,A.I. (1977, pp.338-4)), we find a short classification of the forms of Greek vernacular boats. Others have used structural features (I suggest Hornell,J. (1946) as an example of a work were structural classification can be seen). The function of boats has also been used to classify them (Nicolson,J.R. (1981)). Size or origin have been used for the same purpose (Branco,M.C. (1984)). Taylor,D.A. (1985, p.56) pays attention to a classification related to: genesis, general morphology, construction, crew size and use.

I believe that in any technical study of boats a structural classification is necessary. Since we intend to study vernacular boat-designing techniques it is furthermore necessary to examine the different forms of hulls among the vessels in the Aegean. Therefore the typology of boat hulls in this work consists of two "levels" of classification. In the first "level" there are initial kinds of hulls which are identified by structural features. The second "level" contains the types of vessels which can be identifed by features of the form of their hull. Studying the structure for the different types of boats in the Aegean I believe that the following features are sufficient to provide us with a clear structural classification.

1. Structure of the stern of the hull(1) ([15]-Vrochidis, [17]-Papastephanou, [20]-Giamougianis)

2. Designing methods applied to produce the shape of the boats

According to these features we can determine the following basic formations of hull structure:

2.2.1 Double ended vessels

On these vessels the stern is pointed on the stern post which usually projects above the top sheer line of the hull. The rudder is hanging on the after edge of the stern post which can be either slightly curved or straight. The shape of the hull of these boats can be produced by means of all the designing methods mentioned in the chapter on 5. DESIGNING ([1]-Mavrikos, [3]-Stilianou, [5]-Dardanos, [6]-Chalaris, [14]-Chatzinikolaou, [15]-Vrochidis, [17]-Papastephanou).

2.2.2 Vessels with a transom stern

The transom on the stern of these vessels can vary significantly with respect to shape and size but the structural details remain the same (7.2.2 Boats with transom stern). The rudder can be either hanging on the stern post(2) or placed inboard and driven through a hole in the middle part of the stern. All the designing methods can be applied to determine the shape of these hulls ([5]-Dardanos, [6]-Arvanitis, [8]-Chalaris, [14]-Chatzinikolaou, [17]-Papastephanou).

2.2.3 Vessels with a round stern pointed on the stern post

The upper sheer lines on the stern part of the hull are almost elliptical but they are pointed on the stern post. Unlike a double-ended boat, this stern post does not project proud of the planking surface though it can be seen throughout its entire length on the stern (cp.the canoe and cruiser stern, as described in McKee,E. (1983, p.81)). The rudder is suspended on the lower part of the stern post and its stock passes inboard through the hull. There are references that all the designing methods can be applied to determine the shape of this hull ([4]-Korakis, [6]-Arvanitis, [8]-Chalaris, [14]-Chatzinikolaou). However, I could not find any mould of this kind of hull to be recorded.

2.2.4 <u>Vessels with a counter stern</u>

The upper sheer lines of the stern part of this hull are almost a half elliptical shape. There is no indication of stern posts on these upper part and the whole stern structure is supported by futtocks. The rudder arrangement is similar to that of the round stern category above (7.2.4. boats with counter stern). According to the references ([1]-Mavrikos, [3]-Stilianou, [6]-Arvanitis, [5]-Dardanos, [15]-Vrochidis, [17]-Papastephanou) no moulding method can be applied to determine the shape of the hull of these vessels (5.3. Lofting methods).

More technical descriptions of these types will be given in the 7.CONSTRUCTION chapter.

Each of the above basic kinds contains a number of types of boats which have the same structure but some different features in their form. To study this second "level" of classification we will examine the following basic aspects of their appearance:

1) The profile of the stem post

2) The profile of the stern post

3) The form of the midship section

4) The ratio of principal dimensions (in the chapter of 5. DESIGNING we will call them fundamental dimensions (F.D.))

Additional information about, the name, the function, and the origin of the vessels will be included. Further examination of these types concerning other features of their appearance and influences from their functions and their origin will be given in the chapter on 3.MORPHOLOGY.

2.2 Types of double ended vessels

2.2.1 Trechadiri (Τρεχαντήρι (το))(3)(fig.11, 12)

This is the most common type of hull which is still extensively built in the Aegean sea. Today most of the boats built with a Trechadiri hull have a L.O.A. from 8 to 20m and carrying capacity from 4 to 50tons. Adoniou,A. (1969, p.30) suggests that the maximum capacity of a Trechadiri during the years of the sailing boats was 250tons. The average ratio of the basic dimensions are L.O.A.=3 x M.B. or length of the keel=2 x M.B. and M.B.=3 x M.D. (in table no.5 there are further suggestions about the formula of a Trechadiri hull). There is a slight variation of this ratio depending on the function of the boat, the size, and the local tradition (3. MORPHOLOGY). The earliest evidence of building Trechadiri boats comes from the middle of the 17th century (Kriezis,G.D. (1860, p.18). Konstadinidis (1954, p.137) suggests that the Trechadiri owes its origin to the Adriatic type of Trabaccolo. During the 18th and 19th century Hydra and Spetses were the Islands were most of the Trechadiri were built (Kriezis,G.D. (1860), Adoniou,A. (1969, p.14) and table.no.3 in HISTORICAL INTRODUCTION 1.2. Second period (1830-1880)). However, we do not know if these early Trechadiria had the same features as the Trechadiri today. The most distinctive feature of this hull is the concave curved shape of the stem post. It seems that there is some sort of evolutionary change in the shape of this curve from the earlier illustrations of this boat until today (Damianidis,K. and Zivas,A. (1986, p.44)). We will examine this change in the next chapter on 3.MORPHOLOGY.

The stern post of this type today is straight and raked aft. There are though older illustrations which show the stern post with a gentle curve (fig.12).

The middle section of a Trechadiri is characterized by a smooth turn of the hull at the bilge level. The two upper sides of this section are shaped on an angle of about 15° to a bow and buttock plan (fig.11). According to [17]-Papastephanou the big sailing Trechadiri hull vessel (Bratsera) in the earlier times (early 20th century) had the turn of the bilge sharper and the upper sides (futtocks) in a more upright position than the Trechadiri today (in fig.12 there are the lines of a model of an early two masted Trechadiri hull). The draught of this type varies but we do not have evidence that the Trechadiri was ever close to a flat bottom shape.

[4]-Korakis mentions that in the boatyard of the Island of Spetses they used to build two types of Trechadiri. The one was carrying the feature of "Komiza" (a raised deck on the stern of the boat). According to [13]-Kontatos this arrangement was made to provide extra space inside on the after part of the vessel (fig.121). The other type had on one level the whole deck and it was called "Trechadina". On this last type an extra beam was placed accross the axis of the boat on the bow to form a kind of thwart which was extended outside the gunwale (fig.141d) ([4]-Korakis).

In the first half of the 20th century boats with a Trechadiri hull were built in almost all the yards in the Aegean(4).

All the boatbuilders interviewed built Trechadiri boats (fig.45). However, each one of them seems to have his own slightly different image about how the form of this boat should be. In addition to the differences in the ratios of the fundamental dimensions of this type (see table no.5) there are different opinions about the forms of the bow and stern areas of the hull. In practice this means that different ideas are existing about how much flare or flam the frames should have in the bow or stern area (3.1. The influences of function).

Table.no.5
Ratios of Trechadiri Fundamental Dimensions (F.D.)

Source	
[3]-Stilianou...........	M.B.<or=L.Keel/2, the M.D. depends on the use of the boat and usualy is close to L.Keel/4 or L.Keel/5. Hor.Stem Proj.<or=L.Keel/3 Hor.Stern Proj.<or=L.Keel/6
[8]-Chalaris.............	M.B.=L.O.A./3, M.D.=M.B./3
[10]-Binos...............	M.B.=L.O.A./3 + 10 or 15cm (for small boats about 6m long), M.D.=M.B./3 + 5 or 10cm
[12]-Kozonis.............	M.B.=L.Keel/2
[13]-Kontatos............	M.B.=L.O.A./3
[15]-Vrochidis...........	M.B.=L.O.A./3
Adoniou,A (1969, p.30)...	M.B.=L.Keel/3 (when L.Keel<100ft) M.B.=L.Keel/4 + 0.03L.Keel (when L.Keel>100ft). For a fishing Trechadiri M.B.=L.O.A./3 M.D.=M.B/2 (exept the gri-gri Trechadiri (fishing with long nets)
Throckmorton,P. (1964)... (The formulae was given by G.Mavrikos)	L.O.A.=L.Keel + L.Keel/3, M.B.=L.Keel/2, M.D.=M.B./3, ("He recently varied a 150-ton Trechadiri to L.O.A.=L.Keel + 25% M.B.=L.Keel/3, M.D.=M.B./2")

FUNDAMENTAL DIMENSIONS (F.D.)

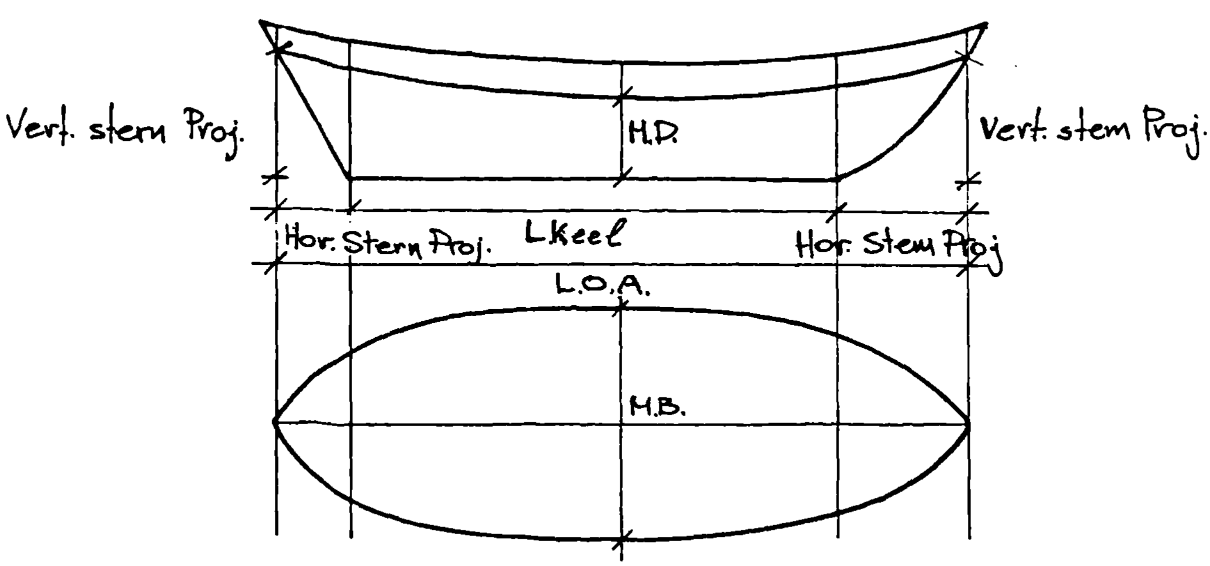

Table.no.6
Ratios of Perama Fundamental Dimensions (F.D.)

Source	
[3]-Stilianou..........	Hor.Stem Proj.<or=L.Keel/4 Hor.Stern Proj.<or=L.Keel/8
[12]-Kozonis...........	L.Keel/3>M.B.>L.Keel/4
[13]-Kontatos..........	M.B.=L.O.A./4
[15]-Vrochidis.........	The Perama boat had the same ratios of F.D. as the Trechadiri boat
[20]-Giamougianis......	L.Keel/2>M.B.>L.Keel/3
Throckmorton,P. (1964)..	L.O.A.=L.Keel +25% M.B.=L.O.A./3 M.D.=M.B./2
(The formulae was given by G.Mavrikos)	

Table.no.7
Ratios of Varkalas Fundamental Dimensions (F.D.)

Source	
[12]-Kozonis...........	M.B.=L.Keel/3
Adoniou,A. (1969, p.20).	M.B.=L.Keel/2.6 (this is for a Bombarda type of hull)

Table.no.8
Ratios of Karavoskaro Fundamental Dimensions (F.D.)

Source	
[3]-Stilianou..........	There is not any standard ratio of F.D. for Karavoskaro. This is the only type where you can start the determination of F.D. from the L.O.A. However he usually built Karavoskaro under the following ratios: M.B.=L.Keel/4, M.D.=L.Keel/8 Height of gunwale=2-3ft
[12]-Kozonis...........	L.Keel/3>M.B.>L.Keel/4
[15]-Vrochidis.........	M.B.=5.6xL.O.A./20
Adoniou,A. (1969)......	M.B.=L.Keel/4 +L.Keel/5

2.2.2 Gatzaos (Γατζάο (Ο))(fig.13).

This type of hull used to be built on the Ionian Islands and on the west coast of the mainland of Greece ([2]-Kornidaris, [6]-Arvanitis, [8]-Chalaris, [15]-Vrochidis). The stem post was slightly concave curved and the stern post straight and raked. The angle between each post and the horizontal level was not less than 60° (fig.13). Often the L.O.A. of the boat was about 20m ([2]-Kornidaris, [8]-Chalaris, [6]-Arvanitis has seen Gatzao of 350tons capacity). The M.B. was equal to 1/3 of the L.O.A. (Adoniou,A. (1969, p.34). The main characteristic of this type was the wide deck even on the fore and after part of it ([2]-Kornidaris, [6]-Arvanitis, [8]-Chalaris). From the illustration provided by Adoniou,A.(1969) (fig.13) the middle section appears with a sharper turn at the level of the bilge and beamier on the part above the water than any other double ended boat (note that all the fore and after sections on the body plan are concave curves providing a beamy hull). Gatzaos was a trading boat with an increased carrying capacity ([2]-Kornidaris).

There is evidence that for the planking of this hull cypress wood was often used ([2]-Kornidaris, [6]-Arvanitis, [8]-Chalaris) (6.1.3.b Cypress).

2.2.3 Botis (Μπότης (Ο)), Koutoulo (Κούτουλο (Το)) ([4]-Korakis, [8]-Chalaris) (fig.14).

This was usually a small boat with straight posts which were almost vertical to the keel posts ([4]-Korakis, [5]-Dardanos, [8]-Chalaris). It is still built in some places in Greece with an L.O.A. not more than 8m and it is used as a small scale fishing boat. In the first half of this century the Botis was often built in bigger dimensions with 30tons capacity ([8]-Chalaris).

In some places a similar boat was common having curved stem and stern posts. It was called Gaita (Γαΐτα (Η))(5) (fig.15a). This was a small boat usually less than 6m L.O.A. ([5]-Dardanos) which was used only for coastal fishing. These small vessels had a similar appearance to a small Trechadiri but they were actually narrower and shallower. By contrast the fore and after deck was wider than that of the same sized Trechadiri ([5]-Dardanos).

The different shape of the posts affects the length of the keel of the boat which was longer than a Trechadiri with the same L.O.A. ([5]-Dardanos mentions that on a 6m L.O.A. Gaita the keel was 60-70cm longer than that of a Trechadiri on the same length). These differences not only caused a more efficient propulsion of these small boats but also made them more stable in a strong stream than small Trechadiria ([4]-Korakis, [5]-Dardanos, [8]-Chalaris). The Gaita type was very popular among the small scale coastal fishermen.

There is evidence ([5]-Dardanos, [10]-Binos) that this name denoted yet another type of hull of small boat from the Bosporus (Κωσταντινοπολίτικη γαίτα) (fig.15b). This boat was even narrower than the one in the Aegean and the fishermen used to pull it on the shore at the evenings. [10]-Binos suggests that the keel of this boat was wide (20-30cm) and shallow (it was extended 5-6cm below the garboard strake) with a L.O.A. less than 10m. This type of Gaita was manoeuvrable with just a single side oar.

2.2.4 <u>Tserniki</u> (Τσερνίκι (Το))(fig.16).

This type of hull gradually disappeared from the Aegean Sea after the second world war. [10]-Binos and [15]-Vrochidis mention that Tserniki had Turkish origin. In Verwey,D. (1932) some schematic profiles of hulls appeared similar to Tserniki type. Konstandinidis,T. (1954, p.139) suggests that this was the same kind of hull as the Turkish type "Tsikirné". The stem and stern posts of this type were straight and raked forward (see F.D. table,no.20, boat,no.14 and table,no.30, boat,no.11,13). The stem post was raked more than the stern post ([8]-Chalaris, [10]-Binos, [11]-Polias). In addition to the illustration provided by Adoniou,A. (1969, fig.18) (F.D. table,no.20, boat,no.14 and fig.16) there are two other illustrations of a similar hull with the same features but without any identification of the actual type of hull. The first is in fig.35 in the section on 2.6 Sails. In this figure there is the fore part of a vessel with Tserniki "stem" (even with the same sort of decoration on the gunwale as on Adoniou's illustration). The deck of the vessel appears quite beamy on its fore part and the top sheer line of the hull rises steeply from the middle to the bow. The L.O.A. should be more than 25m and this fore part is under Polacca rigging.

Another illustration of a similar kind of boat is provided by Throckmorton's collection (see F.D. table no.30, boat,no.11 & 13 (fig.17)). The rake of the stem post of this example is even greater than on the other illustrations (43^{o} from an horizontal line). A scale is not given as the plan is not completed but if the marked measurements are in metres then the overall length of the boat would be 11m. There is again a steep rise of the top sheer line from the middle to the two ends of the boat and the M.B. is equal to 0.38 of the length of the keel. Almost the same ratio applies to the example from Adoniou : M.B./L.Keel=0.39.

In Adoniou,A.(1969,fig.14) the illustration of Tserniki has a distinctive deep draught and the whole middle section is close to a V-shape (fig.16).

The Tserniki hull was common in the boatyards of Asia Minor and on the Islands of the Eastern Aegean ([8]-Chalaris, [10]-Binos, [11]-Polias, [12]-Kozonis, [15]-Vrochidis, Denham,H.M. (1986, p.284)). On the Island of Symi they built small Tserniki (L.O.A.=13-17m) as sponge divers' boats ([10]-Binos, [11]-Polias, Zouroudis,G.I.(1974, p.175)). [11]-Polias considered Tserniki as more manoeuvrable but less stable than boats with a transom on the stern (e.g. 2.3.1 Varkalas, 2.3.3 Skaphi).

On the other Islands the small Tserniki was a fishing boat and the less numerous bigger version was used as a trading boat ([8]-Chalaris, [10]-Binos, [12]-Kozonis, [20]-Giamougianis). Most of the evidence suggests that one masted Tsernikia were usually rigged with a sacoleva sail ([8]-Chalaris, [10]-Binos, [11]-Polias, Denham,H.M. (1986, p.282)), however Zouroudis,G.I. (1974, p.175) gives an illustration of a Tserniki hull under lateen sail.

2.2.5 Perama (Πέραμα (Το))(fig.18a, b and c)

This was similar to the Tserniki hull and it was usually built bigger than the Tserniki ([1]-Mavrikos, [3]-Stilianou, [10]-Binos, [13]-Kontatos, [15]-Vrochidis, [20]-Giamougianis). Boats of this type are still sailing in the Aegean, representing the last examples of these vessels, as they are no longer built (lines of "Evaggelistria" on the fig.105a,b and c, lines of "Phaneromeni" on the fig.18a,b and c and lines by [3]-Stilianou fig.111a,b). Most of the available evidence suggests that Perama has almost the same ratio of principal dimensions as Trechadiri ([1]-Mavrikos, [3]-Stilianou, [15]-Vrochidis, [20]-Giamougianis). This is to say M.B. close and less than half the length of the keel and M.D. about half M.B. There is information ([13]-Kontatos), however, stating the M.B. was 1/3 of L.Keel. From the available plans of seven Perama the wider of them was M.B.=0.50 x L.Keel (table.no.9, boat,no.48) and the narrower M.B.=0.38 x L.Keel (table.no.24, boat.no.47). Therefore it is likely that there is a range of different ratios of dimensions applied in the past in Perama. The narrower vessels were possibly built to increase the speed whereas the wider vessels were built in order to produce more carrying capacity. This goes along with another information which suggests the same 1/3L.Keel<M.B.<1/2L.Keel. ([20]-Giamougianis) and 1/4L.Keel<M.B.<1/3L.Keel ([12]-Kozonis). All the available information about formulae of Perama hull (table.no.6) shows a remarkable variety of the ratio M.B./L.Keel. Studying, however, this ratio on the available examples of Perama plans we can introduce the following table:

Boat	M.B./L.Keel	M.B./L.O.A.
Table,no.17		
1.boat:"Evaggelistria"	0.43	0.32
Table,no.24		
2.boat,no.48	0.50	0.35
3.boat,no.47	0.38	0.30
4.boat,no.46	0.40	0.31
Table,no.27		
5.boat:"Labraki"	0.45	0.35
Table,no.31		
6.boat,no.14	0.41	0.32
Table,no.33		
7.boat:"Phaneromeni"	0.44	0.33

It is noticeable that we can apply [20]-Giamougianis' formula on all the ratios M.B./L.Keel of the table (1/3L.Keel<M.B.<1/2L.Keel). Furthermore we can see on the table the variety of M.B./L.Keel on Perama can be transferred to a less varying ratio of M.B./L.O.A. Therefore we can suggest that the ratio M.B./L.Keel was in respect to the ratio L.Keel/L.O.A. However, the former ratio was more valuable than the latter from a constructional point of view (5. DESIGNING). [17]-Papastephanou suggests the distinction between the Perama and the "Tserniko-perama" hull. This latter one was a version between Perama and Tserniki hull (fig.19a).

The Tserniki, however, had a shorter keel than the Perama with the same L.O.A. ([8]-Chalaris, [10]-Binos, [11]-Polias) and then the ratio L.Keel/L.O.A. was different between the two sub-types as well as the ratio M.B./L.Keel.

From the Peramata which have survived we can recognize that apart

from the different beam there are examples of this type with high sides and other with low sides. The available information for this difference is that the higher Peramata are also the wider ones in order to create more carrying capacity. Today the few lower and narrower Peramata are cruising vessels ([3]-Stilianou, fig.111a,b). An other feature which effected the appearance of the vessels was the formation of short or tall gunwale (7.5.4 Forming the gunwale).
The distinctive feature of a Perama hull is the small board across the stem post which accommodates the fore end of the gunwale (fig.18a,b and c). We are going to examine more about this feature in the chapter on 3. MORPHOLOGY (3.3.4. The bow and the stern of Perama hull). Apart from the ratio height/beam/length, Perama had a profile of the middle section of the hull very similar to Trechadiri. This is possibly the reason why most of the boatbuilders interviewed considered this vessel similar to the Trechadiri with which they were more familiar. However, Denham, H.M. (1986, p.286) mentions that the hull of the Perama was a more efficient sailor than the Trechadiri. All the available information suggests that the Perama was often a two masted vessel with rigging of Bratsera or Lauver type during the beginning of the 20th century. However, there are examples of one masted Perama under lateen sail ([17]-Papastephanou) or under gaff sail (private old drawing representing a Perama from the early 20th century). The most famous places for building Perama during the same period were Syros, Samos, and Plomari (Lesvos) ([1]-Mavrikos, [3]-Stilianou, [10]-Binos, [13]-Kontatos, [15]-Vrochidis, [20]-Giamougianis, Adoniou,A (1969, p.14))
Konstadinidis,K. (1954, p.137) suggests that the Perama was similar to the Mistikon (2.7 Early types) especially those built in the Cyclades. He adds that until 1900 it was used as a transport boat for people or pirate boat under two big lateen sails and two jibs.
Throckmorton,P. (1964, p.214) suggests that the earliest evidence of

a Perama hull comes from the late Byzantine period according to a graffito on a jar of that period (Maritime Museum of Piraeus). Furthermore he mentions that "the Perama hull was narrower in relation to length, but deeper and shorter overall with a flatter floor than the Trechadiri". In another publication Throckmorton,P. (1971, p.505) mentions the following: "I believe that they are direct descendants of Roman ship types like the wrecks we have excavated at Yassi Ada, the Pantano Longarini and Torre Sgarrata".

On Lesvos there was a local type of small boat called "Perama" which was usually shorter than 6m. The reason that they called this boat Perama was that it appeared to have some similar details on the bow and stern to the usual Perama. The gunwale of this type ended before meeting the stem or the stern posts (fig.19b), exactly like on the big Perama vessels ([20]-Giamougianis). However, these small boats did not carry the distinctive cross board on the bow like all the big Peramata. We can readily assume that one of the reasons for the absence of this board was the narrow area of the bow of the small boat. The most interesting remark about this detail is that on these small "Perama" the bow and stern had more flare than on any other kind of boat with the same size. This form provides an extremely raked gunwale on the bow and stern which was very difficult to attach to the stem or the stern post. In this case the location of the end of the gunwale before meeting the posts solved this difficulty. We are going to examine the question of the form of the Perama's bow further in the chapter on 3. MORPHOLOGY (3.3.4. The bow and the stern of Perama hull).

2.2.6 Trata (Τράτα (H))(fig.20,21a and 21b)).

This was a very popular long net fishing boat in the Aegean during the first half of the 20th century. A horizontal board in front of the stem post, like a "ram" was the distinctive feature of this type (fig.21b) (Κατσούλι ([8]-Chalaris), Gaga ([4]-Korakis, [10]-Binos)).

This was a functional feature during fishing and it was also applied on fishing boats from other traditions (Filgueiras,O.L. (1985, p.224)). The boat can be as long as 10-12m ([8]-Chalaris, [10]-Binos) and is propelled usually by means of oars. However, [12]-Kozonis mentions that the Trata was less than 15m long. Sometimes it carried a light lateen ([7]-Chalaris, Adoniou,A (1969, p.21) or sprit sail ([10]-Binos). The Trata was narrow and shallow, especially formed to float on shallow waters. [7]-Chalaris mentioned the existence of a small transom board on the stern of this type in order to provide some beamy area on the stern.

[4]-Korakis showed me a Trata on a painting in Panagia Armata, a chapel on the Island, which dated from 1887 and he noticed that the boat looked exactly the same as the last Trata that they built on the island (thirty years ago).

There are some other names of double ended types of hull which survived as late as the first half of the 20th century but I could not collect enough evidence for a full description of them. These vessels are included in the 2.7 Early types section.

2.3 <u>Vessels with a transom stern</u>

2.3.1 <u>Varkalas</u> (Βαρκαλας (O))(6) (fig.22a,22b and 23)

This is usually a general name for all boats with a transom stern today. However, in the past types of hull with a transom were identified by special names. We are going to examine these under their specific names in this section. Under the name of Varcalas there are today small boats of 8-10m L.O.A. but bigger Varkalas used to be about 20-25m L.O.A. and usually under 250tons capacity ([3]-Stilianou).

The ratio of the M.B./L.Keel seems to vary from 1/2 to 1/3 in relation to the actual size of the boat. On small Varkalas this ratio was closer to 1/2 while on bigger ones it was closer to 1/3 ([11]-Polias, [12]-Kozonis). The profile of the stem post had quite a few versions: as a straight and raked post ([11]-Polias suggests that the straight stem was the older form of a Varkalas' hull. In Throckmorton's collection of plans there are two Varkalas with straight stem posts, boat,no.6 & boat,no.20), as a concave post (Throckmorton's collection, boat,no.1,2 & boat,no.15), as a convex one (Throckmorton's collection, boat,no.8 (fig.22a, 22b). & boat,no.18) or as a reflexed curved one ([11]-Polias, suggests that the reflex profile of stem (the same as on a Karavoskaro hull) was the latest version introduced on the Varkalas, fig.23).

The old form of the stern was with a straight stern post and the transom on the upper part of it. In this case the rudder was hanging on the after edge of the post ([11]-Polias), [13]-Kontatos). Later (until today) the stern post consisted of three pieces with the transom fastened on the upper one ([11]-Polias, [12]-Kozonis, [13]-Kontatos) and the rudder placed inboard (7.2.2 Boats with a transom stern). At the same time it seems that the actual position of the transom board was changing from the older structure to the modern one. In the first case of the straight post the transom board seems to have occupied less than the upper half of the whole height of the stern post ([11]-Polias, [12]-Kozonis, Throckmorton's collection, boat,no.6 & boat.no.20). In the second case with the stern post constructed of three pieces, the transom board occupied more than the upper half of the whole height of the stern post ([4]-Korakis, [11]-Polias).

The profile of the middle section of a boat with a transom was similar to the profile of the same section of a trading Karavoskaro hull (without though the equal M.B.).

This profile had a sharper turn at the bilge level and more vertical sides on the upper part than a double ended vessel (Trechadiri, Botis, Tserniki, Perama) ([11]-Polias, [12]-Kozonis, Throckmorton's collection, boat,no.1&2 & boat,no.8 & boat,no.15). Although small

Varkalas seem to be built today in most of the boatyards in the Aegean there is evidence that during the first half of the 20th century this type of hull was common for big vessels among the Islands of the Eastern Aegean Sea (Symi, Kalymnos, Samos, Rhodes etc.) ([3]-Stilianou, [9]-Chilas, [11]-Polias, [12]-Kozonis, [13]-Kontatos, [14]-Chatzinikolaou, [18]-Kastrinos). There are some illustrations of a Varkalas hull from this area and this period when the after side of the transom board was very elegantly decorated (Throckmorton,P. (1971, p.504), Denham,H.M. (1986, p.286)).

2.3.2 Bombarda (Μπομπάρδα (Η))(fig.24 and 25).

This is a type of vessel which was used until the early years of the 20th century. There is not enough evidence to give a complete description of this type but some of the available information suggests that the name refers to a type of hull. The Bombarda had a transom board on the stern which was shallower and wider than the transom of the Varkalas. ([3]-Stilianou, Adoniou,A (1969, fig.19)).

[3]-Stilianou mentioned that the stem post was straight and very close to the upright position. By contrast Adoniou,A (1969, fig.8) (fig.24a in this work) gives an illustration of a Bombarda with a noticeably raked stem. The middle section was like the Varkalas. The ratios of the basic dimensions of the only available plan are: M.B.=0.37 x L.Keel and M.D.=0.17 x L.Keel (fig.24, from Adoniou,A (1969, fig.8)). Adoniou,A. (1969, p.20) mentions that Bombarda were built with less than 200tons capacity.

We think that the above features of this type of hull are not distinguished enough to identify it clearly as a different type from the previous Varcalas type. The only distinctive feature of it mentioned in all the historical sources is that this type of hull with a transom stern was always under a Polacca rig (Kotsovillis,G.I. (1919, pp.61-5), Adoniou,A. (1969, p.20), Denham,H.M. (1986, p.285)). Further more Segditsas,P.E.(1940, p.238) mentions that the Bombarda was a vessel under the Polacca rig without identifying it as a particular type of hull (2.6.1 Square sail). Possibly the Bombarda type was nothing more than a Varkalas hull under Polacca rig. Lemos,A.G. (1963, p.88) published an illustration of a Bombarda under polacca rig, from Chios, where the feature of the transom on the stern is very prominent (fig.24b). [3]-Stilianou mentions that this type was common in the eastern Aegean early this century.

2.3.3 Skaphi (Σκάφη (H))(7) (fig.25)

This type of hull was built especially on the island of Symi and rather rarely on other Dodecanese Islands ([11]-Polias, Adoniou,A.(1969, p.23)). The type has been practically abandonded early in the 20th century. However, [17]-Papastephanou showed me the last survivor of this type which was in the port of "Zeas" in Piraeus. The boat was fibre-glassed on the hull below the water level but the features of the Skaphi were still recognizable.

It was only used by sponge divers and the form of the hull was associated with this function (3.1 The influence of the function). Usually the L.O.A. was about 15m and less than half of that was the actual keel. The stem post, being straight and extremely raked, occupied forward more than 1/3 of the L.O.A. On the stern the transom board occupied about 1/3 of the whole height of the stern post and it was raked. The M.B. was about 2/3 of the length of the keel but that means about 1/3 of L.O.A.([11]-Polias, [17]-Papastephanou, Adoniou,A.(1969, p.23)). [11]-Polias gives the information that the strakes of the upper part of the hull were painted with different colours. They paint each one of the planks of the hull before they set it on the skeleton (?). The most common of these colours were red, blue, green and brown.

[11]-Polias kindly sent me the patterns of one of his models of a Skaphi. The profiles of these patterns are included in fig.25, together with a copy of Adoniou,A. (1969, fig.16). An other three

illustrations of Skaphi appear in Phlorakis,A (1982, fig.113), in Zouroudis,G.I. (1974, fig.17) and in a popular painting by Oikonomopoulos,N. included in the same publication (fig.40 in this work). Although the above mentioned ratio can be applied to all the available illustrations Adoniou,A.(1969, p.23) suggests the ratio M.B.=1/4 x L.O.A. and he adds that L.O.A. was about 15m and with a capacity of 40-50tons.

Skaphi had an extensive draught and a very pronounced sheer. The profile of the middle section of the vessel was like a double ended boat below the water level (like a V-shape) and like a boat with a transom on the part above the water level (the sides fairly parallel to a bow and buttock plan). Because of this special form of the hull the boat needed a lot of ballast in order to sail properly and have the right stability ([11]-Polias, [17]-Papastephanou, Adoniou,A (1969, p.23)).

2.3.4 Varkalas from Hydra (Υδραΐκος Βαρκαλάς) (fig.26)

This small boat had usually L.O.A. less than 7m ([3]-Stilianou, [5]-Dardanos and unrecorded information from Mr.Kalodimos who used to be a boatbuilder on Hydra) and it was extensively built and used on the island of Hydra as a fishing and sponge divers' boat ([3]-Stilianou, [5]-Dardanos). The stem and the stern post were vertical to the keel and the transom board occupied about half of the total height of the stern. [5]-Dardanos suggests that the stem post was slightly raked aft. The boat was beamy M.B.>1/3 L.O.A. with a slightly pronounced sheer line (in F.D. table.no.21, boat.no.78, and table.no.32 boat from Hydra).

On the two available plans fig.26 (Adoniou,A. (1969, fig.78)) and fig.108 the stern was higher than the stem ([5]-Dardanos).

On the profile of the middle section of the hull the boat appears rather shallow and with a sharp turn of the profile at the bilge level (fig.26, 108). This type of boat was famous for its very light structure. This structure together with the short draught of the hull provided the ability for the fishermen to haul the boat easily onto the beach ([3]-Stilianou, [5]-Dardanos and unrecorded information by Mr. Kalodimos).

[5]-Dardanos suggests that the light structure consisted of thin components of the skeleton and planking of the boat and of no caulking (7.5.4 Planking up the hull). He actually mentions that he was able to built a "Υδραΐκο βαρκαλά" of 5m L.O.A. which could weigh as little as 80 kg.

2.3.5 <u>Boat from Chanea</u> or Begedes (Μπεγεντές (O))(8)(fig.27)

Today only few survivors of small boats of this type are in the fishing port of Chanea (Chora). In the first half of the 20th century they built boats of this kind more than 10m L.O.A. (Unrecorded information from Mr.Kokkinakis, Mr.Louradakis,S. and Mr.Pariotakis who were boatbuilders in Chanea/1987). There is information that the same type was built in the boatyards on the south-west coast of Turkey under the name "Begendes" (Mr. Kokkinakis, and Mr. Pariotakis).

Both the stem and the stern post are straight and a small transom board was placed on the upper part of the stern post to accommodate the after ends of the gunwale. In the case of this boat from Chanea the purpose of this small transom board obviously is to provide a wider space on the after part of the deck (fig.27).

The ratios of the fundamental dimensions of the recorded profiles of a boat (fig.27, L.O.A. = 5.64m, in F.D. table,no.18 boat from Chanea) suggest that the vessel was beamy and shallow. However, it is possible that these dimensions were specially adapted to the small size of boat. The pronounced sheer line and the curved upper edge of the small transom board are noticeable. The rudder of this boat appeared wider than those of other boats and the stern post was sufficiently projected to accommodate the heavy rudder. The last survivors of this type have still the gear of a sacoleva sail and they are all fishing boats.

Under the name of "Γιαλάδικη βάρκα" the boatbuilders called local small vessels which they have used for a special kind of fishing with the aid of a box with a glass bottom.

[4]-Korakis calls the Varkalas from Hydra a gialadiki Varka.

[11]-Polias mentions the gialadiki Varka from Symi. The boat had a transom on the stern and it was used by sponge divers under a lateen sail. Bigger vessels under the name of "Bageta" (Trechadiri, or Varkalas, or Karavoskaro) carried 5-7 small "Γιάλες" (gialadiki Varka) to the area where they were going to fish (Zacharia-Mamaliga,E. (1986), Zouroudis,I.G. (1974, fig.19) [11]-Polias).

[18]-Kastrinos mentions the gialadiki Varka from Kalimnos. The boat had a transom stern and a shallow gunwale because of the special kind of fishing.

2.4 <u>Vessels with a round stern pointed on the stern post</u>

1) <u>Liberty</u> (Λίμπερτι (Το))(fig.28)

This is one of the common types of hull in Greek boatyards today. The L.O.A. can be as short as 8m and as long as 30m and theoretically longer ([3]-Stilianou, [4]-Korakis). The stem post was usually very slightly concave raked about 60^{o}-50^{o} to the horizontal line of the keel (fig.30) and (Adoniou,A. (1969, fig.49,51,52)).

At the stern the water lines were shaped in a counter form and they ended on the stern post. The stern post was built in a way which could provide inboard access to the rudder. The upper and after part of the stern post did not project at all (fig.30)(7.2.3 Boats with counter stern).

The Liberty was usually a narrow hull ([1]-Mavrikos, [3]-Stilianou, [6]-Arvanitis, [7]-Chilas). On the one hand there is information that

M.B. was equal to 1/4 L.Keel ([12]-Kozonis) and on the other hand on four of the available examples (Fundamental dimensions table,no.17, black boat, and table no.23, boat,no.51, 49 and 52) the ratio M.B/L.Keel was just over 1/4 and on two of them (Fundamental dimensions table.no.17, brown boat, and table.no.26, fishing boat on 1:25 scale) this ratio was just below 1/3. The profile of the middle section usually shows a noticeable draught, a sharp turn of the lines on the bilge level with the top sides fairly parallel to a bow and buttock plan (fig.28).

The sheer line on the deck was not pronounced as much as in the double-ended vessels and the height of the stem and stern was more or less equal. According to [3]-Stilianou this type of boat was introduced in Greek boatyards after the Second World War (Adoniou,A. (1969, p.32)). This type owes its name to the construction of cheap ships for Europe in Northern America. However, [15]-Vrohidis suggests that some of the features of the Liberty hull existed on other older types of hull before the introduction of the Liberty type in the Aegean's yards.

D) <u>Vessels with a counter stern</u>

1) <u>Karavoskaro</u> (Καραβόσκαρο (Το))(fig.29,30,112)

According to most of the boatbuilders interviewed the lines of this type of hull can in practice not be determined by a moulding method and therefore a laying out and lofting technique had to be used. The Karavoskaro type was usually built greater than 10m L.O.A. ([1]-Mavrikos, [3]-Stilianou, [6]-Arvanitis, [7]-Chilas, [15]-Vrochidis). Adoniou,A. (1969, p.25) suggests that the L.O.A. of a Karavoskaro could be as long as 40-50m with a capacity of 400-500 tons.

The profile of the stem of this type had a reflex shape (Throckmorton,P. (1971, p.505) describes the Karavoskaro' stern as "clipper-bowed").

The stern had a straight post only on the lower part (7.2.4 Boats with counter stern). The upper sheer lines of the stern part were on a half-elliptical shape and only the elliptical edge of the water way timber was pronounced on the after part of the hull. Among the examples in the tables of fundamental dimensions there is a variety of the ratio M.B./L.Keel from 0.23 until 0.41. However the first ratio was on a boat with L.O.A.=43.85m (in F.D. table,no.22, boat,no.22) and the second one on a boat with L.O.A.=10.57m (in F.D. table.no.26, boat,"Ageliki,II"). Table.no.8 includes all the information about the formulae of a Karavoskaro hull. The sheer line was usually very gently curved.

There were two different kinds of profiles of the midship section. The first referred to trading vessels (in F.D. table.no.22 boats,no.22,24,26, and table,no.26, boat,"two masts vessel, 1:50 scale"). It was very wide with shallow draught at the lower part, the turn of the bilge was very sharp and the upper part was extensively parallel to the bow and buttock plain (fig.29).

The second version referred to fishing or cruising vessels (in F.D. table,no.22, boats,no.8, 29, and table,no.26, boats, "Naphtilos", "Ageliki,II") and the bottom has a wide V-shaped form with deeper draught than the other type. The turn of the bilge on this version was not as sharp as on the first version and a shorter part of the upper profile was parallel to a bow and buttock pla~~in~~ne (fig.30).

There is a hypothesis that the Karavoskaro hull owes its origin to the American topsail schooners (Throckmorton,P. (1971, p.505)). Moreover, since building the Karavoskaro required lofting techniques, it is likely that this type appeared in the Aegean after the introduction of lofting floors (last quarter of the 18th century). In the 19th century most of the Karavoskaro boats were built in Syros and Galaxidi (1.3 Second period (1830 to 1880)). In this period most of the bigger vessels built in Greece had this type of hull. Segditsa,P.E. (1940, pp.237-8) and Denham,H.M. (1986, p.286) suggest that both Varkalas and Karavoskaro have been built at the Greek Islands for nearly two centuries and that they were influenced by Western practices.

Despite the types mentioned above often a synthesis of features from different types occurred on some vessels. The most popular name of all these vessels was "Bastard".
In this way there are still examples in the Aegean of vessels with Karavoskaro' stern and Trechadiri'stem or others with Liberty stern and Karavoskaro stem ([1]-Mavrikos, [3]-Stilianou, [6]-Arvanitis, [7]-Chilas).

2.6 Sails

Apart from the names which referred to types of hull, it was very common to find vessels named according to the types of rigging they carried. The classification based on rigging is more complex. This is due to the shortage of information, and also the great variety of different kind of rigging used in the Aegean during the 19th and 20th century.
Firstly, I will present some features concerning the number and the positions of the masts and later the types of rigging.
Table no.9 contains the number of masts on a vessel in relation to its L.O.A. according to [19]-Bilias (one of the last traditional sailmakers).

Table no.9

L.O.A.	Number of masts
L.O.A.<15m.	One mast
15m.<L.O.A.<28m.	Two masts
28m.<L.O.A.	Three masts

Table.no.10

TYPE OF VESSEL	PAGE(*)	NUMBER OF MASTS	L.O.A.
1)Korveto(Nava, Dromon)	p.12	3	173ft
2)Gavara(Barco, Miodromon)	p.25	3	130ft
3)Barco-Bestia(Imimiodromon)	p.33	3	116ft
4)Briki(**) (Paron)	p.40	2	116ft
5)Goleta(***) (Mioparon)	p.46	2	113ft
6)Scouna-Stavrosis (Imiolia)	p.52	2	72ft
7)Scouna-Lauver (Epidromis)	p.57	2	83ft
8)Bombarda (Livirnis)	p.60	2	50.5ft
9)Kotero (Kerkouros)	p.66	1	75ft
10)Tsirniki (Sakkolefi)	p.70	1	54ft
11)Bratsera (Gavlis)	p.75	2	58ft

Table.no.11

TYPE OF VESSEL(****)	POSITION OF: FORE MAST / OF AFTER MAST
4)Brick (Paron)	From stem 1/4 L.O.A. / 19/28 L.O.A.
5)Goélet (Mioparon)	1/4 Keel L. from Keel fore end / 21/36 Keel L.
6)Scouna-Stavrosis	From stem 3/10 L.O.A. / 6/10 L.O.A.
7)Scouna-Lauver	From stem 1/5 L.O.A. / 3/5 L.O.A.
8)Bombarda (Livirnis)	From stem 2/5 L.O.A. / 17/20 L.O.A.
11)Bratsera	From stem 1/8 L.O.A. / 5/8 L.O.A.

(*) Pages in Kotsovilis,I.K. (1919)

(**) Brig

(***) Goélet

However this rule does not seem to apply in all the examples illustrated by Kotsovillis,G.I. (1919). In table no.10 we have these examples with the number of masts and their L.O.A.

The main differences between the content of tables no.9 and no.10 are, first, the type of -4-Brig and -5-Goélet which had two masts, but which according to table,no.9 should have had three masts; and secondly the types -9-Kotero and -10-Tserniki which had one mast, yet according to table.no.9 should have had two masts. However, the fact that the examples -3-Barco-Bestia and -4-Brig had three masts and two masts, respectively, both with the same L.O.A. persuades us that Kotsovillis,G.I. (1919) determined the number of masts from the type of rigging rather than from the L.O.A. of the vessels.

[19]-Bilias suggests that, on the boats with two masts, the fore mast is placed at 1/5 of the L.O.A. from the stem, and the after mast at 3/5 of the L.O.A. from the stem. I found once again some difficulties in confirming this information by the available examples from Kotsovilis. Table no.11 contains the two-masted vessels from Kotsovilis and the positions of the masts on each of them.

There is great variety in the positioning of masts on the deck, and only the positions of the masts on the vessel -7-Skouna-Lauver are in the same ratio as those stated in the interview. In this case, it is not irrelevant that Skouna-Lauver was the last common rigging in the Aegean before the inboard engines were well established (in the 1920's) ([3]-Stilianou, [6]-Arvanitis, [8]-Chalaris, [19]-Bilias, Denham,H.M. (1986, p.283)).

In order to represent better the ratios of the positions of the masts on the vessels described by Kotsovilis,G.I. (1919), I introduce the diagram in fig.31, on which all of the 6 two-masted vessels are reduced to the same L.O.A.

The results of this diagram show that there are two vessels with very similar positions of masts and these are -5-Goélet and

-6-Skouna-Stavrosis. Another two types are very close to the former two but with differences which I believe are related to the different ways of rigging. The main common feature of all four types is that the after mast was fairly close to the middle of the hull of the vessels. That suggests that this after mast was carrying the main sails of the vessels. On the contrary the type -8-Bombarda-Livirnis, which might be more familiar under the name of Polacca, had a very different position of the masts. In this example the fore-mast was closer to the middle of the hull than the after mast. This, I think, suggests that on this vessel the mast which carries the main sails is the fore rather than the after one.

We will examine the Polacca type later, in the section on square sails and on the early types. At the moment, it seems that the positions of the masts in the last vessel -11-Bratsera are determined by the dimensions of the lug sails. However, we should mention here that most of the traditional Greek vessels under various types of rigging had pole-masts (Konstadinidis,K. (1954, p.138), Lyman,J. (1970), [10]-Binos, [19]-Bilias).

[19]-Bilias mentioned that on Bratsera rigging the after mast was built vertical while the fore mast was raked forward. (A plumb line from the top of the fore mast should point about 50cm aft from the after end of the bowsprit ([19]-Bilias)) By means of this arrangement a greater area for the fore lug sail was provided. On the single mast vessels with a sprit sail a noticeable rake of the mast was also common. (Paris,A.E. (1882-6, plat.91), Landström,B. (1962, fig.510), Adoniou,A. (1969, fig.15,19), Zouroudis,G.I. (1974, fig.17), Damianidis,K & Zivas,A. (1986, fig.17,18))

[10]-Binos mentions that Tserniki hulls with one mast were always rigged with a sprit sail. The mast was at the 1/3 L.O.A. from the stem and raked forward to provide a greater area for the sail. He adds that this rake of the mast was even more extreme on the Tserniki

from the Dodecanese than on those from the northern Aegean.

Before the presentation of types of rigging, I must notice that the evidence from interviews concerning rigging and sails is scarce. [19]-Bilias is one of the very few last traditional sail makers in Greece and he can hardly provide us with information before the 1920's. Unfortunately it is well confirmed from different sources that in the 20's inboard engines were spread all over the Aegean and only a limited number of vessels, most small, were propelled only by means of sails. ([1]-Mavrikos, [3]-Stilianou, [10]-Binos, [19]-Bilias, Denham,H.M. (1979, p.283) So interviews today can only give information about the end of the decline of sailing vessels in the Aegean. Therefore we will give more emphasis to the bibliographical and iconographical sources in this section than to the material from interviews.

We must add here that information about the types of hull of vessels will occasionally be mentioned in this section on sails as it forms one of the main parts of the subject of this work.

2.6.1 <u>Square sail</u> (Σταύρωση or Πηνά ([19]-Bilias, Gourgouris,N.G. (1983, p.536))(fig.32,1)

There are two photographs from 1863 - 1875 (fig.32a, 32b) which show four Brigs in the port of Chanea. All of them are under two masts with square sails and a gaff sail on the after mast. Their hull (at least two of them) was with a relatively raking transom on the stern. According to [3]-Stilianou that was a Nava hull (2.7 Early types). However there are other references ([19]-Bilias, Segditsas,P.E. (1940, pp.237-8)) which suggest that the most common hull carrying this type of rigging was the Karavoskaro type.

Cap. Kotsovillis,G.I. (1919, p.40) provides us with a description of the rigging of Greek Brigs (Μπρίκι, Βρίκι, Πάρον). From table no.3 (1.2 Second period (1830-1880)), about boats built in the period of

1843-1858, we can see that Brigs were 1/3 of all the vessels included in the table.

The photograph on fig.34a is from the Gulf of Chalkis and shows a two masted ship with transom stern, in 1880. The fore mast carries five square sails and the after mast carries a gaff sail and a top sail. According to Cap. Kotsovillis,G.I. (1919, p.47) this is a Γολέτα rigging (Goélet) or Μυοπάρων. Moore.A (1925, p.58) describes a Brigantine which he met in the Gulf of Salonika in 1918. From his description of this vessel we can assume that this was the same kind as the Goélet described by Kotsovillis,G.I. As we have seen in the HISTORICAL INTRODUCTION (1.2 Second period) Brig and Brigantine (Goélet) were the most common kind of rigging among the Greek ships of 1843-1858. Konstadinidis,T.P. (1954, p.140) suggests that these types of rigging were introduced in Greece as copies from the northern American type of schooner in 1800.

I think, the most interesting use of square sails, as a Mediterranean example, is that which appears in the two other photographs. The photograph from Chalkis (fig.34b) is from the same source and date as fig.34a and the other one is from Chios in 1907 (fig.35).

The two front ships of fig.34b as well as the ship on fig.35 had square sails on the fore mast. The interesting remark on this rigging is that when the sails are bent on the yards, the yards of the top sails can be lowered down upon the mainsail yard. This is the Polacca or Polacker rigging. Denham,H.M. (1986, p.285,287) provides us with another photograph of a ship with the same rigging from the Gulf of Moudros, 1915. He calls the ship "Poleacre Bombarda" and he identifies the type of the ship as "a Brigantine with a pole-mast (lower and topmast all in one piece)". Moore,A (1925, pp.53-7) mentions the "polacca Brigantine"(9) as a common type all over the Eastern Mediterranean. "The craft, which are usually Greek, are beautiful toy-like little vessels. The form of hull varies greatly.

Some have a rounded stem like that of a boat, others have a schooner bow with great overhang, some have counter sterns, some a square transom, and some pointed sterns".

Throckmorton,P. (1964, p.213) mentions that in 1800 most big Trechadiria were rigged as Polacca Brigs.

Another representative illustration of the Greek Polacca, as I believe, has been included in Vasiliou,S. (1961, p.112) with the subtitle of "Schooner under Turkish flag. Early 20th century". The vessel was obviously a Polacca with a similar stem to the stem of the vessel in fig.35 (Tserniki stem) and stern with a transom board (Varkalas stern).

Lemos,A.G. (1963, pp.93-107) published a list of the vessels built on Chios from 1892 until 1908. In this list appeared the name and the type of each vessel. We can at least suggest that there are a few cases where the type of the vessels has been identified as "Perama-Bombarda" or as "Trechadiri-Bombarda". This obviously indicates that bombarda was the type of rigging and the type of hull was Perama or Trechadiri. This of course contrasts with the other sources which suggest bombarda as a type of hull. (2.3.2 Bombarda)

So Polacca rigging was well adapted to all the traditional types of hull in the area (Trechadiri, Varkalas, Perama, Tserniki, counter stern vessels).

A more detailed description of this type occurs in Kotsovillis,G.I. (1919, p.60) under the name "Μπομπαρδα (Bombarda) (Λιβυρνίς)". He mentions the characteristics of a polacca rigging and he informs us about the fundamental dimensions of the hull of the boat. Here is, I think, one of the interesting remarks on this kind of vessel. Bombarda (which is a typical polacca rigging from Kotsovillis,G.I. (1919, p.61)) had L.Keel:42f. L.O.A.:50.5f. M.B.:16f and M.D.:8.5f. This gives almost the ratio M.B./L.O.A.=1/3 which is typical for the double-ended Aegean boats today. All the other square rigged vessels included in Kotsovilis,G.I. (1919) are relatively narrower. From the above dimensions it seems that the vessel had a deep draught.

Adoniou,A. (1969, p.19) mentions that Bombarda or Λιβυρνίς had a transom on the stern post and gives some similar dimensions to those mentioned above.

One of the obvious ways in which these characteristics of the Polacca's hull can have some effect on this type of rigging (or perhaps the other way around) is that the width of the hull of the boat determined the length of the yards of the square sails. Kotsovillis,G.I. (1919, p.52 & p.60) gives the description that the length of the yard of the main square sail on a Polacca or on a Scouna (stavrosis) rigging was twice the midship beam of the vessel.

To see the relation of the M.B. with the length of the yards and the sail's area let us give an example. Suppose that we have two boats of the same L.Keel (100%) but one under Polacca rigging and the other under Scouna-Stavrosis rigging (tables no.10 & 11 and diagram in the fig.31) and both built within the ratios that Kotsovilis,G.I. (1919) suggests. Then we will have the following measurements concerning the determination of the dimensions of the fore square sails on both vessels.

Type of vessel	L.Keel	M.B.	Length of main yard	Height Mast	Area of fore sails
-8-Polacca (Bombarda)	100%	038%	076%	120%	7.800%^{2}
-6-Scouna (Stavrosis)	100%	030%	060%	138%	6.486%^{2}

From this table we can see that because the Polacca was beamier than the Scouna, and despite the higher mast of the Scouna, the Polacca had 17% more sail area than the Scouna on the fore mast. It is mentioned even about Polaccas from other countries that they were distinguished by the great area of their fore sails (Boyle,V.C.

(1932,p.117), and Nance,R.M. (1931,pp.396-7)).
These wide square sails on the fore mast of these relatively small vessels (Kotsovillis,G.I. (1919, p.62), & Moore,A. (1925, p.56)) provided additional sail area. This was necessary in order to improve the propulsion of these small, but beamy vessels.
Gourgouris,E.N. (1983, p.540) gives some additional evidence about Polacca rigging. He mentioned that the vessels were medium sized in length but beamier in the middle than the other square-rigged vessels. The fore mast was in the middle of the vessel, and carried square sails ("πινά") and the after mast was smaller with a gaff sail. He suggests that the rigging was very similar to that of the Goélet and Brig. However, in my view this suggestion arises from a superficial study of the iconographic evidence and further analysis produces an alternative suggestion. As we have seen in the fig.31 and earlier on in this section Polacce rigging was different from any other square sail rigging.
First of all the pole mast arrangement was familiar to the Geek boatbuilders. As we will see in the chapter on BOATBUILDING TIMBER (6.1.3.b Cypress) local cypress trees could easily supply the yards in the Aegean with straight long poles for masts ([17]-Papastephanou, [19]-Bilias). Furthermore Denham,H.M. (1986, p.285) mentions the availability of straight long fir "Pyramidal tree" (50-70m) in Greece.
In addition to this technical aspect we can suggest that the long yards of a Polacca rigging can tied up better at the low level of the main yard than on their sailing positions. Fig.40 provides us with the evidence to suggest another feature of Polacca rigging. In this illustration all the square sails and the yard on the mast are not only tied on the yard of the main sail but they are bent in a way such that they would not be extended on the sides of the vessel. This was very useful when the boats were in the small ports of the Aegean

because the space required for them was substantially reduced.

Cap.Kotsovillis mentions two subtypes of Bombarda. The one which is described above is with a gaff as the after sail and often a top sail and the other, which is called Bombarda sabatiera (Μπομπάρδα σαμπατιέρα or ερμαφρόδιτο or γαυλολυβιρνίς), is carrying a lug sail on her after mast. He actually suggests that when the hull of the boat is a Trechadiri it is better to have a Bombarda sabatiera rigging.

Lemos,A.G. (1963, p.88) published the drawing of a Polacca vessel (Bombarda in fig.24b) under a mizzen lateen sail with a peculiar boom heel; though he does not mention the date of this popular drawing.

Evidence about building Polaccas in the Aegean comes from the first years of the 19th century. Bekiaroglou - Exadactylou,A (1988, p.110) gives evidence of a Polacca built in Galaxidi in 1804. Howe,S.G (1828, p.200) mentions that "the Ipsariots pushed their commerce to every part of the Mediterranean, and their light Polacca vessels were everywhere remarked on for the grace of their model, their speed and excellence in manoeuvring".

Further earlier references about Polaccas will be examined in the 2.7 Early types.

Another type with square sails has been described by most contemporary authors. This is a type of rig with one mast carrying two or three square sails and a sprit sail. Moore,A. (1925, p.39) gives a description of this type of rigging. In addition to the description of the rigging he gives us some information about the hull of the boat: " ...she looked less than forty-five feet [in length]. Her beam was great in proportion. Her bows were bluff, her stem high and curved, her forefoot rounded. The stern was pointed and higher than the bow. The rudder head was higher still, and she steered with a tiller. Her dingy black sides were protected by a rubbing streak of dull red.". He mentions that the boat was called in

Bosphorus Tchektima and she carried two jibs running on stays, a fore staysail, a top square sail, a low square sail and a sprit mainsail. He gives the description of an other boat of the same type but with a "modified lateen" sail instead of the spritsail and says that he had been informed but, not for certain, that her name was "Pennah" (Moore,A. (1925, p.44).

Landstrom,B. (1962, fig.508) gives an illustration of a similar vessel as a Turkish coastal vessel and the same type has been illustrated in another two accounts of rigs (Paris,A.E. (1882-6, plat.77), Verwey,D. (1932, p.191)). The same rigging appears in fig.40.

Kotsovillis,I.G. (1919, p.70) describes the rigging of a boat called Tserniki (Τσιρνίκι or Σακκολέφη) which is similar to the boats with one mast and square sails, described by Moore,A (1962, p.44), Landström,B. (1962, fig.508) and Verwey,D. (1932, p.191) The fundamental dimensions of this boat had more or less the same ratio as the "Bombarda Brigantine" two masts vessel:

	L.Keel	L.Stem	L.Stern	L.O.A	M.B.	M.D.
Bombarda:	42ft.	5ft.	3.5ft.	50.5ft.	16ft.	8,5ft.
Tserniki:	43ft.	7ft.	4ft.	54ft.	16ft.	7ft.

I believe than these similar dimensions of the two boats are associated with their common feature of pole-masted square sails. The same remarks that we suggest on the Polacca type can be applied respectively to this type of rigging.

[19]-Bilias mentions that a square sail can drive a vessel as close to the wind as about 40°. This can give an idea how difficult it was to sail between the Greek Islands under square sails.

2.6.2 <u>Lateen sail</u> (Λατίνι (το))(fig.32,2)

Two photographs show a number of boats with lateen sails (fig.36 and 37). We can distinguish four types of lateen rigging on these photographs. The simplest one is a lateen sail with a jib. The hull seems to have a transom stern (fig.36). Moore,A. (1925, fig.92) contains a description of the same rigging mounted on a double ended boat.

Another type is the boat with a lateen main-sail, a jib and a small lateen as a mizzen sail. This again has been mentioned by Moore,A. (1925, p.141). The next is a half lateen sail (Μισολάτινο ([19]-Bilias)). (The luff or leading edge of the sail was set on the mast and it was not extended before the mast). A stay sail occupied the area in front of the mast. The boat does not seem to have any bowsprit and she is double-ended (fig.37). Moore,A. (1925, fig.136) gives an example of this sort of rigging where in addition to the half lateen sail and the fore sails two jibs appeared.

The last is the third boat on the photograph (fig.37) and her lateen sail is carried by a half boom attached at its fore end to a post. There is a fore-sail and a jib. The boat is double ended and shows a great sheer. There is a detailed description of this kind of rigging in Moore,A (1925, p.142).

Verwey,D. (1932) gives a short account of the first and the last of these types of rigging as "Turkish rigs".

Boats with one mast under a traditional lateen sail and a jib were very common in the Aegean even in the second half of the 20th century ([3]-Stilianou, [10]-Binos, [12]-Kozonis).

Kriezis,G.D. (1860, p.19) gives the earliest evidence about the type of "Λατινάδικο" in Hydra. This was a Trechadiri hull under one or two masts with lateen sails and it was used about the middle of the 18th century. Konstadinidis,T.P. (1954, p.138) mentions that Latinadiko was a vessel about 40-50tons capacity and pole-masted (earlier with two and later with three masts). The type was extensively built in the Aegean during the 18th century (Konstadinidis,T.P. (1954, p.138)).

[19]-Bilias suggests that a type of bigger boat than the usual size of boats under lateen sail (10m) was used rarely by the people around Messologi (West coast of the Greek mainland) where they called it "Passara". There is a description that instead of lowering the lateen sail people climbed on the yard and stowed the sail on the yard ([19]-Bilias). This type of lateen sail was very similar to the one which existed in the Adriatic sea (Denham,H.M. (1967, p.175)) (similar lateen sail arrangement can be seen in Egypt today).
[19]-Bilias and [10]-Binos suggest that a lateen sail could drive a boat closer to the wind than any other sail in the Aegean. However the lateen sails on the small boats were very light and the sails could not work well under strong wind. So this kind of sail was used under the light breeze which is very common in the Aegean. Only one person was required to set the lateen sail on a boat about 5m L.O.A. ([19]-Bilias). The position of the mast for a lateen sail was at 1/3 of the L.O.A. from the stem ([10]-Binos, [19]-Bilias and Kotsovillis,G.I. (1919, p.116).

2.6.3 <u>Spritsail</u> (Σακκολεύα or Σακολαίφι)(fig.32,33)

Konstadinidis,T. (1954, p.140) suggests that the name "Saccoleva" comes from the "sacco" & "levare" (French). Koukoule,F.I. (1950, p.300) however identifies the word "Σαγολαίφεα" in a Byzantine text and mentions that this word was used for the spritsail during the 12th century in the Aegean. Throckmorton,P. (1964, p.213) suggests that this type of rigging was in use as early as classical times. Nance,R.M. (1913) however mentions the northern European origin of spritsails and put the question whether the spritsail in the Levant was a northern European influence or a local development of this type of sail.
There is a post card from the early 20th century from Piraeus which shows a simple form of spritsail used in the Aegean (fig.38). The

hull is a Trechadiri with curved stem and stern posts. The mast has a forward rake of about 30^{o} and the yard is longer than the length of the boat. There is a spar hanging on the side of the boat wich is possibly a sort of setting-boom for running sailing.

On another photograph from Thessaloniki, 1928-32 (fig.39) there is another double-ended boat with one mast and a spritsail, fore sail and jib. The boat had an extremely curved sheer and the gunwale ends before the stern and the stem post.

Another photograph (fig.15b) shows the attachment between the sprit and the mast of a spritsail. We must mention here that the sprit does not seem to have any special way of fastening on the mast. The hull as we mentioned in the section 2.2.3 Botis (Gaita) is a "Gaita Kostadinopolitiki".

There is the photograph (fig.37) which shows a boat carrying a spritsail and a jib or a fore sail.

Moore,A. (1925, p.39-40) describes a boat with a spritsail, two square sails, a fore sail and two jibs. Later in his book he gives another example of the same boat where the square sails have been abandoned (Moore,A. (1925, p.40). Verwey,D. (1932) gives short illustrations of the same type and he suggests that the first type was for vessels of about 40tons while the second one (without square sails) was for vessels of about 10tons.

The spritsail was a common main sail on a Tserniki boat. The illustration that Kotsovillis, G.I. (1919, p.70) provides shows again square sails and it has been described earlier on in the text (2.6.1 Square sail).

He mentions that there is a special form of spritsail which has been carried by a type of boat called belou which was common in Cycladian islands. The sprit of these boats instead of a separate fore sail was extended foreward of the mast with the forefoot attached to the head of the stem post (Kotsovillis,G.I. (1919, p.73) and Konstadinidis,T.

(1954, p.136)). [19]-Bilias suggests that this type of spritsail on small vessels was the last one which has survived as late as the middle of the 20th century. This last version of this sail was without a jib sail and could not be reefed ([19]-Bilias).

The most complex representation of a spritsail comes from Landström,B. (1962, fig.510) who names the type of the boat "Trechadiri". In addition to the main sail she carried a jib, a fore sail, a small square top-hanging sail, a top trapezoid sail and a mizzen lateen sail. When I asked [19]-Bilias about this kind of rigging he suggested that I should pay no attention to these kinds of complex representations. He said that it is impossible to serve all these sails at the same time and in any case they can never be set altogether. [19]-Bilias however had no particular knowledge about rigging during the period that Landström's illustration refers to (18th century). Paris,A. (1882-6, plat.91) and Nance,R.M. (1913, fig.8) illustrate a similar rig under the name of Greek "Sacolève" and "Σακκουλεύη" in 1835. In both illustrations there appeared, in addition to the spritsail, two square sails, a jib and a "little leg of mutton steering sail". The hull can clearly be identified in the first reference as having a transom on the stern and a straight raked stem post (F.D. table.no.29, boat,sacolève).

Konstadinidis,K. (1954, p.139) mentions the use of this type of rig on Tserniki hull. So this type of rig was used on all of the Trechadiri, Varkalas or Tserniki hulls.

A similar sort of rigging has been presented on sponge divers' boats from the island of Symi which can be identified as a Skaphi hull (this is in Zouroudis, G.I. (1974, n.p.) and the name of the artist is Oikonomopoulos,N.) (fig.40) (2.3.3 Skaphi from Symi). The boat carried a spritsail, two square topsails, a steering sail, a fore sail and three jibs. The setting of the two square topsails shows influences from Polacca rigging (in the chapter on 3. MORPHOLOGY we are going to study further the purpose of the steering sail on this type of hull (3.2 Propulsion and ballast)).

[19]-Bilias suggests boats under saccoleva sail can be driven as close to the wind as 10-15 degrees (obviously exaggerated). The main advantage of this sail is the stability that it provides to the boat during rough weather. The form of the sail can be described as "baggy" in the upper part and because of this, the propulsive force on the boat from the sails had a degree of upwards direction or lift. This direction of the force determines the good stability of boats under the saccoleva rig ([8]-Chalaris, [10]-Binos, [19]-Bilias). The disadvantage of this sail was that in order to be set it required more people than any other type of sail. [19]-Bilias suggests that the minimum number of people required to serve a saccoleva sail was three.

2.6.4 <u>Lug sail</u> (Ψάθα (Η) or Τουρκέτο-Μαίστρα ([19]-Bilias, Gourgouris,E.N. (1983, p.539))(fig.32,4)

There is a photograph of a Trechadiri hull with two masts which carried two lug sails and two jibs (fig.41a). The after is a standing and the fore is a balance lug. The boat has again a greater sheer line than the usual Trechadiria of today. There is an other photograph of a boat with the same rigging (fig.41b). The hull of this boat seems like a Trechadiri but it is more beamy on the fore part than the Trechadiri. Denham,H.M. (1986) mentions the similar rigging of a Trechadiri with lugsails and a Trabacolo from Adreatic sea. The hull on the fig.41b was possibly a Trabacolo hull rather than a Trechadiri one or a modified type which showed influences from both Trabacolo and Trechadiri types.

Moore,A. (1925, p.231-2) describes the same sort of rigging and refers it to both Greek and Italian sailors. In addition to two mast lugers he illustrates an one mast boat with a lugsail ([19]-Bilias mentions the existence of single masted luggers).

Kotsovollis,G.I. (1919, p.75) also described the rigging of the Bratsera (Μπρατσέρα or Γαυλής). It is worth noting that he illustrates the Bratsera boat with two dipping lug sails, in addition to a square top sail on the after mast.

Danham,H.M. (1986, p.28) presents a two lugsail boat from the Aegean which is called a Bratsera. He gives some interesting consideration about the similarities in the appearance between a Bratsera rigging and a late example of the lug sailed Trabacolo. According though to [19]-Bilias there was a difference between the Italian and the Greek Luggers. The Italian had both sails on the same side of the mast while on the Greek boats the fore lug was always on the starboard side of the mast and the after one always on the port side of the after mast (fig.41b, Bonino,M. (n.d. p.20,41), and Denham,H.D. (1967, p.23)).

Landström,B. (1962, fig.504) gives an illustration of a Bratsera rigging on a hull like a Trechadiri with an extremely curved sheer line. There are a lot of contemporary popular artistic representations which illustrate this kind of rigging especially on a Trechadiri or a Perama type of hull (Maritime Museum of Galaxidi, Maritime Museum of Pireaus, Folk Museum of Salamis, Vasiliou,S. (1961), etc). The fore mast of a Bratsera vessel was usually raked foreward in order to give a greater area of sail abaft the mast ([19]-Bilias, and a number of contemporary illustrations from the above mentioned collections).

The Lugsail was the heaviest sail types to set up. On a Bratsera at least five people were required to use adequately both lug sails. There is evidence that for a Bratsera rigging the hull of the vessel had to have more draught and more ballast than with other types of rigging ([19]-Bilias). On most of the illustrations of Bratsera the after sail appeared as a standing lug and the fore as balance lug (fig.41a). This arrangement of Bratsera rigging has been mentioned as more effective by both [19]-Bilias and Poulianos,A.I. (1977, p.575). [19]-Bilias suggests the Bratsera could sail as close to wind as almost "5°" (!). On the one hand there is a suggestion that the name Bratsera had an Adriatic origin (Konstadinidis,T.P. (1954, p.137)) but on the other hand Denham,H.M. (1967, p.24) suggests that Bratsera must not be confused with the Dalmatian Brazzera.

Another version of a Bratsera boat appears on a photograph (fig.42). She carried a fore lug sail and an after gaff sail. She again has a great curved sheerline. This version of the Bratsera has been mentioned both by Kotsivillis,G.I. (1919, p.74), Moore,A. (1925, p.233), and Gourgouris,E.N. (1983, p.539). Another illustation of a Trechadiri hull carrying a lug sail on the fore mast and a gaff sail on the after mast has been included in Zouroudis.I.G. (1974, p.76). Another interesting illustration has been provided by the same source on which a Karavoskaro hull was carrying on the fore mast four square sails and on the after mast a lug sail, the suggested name was "Karavoskaro Goélet or Scouna" (Zouroudis,I.G. (1974, p.76)).

2.6.5 <u>Gaff sail</u> (Μπούμα or Ράντα)(fig.32,5)

There are some illustrations with a Trechadiri boat carrying a gaff sail (Damianidis,D, & Zivas,A. (1986, fig.21,24). Moore,A. (1925, p.82) also noticed boats with one mast carrying this rigging in the eastern Mediterranean. The same type of rig appeared on the photograph in the fig.43.

Kotsovillis,G.I. (1919, p.66) presents a special sort of rigging of a boat called: "Κότερο or Κέρκουρος". This had one mast and it carried a gaff sail, a square low sail, an upper sail, a fore sail and a jib. The hull of the boat is beamier than a Bratsera, or Tserniki or Bombarda with the same length.

There is a photograph from Piraeus (fig.44) which shows Peramata hulls with two masts carrying two gaff sails. The sheer line of these Peramata is extremely curved and one of them has a longer bowsprit than usual. This type of rigging was common in the Aegean during the early 20th century under the name "Lauver" (Λόβερ)([19]-Bilias, Kotsovillis,G.I. (1919, p.58). [3]-Stilianou mentions that both Trechadiri and Karavoskaro hulls were sailing under Lauver rigging.

"Evaggelistria" the vessel with a Perama type of hull which appears in fig.122h carried this type of rig. The first years after she was built in 1939 were spent under Bratsera rigging but soon after that she was modified to a Lauver rig. Early in the 20th century the very common type of Bratsera rig was replaced by the Lauver type ([19]-Bilias) (fig.43, 44). This is because the Bratsera although, a faster type of rig, required more effort and almost double the number of people to set the sails than the Lauver.

In Throckmorton,P. (1964, p.213) we can find another suggestion about the evolution of rigging on the type of Trechadiri hull. He mentions that "In 1800 most big trechandiris were rigged as Polacce Brigs. In 1850 the same hull might have been rigged as a Brigantine. Smaller trechandiris at the same period were often rigged Bratsera, that is with two lug sails and a large foresail. The smallest were rigged sakoleva, a rig which existed in classsical times. When steam began to compete heavily with sail in the last half of the century, and owners had to cut down their crews, some of the big trechendiris were rerigged as schooners or psatha randa, that is with a Bratsera foresail and a European type gaff mainsail".

Tzamtzis,A. (1972, p.45) mentions the type of "Σκούνα" (Skooners) as vessels with a transom board on the stern and two gaff sails (bouma). According to [19]-Bilias, vessels under Bouma can sail as close to the direction of the wind as about 10^{o} (!).

2.7 Early types

There is evidence of other types which existed earlier than those which are mentioned above. For those early types the interviews can not provide any specific information. Most of these vessels were not built as late as the 20th century and only few bibliographical or iconographical sources provide us with information about them. There is an obvious lack of technical information about these types but I think it is worth to note them as some of the fore-runners of the traditional vessels in the Aegean during the 20th century. The available information on these types is often not even enough to indentify them as types of hull or types of rig. Therefore I will mention them in alphabetical order without any intention to introduce any sort of classification among them.

<u>Alamana</u>. [10]-Binos mentioned this as another type of vessel without giving any specific description. Konstadinidis,T. (1954, p.137) mentions the Turkish origin of this type. According to this last source the Alamana had a crew of about twenty people and she was often under a big lateen sail. The same source mentions the similar type of "<u>Malteza</u>" which was common in Sphakia (Krete).

<u>Gagava</u>. Denham,H.M. (1979, p.114) publishes a photograph of a vessel of this type. The stem was straight like the Tserniki and the vessel was under a lateen sail and stay sail. Denham,H.M. (1986, p.281) identifies the vessel as a "settee or spritrigged sponge-drogher". [11]-Polias mentioned Gagava as a method of sponge diving related to the Skaphi hull.

<u>Kagalis</u>. This was a vessel with a bow like a Perama hull and stern like a Botis hull (Poulianos,A. (1977, p.539). According to one other source Kagalis was a boat from the black Sea (Kodoglou,F. (1981, p.48). However there is information that particular vessels from the Black Sea (known as <u>Μαυροθαλασσίτικα</u>) had a transom on the stern ([3]-Stilianou, [12]-Kozonis). According to Denham,H.M. (1986, p.281) vessels from the Black Sea had more pronounced sheer than the other

types in the Aegean. Vessels under this later name have survived as late as the first half of the 20th century.

Karavosaita. Konstadinidis,T. (1954, p.138) mentions that this type was a vessel with a carrying capacity of 40-50 tons and pole masts.

Kokorely. This was a type of hull with both posts curved. There is information for this type that it was built on the island of Ikaria (Poulianos,A. (1977, p.539)) and in Southern Peloponneses ("Αιγαιοπελαγίτικα καράβια" (n.d. pl.5).

Lephka. Konstadinidis,T. (1954, p.115) mentions that Lephka was another name for a type of Saccoleva and that it was common on Samos and Ainos. This type was a vessel with two masts under square sails (?) and about 100 tons. The building of this type declined after 1780 when other more modern types were introduced. In another source Lephka has been mentioned as a type of rigging.(Kodoglou,F. (1981, p.48)) Nikodimos,K. (1862, p.73) however mentions that people from Chios called their ships Lephka because they were not allowed to built "Καράβια" from the Turkish authorities. We do not know which exact type Nikodimos,K. calls "Καράβι" but we have the information that Lephka was a devious name for vessels used by the people of Chios. Furthermore the word "Λευκα'" means white in Greek and there is a late Byzantine source (12th century) where this word is mentioned as identifying the sails (Koukoule,P.I. (1950, p.297) "Τό δέ ίστία λευκά πέτασον"). According to all the above information we can assume that Lephka was nothing more than a general name of early sailing vessels used by the people from Chios.

Martigos. Tzamtzis,A. (n.d. p.45) mentions Martigos as a small Brig or Goélet of 20-40tons capacity. The vessel had two masts with the fore under square sails and the after under gaff sail and top sail. In Turkey this vessel was called "Caramousal".

Lyman,J. (1972, p.203) associates the Greek Martigos with the Mediterranean Martigana and he suggests that the type was in existence during the 19th century in Italy, Tripoli, Malta, Turkey, and Greece. Furthermore he mentions that in 1821 this type was the second most common vessel type in the Island of Hydra.

Mistikon. Konstadinidis,T. (1954, p.135) gives information of a type called "Mistikon (Spanish Mistico) or Zambekon (Italian sciambecco, French chebec)". He suggests that the Mistiko was a pirate's boat which was propelled either by means of oars or of sails. The type had three pole masts under lateen sails. He suggests that the small Mistikon was similar to the later type of Trata (20-30tons). During the war for independence the names of Mistikon and Goélet were common names for any type of vessel (Konstadinidis,T. (1954, p.135)).

Nava. [3]-Stilianou mentions that the Nava was like a Karavoskaro with an oval transom on the upper part of the stern instead of an counter stern (fig.35,36). He believes that the origin of this type was from North America. [19]-Bilias mentions that the Nava was a vessel with four masts carrying gaff sails and top-square sails.

Polacca. Despite the type of Polacca rigging described earlier in the section on sails there are some earlier accounts of Polacca types which show some differences from the later 19th century version of this type. On an early illustration of Greek Polacca (1801) (Tillemite,E. (1967, p.143)) this type of rigging appeared with three masts. The fore and main masts were carrying square sails on a Polacca style and on the mizzen mast was a gaff sail with a square top sail. Another Polacca appeared as a silhouette in a modern source (Tzamtzis,A. (1972, plan,no.25)) with three masts as well.

Here the mizzen sail was a lateen sail instead of a gaff sail.

Tzamtzis,A. (n.d., p.44) mentions the Polacca as a three masted vessel with a triangular sail on the mizzen mast. He adds that the stern of the vessel was raised and on the gunwale level a structure like a balcony projected abaft the stern.

The name of Polacca has been mentioned in connection with an illustration more than a century earlier (1679) (Roërie,G. (1946, p.203)). However in this earliest illustration the vessel depicted was not under a Polacca rig as it was later known (2.6.1 Square sails). The forward raking mast was under lateen sail, the main mast carried two square sails and the mizzen mast a lateen and a square top-sail. Konstadinidis,T.P. (1954, p.152) mentions that a type of merchant Polacca was common in Western Europe from the middle of the 16th century onwards. The most interesting part of this search about the Polacca is that the same vessel as had been illustrated in the previous sources, or sometimes with the name of Polacca, has been associated in some other sources with the name Kirlangitch a type not clearly indentifed as part of the Eastern Mediterranean (Vaughan,H.S. (1923), Lyman,J. (1954), Anderson,R.G. (1955)).

Bekiaroglou-Exadaktylou,A. (1988, p.112-3) gives some evidence from Turkish sources that Greek shipwrights on the Island of Hydra built to order a number of Kirlangitch for the Turkish Navy in 1769 and in 1791. She mentioned that in addition to the vessels of this type for the Navy there was another kind of trading Kirlangitch (Bekiaroglou - Exadaktilos,A. (1988, p.143)) and that both kinds were relatively small vessels (about 24m length of the keel).

Euthimiou-Chatzilakos,M. (1983, p.201) gives evidence that the Kirlangitch or Kirlanguich was a type of vessel built in the greek boatyards of the island of Rhodes during the 18th century. Konstadinidis,K. (1954, p.144) suggests the dimensions of 23m L.Keel and 28m L.O.A. for a Kirlangitch.

I could not longer continue researching this type but I suggest that the Polacca type was one of the oldest types of the Aegean vessels which survived as late as the middle of the 20th century. Lyman,J. (1970) publishes some notes on Greek pole-masted vessels based on illustrations of the "Greek Merchant Ships" (Vasiliou,S. (1961)). He actually focuses on the vessels with pole-masts rather than on the

Polacca style and suggests that pole-mast structure was very common among Greek vessels. Most of those vessels carried three masts of which often the main and the mizzen were pole-masts. The dates of all of these vessel are within the 19th century. However only one of those vessels was a Polacca Bombarda (1908) with the typical rigging and had two masts.

Sachtury. Tzamtzis,A. (1976) suggests that this was a common type of small vessel in the Aegean during the 18th century.

Konstadinidis,T.P. (1954, p.114) mentions that the first Sachtury boats were built on Hydra in 1701 after the introduction of the Trechadiri type. These first Sachtury were about 10-15tons carrying capacity. Sachtury was one of the early types of small vessels under square sails (Kostadinidis,T.P. (1954, p.138)).

Trabaccolo. Gourgouris,G.N. (1983) mentions that the Trabaccolo was a small and beamy vessel under rigging similar to the Bratsera rigging and with only one jib. This name of the common Adreatic type was often applied to vessels from the Ionian Sea.

Konstadinidis,K. (1954, pp.126-60) and Tzamtzis,A. (1972) mention some other types of vessels without though any clear identification of them. It is beyond the scope of this thesis to give an extensive historical account of all the named vessel types which have existed in the Aegean during the last three centuries.

2.8 Comments on the classification

In the chapter on 7. CONSTRUCTION we are going to study further the structural differences between the four basic formations of hull.

The variety of types among the double-ended and transom-stern vessels is remarkable. By contrast counter-stern and round stern vessels showed limited variation. Is this a matter of the different origins of these forms and the different periods of their life in the Greek waters? All the evidence above supports this hypothesis. Furthermore

I suggest that the Liberty type was a simplified version of the Karavoskaro type. Liberty was not associated with any type of rigging and all the evidence suggests that this type was a wooden motor boat introduced after the Second World War ([3]-Stilianou, [15]-Vrochidis, Adoniou,A. (1969, p.32)).

The difference in form between the Liberty stern and the Karavoskaro stern is not so easily identified by inexperienced people. Boatbuilders, however, considered the two types as totally different. This is true from a technical point of view. Liberty can be built by the old traditional moulding method while the Karavoskaro requirs laying out and lofting. This difference in method allows the boatbuilder without knowledge of laying out and lofting to build vessels similar to a Karavoskaro. Thus the well established tradition of the moulding method was able to assimilate for the last time (at the middle of the 20th century) a foreign type (Karavoskaro) and to produce the new type of Liberty which resembled it (10) (2.4.1 Liberty, 5.2.2 Moulding with adjustable templates, 5.3 Lofting methods).

The Karavoskaro was undoubtedly introduced in the Greek yards earlier than the Liberty. Most of the historical evidence suggests that this type was introduced at the same time as the contemporary new technique of laying out and lofting ("Sala") (5.3 Lofting methods). This was around the end of the 18th century. At the same period, I suggest, the introduction of the new contemporary types of rigging took place which were based on the main gaff sail (Brig, Goélet) and which were associated with the Karavoskaro hull.

As we have shown in the HISTORICAL INTRODUCTION (1.1 First period) this naval and technical boom by the end of 18th century in the Aegean owes its generation to the development of merchant activities among the islanders. Another reason which determined this technical improvement lay in the permission that the Sultan gave to the non-Ottoman people on the three main maritime Islands to build "Karavia" which could be armed (Nikodimos,K. (1862, pp.73-4), Denham, H.M. (1986, p.286)). Despite the stem and the stern structure the main feature which can distinguish all the old types of hull from those of the Karavoskaro and Liberty is the ratio M.B./L.Keel. According to the information which is included in the tables no.5,6,7,8 these ratios had the following limits:

Trechadiri.......1/2 > M.B./L.Keel >1/3 (most of the information suggests M.B./L.Keel=1/2)

Perama...........1/2 > M.B./L.Keel >1/4 (most of the information suggests 1/2 > M.B./L.Keel >1/3)

Varkalas.........1/2.6 > M.B./L.Keel >1/3

Karavoskaro......1/3 > M.B./L.Keel >or=1/4

Liberty..........1/3 > M.B./L.Keel >or=1/4 (sometimes even narrower)

Moreover this difference of the ratio M.B./L.Keel was related to the types of rigging which were applied to the different hull types.

As we will see in the chapter on MORPHOLOGY (3.3.1 Middle part of the hull, 3.3.3 Bow and stern) in addition to the different origin between the new types (Karavoskaro, Liberty) and the old ones (Double-ended, Transom-stern) the structure and the form of the stern, stem and middle frame on these vessels was one of the features which influenced the different ratios of M.B./L.Keel.

The developed old types of double-ended and transom-stern vessels provided forms of local craft adapted especially to the demands of local activities. We showed some of these local crafts like: Skaphi from Symi, Varkalas from Hydra, Konstadinopolitiki Gaita, Varka from Chania. We will examine further these local influences on boats' hull in the chapter of MORPHOLOGY (2.8 Geographical relationships).

The distribution of these local craft together with the information on the distribution of the most common types of hulls in the Aegean during the 20th century is illustrated in the map in fig.45. We must explain that this distribution is based on information from the interviews which form part of this research. This means that we necessarily omit other places with boatyards but from where no available interview information exists. However studying the bibliographical sources we can assume that the distribution in fig.45 is sufficienctly reliable for the present purposes. So we can see that Trechadiri has been built in all these places. The Gatzao was built only in the Ionian sea. The Botis was more often built on the Western Aegean Islands, the Gaita as a small fishing boat was built in various islands in the Aegean. The Tserniki was more often built on the Eastern islands. The Perama was built particularly in Lesvos, Samos, and Syros (because of the relationship of this island with the eastern islands (HISTORICAL INTRODUCTION, 1.2 Second period (1830-1880)). Small Perama were found only on Lesvos. The Trata was extensively built in various islands. The Varkalas was commonly built in the Dodecanese. The Skaphi was built in the Dodecanese and especially on Symi. Varkalas from Hydra were built in the islands of the Argosaronic Gulf. Boats from Chanea were found only in Chanea. The Liberty was built in most of the places, and the Karavoskaro was built in places were laying out and lofting facilities were used. So we can see that within the Aegean boatbuilding tradition other local traditions of the form of boats existed and determined the variation of the old basic formations of hull. We are going to examine this determination of boat'forms by local traditions or function in the next chapter on 3. MORPHOLOGY.

<u>notes:</u>

(1) Despite the morphological differences of the stem post from type

to type the actual structure of this part of the boats remains almost the same.

(2) The stern post is projected after of the transom in the case of an external rudder (e.g 2.3.3 Skaphi from Symi).

(3) Τρεχαντήρι comes from the verb Τρέχ/ω

Τρέχ/ω......v.i.&t. run; hasten; go round (all over the place); wander; flow; run; leak (The Oxford Dictionary of Modern Greek, Pring,J.T.).

Moore,A. (1925, p.166) mentions the name of "Trahandilla" as a type of Maltese rigging.

(4) Filgueiras,O.L. (1985, p.228) gives the profile illustration of a traditional Portugese vessel under the name "Bateira" which seems very similar to the profile of a Trechadiri. This does not necessarily indicate a common origin, profiles similar to Trechadiri occurred independently also in other traditions.

(5) There is evidence from the 18th century about a vessel called Sayka or Çayka or Saita, Bekiaroglou - Exadactylou, A. (1988, p.145) & Konstadinidis,T. (1954, p.139). This vessel was bigger and was propelled by means of oars or simple rigging which consisted of a square or lateen sail.

(6) The name of "Varkalas" can possibly be associated to Barque. Denham,M.H. (1970, p.289) suggests that Varkalas related to the Arab "Baggala". Hourani, G.H.(1951) mentioned "Baghalah" as a traditional Arab vessel with a transom on the stern. He believes, however, that boats with transom on the stern became common in the Arab boatyards after Western influences in the last three centuries. And the name "Baghalah" originally related to a double ended vessel.

(7) [11]-Polias mentioned that Turks called this type "Shubeki" and the island of Symi "Shubekili". He translates the first as "Skaphi" and the second word as "Skaphi's island". Slot,B.J. (1977, p.220) mentions the information from a source in 1650 about the local small

vessels from Symi under the name "Simbequirs" or "Sumberchi", and he gives the explanation of Symi & barcki (vessels). It is not clear how this early name of the vessels was spelled but in respect to the Turkish origin of the word we might wonder about its relationship with the name of chambequir or chabek or jabeque or ziember or xebeck or xebec which combine an apparently common Eastern Mediterranean type of vessel around the 17th and the 18th century (Corney,B.G. (1911), Anderson,R.C. (1929), Lyman,J. (1954) and Anderson,R.C. (1955)).

(8) Begede is the Turkish name for this type of boat.

(9)Sir Alan Moore p.53-57. His description about the fore part of the rigging of these boats is clear. "From the topmast head of an ordinary square-rigged formast three stays lead to the bowsprit and jibboom,viz. the fore topmast stay , the inner jibstay, and the outer jibstay. Were these present at the morphological equivalent of the topmast head of a 'Polacca' they would prevent the lowering of the topgallant yard in the manner described, and so she has no fore topmast stay or jibstays there, but instead has three stays springing from the head of what corresponds with the topgallant mast."

(10) Adoniou,A (1969, p.32-3) suggests that the Liberty type was introduced in the Greek shipyards as a copy of Northern European fishing vessels. This does not however conflict with the hypothesis that the Liberty was a practical simplification of the Karavoskaro type.

3. MORPHOLOGY

Studying the classification of the vessels it proved very difficult to provide a clear way to i~~d~~dentify any particular boat. For example in the Trechadiri type of hull there are a number of boats included carrying the initial features of this type but with noticeably different lines or even different ratios of F.D. (see F.D. table.no.16 boat, red, green, and table.no.18 boat,no.30, table.no.19 boat,no.37). We mentioned already some of these additional variations of parts of the hull within some types (for example: Karavoskaro - middle section, Varkalas - stern post).

At the same time there is much information from the interviews which suggests differences in the hull of the boats (often of hulls from the same type) which can depend on the use or the kind of rigging or even the origin of the vessel.

We showed on the distribution map of types (fig.45) that some types of hull were associated with particular areas in the Aegean or with a particular island. And we suggested that this was in respect to local traditions or activities.

These facts lead us to an additional study of the shape of the hull of the vessels without necessarily looking only into separate types (often the same influence of the use of a boat on its hull applied on more than one type).

Therefore this chapter does not deal particularly with structural features or names of types or even basic formations of boats. The content of this chapter is a study of the relation between the form of the hull and the causes which determine this form. We decided to call this a study on morphology because we think this term suggests a search for the relationship between causes and forms rather than a classification of forms.

Besides the aim of a closer study of the realization of a boat's hull

I will pay more attention to features which can be used as additional evidence for the study of traditional methods for controlling the shape of the boat during building in the Aegean.

In order to have a basic order of the material of this chapter I will separate the four following categories:

3.1 The influence of function

3.2 Propulsion and ballast

3.3 The concept of fair lines

3.4 Geographical relationships

Bibliographical sources on the subject are really rare(1) and most of our evidence is provided by interviews, field recording and iconographic sources.

3.1 <u>The influence of function</u>

There is a substantial amount of information from the interviews about the influences of the basic use of a boat on the shape of the hull. Most pieces of information suggest as basically distinguishable types of function: fishing, trading and diving for sponges. Cruising some times appeared as a fourth function but it seems to have the same influences on the form of the hull as the diving function. Often this influence of the use (function) on the form of the hull was not particularly relevant to the <u>type</u> of the boat. Most of the pieces of information have the standard form of a simple description concerning comparis.ons of the beam and the draught among boats with different functions. This form of information allows us to present the relationship of function to form in the following table.no.12.

In fig.46,47 and 48 we represent how these suggestions of form according to the function can determine the overall formation of the hull of a Trechadiri boat. In these figures there is a schematic representation of some lines of boats. In fig.46 the vessel appears of the sort used as a fishing Trechadiri. In fig.47 there are lines

Table.no.12

Part of the hull.	Function.	Interview.
	FISHING	
Bow :	Narrow under the the sea and wide on the deck.	[5]-Dardanos
Middle section:	Some draught without need of cargo (1/3 of M.B.) trawlers need more draught than others, Small boats shallow	[5]-Dardanos [6]-Arvanitis [1]-Mavrikos [13]-Kontatas [3]-Stilianou [17]-Papaste/nou
Stern :	Narrower than trading similar to V-shape	[3]-Stilianos [12]-Kozonis
Deck :	Widest Sheer line less pronounced than on the other boats	[1]-Mavrikos [12]-Kozonis [13]-Kontatos [17]-Papaste/nou
Lower W.L. :	Narrower than trading	[1]-Mavrikos [11]-Polias
	TRADING	
Bow :	Beamier than the other boats.	[2]-Kornidakis [11]-Polias
Middle section:	More draught than fishing boats(loaded); it needs ballast (unloaded)	[3]-Stilianou [6]-Arvanitis [11]-Polias [13]-Kontatas [17]-Papaste/nou

(Table.no12)

Stern :	Higher and beamier than the bow	[2]-Kornidakis [17]-Papaste/nou [12]-Kozonis
Deck :	Sheer line pronounced more than fishing but less than diving	[12]-Kozonis [13]-Kontatos [17]-Papaste/nou
Lower W.L. :	Beamier than the boats with other functions	[1]-Mavrikos [6]-Arvanitis [11]-Polias [16]-Papaste/nou
	DIVING	
Bow :	Beamier and higher than fishing boats	[6]-Arvanitis [9]-Chilas
Middle section:	Narrowest, more draught than others	[11]-Polias [9]-Chilas
Stern :	Narrow below the water and wide on the deck	[6]-Arvanitis
Deck :	Rising on bow and stern more than any other boat, great sheer line	[6]-Arvanitis [11]-Polias
Lower W.L. :	Narrower than boats with other functions	[17]-Papast/nou [11]-Polias

of a Trechadiri used as a trading vessel. In fig.48 there are lines of the same type used as a diving vessel. On these schematic drawings we can see clearly how the above mentioned differences according to the function of the boat influence the formation of a certain type of hull.

The other example that we can suggest here is the division of the Karavoskaro type into fishing and trading boats (2.5.1 Karavoskaro).

According to [1]-Mavrikos, [6]-Arvanitis, [11]-Polias, [17]-Papastephanou the same differences as those on Karavoskaro, in respect to the function, occurred on Trechadiri, Perama and Liberty boats.

In addition to these functional determinations of form (not necessarily of particular types of hull), there were specific types associated with certain functions. However most of the types of hull have been used at some times in the past for different purposes. The available iconographic, bibliographic and interview sources allow us to introduce the following table.no.13. In this table there are included the most common cases of relationship between the types of hull mentioned in 2. CLASSIFICATION OF BOATS and the functions mentioned earlier on.

We can suggest that the same sort of relationship can be applied between function and types of sails as is shown on the following table.no.14.

We have some evidence which allows us to carry further the study of particular cases of relationship between functions and types of hull or rigging.

The hull of the Trata was narrow and shallow in order to be easily propelled by means of oars and to be easily hauled on shore after fishing. ([4]-Korakis, [5]-Dardanos, [8]-Chilas) The same functional elements determined the form of the "Konstadinopolitiki Gaita".

Table.no.13

TYPES	FISHING	TRADING	DIVING	CRUISING
Trechadiri	extensively,	extensively,	extensively,	rarely
Gatsao		extensively .		
Botis	extensively,			rarely
Tserniki	extensively,		extensively	
Perama		extensively,		rarely
Small Perama	extensively			
Trata	extensively			
Varkalas		extensively,		rarely
Bobarda		extensively (?)		
Skafi			extensively	
Boat/Hydra	extensively,		rarely	
Boat/Canea	extensively (?)			
Liberty	rarely,			extensively
Karavoskaro	extensively	extensively,		rarely

Table.no.14

TYPE OF MAIN SAILS	FISHING	TRADING	DIVING	CRUISING
Main square		extensively		
Lateen	extensively,	rarely,	extensively	
Sprit	extensively		extensively	
Luger		extensively		
Gaff		extensively		extensivly

Furthermore the Trata's bow structure was determined by the kind of trawler fishing that she was built for ([4]-Korakis, [5]-Dardanos, [8]-Chilas).

Another example that we mentioned already in the classification was the form of the small Perama in order to provide wider decks on the bow and stern.

The most representative example was the Skaphi with the very distinctive form (2.3.3 Skaphi from Symi). Most of the evidence suggests that this type was always spritsail rigged and that she was used by sponge divers ([11]-Polias, [17]-Papastephanou, Zouroudis,G.I. (1974, fig.17) and in the same source the contemporary painting by Oikonomopoulos,N. (out of the text, no page number)) (fig.40).

The Skaphi was extensively built only on the island of Symi during the last century ([11]-Pilias, [17]-Papastephanou). Sponge diving was one of the main activities in the Dodecanese Islands during the 19th and 20th century. Loukatos,S (1977, p.419) mentions that in 1866 each of the islands of Kalimnos and Symi had about a total number of 370 vessels and on each one of those two islands were approximitely 2600 people working as divers or assistants in the vessels. According to Karanikola,S. (1937) by the end of the 19th century there were - in addition to other boats - more than 160 Skaphi vessels belonging to Symi. The decline of the sponge fishing by diving from skaphi started with the introduction of helmet-diving which occurred about 1870 on Symi (Karanikolas,S. (1937)). The old diving technique was very primitive and no special equipment was used ([11]-Polias, Karanikolas,S. (1937), Grigoropoulos,M.S. (1877, p.53)).

Slot,B.J. (1977, pp.210-2) publishes a very interesting description by Aaron Hill (1685-1750) about the way that people from Symi used to dive for sponge fishing(2).

In the Edinburgh Journal of Natural History (1835, p.16) there is information about Greek divers. It mentions the ability of them to dive as deep as 100 feet for three or four times in an hour. Furthermore there is an argument about the time that these people could sustain submersion which would vary from 76sec to even half an hour (!).

From the above evidence we can see that this kind of diving was very dangerous. Factors like the shortage of time during diving or the synchronized movements of the boat with the diver often against the weather conditions were very important in this work. So the question is how the form of the Skaphi could be influenced by these factors ?

[11]-Polias mentions the special use of the small steering sail on the stern of the Skaphi. This sail in relation to the wide rudder provided slow side movements of the boat when she cast anchor during diving. We can assume that these movements required to be under special control as often the diver was hanging by means of a rope from the boat.

In fig.49 there is a schematic plan in order to explain our suggestion that the Skaphi had this peculiar form of an extremely long stem in order to be able to move very smoothly during diving or to stay on a certain position despite the weather and the prevailing currents. As we can see in fig.49 the position of the boat on the water was very different when the boat was sailing than when the boat cast anchor for diving. During sailing the sprit sail gave the boat a deeper draught on the stern than on the bow. (2.6.3 Sprit sail). During casting anchor for diving the weight of the mast, spars and sails together with the pressure from the anchor gave the boat more draught on the bow than on the stern. The form of the hull supported very well the repositioning of the floating vessel under these two conditions (fig.25). In this way the location of the center of the volume of the vessel's submerged area was moved from the point "A" to the point "B" (fig.49).

Therefore the horizontal distance of the center of the volume from the rudder/steering sail "line" (see fig.53) was increased from "a" to "b". This increasing of this distance let the rudder/steering sail provide an efficient and accurate control on the sideways movements of the vessel.

So the form of the Skaphi's hull was substantially determined by the old way of diving. [11]-Polias mentions that despite the efficiency of the form of this vessel during diving, accidents were more often on these boats than on other types of boats during sailing. In respect to the above mentioned explanation of the Skaphi's floating we can see that a sudden drop of the wind or change of its direction can cause very unstable balance of the Skaphi from one position to the other as in fig.49. That of course could cause accidents in rough weather but we can understand that the danger of accidents during diving was greater than that during sailing.

The Skaphi's relationship with her function is a good example of a dramatical determination of the boats' form by her function.

3.2 Propulsion and ballast

One of the most obvious changes in the hull of the boats which accompanied the evolution of the propulsion from sailing to inboard engines was the reforming of the draught underwater part of the hulls (Damianidis,K. and Zivas,A. (1986, p.54)).

According to [1]-Mavrikos, [3]-Stilianou, [5]-Dardanos, [8]-Chalaris, [15]-Kozonis and[17]-Papastephanou the boats under sails had deeper draught than the boats today under mechanical propulsion. [15]-Kozonis mentions that a boat under sail with 30-40ft length of keel required 30-40cm extra depth of draught compared with an engine-boat of the same length. [1]-Mavrikos, [3]-Stilianou and [17]-Papastephanou mention that the deeper draught on a sailing boat was achieved by a different form of the profile of the midship frames rather than by higher overall frames. However [13]-Kozonis mentions that the taller the overall frames were the deeper the draught was required.

This different form in sailing boats basically consisted of a sharper turn of the bilge and therefore narrower lower water lines than on the boats today. In addition to the ballast the whole structure (skeleton and planking) was heavier on the sailing vessels than on the vessels today (7.7.3 Comments on the evolution of the structure). This additional weight (ballast and structure) provided a deeper draught on the boats.

[17]-Papastephanou suggests that the boatbuilders were avoiding convex shapes on the bottom of the midship frames because they were very difficult to plank (7.5.4 Planking of the hull).

[13]-Bilias mentioned that the Bratsera (two lug sails) required more draught than the Lauver (two gaff sails) because of the greater sail area.

The replacement of the sails by inboard engines influenced as well the form of the deck and the space arrangement of it. The superstructures on sailing boats had a very limited height compared with the boats today. The sailing boats had a more pronounced sheer line and the curves of the deck along and across the axis of the boat were sharper than today.

The sailing boat required the rudder to be placed as far aft as possible and to be wider than in the boats with engines. That was one of the reasons why the old Varkalas hull had the rudder placed aft of the transom board while on the recent Varkalas with engines the inboard placement of the rudder is considered more convenient ([4]-Korakis, [18]-Kastrinos). However, this modification of the rudder on the Varkalas had as an effect the rearrangement of the whole structure of the a stern post (7.2.2 Boats with transom stern).

According to [10]-Binos and Adoniou,A. (1969, p.25-6) the hull of a

Trata was determined dramatically by the method of propulsion. The length of the boat was relevant to the number of oarsmen. The beam and the depth were related to the method of propulsion by means of oars while the bow was related to the special kind of fishing (2.2.6 Trata).

When the boat was sailing, ballast was necessary. According to [5]-Dardanos, [6]-Arvanitis, [8]-Chalaris, [17]-Papastephanou and [19]-Bilias the trading boats had ballast of stones when they were unloaded. To load the boat they had to empty first the ballast. [8]-Chalaris suggests that on a loaded vessel about the 2/3 of the cargo was used as ballast (however he did not mention whether this was a cargo of wine or a cargo of feathers!).

This ability to control the draught of the trading vessels by the ballast or by the cargo was associated with the form of the vessel. In fig.50 there are two schematic middle sections of a fishing and a trading vessel. Let the boats have the same carrying capacity and the same weight. When the boats were unloaded (weight of the structure = F1) the trading boat required additional ballast in order to have the same depth of draught as the fishing boat. However when the boats were loaded with the same weight F2 the trading vessel had deeper draught than the fishing vessel. This schematic illustration can explain the reason why the unloaded trading vessels required more ballast than the fishing boats ([5]-Dardanos, [6]-Arvanitis, [8]-Chalaris).

3.3 The concept of fair lines

Some of the boatbuilders mention some suggestions about the lines of the boat hulls which according to their belief provided more seaworthiness to the vessels. Naval architectural analysis and tests will be the common method to study the influence of these suggestions on the performance of sailing boats. However since this methodology is not included in this work we will study the effects of these suggestions on some forms of boat hulls.

3.3.1 Middle part of hull

We mentioned already the two basic types of midship sections which have been used on traditional Greek vessels according to their function (2.5.1 Karavoskaro, 3.1 The influence of function)

[17]-Papastephanou suggests that convex profiles should be avoided on the lower part of the frames on the midship part of the hull. This is because these kinds of shapes on this part of the boat can not be planked by traditional ways.

[6]-Arvanitis, [12]-Kozonis and [10]-Binos suggest that the beamiest part on the deck of the sailing boats was about two frames aft from the midship pair of frames (this was on the middle of the keel). By contrast the beamiest part of the hull below the deck was on the midship pair of frames.

Studying the lines plans of sailing vessels which are included in this work we can recognize in most of them the application of these suggestions (fig.12, 18a,b,c, 23, 105a,b,c, 143). "Evaggelistria" had a convex profile of the lower part of the middle frames. However this was because of the tension on middle frames which occurred when this vessel was out of the water (she was out of the water for about seven years).

3.3.2 Sheer line

[8]-Chalaris, [17]-Papastephanou and [20]-Giamougianis mentioned the pronounced sheer line on the sailing double-ended and transom-stern vessels. Today they build these types of vessels with less pronounced sheer lines. [3]-Stilianou and [6]-Arvanitis mentioned the more pronounced sheer line of boats from the Black Sea and the Eastern Aegean compared with those from the Western Aegean and the Ionian Sea (Denham,H.M.(1986, p.281)). [6]-Arvanitis mentioned as well the same feature on the sponge divers boats.

Most of the contemporary illustrated sailing boats from the Aegean during the 19th and 20th century appeared with noticeable sheer lines (double-ended and transom-stern boats) (Vasiliou,S. (1961), Papadopoulos,S. (1972), popular paintings from the collections of the Maritime Museums of Pireaus, Galaxidi, Santorini and the Folk Museum of Salamis).

Moore,A. (1925, p.94,142,231) mentioned the pronounced sheer lines of the boats from the Aegean (Greek and Turkish boats). "Phaneromeni", one of the recorded sailing Perama (fig.18a,b,c) had a substantially pronounced sheer line (she was built on Skiathos in 1939).

So one of the changes in the form of boats which occurred in the middle of this century together with the abandonment of the sails was the evolution from hulls with pronounced sheer lines to those with more gently curved sheer lines.

3.3.3 Bow and Stern

According to [6]-Arvanitis, [8]-Chalaris, [11]-Polias and [20]-Giamougianis the stern of a sailing boat was narrower on the lower water lines of the hull and wider on the upper water lines in respect to the boats of today. This means that the profile of the stern's frames on double-ended and transom-stern vessels had more flare on the sailing boats than on the later built engine-boats and that of course determined the shape of the water lines on this part of the hull. However the limits of this stern's formation can be identified by [3]-Stilianou's suggestion that the boatbuilders tried to avoid convex water lines on the lower and aft part of the hull and by [17]- Papastephanou's suggestion that the sharply convex profiles of frames were difficult to plank up by traditional methods. The effects of all these parameters on the formation of the stern in double ended vessels can be studied in fig.12, 18a,b,c.

In respect to these ideas about stern formation we can study the profile of the stern post. [5]-Dardanos and [17]-Papastephanou suggests that the old form of the stern post was gently curved instead of being straight as it appears today. We can identify the same evolutionary feature on some old illustrations of double ended vessels (Moore,A. (1925, p.92), Damianidis,K. & Zivas,A. (1986, p. 44)). The old curved profile of the stern post was related to the attempt by the boatbuilder to form a beamy upper part of the hull and a narrow lower part of it.

[20]-Giamougianis mentions that the form of a Karavoskaro's stern determined dramatically the profile of the frames on the middle part of these vessels and the ratio of M.B./L.Keel (about 1/4) on these vessels. However we can assume that the ratio M.B./L.Keel = about 1/4 was established in respect to the upright position of the upper part of the lines on the body plan (fig.29, 30) (2.5.1 Karavoskaro). Therefore the elliptical form of the upper water lines in respect to the upright position of the body plan's lines indeed determined dramatically the form of the middle and aft part of the hull of this type.

[5]-Dardanos, [8]-Chalaris, [9]-Chilas, [11]-Polias and [20]-Giamougianis suggest that the bow on double ended vessels (in respect to the main types of Trechadiri and Perama) was beamier than the stern when the boats were under sail. [5]-Dardanos and [11]-Polias mention that even the lower part of the stem was beamier than the corresponding part of the stern. Moore,A. (1925, p.40, 56) mentions also the bluff bows of the double ended vessels in the Aegean.

In addition to the beamy form of the bow on the sailing boats in the early 20th century the gently backward curve of the upper part of the stem post of Trechadiri hull is noticeable on most of the iconographic and photographic material (fig.15a) (Damianidis,K. & Zivas,A. (1986, p.44)). We suggest that this last feature of the old Trechadiri's stem post was the result of the intention to form a beamy bow especially on the upper part of the hull of this type. In fig.51 the bows of two Trechaditia are illustrated. The vessel "A" represent the old form of the bow of a sailing Trechadiri and the vessel "B" the form of the bow of a modern Trechadiri both with the same L.Keel. We can see that the difference between the shape of the stem post of the vessel "A" and vessel "B" was in respect to the beamier form of the vessel "A" water lines compared with those of vessel "B". Furthermore we can study these differences in the shape of the frames as they are represented on the parts of the body plan in fig.55. We can understand that despite modern ideas about the less beamy bow of the Trechadiri this evolution from sharp curved stem posts to more gently curved ones had some more practical reasons. These were the easier one-piece construction of the stem post and the increase of the L.O.A. from the old form to the new form (fig.51).

3.3.4 The bow and the stern of the Perama hull.

As we showed in section 2.2.5 Perama the Perama type of hull had a very distinctive form of bow and stern (fig.18a,b,c, 105a,b,c, 111)). There is a question about the origin of this form which remains unanswered in all the studies of this type of boat (Denham,H.M. (1986, p.280), Throckmorton,P. (1964, p.214) and (1971, p.505), Adoniou,A. (1969, p.32)).

Moreover it is difficult to identify any substantially acceptable answer to the question through the interview material. [3]-Stilianou and [8]-Chalaris suggest that the arrangement on the top of the stern post with the board across it which accommodated the ends of the gunwale had this form in order to protect the people on the deck from spray in a rough sea. We can accept that as an advantage of this arrangement but it is difficult to think that this was the reason for a major structural arrangement on the stem like this on the Perama hull. [12]-Kozonis and [13]-Kontatos suggest that the same arrangement of the Perama provides a good support for the bowsprit. This is true but again we can not see the reason for a special structure for this task since the other types of hull can support the bowsprit by enough more simple ways. [12]-Kozonis adds that some arrangements were structural components in order to reinforce the bow of this type. However we know that similar types like the Tserniki (2.2.4 Tserniki) did not require additional structural components at this part of the boat. [5]-Dardanos suggests that the arrangement of the Perama stem and stern provided the capability for additional height on the hull amidship. In this way they increased the carrying capacity of this boat. This suggestion is, however, not far reaching enough to explain why the gunwale on this type had to end before the stem or stern post.

We can consider [5]-Dardanos suggestion similar to the one of [13]-Kontatos according to which the rake of the stem post in respect to the very pronounced sheer line on this type was responsible for these arrangements on the bow and the stern of a Perama hull. Assuming that the sheer line was extremely pronounced on the early Peramata then it is true that the boatbuilders would have difficulties in building the gunwale in a way which can provide an easy accommodation of its ends on the two posts. But we do not have any iconographic evidence of an early boat with extremely pronounced sheer line where the arrangement of a Perama bow appears.

In addition to these suggestions we can see that the arrangement of the bow on a Perama hull can give the person who works the tiller of the boat a clearer view of the area in front of the boat than if the gunwale were to end on the stem post. We can assume that the Perama bow and stern fit in nicely with all the above structural or functional suggestions but we believe that the main reason which required this form of the bow and the stern of the Perama is still missing from all these suggestions.

A good example of a respective reason of this kind of bow and stern form is been provided by the small Perama which is still in use on Lesvos (2.2.5 Perama).

As we explained earlier in the classification of this type the reason for this simpler version of the Perama's bow and stern arrangement was the extremely wide deck on the fore and aft part of the boat. This form of the deck in relation to the flare and rake of the gunwale made the meeting of the gunwale with the stem and stern posts very difficult. So can this formation of deck and gunwale be the main reason for the distinctive bow and stern form of the bigger Perama like on those small boats from Lesvos?

[14]-Giamougianis suggests that the bow of Perama boats was even wider than that of Trechadiri or any other type of hull. This suggestion together with the form of the small Perama brings the question of the Perama's bow and stern to the same consideration as in the case of the sharply curved stem post of the sailing Trechadiri. In respect to the suggestions that the Perama had a very beamy bow, a substantially pronounced sheer line and a raking, straight stem we will now try to represent combining these arrangements of the Perama.

The two fully recorded Perama show some differences concerning these features. "Phaneromeni" (fig.18a,b,c) has a similar beam at the bow and the stern, a slightly more raking stem and a substantially more pronounced sheer line than that of "Evaggelistria" which appears to have been built to a modified pattern (less pronounced sheer line etc.) (fig.105a,b,c). So the form of the bow and stern of "Phaneromeni" is closer to the postulated representation of the earlier form of these parts of a Perama.

In fig.52, the lines of the half breadth plan, body plan and sheer plan of the bow of "Phaneromeni" are marked by a broken line. In the same fig.52 the unbroken lines represent another Perama with a beamier bow. Because the sheer lines of "Phaneromeni" were sufficiently pronounced we keep them as the sheer lines of the beamier Perama. The lines on the body plan of the beamier Perama are markedly beamier than the lines of "Phaneromeni" especially on the upper part of the boat. The lines on the half breadth plan of the beamier Perama are formed beamier than the "Phaneromeni" lines. We keep the same line of the frame no.6 as the representation of the beamier Perama is only for the bow part of the boat.

Then from the whole appearance of the lines of the beamier Perama we can deduce the following. We can create a beamier bow in a Perama without changing the form of the stem post and the sheer line. The cross board where the gunwale ends can be moved further aft in order to have a similar form and size to the one in "Phaneromeni". However the most interesting suggestion is the study of the projections of the gunwale lines of the boats on the half breadth plan. We can see from the dotted lines which represent these projections that the gunwale of "Phaneromeni" can easily end on the stem post but the gunwale of the beamier Perama can only end smoothly some way abaft the position of the stem post. So the arrangement of the across board on the bow saves the form of the boat either from the case of a gunwale which cannot be faired into the existing stem post or of the replacement of this stem post by a curved one which can meet the fair projection of the gunwale. Furthermore this latter case would make the form of the stem post too complicated to be made from a single piece of timber. In respect to this suggestion the form of the bow of a Perama hull served the demands of a fair formation of the ends of the gunwale. This occurred when the boats were only used under sail and the beamier bow was considered an important feature of a desirable sailing Perama.

In respect to the same hypothesis we present in fig.53 the suggestion of a beamier upper part of the stern of a sailing Perama in comparision with the Perama today. The broken lines are again the lines of the recorded "Phaneromeni" and the unbroken lines represent a beamier Perama. We can make respectively the same suggestions and we can see that the dotted lines of the projections of the gunwale face a problem which is analogous to the stem of the beamier Perama. This can be solved easily by the arrangement of the Perama's stern. Of course the structural requirements of these arrangements were not the same on the bow and on the stern and this can explain the strong arrangement on the stem and the rather lighter one on the stern. Therefore we suggest that the special forms of the bow and the stern of this hull were made in order to accommodate the gunwale when the Perama had a beamier bow and stern than today. In addition to the old form of the sailing Perama the same arrangements met the structural and functional demands that they were mentioned by the boatbuilders earlier on.

3.4 Geographical relationships

In the chapter on classification we studied the distribution of types in the Aegean and Ionian Sea according to the information from the interviews (fig.45).

There is evidence that the origin of certain types of boats was related to certain places in the Aegean.

Trechadiri were first built on the Island of Hydra in 1658 (Kriezis,G (1860, p.18)). In the 19th century this type was common among all the Islands in the Argosaronic gulf (table.no.3).

Gatzao had been built extensively only on the Ionian Islands (2.2.2 Gatzao).

The Tserniki, according to the interview sources, was a common type in the Eastern Aegean (2.2.4 Tserniki).

The Perama was extensively built on the Island of Lesvos and Samos. There is evidence that this type was built on Syros but this can be related to the Eastern Aegean origin of the boatbuilders of this place (1.2 Second period (1830-1880)).

Varkalas was extensively built on the Dodecanese islands and Skaphi was the special diver's boat from Symi (2.3.3 Skaphi from Sými).

Syros and Galaxidi were the first famous places were Karavoskaro were extensively built during the 19th century (1.2 Second period (1830-1880)).

Therefore the best established types of hull were originally related to certain areas in the Aegean and Ionian Sea. Since shipbuilding techniques show no differences between these places we can hardly identify technical reasons for this distribution of the origin of the various types

(7. CONSTRUCTION).

Moreover weather conditions in the Aegean do not vary a lot and so they cannot be the reasons for this distribution of types.

Local maritime activities undoubtedly influenced some types (1. Historical Introduction, 2. Classification of boats,

3. Morphology) or modified the form of others (3.1 The influence of function).

However most of the relations concerning the origin of certain types in some places remain unclear even after a!study of the local maritime activities.

Despite the most recently established types of Karavoskaro and Liberty most of the other older types were built in the Aegean earlier than the end of 18th century. Even if we do not have evidence of the early existence of some of them (like Gatzao or Tserniki) we do know that similar types, which can be included in the two basic formations of double ended or transom stern vessels, have existed earlier than the end of the18th century (1.1 First period (18th century to 1830), 2.7 Early types).

Therefore we suggest that most of the above mentioned relations of the origin of types in various places in the Aegean come from earlier times than the end of 18th century.

We have evidence for the early origin of Trechadiri from Hydra (Kriezis,G. (1860, p.17)) but this is not enough to explain why this particular type of hull was extensively built on this Island.

The case of Skaphi or "Simbequir" (1650) (Slot,B.J. (1977, p.220)) can be more substantially studied as we can relate the origin of this type with the early local activities of sponge diving on Symi (3.2 Propulsion and ballast).

We do believe that similar explanations about origins, such as the one of the Skaphi from Symi, exist for most of the other types. However, it is beyond the aims of this thesis to study the early origin of these types.

To summarize the material of this chapter we can mention the essential influence of the function of boats on their form. As we saw with the F.D., the shape of the middle frame, the shape of the water lines of the hull and the form of the bow and stern were determined by certain causes. The most important of them were the function which the boat was going to serve, the local tradition about fair lines of the boats and the mode of propulsion.

Therefore the decision about the type of the boat did not apparently determine the final form of the boat. This last one was a matter of boatbuilders' conception in respect to all the above mentioned morphological causes. This approach to the realization of a vessel's form leads us to one of the most crucial parts of the boatbuilders craft. The traditional methods for determining the form of a vessel by means of moulds or other lofting techniques formed a crucial part of the boatbuilding process, wherein lay the means to modify any traditional hull type to match more closely the function the finished boat would serve (5.DESIGNING).

<u>notes</u>:

(1) There are outstanding studies on the morphology of vernacular boats from other countries (McKee, E. (1983) and Taylor, D.A. (1982) but there is no substantial similar study on boats from the Eastern Mediterranean.

(2) I copy here parts of this description. Because the source where I found this document (Aaron Hill (1685-1750) is in Greek (Slot,B.J. (1977, p.210-2)) the following text is a translation from the Greek version of the document.

" ... We approach the boat and we see that it was a very narrow and small vessel with plenty of oil, where about twenty small objects were floating. As we found out these were sponges of which each one had a cork tied on in order to keep them on the surface of the oil and to let them absorb slowly the oil.

... then he showed us that they can manage by the following way. They soak half of the sponge in the oil and the other half has been previously soaked in a "στιλπτικό" liquid which confines the absortion of the oil to a certain area. Then when it is ready they chew the sponge except the part which remains outside the mouth being completely covered by oil. The oily surface of the sponge does not let the water get into his mouth. They dive like this and with little difficulty they can stay underwater for a substantial amount of time. They have a basket with some stones in it and with some tools they cut the sponge and put them in the basket. Then they throw the stones out of the basket and by means of the cork that they have around their bodies they move easily up to the surface of the sea."

(3) Adoniou,A. (1969, fig.16), model by [11]-Bilias (both in fig.25) and Zouroudis,G.I. (1974, fig.17) and popular painting by Oikonomopoulos, N. (fig.40) are the sources for the illustration of the Skaphi in fig.49.

4. TOOLS

Students of past techniques, when only hand tools were in use, often have difficulties in appreciating the value of these techniques. This is mainly because today our working environment is totally different from that of previous societies.

The method we suggest in this work in order to overcome these difficulties is to start with the study of the tools which were used in a trade and then to continue with the study of the process of the work.

The study of the hand tools used by boatbuilders during the last three centuries was aimed at providing evidence about the technical evolution of boatbuilding in the Aegean. Furthermore it was considered a good opportunity to determine initially the technical framework of this trade.

However, in practice the study of tools became one of the first-hand opportunities to produce significant details of boatbuilding technique. This is the main reason for the substantially long content of this chapter.

Studies on tools of the maritime trades are readily available to the student of the subject (Horslay,J. (1978), Salaman,Q.A. (1957), Salaman,Q.A. (1972,), Frost,T. (1985), Patrignani,W. (n.d.), Zouroudis,G.I. (1974), Poulianos,A.I. (1977)). However, the main effort in my presentation is paid to seeking evidence in respect of the use of the boatbuilding tools and to focusing on some comparisons between tools from different traditions.

No iron-working tools are included in this study. This is because from the field work and also from the bibliography (Gourgouris,N.G. (1983, p.487), Zouroudis,G.I. (1974), Poulianos,A.I. (1977)) it became obvious that iron work was very limited during the main building process. Only parts of the superstructures and of the rigging required some iron work which was caried out by local smiths or by rigging specialists.

In the first part of this chapter there is a classification of the tools together with a presentation of each separate tool. In the second part there is a study of the different groups of tools as they are suggested from the classification in order to determine a framework for the shipbuilding technique based on the use of these tools.

Special attention has been given to the following aspects in the second part of this work: 1) The technological background and the evolution of the craft. 2) The distributive use of the tools during the boatbuilding process which can provide some remarks concerning the different parts of the work. 3) The relation between the boatbuilders and their tools (especially in making and using them) which can provide some preliminary evidence concerning their skills and confidence in the work.

4.1 Classification of tools

John E. Horsley (1978) divides the tools of the main shipbuilding process into two broad categories in his chapters "Timbers and sawing" and "The Shipwright". Obviously he does not pay any specific attention to the classification of the presented material. On the other hand R.A.Salaman (1946) suggests that "...when considering hand-tools, it will be convenient to have a rough classification of the principal types according to their uses" and proposes the following: 1) Hammering 2) Cutting, Splitting and Scraping 3) Piercing and Boring 4) Measuring and Marking 5) Grasping and Holding 6) Sharpening.

The main advantage of this classification into categories of the same fundamental use enable us to examine more thoroughly the technical level of a trade during certain periods. This is to study the development of a group of tools which belong to the same fundamental use throughout that period.

In other ideas expressed about the study of tools or other artifacts from past technologies a strong tendency can be recognised to relate the study of them to the context and the development of the work (Drucker,P.F. (1972), Zacharia Mamaliga,E. (n.d.)). From that point of view the classification of the tools of a trade seems more productive when it is based on the order of the parts of the working process.

We believe that both approaches to the question of classifying tools have their own advantages. Therefore we suggest a combination of them which can provide most of the advantages of both of them. This is a classification which contains groups of tools belonging to the same functional category together with tools of direct functional relation to the former.

In practice this is the study of groups of tools that can be associated with certain tasks of some craftsmen (woodcutter, caulker) or certain application of the work which was not necessarily an individual task (Measuring-Marking, Boring, Hammering).

Under this consideration we suggest the following classification.

4.2 Splitting - Cleaving - Cutting

4.3 Measuring - Marking - Moulding - Lofting

4.4 Holding - Grasping

4.5 Boring

4.6 Hammering

4.7 Hewing

4.8 Smoothing

4.9 Caulking

The content of these groups of tools will be studied in the following section. During my field work the filing information gathered for each tool consisted of: 1.Name, 2.Illustration, 3.Construction of the tool, 4.Function, 5.Other tools used in conjunction with this tool.

Practically however, this system turned out to be both too extensive for some tools and too limited for some others. For that reason this system has not always been strictly applied in the following presentation.

Sources for the study of the tools are the interviews with boatbuilders (especially with some of them who showed a good knowledge about the use of some old tools) and the recorded material from boatyards or private collections. The basic bibliographical sources concerning boatbuilding tools from the Aegean is limited to Poulianos,A.I. (1977) and Zouroudis,G.I. (1974).

4.2 <u>Splitting - Cleaving - Cutting</u>

4.2.1 Frame saw (big saw) (Κουραστάρι)

The boatbuilders used to make the saw by themselves. The frame was made from soft wood, usually pine. The joints between the timbers of the frame were tenons (on the parallel to the blade piece) and mortices (on the vertical timbers). When the blade was stretched by tightening the screw at the one end of it (fig.54) the joints of the frame became more stiff. They used to leave the screw loose overnight because the permanent stretching of the blade caused twist of the wooden frame.

Most of these tools had not permanent blades. At least two blades of different width were in use. [16]-Kritikopoulos mentions two basic widths of blade of 3-4cm and of 1.6cm. The illustrated saw in this work was used fifty years ago and comes from [7]-Chimonas' father. The frame saw was used on the big logs in the boatyard. The 3-4cm blade was for wide logs (more than 50cm width) and the 1.6cm blade for narrower logs ([16]-Kritikopoulos). Also the narrow blade was used to cut primarily curved timbers like knees and posts. The logs were set on two trestles of equal height and the top sawyer stood on the log while the low sawyer stood underneath it.

([16]-Kritikopoulos, [7]-Chimonas, Poulianos,A. (1977,p.531), Zouroudis,G. (1974,p.161))

Horsley,J. (1978,fig.18,d) illustrates a frame saw with the following remark "*... continental method of sawing with a frame or gate on trestles of unequal height, 1675, from an engraving by R Zeeman, probably based on a Dutch shipyard"*. The saw cuts the log only in the direction of the small strong handle ([9]-Polias) and this is obviously the reason for the rather light handle on the other side (its upper side) (fig.54). The teeth had a raked and sharpened edge in the direction of the strong handle and a vertical and unsharpened edge in the direction of the other light handle.

A steel file was used to sharpen the tusk of the saw and a saw setting tool to twist them. There is some evidence that often wooden wedges were used in conjunction with a frame saw to help sawing by keeping open the saw-cut ([9]-Polias, [16]-Kritikopoulos).

4.2.2 Small frame saw (Ξεγυριστάρι)

This is another frame saw on smaller dimensions than the one above (fig.55). All the details of the form and structure of this saw are the same as the big frame saw with the exception of a simpler handle. The illustrated small saw comes from the same yard as the big frame saw. ([7]-Chimonas) The blade of the illustrated small frame was 2cm in width. The narrow and flexible blades on both frames were the main reason for the supporting frame construction.

This saw was commonly used on the ribs of boats where both the dimensions and the curves of the timbers required a lighter saw than the ordinary big frame saw.

Horsley,J. (1978, fig.25d) illustrates a small frame saw and named it as an "early 19th century futtock saw". This saw appears with a handle on the one side similar to the big frame saw's instead of the form without a handle on the figure 55.

4.2.3 Crosscut saw (Καρμανιόλα)

The blade of this saw was made from steel by the local smith. The handles were made of pine. The most common type of blade was wider in the middle part than on either end (fig.56a). The illustrated saw is about fifty years old, from [7]-Chimonas.

This saw could cut the timbers in both directions of sawing and the teeth were sharpened on both edges. For the same reason the teeth of this saw have a symmetrical shape by contrast to the frame saw teeth (fig.56a).

The crosscut saw was used to cut timbers across their grain. For that reason it was one of the most important tool for cutting trees in the forests. The crosscut saw can be considered a stronger tool than the frame saw (wider blade, without support frame) but the frame saw can cut easier than a crosscut saw both in a straight line (thinner blade, easier to drive with the supporting frame) and along the grain of the timbers. The same tools as for the frame saw were used to sharpen the blade of the saw ([16]-Kritikopoulos). Horsley,J. (1978,pp.80-4) gives some different forms of crosscut saws used by one or two hands. However no saw with one hand has been found in the Aegean boatyards.

4.2.4 Small crosscut saw (Ζβανάς or Ζμίνη (According to Mr.Vaios, director of the Ethnological Museum of Milos))

This was a saw with a one side handle and about half the length of the big crosscut saw (a variation could be found between 30cm to 100cm on length ([12]-Polias)). The most distinguished feature of this saw was the pointed end of the blade. One of the reasons of this shape was to enable it to cut sharp curves on the planks ([16]-Kritikopoulos) (fig.57a). The illustrated small crosscut saw comes from [16]-Kritikopoulos' yard in Perama.

The teeth of this saw are again sharpened in both directions and they have a smoother shape than those of the big crosscut (fig.56a). This is because one of the main uses of this saw was to cut the edges of the butts on the planks or sometimes the main long edges of planks for small boats. In this case the smooth teeth provide a finer cut edge of the plank on a more accurate angle than the sharp teeth (7. CONSTRUCTION, 7.5.4 Planking up the hull). Another use of the small crosscut saw was to cut the scárph on the keel and posts ([16]-Kritikopoulos) (for similar forms of small crosscut saws see Salaman,Q.A. (1972,p.433)).

4.2.5 Bow or turning saw (Πισκί)

The basic idea of this saw was to provide enough tension of the extremely thin and long blades. By means of a sufficient narrow and thin blade the boatbuilder could saw the planks of the hull by following a curved path.

The blade was fixed on the wooden frame by means of a flexible joint which allowed the blade to saw at an angle to the level of the plank's surface (7. CONSTRUCTION, 7.5.4 planking up the hull) (fig.57b). This saw and the small crosscut saw were the two main saws for the planks of the deck and hull of the boats.

The illustration of this saw comes from Mr. Chaskas'yard from the Island of Symi (Pedi) (additional information about the bow or turning saw is provided by Horsley,J. (1978, p.95) and Salaman,Q.A. (1972, p.410)).

4.2.6 Axe (Τσεκούρι)

On the one hand we have information which suggests that the axe was not among the boatbuilders' tools ([16]-Kritikopoulos) and on the other hand the use of the axe is mentioned both in one of the publications about local boatbuilding from Ikaria (Poulianas,A.I. (1977,p.525) and in information from an interview ([11]-Polias). The difference between the two sources can possibly be explained by the fact that the first comes from yards located in a city (which could be supplied with timbers from the market) and the second from a yard on the islands where they often had to provide themselves with timbers from the local wood ([11]-Polias). This difference might suggest in fact that the use of an axe was abolished earlier in the yards of the cities than in the yards of the country.

I could not find any example of a boatbuilders' axe in the yards which I visited. Possibly the axes that they used were not different from the axes of woodcutters. The main use of these axes was to fell the trees. The bigger axe was called "Μπαλτάς" ([11]-Polias).

4.2.7 Wooden Wedge (Σφίνα)

This was a wooden wedge of simple triangular crossection. The dimensions which have been given ([16]-Kritikopoulos) are about 5 x 27cm in crossection. It was made of hard wood, often oak. Wedges were miscellaneous objects (it is possibly not necessary to identify them as tools) with various uses throughout the whole process of boatbuilding. The reason that Greek boatbuilders preferred wooden wedges to metal ones (Horsley,J. (1978,p.17)) was that they believed that metal wedges would cause damage on the surface of the planks which could be greatly reduced by means of a wooden wedge ([16]-Kritikopoulos). Because oak wood was valuable and not so easy to replace they paid great attention saving the wedges for as long as possible. For this reason they often used a wooden sledge hammer instead of a metal one to hit them. Wedges were used in most of the tasks which deal with timber splitting. That was the only way to cleave a timber along the grain and produce stronger lumber than with sawing ([10]-Binos, [11]-Polias, [19]-Kritikopoulos). The most common use in fact was a combination of both a frame saw and a wedge to cut and cleave a timber at the same time ([11]-Polias). Furthermore small wedges were used during planking.

4.2.8 Wooden sledge hammer (Ματσολα (the same word as caulking mallet))

This was a wooden sledge made of hard wood, often oak. The illustration (fig.56b) shows a sledge recorded at the Maritime Museum of Galaxidi (this sledge has been dated by the museum to the second half of the 19th century). The shape of this recorded sledge is rough although there is information that also more elaborated sledges were in use ([11]-Polias, [10]-Binos). Apart from the use for cleaving with a wedge this sledge was associated with launching. With this sledge the boatbuilder hit the wedges of the launching structure and the boat started to slip from the launching grid into the sea. Gourgouris E.N. (1983, p.528) suggests that this wooden sledge hammer was the special big caulking mallet (Καταράφα) which is mentioned in the section on caulking tools (4.9.14 Big caulking mallet)

4.2.9 Saw setting tool (Τσαπράζι)

This was a common miscellaneous tool (fig.57c) which was used for setting the teeth of saws. This was necessary particularly on the saws with long teeth. The illustrated example was for setting the blade of the frame saw ([16]-Kritikopoulos).

4.2.10 Trestle (Καβαλέτο or Καλαφάτης) (Poulianos,A.I. (1977, p.528,531))

These are the trestles on which the logs were placed in order to be cut by the big frame saw. An illustration of them is included in Poulianos A.I. (1977, p.531) and one old photograph is included in Zouroudis,G. (1974, fig.1). The equal height of both trestles has been noted in both illustrations despite the suggestion of an unequal height by Horsley,J (1978, fig.18.d).

4.2.11 File (Λίμα).

An ordinary long file was used for the blades of the saws.

4.3 Measuring - Marking - Moulding - Lofting

4.3.1 Bevel gauge (Στέλα)

This was possibly one of the simpler and at the same time more useful boatbuilder's tools. The basic idea of the tool was to enable him to provide angles of any degree. It was easily made by the boatbuilder of any kind of hard wood. The bevel gauge was used in all stages of the boatbuilding process for recording or determining angles on wooden components of the boat's structure (fig.58a).

4.3.2 Big bevel gauge (Στέλα or Φαλτσολόγος)

This has the same function as the bevel gauge and the only difference is that one arm of the gauge was at least two times longer than the length of the other arm (fig.59a). This was the used in cases where in order to find the bevel of a component of a boat it was necessary to have one of the two arms of the bevel gauge longer than the other (for example to find out the bevel on the deck beams ([16]-Kritikopoulos)). Often the dimensions of a gauge are related to the size of the boat at hand. In fig.58a there is a gauge which had one arm of adjustable length. This was an alternative tool which could replace both the gauges with equal or unequal arms.

4.3.3 Small square angle (Μικρή γωνιά)

This was a simple square angle to be used in the case of a square angle bevel. Again it was made by the boatbuilder of hard wood. One arm of this angle as well as of all the other gauges was thicker than the other. This is enable the gauges can be used both on a perpendicular and on a parallel to the plain of the arms. One arm of the square angle is pointed with a small hole on the arm (fig.58b). This is possibly an indication that it can be used as a marking tool. The hole was too small to be used as a hanging hole. At least one of the arms of all boatbuilder's gauges which are recorded in this work are pointed. This served as a marking point ([8]-Chalaris). With a point and an angle marked it was possible to justify the position of the square angle.

4.3.4 135^{o} gauge (Φαλτσογωνιά)

This was not a boatbuilder's tool ([16]-Kritikopoulos) (fig.59b). It is nevertheless included in this selection because it was often used in the superstructure work and in fitting out the boat inside.

4.3.5 Pair of Sweeps (Κουμπάσσο)

The two arms of the tool are made of oak and the two spikes are made of steel (fig.86). The sweeps were used especially in lofting, moulding or modelling. Another use of them was to measure fractions from the skeleton or the planks of a boat and transfer them to timbers for cutting. Sweeps were often used with a plumb line to check or adjust the symmetry and the right position of the frames (see CONSTRUCTION, 7.3 Framing up, 7.5.4 Planking up the hull).

4.3.6 Mastari (Μασταρί)

This was a trapezoid piece of any kind of soft wood (Today they use ply-wood) (fig.130). The size of the Mastary depends on the size of the boat which was going being built. For a small boat the length of the tool was about 20cm and the shape was a simple trapezoid. For bigger boats (L.O.A. about 20m) the tool can be 30 or 35 cm and it was shaped with five angles instead of four as in the simple trapezoid shape (fig.130). This last case provides a better marking with the more distinctive shape of five angles. The extensions of the lines of the two small edges of the tool in both cases were perpendicular. This was related to the form of lines and angles that this tool was used for recording. The mastary was always used in connection with another marking tool called the stantsola.

4.3.7 Stantsola (Στατσόλα)

This was a long and thin plank of pine (fig.130). The shape of the plank varies according to its use. Especially when used in planking a boat it must have a shape close to the shape of the planks of that area of the hull (while might require shape of planks with a considerable curve and taper). For this reason when planking up a boat, boatbuilders use one mastary but more than two stantsola boards of different shapes. The use of Mastary and stantsola was a practical method to trace out a particular, often curved shape of timber. This was extensively used in planking as well as on quite a few of the skeleton components (waterway, clambs, shelves, etc.).(7.4 Reinforcements of the skeleton, 7.5.4 Planking up the hull). The earliest reference to these tools comes from the end of the 18th century (Nikodinos,N. (1862, p.72)). After any use they clear away the marks on the stantsola by painting it with a reddish earth colour to be ready for the next use. Boatbuilders often make a mastary and a couple of stantsolas for a particular boat and do not save them after the end of the building.([1]-Merikos, [13]-Kontatos) The knowledge how to use these tools was more important than the actual tools, which can be simply made any time.

4.3.8 Marking tool (Σημαδούρα)

This was not only a boatbuilders' tool but was extensively used on boats. The basic function of the tool was to measure and transfer fractions of lines from one timber to another (fig.60a). Another use was to mark on a plank a line parallel to another component (This was used often to mark stripes on the plank which runs parallel to the waterway or to gunwale timbers).

4.3.9 Stripes marking tool (Σημαδούρα λούκι)

This was a simple tool related to the size of the boat which was being built. It was a long and narrow piece of timber with a transverse smaller piece nailed on one end and a spike on the other end. The small transverse piece was moving smoothly along the gunwale and the spike marked at the same time a stripe parallel to the gunwale (fig.60b).

4.3.10 Plumb line (Νήμα της Στάθμης)

This was an ordinary plumb line used to check or to determine vertical positions and the symmetry of timbers.

4.3.11 Marking line (Στάθνη)

This line consists of three woollen strands which are plaited together. This form of line provides some elasticity which was necessary during marking ([8]-Chalaris). The use of the line was to mark straight lines on timbers. For this reason the line was painted with reddish earth colour and by means of tensing and snapping the line they mark a straight line on the timbers. For the reddish colour often a simple pot was used however in this study an elaborate boxed marking line with integral coloring pot has been recorded (fig.61). This comes from [8]-Chalaris' boatyard on Santorini. With this method the boatbuilder marked the shape of all the planks of the hull (7.5.4 Planking up the hull) and all the long components of the skeleton ([1]-Mavrikos). Also with the marking line they marked the logs when they had brought them from the forest in order to saw them on straight paths with the frame saw (7.1 Preparation). There is evidence for some sort of this marking line being used in boatyards as early as the middle of the 12th century in the Aegean (Koukoule,F.I. (1950, p.281)).

4.3.12 Three or four aids of Moulding (Χνάρια)

The question whether moulds can be considered tools seems equivocal, though they are used in the moulding out of timber. Therefore moulds are listed for the sake of completeness in this account of boatbuilding tools but are discussed in detail later in the chapter of 5. DESIGNING (5.2.2 Moulding with adjustable templates).

4.3.13 Patterns for lofting (Χνάρια Σάλας)

There are six kinds of patterns used in the lofting process which are described in the section of 5.3 Lofting methods.

4.3.14 Lath (Πηχής)

This was a simple thin and long (more than two meters) lath used on the lofting floor (see 5. DESIGNING). In the lofting shop a number of these laths with different lengths was available ([11]-Mavrikos).

4.3.15 Big square angle (Γωνιά)

This square was used more often on the lofting floor (fig.59c). The square angle, the pair of sweeps, the laths and the marking line were the tools, in addition to the patterns for lofting, which the boatbuilder used in order to draw the lines of a boat on the lofting floor ([1]-Marikos).

4.3.16 Small chisel (Κοπίδι)

This was used to trim the model of a boat (5. DESIGNING). I could not find any of these chisels and the only description which has been recorded is the following : "this was an ordinary chisel with a sharp and horizontal blade" [5]-Vrochidis.

4.3.17 Small mallet (Μικρή Ματσόλα)

It was used together with the small chisel in making models.

4.3.18 Moulds for the bow and stern frames (Χνάρια Βαθικών)

This was a simple form of mould which was used to determine the form of the ribs which lay in the bow or the stern part of a boat (7.3 Framing up).

4.3.19 Patterns for stem and stern posts (Χνάρια Ποδοσταμάτων)

In the boatyards there were patterns of stem or stern posts which were used to determine the shape of the stem or stern post of a boat of a certain type and length (7.2.1.c The stem post). All the patterns or moulds are often made of cheap soft wood (usually ply-wood) and only in few cases harder wood was used to provide a longer life of these patterns ([8]-Chalaris).

4.4 <u>Holding - Grasping</u>

4.4.1. Wooden cramp

This was a cramp made of oak with corners which are comb-jointed (fig.62). The illustrated cramp comes from Trikeri (Volos) and is late 19th century. This cramp belongs to the Hellenic Institute for the Preservation of Nautical Tradition. A similar illustration is in Salaman,Q.A. (n.d, p.170). Usually the wooden cramps were made by the boatbuilders themselves. They have been used on the planking because they cause less damage on the outer surface of the planks than the metal cramps. According to [16]-Kritikopoulos wooden cramps were gradually abandoned after the introduction of metal cramps.

4.4.2 Ship Cramp (Σφηχτήρες)

This was a heavy type of cramp which was used to hold joints of the heaviest pieces of the skeleton (keel/posts deadwood/posts etc.) ([16]-Kritikopoulos).

4.4.3 Joiner's Cramp (Νταβίδια)

This is another type of heavy cramp where both jaws can slide on the bar. They are used especially to hold joints of three components like keel with floor timber and with keelson ([16]-Kritikopoulos).

4.4.4 Gee Cramp (Γρηλοι)

They are lighter than the other types and used especially for rib/plank joints (Salaman,Q.A. (1972, pp.165-69) gives further description for all the metal cramps).

4.4.5 Blocks (Τάκος or Πάλος)

Rectangular blocks for supporting the whole boat during building. Placed underneath the keel (Poulianos,A. (1977, p.540)).

4.4.6 Stands for the keel (Αντιλείχτες)

Poles of short length (about 80-100cm) to hold the keel on the blocks (Poulianos,A. (1977, p.541)).

4.4.7 Stands for the posts and the ribs (Μπουντέλια)

Poles which were used for holding the posts or the frames from both sides (usualy more than two meters long). Where the posts and stands meet they are often reinforced by means of a cross timber nailed to both of them. The poles for the frames existed in a variety of lengths in order to be adapted to frames with different dimensions ([16]-Kritikopoulos, Poulianos,A. (1977, p.541)).

4.4.8 Launching cradle (Βάζια)

These are two heavy beams connected by means of two iron tubes (about 5cm diameter). The tubes are removable and they can be locked on the beams with a key system (fig.63). They place the beams underneath the hull on both sides of the keel and they join them with the iron tubes. The whole system was able to support the boat on launching. Gourgouris,E.N. (1983) mentioned that this structure was used in the boatyards of Galaxidi in the middle of the 19th century. Nikodimis,N. (1860, p.72) suggests that Mr.Stamatis, a shipwright from Chios, introduced this structure in the yards of the island of Psara during the last years of the 18th century.

4.4.9 Single beams (Φαλάγκια)

They were used as an extension of the launching grill during launching and pulling out the vessels (1.5 Aspects of the working environment).

Koukoule,F.I. (1950, p.290) gives evidence of the use of these beams in the 12th century in the Aegean

4.5 <u>Boring</u>

4.5.1 Shell augers (Τριπάνι)

There was a great variety of augers of different sizes used in the yards. They used to be made of steel by the local black smiths. The width of the mouth of the auger varied from 2.5mm to 5cm ([16]-Kritikopoulos).

There are two types of shell auger recorded in this work (fig.64a, 65a, 65b). The first one was the simplest (plain auger) (fig.65a) with a flattened end cut in the middle and the two parts twisted to form the point of the auger. Horsley,J.E. (1978, pp.132-4) mentions this type as older than the next one. The second one was more elaborate with a screw shaped end. (fig.64a). Salaman,Q.A. (1972, 31-44) contains an extensive account of augers of both types.

4.5.2 Twist augers (Βίδα)

These were made of steel again by local smiths (fig.79). There is though some evidence for imported manufactured augers from Western Europe. The width of the mouth of these augers varied from 5mm to 8cm

([16]-Kritikopoulos).

In the local Maritime Museum in Galaxidi there is the longest example of twist auger which I have noticed in Greece (two meters length and greater than 6cm diameter).

4.6 Hammering

4.6.1 Maul Hammer (Ζουπας)

The head has been made of steel and the helve of oak or elm. [16]-Kritikopoulos mentions that in addition to these two kinds of wood eukalyptus wood was used to make the helve of hammers. However this is not a hard wood like oak or elm.

The face of the hammer was wide for driving treenails, nails, or bolts with enough force. The pein was narrowly formed in a pin shape. When the nails were driven deep enough in the wood the pein side of the hammer was used to drive them further below the surface of the wood. For this purpose the maul hammer was held on the nail as a punch by one person and another used a sledge hammer to drive both maul hammer and nail further into the wood.

There are three kinds of maul hammer recorded in this work. The heaviest one was used on bolts (fig.66a). The middle weight one was used on spikes (fig.66b). And the last one was used on small nails and on treenails (fig.66c) (Ζουπάς ψηλός). The illustration of this last kind comes from a home-made one. All the illustrated maul hammers comes from [16]-Kritikopoulos boatyard.

4.6.2 Small hammer (Σφυράκι)

This was used on moulds or lofting floors or light parts of the boat structure (fig.66d). Salaman,Q.A. (1972, p.225) published the illustration of a similar small hammer under the name "French pattern hammer".

4.6.3 Sledge hammer (Βαριά)

These were heavy hammers with two faces. They were used together with maul hammers for driving nails and bolts into the wood. They were used as well to drive heavy timbers into place. The first sledge illustrated in this work (fig.66e) has a flat face to be used on metal pieces (bolts, maul hammer etc.). The second has a domed shape on both faces of the head to be used on wood (treenails, components of the boat structure etc.) (Μπάλα Βαριά) (fig.66f) (Salaman,Q.A. (1972, pp.234-5)).

4.6.4 Wooden Mallet (Ματσόλα)

The wooden head of this mallet was homemade of oak (fig.66g). It was used to drive into place wooden components of the structure, chisels etc. Wooden mallets cause less damage on the surface of the wooden components than metal sledges ([16]-Kritikopoulos, [8]-Chalaris).

4.6.5 Treenail maker

This was a simple metal plate with a hole. Driving the treenail several times through this hole they produced the desired width of the treenail ([8]-Chalaris).

4.6.6 Iron tongs

This was a long iron tool which was used to hold the bolts when they were driven into the wood by the heavy maul hammer.

4.7 <u>Hewing</u>

4.7.1 Chisel (Κοπίδι)

There are two recorded types of chisel both without a wooden part. One type had the sharp end wider than the thickness of the shank of the chisel (fig.65c) and the other narrower than the thickness of the shank (fig.65d) (Στραυορόκανο). Both are used to cut various bits of timber or end of nails or treenails ([16]-Kritikopoulos).

The chisel with the narrow sharp end was used in narrow places where the normal chisel could not be fitted.

4.7.2 Mortice chisel (Κοπίδι γιά παρέλες)

A mortice chisel was used on mortice and scarph joins. The sharp end of this chisel was formed only on the one side. The other side was left straight in order to form vertical edges on the mortices and on the scarphs ([16]-Kritikopoulos, Horsley,J.E. (1978, p.121).

4.7.3 Adze (Σκεπαρνιά)

The head of the adze is made of steel and the helve of oak. The helve is always a straight timber with a well formed oval cross-section (fig.67a). This is in contrast to Northern European sources which often illustrate the handle of the shipwright's adze with a double curve (Salaman,Q.A. (1972, p.28), Horsley,J.E. (1978, p.111), Frost,T. (1985, p.81)).

However in Nielson,Ch. (1980, p.8) there is a drawing of an adze with a straight handle from Danish shipyards. Patrigniani,W. (n.d. p.60) includes another drawing of an adze with a straight handle from Andreatic shipyards.

The blade was extensively long and was given an angle to the helve about 65^{o}. According to boatbuilders this was the best form to provide smooth hewing on the planks ([1]-Mavrikos, [16]-Kritikopoulos).

In order to examine this precise form of the head of the adze we suggest the following schematic illustration of the simplified use of the adze (fig.68). Let the arm of the user of the adze be about 38cm (from elbow to palm). The movement of the palm holding the adze will follow the curve <a> when the man is hewing with the adze. At the same time the end of the head of the adze will be following the curve <b>. If the blade of the head was perpendicular to the helve of the adze the end of the blade would follow the curve <d>. But with the angle at 65^{o} the end of the blade follows the curve <c>. Let us imagine the wooden surface <e> being tangent to the curve <b>. With the end of the blade following the curve <d> the adze can cut from the wooden surface all the volume included in the lines <e>-<d> (fig.68). With the end of the blade following the curve <c> (65^{o}) the adze can cut from the wooden surface only the volume included in the lines <e>-<c>. With this example it is obvious I believe that this form of the blade of the adze provides, in addition to the smooth hewing, a sort of limit on the volume of the wood which can be cut and therefore protects the planks from damage caused by hewing.

The pin on the other side of the head was used as a punch to drive spikes and nails below the surface of the timbers in order to protect the cutting edge of the adze (Salaman,Q.A. (1972, pp.28-9)).

Nevertheless the adze was used only by certain carpenters who were specialized on that task. It was used in several parts of the boatbuilding process. The adze was extensively used on all parts of the boatbuilding before the introduction of electric tools. Today the successful use of an adze is admired as a very skilful task in the boatyards (Συμπελέκημα) ([1]-Mavrikos, [16]-Kritikopoulos) (7.5.4 Planking up the hull).

4.7.4 Small Adze (Σκεπάρνι)

This was a small version of the shipwright's adze (fig.67b). It was used on the same tasks as the adze but on narrower surfaces than the former tool and for lighter hewing and scraping. The key-shape hole on the middle of the blade was used to extract nails. The tool was similar in size and general appearance to the other small adze which was used in Greece among builders. Moreover the angle of the blade (65^{o}), the extensive length of the blade and the pin on the other side of the head are distinctive details of the shipwright's small adze. ([16]-Kritikopoulos)

In Salaman,Q.A. (1972, p.30) a drawing of a similar small adze is included under the name of "Turkish adze (Oriental adze)".

A similar small adze was in used in the Adriatic boatyards (Patragnani,W. (n.d. p.60)).

4.8 <u>Smoothing</u>

4.8.1 Keel and post rabbet planes (Νύχια)

All the planes are made of hard wood, especially oak, in order to avoid damage by means of friction on the planks. As seen from the illustrated examples there are both home-made and manufactured planes.

There are three types of keel and post rabbet planes recorded in this work. The main difference between these three types was based on the angle that the sharp edge of the blade forms with a surface perpendicular to the axis of the blade. The first is with an angle about 15° (Νύχι ψυλό) (fig.69c), the second with an angle about 27°(Νύχι) (fig.69b) and the third with an angle 36° (Νύχι Χοντό) (fig.72b).

There were two basic uses of these planes. The first was to form the rabbets on the keel and on the posts. In this case the different types of these plane are used to form the different bevels of the rabbet cut along the length of the keel and the posts. The second use was to make the starting mark of any sort of line or stripe on the planks of the hull. This was because these planes were pointed and they could easily be used to begin any sort of stripe. After that, other planes were applied to form the required final cross-section of any stripe on the hull ([16]-Kritikopoulos).

4.8.2 Grooving plane (Πάνιστρο)

This was a plane with a straight wooden strip on one side of the sharp end of the blade which acts as a fence. The sharp end of the blade was set straight and horizontal (fig.70b,c). There was a variety of grooving planes with different lengths in the boatbuilders work-shop. There were short planes about 20cm in length and long planes about 70cm in length. Planes with different lengths were used in relation to the length of the boat. There were also different kinds of grooving planes according to the width of the sharp side of the blade. The three illustrated examples had different blade widths.

The basic use of grooving planes was to form grooves at the corner lines of two edges of a wooden commponent of a boat. These grooves on the timbers of the boat can either remain as purely functional or cosmetic ones or they can be developed into a more complicated cross-section by other moulding planes. An example of functional use was the groove formed on the outside and upper corner of the gunwale timber (Μπαστιγάγιο) to accommodate the lower edge of the side canvas of the boat ([8]-Chalaris).

Often grooving planes are used on the edges of planks to determine the desired bevel on the edge of this plank (Αρμολόγος). After that a flat plane was applied to set the whole edge of the plank to the level of the predetermined groove (a sort of "guide groove") ([16]-Kritikopoulos).

In the illustrated examples there is a manufactured grooving plane possibly made by a European company at the end of the 19th century (fig.71, recorded from the collection of the Hellenic Institute of Preservation of the Maritime Heritage).

4.8.3 Flat plane (Γκινόσσος)

This was a simple plane with a blade heving a horizontal sharp end (fig.70a). It was made on a variety of lengths from a "thumb" size to about 70cm length ([16]-Kritikopoulos).

The main use of this plane was to bevel the edges of the plank. As we already mentioned the grooving planes were first used to determine the line of the edge with a groove and later the edge were bevelled with the flat plane the whole edge on the level of the groove.

These flat planes as well as most of the other planes were home made by the boatbuilders.

4.8.4 Moulding planes

There was a variety of moulding planes which can produce cosmetic stripes on the hull of the boat. In this work we will mention the most common examples of them.

4.8.4a Bound moulding plane (Λούκι)

The sharp edge of the blade of this plane was curved. This can provide a smooth curved concave stripe on the hull of the boat (fig.69a). In order to use this plane they nailed a thin lath on one side of the line on which the stripe will be scraped. This lath was used as a side-guide for the plane.

4.8.4b Side-hollow moulding plane (Τσιμπουκάκι)

This plane was used to produce stripes with curved cross-section on the corners of hull components. There are two illustrations of this plane. One was used by a right hand person (Τσιμπουκάκι Δεξί) (fig.72c) and the other by a left hand person (Τσιμπουκάκι Αριστερό) (fig.72a).

Often they used first the grooving planes to determine the line of the stripe and later they used the side hollow moulding planes to form the final cross-section of the stripe. This sort of stripe was often on the edge of the gunwale timber or on the edge of the water-way timber.

4.8.4c Middle hollow moulding plane (Κορδονιέρα της μέσης)

This was used to produce curved stripes on the middle of wooden surfaces (fig.73a). The same guide lath as in the case of the bound moulding plane was used. These sort of stripes were common on the hull of the boat either above or below the water-way timber and on the sides or the middle of the deck ([16]-Kritikopoulos).

4.8.4d Almond-shape moulding plane (Αμιγδαλάκι or Εργαλείο τραβιχτό)

This was used again on the corners of components of the boat to produce concave stripes. It has the same process of use as the side hollow moulding planes (fig.73b).

4.8.5 Flat "surface" plane (Ροκάνι)

In Greek boatyards the planes which are applied on an extensive surface have the common name of Rokani (Ροκάνι). The planes which are used to form stripes or to set seams are called Plani (Πλάνη) or Nichi (Νυχι). The flat "surface" plane as well as the next three planes are under the general name of Ροκάνι. This was used on trimming down almost flat surfaces of the hull or the deck. The plane had usually a horn on the front side to be held by the left hand of the user (fig.74a). In Salaman,R.A. (1972, p.305, 350) there are mentioned two similar planes under the names "Bismarck plane" and "Roughing plane".

4.8.6 Bound "surface" plane (Στραυορόκανο)

This was used on concave surfaces along the axis of the plane (fig.74b, 75b). All the illustrated examples of "surface" planes are home-made and the blades are made by local smiths of steel.

4.8.7 Across-bound "surface" plane (Σκαφιδορόκανο or Λακορόκανο)

This was used on concave surfaces of the hull across the axis of the plane (fig.75c). It was used as well to trim the inside of the planks before they were set on the most curved parts of the hull. During this use the same plane was often called "Λακορόκανο" ([1]-Mavrikos).

4.8.8 Smooth-across-bound "surface" plane (Ροκάνι φαρδί)

This was a plane used on smooth concave surfaces across the axis of the hull and with a wider blade than that of the previous plane (fig.75a). All of the "surface" planes were used only along the grain of the planks. For this reason the basic idea of the form of these planes was on the one hand to use them always horizontally (along the grain of the planks) and on the other hand to trim all the curved surfaces of the hull.

4.8.9 Sharpening stone (Ακόνι)

All the blades of the planes were honed on a sharpening stone. This was made by the boatbuilder of sand-stone and framed in a wooden box (fig.76). The illustrated example is from [7]-Chimonas' yard in Chalkis.

4.9 Caulking

4.9.1 Caulking Mallet (Ματσόλα)

The head of the mallet had almost circular faces at the two ends. The section across the middle of the head of the mallet was oval-shaped. The faces of the ends of the head were tapered by means of iron rings. These faces at the two ends were set on a slight angle to the horizontal axis of the head (fig.77).

When the faces of the head are damaged by extensive use the boatbuilders removed the iron rings and trimmed both faces and the grooves of the irons by means of a rasp (Ράσπα). Then they replaced the iron ring which now was placed 1 or 2mm closer to the eye of the head. To fasten firmly this ring on the mallet they used to make a couple (or more) splits on the faces by means of the sharp iron and to drive small wooden wedges in these splits ([10]-Binos).

At a distance of 7cm from the center of the head of the eye (fig.77) one vertical hole (about 70mm in diameter) was bored on each side. These holes are linked with the eye of the head by a sawn cut. The most obvious explanation of this structural arrangement of the head of the mallet is a desired flexibility of the head at the eye in order to accommodate more firmly the helve. [10]-Binos who used to work as a specialized caulker) claimed that this arrangement even provided even extra strength to the mallet, though he was unable to explain how this arose. To prevent splitting of the head in half (because of the central cut) two horizontal rivets were inserted on the head at a distance of about 2cm from the vertical holes in the direction of the faces (fig.77).

Frost,T (1985, p.49) includes the illustration of a caulking mallet from Britain. Apart from the difference in the form of this mallet from the Greek one all the other details can be very clearly identified there as well.

The head was made of hard wood (usually of scrub oak) and the helve of soft wood (usually pine). This difference of the kind of the wood provides a firm set of the helve into the eye of the head and a stronger head-piece with longer life ([10]-Binos). Apparently the pine helve had more elasticity than a helve made of hard wood which seems to be important for the use of the mallet (we will explain soon the oscillation which occurs in the mallet which was obviously related to the elasticity of the helve).

The helve was extended above the head of the mallet about 14cm, the part below the head was about 29cm in length on the illustrated example in fig.111 and the height of the head was about 7cm. According to the boatbuilders this extention of the helve above the head is necessary for a proper use of the mallet ([8]-Chalaris, [10]-Binos, [16]-Kritikopoulos).

If we examine a simplified diagram (fig.78) of the use of the mallet we can produce a likely explanation of the necessity of this form of the tool. Let the line ABC represent the helve of the mallet where A was the handling point and B the center of the head's weight. When the caulker hit the iron by means of this mallet a force <f> occurred at the point B of the helve. This force causes an oscillation of the helve. This oscillation produces the maximum vibration at the point B and the minimum one at the point A. This means that the vibration from the use of the mallet which occurs on the caulker's hand was as minimal as possible. The fact that the extension of the helve takes part in the oscillation provides the mallet with a tendency to come back to the starting position (ABC) (fig.78). This arrangment increases the "elasticity" of the tool and means that the caulker has to spend less effort to use it for hitting the iron continuosly. This provides a better and more comfortable holding and use of this tool.

Another well known remark which the caulkers usually mentioned is the characteristic sound that the mallet produced when it was used. The likely explanation is that the two vertical holes on the head of the mallet were a source of acoustic waves. A certain number of these waves could be synchronized and produce some clear sounds. Of course for a further study of this property of the caulking mallet some acoustic experiments are required. It is remarkable however that the caulkers could understand if the oakum was set at the right position into the seams by the sound that the mallet produced. Moreover this sound was different at the first set of oakum that at the second one ([10]-Binos).

This study of the mallet produced I think sufficient evidence in order to understand why caulking was a special and distinctive task during the boatbuilding process.

4.9.2 Old caulking mallet (Ματσολίνο)

The caulkers used to keep old used mallets and trim them like the illustrated examples (fig.79a,b). These old mallets were used as miscellaneous tools. The caulkers preferred to use old mallets in cases where the use of the proper mallet might cause damages to it (e.g when checking the conditions of nails during repairing work) ([10]-Binos).

4.9.3 Sharp iron (Κοφτερό)

This iron was narrower than most of the other caulking irons with the working edge sharpened almost like a knife (fig.80a). The sharp iron was used to widen the seams of the hull in preparation for caulking (7.6 caulking). They used to sharpen this iron almost every day by means of an ordinary file ([10]-Binos).

4.9.4 Setting iron (Παρέλα)

By means of the setting iron they fill the seams of the hull with oakum. This iron had a special flattened form with three sharp edges (fig.80b).

This was necessary because the setting iron was used at an angle rather than normal to the seam, so the oakum is lightly tacked into the seam using the corner of the iron. In order to use this iron properly the caulkers used to hold it in a special way ([10]-Binos).

4.9.5 Thick Single iron (Χοντρό Δυπλό)

The edge of this iron had again a single crease but in section was thicker than thin single iron (see below) (about 5mm) (fig.80d). This was used after the setting iron to press the first part of the caulking oakum in to the seams ([10]-Binos).

4.9.6 Thin single iron (Στενό Δυπλό)

The edge of this iron had a single crease and in section was about 2.5mm thin (fig.80c). This was used after the thick single iron to press the oakum further into the seams of the hull. Often the caulker had spare irons in case of damages or for different thicknesses and sections of seams (fig.116).

4.9.7 Double iron (Τσιμπουκάκι)

This was an iron with a double crease and a thickness on the working edge of about 7mm. It was used after the thin and the thick single iron and only on boats of more than 20m ([10]-Binos) (fig.80e). Because of the thickness and the length of the planks of this size of boats the seams were wider than on smaller boats. They often required caulking two and three times including the use of the double iron. Even a thick double iron was used if it was necessary ([10]-Binos).

4.9.8 Bent iron (Στραβό)

This was a bent setting iron used in seams were the normal setting iron was unable to fit properly. This was the case on the rabbets on the keel and the posts and some deck seams near the scuppers (fig.80f) ([10]-Binos).

4.9.9 Treenail or spike iron (Στενάκι)

That was the narrowest of the irons with a simple sharp edge (fig.80g). It was used to put oakum in cracks of the planks and to caulk treenails and scarf-joins ([10]_Binos).

4.9.10 Tool for checking nails on the hull

That was an ordinary bolt sharpened on one end (fig.80h). This was not an ordinary caulking tool but it existed with the other irons in the caulker's kit. It was used with old mallets to test the nails of the hull especially during repairing boats ([10]-Binos).

4.9.11 Old iron

These were often kept in the caulker's kit (fig.80i) as miscellaneous tools. ([10]-Binos)

4.9.12 Caulker finger stall (Δαχτιλίθρα)

This was often made of leather or in some cases just of piece of cloth. The recorded caulker's kit did not include a caulker's finger stall.

4.9.13 Caulker tool box or "kit" (Κασσέλα)

That was a small wooden box to carry the irons. It was commonly used by the caulker as a working seat when he was working on the lower part of the hull of a boat (fig.80j).

4.9.14 Big caulking mallet (Καταράφα)

This was a mallet bigger and heavier than the ordinary caulking mallet. I could not find any example to illustrate in this work but according to [10]-Binos' descriptions this tool was a simpler version of the caulking mallet with bigger dimensions. It had tapered iron rings on the two faces but no holes, or saw cut or rivets on the head. It was only used with the thick double iron as the last step of setting the oakum into the seams of big boats. This mallet was used by one caulker while another one hold the thick iron by means of iron-tongs. ([10]-Bilias)

4.9.15 File (Λύμα)

An ordinary long file was used for sharpening the irons.

4.9.16 Box for tar (Δοχείο Πίσσας)

This was a small wooden box or any other kind of box where they used to keep the tar which was used on top of the oakum on the seams.

4.9.17 Brush for tar (Μαλαχτάρι)

This was a big brush with a handle about one meter long. A long stick was used to make this brush. At the end of the stick they tied a piece of skin from a young sheep. According to [10]-Binos the skin of the lamb provides a better caulking brush on tar than any other material for that.

In Frost,T. (1985, p.49) there is included a similar home made brush for tarring in the boatyards in Britain.

4.10 Comments on tools

[1]-Mavrikos, [8]-Chalaris, [11]-Polias and [12]-Kozonis mention that "the less number of tools which a boatbuilder required to build suffienciently a boat the more skilled this boatbuilder was". This statement suggests very clearly that the skill of the boatbuilder was more important than any increase in the number of special tools available.

Moreover the same statement reflects the reluctance of boatbuilders to use modern methods or tools before these have been suffi ciently tested and adapted to the tasks of the work.

In any case this kind of suggestion which minimizes the importance of the development of tools in comparison to personal skill seems to characterize the relationship between the Aegean boatbuilders and their tools. This is a subject that we are going to study in the following sections of this chapter.

At the moment let us examine the tools presented as groups in respect to the phases of the boatbuilding process.

4.10.1 Tools and the boatbuilding process

In order to examine in a convenient form the relation between tools and building process we suggest table.no.15 where most of the tools studied are listed and related to the phases of the work. Some of the tools are not included in this table either because they were miscellaneous, (saw setting tool, treenail maker, old iron, caulker's tool box) or because they are not clearly identified as tools, (moulds, patterns) or because they were not in use during these phases of boatbuilding (launching cradle).

Studying this table we can see that the relation between tools of

Table.no.15

Phases of boatbuilding process
A: Cutting and splitting timbers
B: Designing and lofting
C: Keel and posts
D: Skeleton
E: Planking
F: Caulking and tarring

4. TOOLS		A	B	C	D	E	F
4.2	Splitting Cleaving and Cutting						
4.2.1	Frame saw (Κουραστάρι)	A					
4.2.2	Small frame saw (Ξεγυρισταρι)	A		C	D		
4.2.3	Crosscut saw (Καρμανιόλα)	A					
4.2.4	Small crosscut saw (Σβανάς, Σμήνη)			C		E	
4.2.5	Bow or turning saw (Πισκί)				D	E	
4.2.6	Axe (Τσεκούρι)	A					
4.2.7	Wooden wedge (Σφίνα)	A					
4.2.8	Wooden sledge hammer (Ματσόλα)	A					
4.3	Measuring Marking and Lofting						
4.3.1	Bevel gauge (Στέλα)		B	C	D	E	
4.3.2	Big bevel gauge (Στέλα, Φαλτσολόγος)		B		D	E	
4.3.3	Square angle (Μικρί γωνιά)		B	C	D	E	
4.3.5	Pair of sweeps (Κουμπάσο)		B		D	E	
4.3.6	Mastari (Μασταρί)				D	E	
4.3.7	Stantsola (Σταντσόλα)				D	E	
4.3.8	Marking tool (Σημαδούρα)			C	D	E	
4.3.9	Stripe marking tool (Σημαδούρα λούκι)					E	
4.3.10	Plumb line (Στάθμη)	A		C	D		
4.3.11	Marking line (Στάθνη)	A	B	C	D		
4.3.14	Lath (Πήχης)		B				
4.3.15	Big square angle (Γωνιά)		B				
4.4.	Holding and Grasping						
4.4.1	Wooden cramp				D	E	
4.4.2	Ship cramp (Σφοιχτήρας)			C	D		
4.4.3	Joiner's cramp (Νταβίδι)				D		
4.4.4	Gee cramp (Γρήλος)				D	E	
4.4.6	Stands for the keel (Αντιλείχτες)			C			
4.4.7	Stands for posts/ribs (Μπουντέλια)			C	D		
4.5	Boring						
4.5.1	Shell augers			C	D	E	
4.5.2	Twist augers			C	D	E	
4.6	Hammering						
4.6.1	Heavy maul hammer (Ζουπάς βαρής)			C	D		
.1	Maul hammer (Ζουπάς)				D	E	
.1	Light maul hammer (Ζουπάς ψηλός)					E	
4.6.2	Small hammer (Σφιράκι)		B				
4.6.3	Sledge hammer flat face (Βαριά)			C	D		
.3	Sledge hammer domed shape face (Μπάλα)				D	E	
4.6.4	Wooden mallet (Ματσόλα)				D		
4.7	Hewing						
4.7.1	Chisels of different sizes (Κοπίδι)			C	D		
.1	Chisel with narrow end (Στραυοκόπιδο)				D	E	F
4.7.2	Mortice chisel			C	D		
4.7.3	Adze (Σκεπαρνιά)	A		C	D	E	

4.8	Smoothing			
4.8.1	Keel and post rabbet plane (Νίχι)	C	E	
4.8.2	Grooving plane (Πάνιστρο or Αρμολόγος)		E	
4.8.3	Flat plane (Γκινόσσος)		E	
4.8.4	Moulding planes (Τζιμπουκάκι, Κορδονιέρα, Αμιγδαλάδι)		E	
4.8.5	Flat "surface" plane (Ροκάνι)		E	
4.8.6	Bound "surface" plane (Στραυορόκανο)		E	
4.8.7	Across-bound "surface" plane (Σκαφιδορόκανο)		E	
4.8.8	Smooth-across-bound "surface" plane (Ροκάνι Φαρδί)		E	
4.9	Caulking			
4.9.1	Caulking mallet (Ματζόλα)			F
4.9.2	Old caulking mallet			F
4.9.3	Sharp iron (Κοφτερό)			F
4.9.4	Setting iron (Παρέλα)			F
4.9.5	Thick single iron (Χονδρό δυπλό)			F
4.9.6	Thin single iron (Στενό δυπλό)			F
4.9.7	Double iron (Τσιμπουκάκι)			F
4.9.8	Bent iron (Στραυό)			F
4.9.9	Treenail or spike iron (Στενάκι)			F
4.9.14	Big caulking mallet (Καταράφα)			F
4.9.17	Brush for tar (Μαλαχτάρι)			F

"Splitting & cutting" and the phase of "Splitting and cutting timbers", as well as the relation between tools of "Caulking" and the phase of "Caulking" were rather independent from the other parts of the table. Indeed we know from the interviews ([10]-Binos, [11]-Polias) that the most independent tasks in the yard were those of the wood-cutter (Πισκιτσής) and the caulker (καλαφάτης). Despite any social and economical reasons for this division of the boatbuilding process we can add some relevant aspects from a technical point of view.

From the study of "Splitting & cutting" tools we can see that most of them are well adapted to the rough condition of the wood. The wood-cutter too must know more things about trees and rough wood than about setting planks on the skeleton or working on a lofting floor. On the other hand although this job seems more relevant to the general wood-cutter work there are noticeable differences between them. These are basically the requirement of adequate curved logs (which determine the form of the frame saw with narrow blade, the small frame saw, the small cross-cut saw, and the bow or turning saw) and the need for specific properties of the timber for boatbuilding purposes (6.2 Properties of boatbuilding timber).

In the case of "Caulking" we can suggest that this was the "micro-work" in the yard. The caulking irons are well adapted to be used in seams and splits of the hull (sharp iron, setting iron, single and double irons, bent iron). Because of the somewhat limited ability of the caulker to have visual control of his work he took advantage of the acoustic effects of his job and produced the caulking mallet with sophisticated acoustic details.

We do not have any evidence about the time that these two parts of the boatbilding process became independent jobs in the Aegean boatyards. However taking advantage of the technical examination of the tools we can suggest that the tradesman of both jobs must have developed their skill at least as early as the last quarter of the 18th century in respect to the technical improvements occurring in that period (1.1 First period (18th century to 1830)). [8]-Chalaris noticed three specialised groups of workers in the boatyard of Santorini: the carpenters, the woodcutters and the caulkers.

Koukoule,F.I. (1950, pp.302-3) mentions the caulking facilities in the boatyards of the Aegean Sea during the 12th century. However, we do not know if tools similar to the ones mentioned above were used in these early times.

Gourgouris,E.N. (1983, p.449, 467) mentions the existence of at least six specialized groups of workers in the boatyards of Galaxidi during the second half of the 19th century as the following: carpenters (Καραβομαραγκοί), keel makers (Τροπηταί), auger users (Μπουργουντζηδες), caulkers (Καλαφάτες), adze users (Πελεκιτσίδες) and woodcutters (Υλοτόμοι). He even mentions the distinction between the carpenters and the shipwrights (Αρχιναυπηγος). Zouroudis,G. (1974, p.168) mentions the special task of the group of "πουργουdζής" which was to drill the holes and to drive the bolts, the nails and the treenails into the holes. For the rest of the specialized groups of workers the indications in table.no.15. are not so obvious. However we can note that the tools of "Measuring, marking, moulding and lofting" were very well distributed in the phases B, C, D and E of the boatbuilding process. On the other hand the phase B, Designing and lofting, was engaged with only tools of this group. We suggest that this last relation, which apparently was associated with initial decisions about the form of the vessels, reflects the shipwright's work (Αρχιναυπηγός).

Furthermore we can suggest that the curved shape of every single one of the components of the boats required a special development of the measuring and marking tools and even the invention of new ones (stantsola, mastari, moulds). Historically it is rather difficult to suggest anything about the evolution of these groups of tools. We know, for example, that the "stantsola" and "mastary" tools were introduced at least in the island of Psara at the end of the 18th century (Nikodimos,N. (1862, p.73). The moulds for the moulding with adjustable templates method (5.2.2 Moulding with adjustable templates) were in use even earlier than the end of the 18th century (Nikodimos,N. (1862, p.71). So what we can suggest at the moment is that the "Measuring, marking and lofting" group of tools was one of the fundamental parts of this trade. We will later resume the study of these tools and we will get a clear understanding of their use in the following chapters (5. DESIGNING, 8. CONSTRUCTION)

The tools of "Holding and grasping" were distributed in two basic ways. The first was in the phases C and D (keel/posts and skeleton) and the second into the phases D and E (skeleton and planking). This division was associated with the distinction between heavy and light tools. This is something that we will study later in this section.

The tools of the "Boring" group were distributed in all phases of the main construction process (keel/posts, skeleton, planking). In respect to the evidence of the existence of specialized auger users we can realize a special identity of this group (Gourgouris,E.N. (1983, p.449)). However, the fact that these tools have been used at the same time as some of the tools of the other groups is suggesting a different kind of independence than the "Splitting, cleaving and cutting" or the "caulking" tools. This can be distinguished in table.no.15 by the destribution of the use of these tools through most of the phases in contrast to the absorption of the "Caulking" and initially the "Splitting, cleaving and cutting" tools by certain phases of boatbuilding. This difference, we suggest, reflects in practice two kinds of worker specialization. The one was in respect to the groups of "Splitting, cleaving and cutting" and "Caulking" and it required special knowledge and experience of the work. The other was in respect to the group of "Boring" and it served the requirement of more organized and better timed work. Therefore our suggestion is that this last kind of specialized task was a more recent event than the others. Probably this occurred after the development of shipbuilding by the end of the 18th century.

The next group "Hammering", shows the same kind of distribution as the group "Holding and grasping" and we can make the same comments about the heavy and the light tools (4.4 "Holding and grasping" tools above).

In the group "Hewing " there are two remarks to be made. The first is that the chisels show the same kind of distribution as for "Hammering" and "Holding and grasping". The second is in respect to the evidence about the existence of specialised adze users (Πελεκιτζηδες) (Gourgouris,E.N. (1983, p.449)). If we study in table no.15 the extent of use of the adze and the small adze we will realize the similarity with the group "Boring". So for the same reasons we can suggest that this specialized task in the boatbuilding process appeared after the end of the 18th century (4.5 "Boring" and 1.1 First period (18th century to 1830)).

The tools of "Smoothing" are rather independent from the other groups of tools. Their use for trimming surfaces and producing strips associates them with the "Planking & Decking" part of the building process. Some of them provide more cosmetic than structural treatment. The use of this group of tools was possibly associated with the carpenters rather than with the shipwrights (Gourgouris,E.N. (1983, p.449)).

As we mentioned already, the groups "Holding and grasping", "Hammering" and the chisels contain tools which were used during the phases C and D, and tools which were used during the phases D and E. We mentioned also that this was in respect to different sizes or weights of the same fundamental tool. Furthermore there is a substantial number of tools that can be regarded as developments of fundamental tools. (for example: small and big frame saw, small and big bevel gauge, small and big augers, heavy and light maul hammer, small and big adze).

Studying the table.no.15 we can detect two specific patterns of tool-use during boatbuilding. First a general or widespread use through most of the boatbuilding phases (bevel gauge, square angle, marking line, adze). Second a use of group of tools only during a specific phase (planes during planking and caulking tools during caulking). The tools used under the first pattern were either fundamental tools for the whole process (bevel gauge, square angle, marking line, adze) or the same kind of tools in different sizes (frame saw and small frame saw, ship cramp and gee cramp, small and big augers, heavy and light maul hammers, chisels with wide and narrow end). The groups of tools used under the second pattern can be justified by a fundamental pattern of tools-use (scraping down the hull or caulking) which was carried out by a variety of similar tools (moulding planes, "surface" planes, single and double caulking irons).

We can pin-point at the end of this part the two categories of boatbuilders' tools. The first was the rather "fundamental" group of tools which were necessary in respect to the structure of the boats (for example: frame saw, cross cut saw, turning saw, adze, augers, maul hammer, sledge hammer, ship cramp, gee cramp, chisels, pair of sweeps, bevel gauge, plumb line). The second consisted of tools which can be regarded as "not fundamental" in respect to the structure of the boat (for example, small frame saw, wedges, big bevel gauge, marking tool, stripes marking tools, joiner's cramp, heavy or light maul hammer, wooden mallet, small adze, most of the planes).

However, in practice the importance of these tools was by no means inconsiderable. Since the contemporary values of society determined the ideas about the decent appearance of boats the important tools were not necessarily the ones denoted above as being "fundamental".

4.10.2 Tools and boatbuilders

The point of the distinction between "fundamental" and "not fundamental" tools can be associated with the boatbuilders comment mentioned at the beginning of this second part ([1]-Mavrikos, [8]-Chalaris, [11]-Polias, [12]-Kozonis).

This is about the capability of the most skilful of them to use as few tools as possible in order to build a decent boat. We can now better understand the meaning of this comment if we revise it to read "the most skilful boatbuilder could build a decent boat using only the "fundamental" group of tools".

Howe,S.G. (1828, pp.332-3) describes his meeting with a boatbuilder on the Island of Skopelos. He was building a boat only by means of a "rude axe", a "block of wood with a handle driven into it, for a mallet", a "saw like a notched iron hoop" and a "divider formed by a piece of oak wood split half way up, with a wedge to push up and down, to open or shut the arms".

Despite the really bad condition of his tools the boatbuilder from Skopelos must have been very capable in building a boat using this small group of "fundamental" tools.

Although we do not know the date S.G.Howe met this boatbuilder on Skopelos we can suggest that in the late 18th century there were two kinds of equipped boatyards in the Aegean. Those with primitive tools like the Scopelos' one and those with more organized tool selections having some specialization among the separate tasks in the trade like the boatyards on Hydra, Spetses, and Psara (1.1 First period (18th century to 1830)).

In the examination of the tools we mentioned that most of them are made by the boatbuilder (all the wooden parts). A few of them are even made only to be used on one particular boat (stripe marking tool, stantsola (σταντσόλα) and mastari (μαστορί)). Most of the tools were well adapted both to the ability and the knowledge of the boatbuilder and to the demands of the work (the different size of some caulking mallets were in respect to body-dimensions of some boatbuilders, the right and left hand planes, the different sizes of tools in respect to different lengths of boats).

Therefore we can suggest that the skill and the experience of the boatbuilder was behind the generation and the use of all the tools in the boatyards. He was capable of making new tools, to replace some of them with others, to adapt some tools to the demands of the work and at the end of the day to teach all this to the apprentices in the yard.

Based on these suggestions we can start drawing the outline of the boatbuilders skill and confidence in his work.

5. DESIGNING

(The practical determination of the dimensions and lines of a vessel)

At the end of the chapter on 3. Morphology we pinpointed the importance of the fundamental phase of determining the form of a vessel during boat building. We mentioned that in addition to the decision about the type of the boat, the boatbuilder had to determine the form of the hull in respect to the function, the method of propulsion and his ideas about fair lines of hulls. This determination was undertaken during the phase of designing which usually was something more abstract than the production of the lines plans. In practice the most extensively used methods of moulding required some decisions about the form of the boat without providing visual representation of them in advance. We suggest that this apparently traditional method was based on a more abstract conception of a boat's form than the methods by means of models or plans. The use of the moulding method required a great knowledge of both this method and the forms of the vessels. The first aim of this chapter is to study this knowledge of designing which apparently has been maintained through successive generations of boatbuilders.

Furthermore, practice in the boatyards across successive generations of boatbuilders provided for sophisticated development of these methods. The study of the evolution of these methods of designing during the period with which this thesis deals is the second aim of this chapter.

As we will see there is evidence for the existence of all these methods in other parts of the world where the same or similar tasks were carried out. This suggests the study of the origin of the practices in the Aegean Sea as the third aim of this chapter.

In respect to the following chapter on the 7. Construction process we are going to study first the determination of the fundamental dimensions of the boats as it practically occurred in the boatyards. Then we will continue with the study of the methods of moulding and the methods of lofting. At the end we will study all the traditional methods of designing with an overall view and their evolution through the last two centuries in the Aegean.

5.1 Fundamental dimensions

Two versions of starting the determination of the fundamental dimensions are recorded in this work. [8]-Chalaris and [10]-Binos mention the L.O.A. of a vessel as the starting point of this task. Adoniou,A. (1969, p.50) mentions the L.O.A. as the first determined dimension of a boat during the boatbuilding process. He adds however that most of the traditional boatbuilders used the length of the keel as the first determined dimension. This goes along with all the remaining evidence available on the matter ([3]-Stilianou, [5]-Dardanos, [6]-Arvanitis, [14]-Chatzinikolaou, [17]-Papastephanou, Throckmorton,P. (1964, p.214), Poulianos,A. (1977, p.533)).

In Nikodimos,K. (1864, p.70) there is the suggestion that during the last years of the 18th century the boatbuilders on the Island of Psara used the length of the keel as the starting point for the determination of all the rest of the boats' dimensions.

Nevertheless the two versions did not provide any major different effect on the rest of the boatbuilding process since the next step was the determination of the horizontal projections of the stem and the stern post together with the L.O.A. or the length of the keel respectively ([1]-Mavrikos).

However the determination of the length of the keel was in practice more accurate than that of the L.O.A. since it was based on the length of a single component rather than on the total length of three or even more structural components.

The remaining fundamental dimensions (F.D.) which were determined in this very first part of the building process were the mid-ship beam (M.B.), the mid-ship depth (M.D.), the horizontal projection of the stem post (Hor.Stem Proj.), the horizontal projection of the stern post (Hor.Stern Proj), the vertical projection of the stem (Vert.Stem Proj.) and the vertical projection of the stern (Vert.Stern Proj.). All these measurements were usually considered to start from a point located on the waterway timber of the boat or on the rabbet line of the keel. On the tables no.5,6,7,8 there are sketches where these measurements are explained.

In the chapter on 2. Classification of boats we introduced the tables no.5,6,7,8 where the suggested formulae concerning ratios among the F.D. are included. However the variety of those suggestions together with the study of the available lines plans made us cautious about the existence of any ideal ratios which would cover the determination of all the above F.D. on any one of the types of hull.

In order to study farther these ratios between the F.D. of the different types of vessels we introduce the tables no.16, 17, 18, ... and 33. On these tables the F.D. of over sixty boats are included together with the percentage of their dimensions in respect to the L.Keel (100%).

The sources of these measurements vary and they are mentioned at the end of each table as footnotes. The F.D. which are mentioned in these tables have been used as examples in different places throughout this thesis.

Coming back to the determination of the rest of the F.D. at the beginning of the boatbuilding process the next step was to find out the M.B. and the M.D. of the vessels. These dimensions seemed to be related most often by means of a ratio with the L.Keel. (tables, no.5,6,7,8). However we mentioned in the chapter on 3. Morphology the factors that influenced the determination of the M.B. and the M.D. of each boat despite its type. Table no.34 includes the maximum, the minimum and the average of the ratios M.B./L.Keel and M.B./L.Keel from the examples on the tables no.16,17, ... ,and 33. These are only for the types of hull which are represented on these tables with a sufficient number of examples (Trechadiri, Perama, Varkalas, Karavoskaro, Liberty).

From table no.34 we can notice the similarities of some of the average figures with the suggested ratios on the tables no.5,6,7,8. However it is worth noting the relatively pronounced deviation of some of the min. amd max. figures from the respective averages.

The next step was to determine the dimensions of the stem and the stern post. We mentioned on tables.no.5 and 6 some formulae concerning the ratios of Hor.Stem Proj./L.Keel and Hor.Stern Proj/L.Keel on Trechadiri and Perama hulls.

In practice most of the boatbuilders drew the profile of the stem and the stern post straight on the lofting floor or on any board which was wide enough.

However for the purposes of this thesis we analyse the profile of the posts into their horizontal (Hor.Stem Proj. or Hor.Stern Proj) and vertical projections (Vert.Stem Proj. or Vert.Stern Proj.). Table no.35 includes the minimum, the maximum and the average of the ratios Hor.Stem Proj./L.Keel, Hor.Stern Proj/Hor.Stem Proj., Vert.Stem Proj./L.Keel and Vert.Stern Proj./L.Keel from the examples of the tables no.16, 17, ... ,and 33. These are in respect to the type of hull and they include only the types Trechadiri, Perama, Varkalas, Karavoskaro and Liberty.

We can notice that as we showed in the chapter on 3. Morphology the horizontal projection of the stem (Hor.Stem Proj.) and the stern (Hor.Stern Proj) were formed in respect to the width of the hull on the bow and stern area. Furthermore the depth of the stem (Vert.Stem Proj.) and the stern post (Vert.Stern Proj.) were formed in respect to the desirable curve of the sheer line and also to the M.B. that the boatbuilder determined in the previous step.

We can see then that the dimensions of the stern posts and the stem posts were directly related to the rest of the form of the hull. In places lacking a good supply of timber often the shape of the available naturally curved timbers was another point under consideration when they formed the stem and the stern posts.

By the end of this determination of the F.D. the boatbuilder could give an estimation about the capacity of the vessel.

According to [6]-Arvanitis, [8]-Chalaris and [10]-Binos the boatbuilder estimated the capacity of the boat by rule of thumb before starting to build her. However there is evidence about calculations in order to have an approximate estimation of the carrying capacity of the vessels.

Adoniou,A. (1969, p.47) suggests the following three practical ways to estimate the clear tonnage (Φ) of a Trechadiri.

On Syros they used the formula:

Φ =Lw.l. x Bin x Din x 35.3 x 17x2 x 0.000001 [where Lw.l.is the inside length of the boat on the water level, Bin. the inside midships beam (underneath the beams of the deck) and the Din. is the inside midship depth of the boat.]

For a Perama they used the formula:

Φ =L.Keel x M.B. x M.D. x 128 x 0.0001

On Samos they used the formula:

Φ =1.28 x (L.Keel+0.25x M.B x M.D)

[3]-Stilianou mentions another practical way:

Φ =75% of L.Keel x M.B. x M.D. (for Trechadiri and Perama)

Φ =82% of L.Keel x M.B. x M.D. (for Karavoskaro and Liberty)

However we can understand that since the actual form of the boats was not entirely dependent upon either the type of the hull or the fundamental dimensions (3. MORPHOLOGY) any calculation which was based on those two factors was rather approximate.

When the fundamental dimensions of the boats were determined either on the lofting floor or on a piece of paper or in the boatbuilder's mind, the process of designing proceeded into the determination of the form of various components of the boats' structure.

FUNDAMENTAL DIMENSIONS (F.D.) Table,no.16

Source :[1]-Mavrikos'lofting floor(*)

Identity of vessel	Red boat	Blue boat	Green boat	Yellow boat
Type of vessel	:trechad.	trechad. fishing	trechad. gri-gri	trechad. fishing
	m %	m %	m %	m %
L.Keel	:07.25(100)	10.30(100)	13.00(100)	13.00(100)
Hor.Stem Proj.**	:02.05(028)	02.10(020)	02.45(019)	02.45(019)
Hor.Stern Proj.	:01.70(023)	01.80(017)	02.15(017)	02.15(017)
L.O.A.	:11.00(151)	14.20(137)	17.60(136)	17.60(136)
M.B.	:04.25(058)	04.85(047)	05.00(038)	05.75(044)
M.D.	:01.40(019)	01.60(015)	02.10(017)	02.00(015)
Vert.Stem Proj.	:02.35(032)	02.40(023)	02.70(021)	02.70(021)
Vert.Stern Proj.	:02.35(032)	02.40(o23)	02.70(021)	02.70(021)
Differ. between fore & aft draught	:00.00	00.00	00.00	00.00

(*) The measurements of the dimensions are based on the lines of the boats recorded by K.Damianidis and R.G.W.Prescott.

** The measurements of the Hor.Stem Proj., Hor.Stern Proj., Vert.Stem Proj. and Vert.Stem Proj. are explained table,no.5

FUNDAMENTAL DIMENSIONS (F.D.) Table.no.17

Source: [1]-Mavrikos' lofting floor(*) and survey of "Evaggelistria"(**)

Identity of vessel	Brown boat	Black boat	"Evaggelistria"
Type of vessel	Liberty	Liberty	Perama
	m %	m %	m %
L.Keel	11.65(100)	16.20(100)	14.00(100)
Hor.Stem Proj.	02.35(020)	02.40(015)	03.24(023)
Hor.Stern Proj.	02.50(021)	02.40(015)	01.68(012)
L.O.A.	16.50(141)	21.00(130)	18.92(135)
M.B.	05.20(045)	05.30(033)	06.08(043)
M.D.	02.00(017)	02.20(014)	02.52(018)
Vert.Stem Proj.	03.30(028)	03.70(023)	03.60(026)
Vert.Stern Proj.	03.20(027)	03.80(023)	03.36(024)
Differ. between fore & aft draught	00.00	00.00	00.00

(*) see footnote (*) in Table.no.16

(**) The boat belongs to the Aegean Maritime Museum and has been recorded by K.Damianidis in summer 1988.

FUNDAMENTAL DIMENSIONS (F.D.) Table.no.18

Source: Adoniou, A. (1969)

Identity of vessel	no.30	no.31	no:33	no:34
Type of vessel	Trechadiri gri-gri(*)	Trechadiri fishing	Trechadiri	Trechadiri
	m %	m %	m %	m %
L.Keel	13.58(100)	09.25(100)	10.20(100)	08.75(100)
Hor.Stem Proj.	02.14(016)	02.48(027)	03.15(031)	02.05(023)
Hor.Stern Proj.	01.38(010)	00.87(009)	01.45(014)	01.15(013)
L.O.A.	17.00(126)	12.60(136)	14.80(145)	11.95(136)
M.B.	05.00(037)	04.16(045)	04.58(045)	03.84(044)
M.D.	01.70(012)	01.38(015)	01.78(017)	01.45(017)
Vert.Stem Proj.	02.40(018)	02.21(024)	02.38(023)	02.11(024)
Vert.Stern Proj.	02.41(018)	02.21(024)	02.68(026)	01.72(020)
Differ. between fore & aft draught	00.00	00.00	00.32(003)	00.39(004)

(*) fishing with long nets

FUNDAMENTAL DIMENSIONS (F.D.) - Table,no.19

Source: Adoniou,A. (1969)

Identity of vessel	:no.35	no.36	no.37	no.38
Type of vessel	:Trechadiri	Trechadiri	Trechadiri	Trechadiri
	m %	m %	m %	m %
L.Keel	:07.00(100)	07.40(100)	04.30(100)	13.00(100)
Hor.Stem Proj.	:01.80(026)	01.85(025)	01.00(023)	03.90(030)
Hor.Stern Proj.	:01.00(014)	00.85(011)	00.60(014)	01.90(015)
L.O.A.	:09.80(140)	10.10(136)	05.90(137)	18.80(145)
M.B.	:03.40(048)	03.05(041)	02.16(050)	05.60(043)
M.D.	:01.48(021)	01.36(018)	00.68(016)	02.28(017)
Vert.Stem Proj.	:02.40(034)	01.80(024)	00.85(020)	02.80(021)
Vert.Stern Proj.	:02.00(028)	01.80(024)	00.90(021)	03.30(025)
Differ. between fore & aft draught	:00.22(003)	00.00	00.00	00.00

FUNDAMENTAL DIMENSIONS (F.D.) Table,no.20

Source: Adoniou, A.(1969)

Identity of vessel	:no.18		no.14		no.74		no.20	
Type of vessel	:Divers Trechadiri		Tserniki		Gatsao		Trata	
	m	%	m	%	m	%	m	%
L.Keel	:07.70	(100)	11.00	(100)	21.60	(100)	09.58	(100)
Hor.Stem Proj.	:02.87	(037)	02.90	(026)	02.70	(012)	02.48	(026)
Hor.Stern Proj.	:01.33	(017)	01.20	(011)	02.20	(010)	01.20	(012)
L.O.A.	:11.90	(154)	15.10	(137)	26.50	(122)	13.26	(138)
M.B.	:03.71	(048)	04.26	(039)	08.97	(041)	02.75	(029)
M.D.	:01.82	(024)	02.13	(019)	03.30	(015)	00.92	(010)
Vert.Stem Proj.	:02.48	(032)	02.79	(025)	04.57	(021)	01.42	(015)
Vert.Stern Proj.	:02.16	(028)	02.70	(024)	04.57	(021)	01.38	(014)
Differ. between fore & aft draught	:00.00		00.00		00.00		00.00	

FUNDAMENTAL DIMENSIONS (F.D.) Table.no.21

Source : Adoniou, A.(1969)

Identity of vessel	:no. 16	no. 8	no. 54	no. 78
Type of vessel	:Skaphi Symi	Bobarda	stem-liberti transom-stern	Boat from Hydra.
	m %	m %	m %	m %
L.Keel	:05.49(100)	14.50(100)	16.00(100)	06.30(100)
Hor.Stem Proj.	:03.55(064)	03.15(022)	03.10(019)	00.00
Hor.Stern Proj.	:02.79(051)	01.15(008)	01.44(009)	00.00
L.O.A.	:11.83(215)	18.80(130)	20.75(128)	06.30(100)
M.B.	:03.75(068)	05.40(037)	05.45(034)	02.66(042)
M.D.	:02.50(045)	02.50(017)	01.80(011)	01.22(019)
Vert.Stem Proj.	:02.92(053)	03.25(022)	01.98(012)	01.36(021)
Vert.Stern Proj.	:03.24(059)	03.38(023)	02.57(016)	01.50(024)
Differ. between fore & aft draught	:00.00	00.00	00.00	00.00

FUNDAMENTAL DIMENSIONS (F.D.) Table.no.22

Source : Adoniou,A. (1969)

Identity of vessel	no.22		no.24		no.26		no.27(*)	
Type of vessel	Karavosc. from Syros		Karavosc. trading		Karavosc.		Karavosc. Psarotrata	
	m	%	m	%	m	%	m	%
L.Keel	38.01	(100)	13.42	(100)	31.68	(100)		(100)
Hor.Stem Proj.	03.09	(008)	03.63	(027)	05.50	(017)		(011)
Hor.Stern Proj.	02.75	(007)	03.21	(024)	04.84	(015)		(020)
L.O.A.	43.85	(115)	20.26	(151)	42.20	(122)		(131)
M.B.	08.65	(023)	05.19	(039)	09.00	(028)		(035)
M.D.	06.00	(016)	02.58	(019)	04.02	(013)		(016)
Vert.Stem Proj.	07.19	(019)	03.29	(030)	06.16	(019)		(019)
Vert.Stern Proj.	06.30	(016)	02.90	(022)	05.06	(016)		(020)
Differ. between fore & aft draught	00.00		00.74	(005)	00.00			00.00

(*) The scale or the marked dimensions are not so clear on this plan. So all measurements taken are only in percentages of the dimensions of the plan.

FUNDAMENTAL DIMENSIONS (F.D.) Table.no.23

Source : Adoniou,A. (1969)

Identity of vessel	:no.29	no.51	no.49	no.52
Type of vessel	:Karavosc. for cruising	Liberty from Syros	Liberty	Liberty from Paloukia
	m %	m %	m %	m %
L.Keel	:17.69(100)	13.74(100)	09.22(100)	12.00(100)
Hor.Stem Proj.	:04.69(026)	02.27(024)	02.23(024)	04.10(034)
Hor.Stern Proj.	:03.55(020)	01.65(012)	01.71(018)	02.45(020)
L.O.A.	:25.93(146)	17.66(128)	13.16(142)	18.55(154)
M.B.	:06.50(037)	04.53(033)	03.74(040)	05.00(041)
M.D.	:03.60(020)	01.73(013)	01.75(019)	02.30(019)
Vert.Stem Proj.	:05.65(032)	01.96(014)	02.38(026)	02.95(024)
Vert.Stern Proj.	:04.18(024)	02.20(016)	02.35(025)	02.85(024)
Differ. between fore & aft draught	:00.75(004)	00.00	00.00	00.00

FUNDAMENTAL DIMENSIONS (F.D.) Table.no.24

Source: Adoniou,A. (1969)

Identity of vessel	no 48		no.47		no.46	
Type of vessel	Perama		Perama from Plomari		Perama	
	m	%	m	%	m	%
L.Keel	11.85	(100)	15.58	(100)	16.26	(100)
Hor.Stem Proj.	02.76	(023)	02.20	(014)	03.05	(019)
Hor.Stern Proj.	01.90	(016)	01.40	(009)	01.98	(012)
L.O.A.	16.51	(139)	19.20	(123)	21.29	(131)
M.B.	05.80	(050)	05.85	(038)	06.50	(040)
M.D.	02.57	(022)	02.45	(016)	02.95	(018)
Vert.Stem Proj.	03.16	(027)	03.02	(019)	03.96	(024)
Vert.Stern Proj.	03.12	(026)	02.84	(018)	04.28	(026)
Differ. between fore & aft draught	00.00		00.00		00.00	

FUNDAMENTAL DIMENSIONS (F.D.) Table.no.25

Source: A.Polias' models(*)

Identity of vessel	Trechadiri		Varkalas		Skafi(**)	
Type of vessel	Sailing		Trading		Divers boat	
	m	%	m	%	cm	%
L.Keel	11.64	(100)	10.28	(100)	14.00	(100)
Hor.Stem Proj.	03.40	(029)	03.14	(030)	13.00	(093)
Hor.Stern Proj.	02.12	(018)	03.24	(031)	07.00	(050)
L.O.A.	17.14	(147)	16.70	(161)	34.00	(243)
M.B.	05.74	(049)	05.60	(054)	17.34	(124)
M.D.	03.76	(032)	03.80	(037)	11.00	(078)
Vert.Stem Proj.	05.14	(044)	04.50	(044)	12.00	(085)
Vert.Stern Proj.	05.14	(044)	04.65	(045)	13.50	(096)
Differ. between fore & aft draught	00.00		00.00.		01.50	(11)

(*) The models have been recorded by K.Damianidis. Although the models are supposed to represent sailing vessels of the last century some of the measurements of the dimensions like the midship-height 32% and 37% seem to be exaggerated in order to improve the appearance of the vessel.

(**) The dimensions of the Skafi boat come from a sketch and some patterns made by Mr.A.Polias (fig.25).

FUNDAMENTAL DIMENSIONS (F.D.) Table.no.26

Source: [3]-Stilianou(*)

Identity of vessel	Two mast vess.1:50		Naftilos ΣΑΜ 225		Ageliki II Λ.Σ.1192		Fishing Vess. 1:25	
Type of vessel	Karavosc.		Karavosc.		Karavosc.		Liberty	
	m.	%	m.	%	m.	%	m.	%
L.Keel	20.50	(100)	13.00	(100)	07.65	(100)	13.20	(100)
Hor.Stem Proj.	02.50	(012)	01.50	(012)	01.27	(017)	01.30	(011)
Hor.Stern Proj.	02.90	(014)	01.30	(010)	01.65	(021)	02.02	(015)
L.O.A.	15.90	(126)	15.80	(122)	10.57	(138)	16.52	(026)
M.B.	06.55	(032)	04.50	(035)	03.20	(041)	05.40	(041)
M.D.	03.30	(016)	01.50	(012)	01.25	(016)	01.53	(012)
Vert.Stem Proj.	03.53	(017)	02.25	(017)	01.50	(020)	02.05	(015)
Vert.Stern Proj.	03.87	(019)	02.10	(016)	01.63	(021)	02.17	(016)
Differ. between fore aft draught	00.34	(002)	00.50	(004)	00.40	(005)	00.45	(003)

(*) [3]-Stilianou kindly gave me some copies of his plans of vessels which he had built some years ago in his boatyard on Spetses.

FUNDAMENTAL DIMENSIONS (F.D.) Table.no.27

Source: [3]-Stilianou(*)

Identity of vessel	G. Vrontamiti	Labraki		
Type of vessel	Trechad.& Karavosc.	Perama		
	m %	m %	m %	m %
L.Keel	07.80(100)	12.40(100)		
Hor.Stem Proj.	02.00(026)	02.54(020)		
Hor.Stern Proj.	01.57(020)	01.22(010)		
L.O.A.	11.37(046)	16.16(130)		
M.B.	03.70(047)	05.64(045)		
M.D.	01.52(019)	01.66(013)		
Vert.Stem Proj.	01.80(023)	02.28(018)		
Vert.Stern Proj.	01.75(022)	02.32(019)		
Differ. between fore & aft draught	00.00	00.00		

(*) see note in table.no.26

FUNDAMENTAL DIMENSIONS (F.D.) Table.no.28

Source: Throckmorton's collection(*)

Identity of vessel	no.1 & 2(**) no scale	no.6 (Virginia)	no.15 no scale	no.8,M.V(***) no scale
Type of vessel	: Varkalas	Varkalas	Varkalas	Varkalas
	%	m %	%	%
L.Keel	: 27.50(100)	14.37(100)	18.00(100)	83.10(100)
Hor.Stem Proj.	: 06.20(022)	00.50(003)	03.30(018)	05.80(007)
Hor.Stern Proj.	: 05.00(018)	00.50(003)	09.10(050)	03.40(004)
L.O.A.	: 38.70(140)	15.37(106)	30.40(168)	92.30(111)
M.B.	: 14.20(052)	04.75(033)	05.60(031)	28.20(034)
M.D.	: 06.40(023)	02.00(014)	05.50(030)	19.30(023)
Vert.Stem Proj.	: 09.10(033)	02.47(017)	06.00(033)	14.30(017)
Vert.Stern Proj.	: 08.80(032)	02.85(020)	06.80(038)	13.00(016)
Differ. between fore & aft draught	: 00.00	00.67(005)	00.00	00.00

(*) Mr. H.E. Tzalas kindly gave me to study this unpublished collection of plans and sketches which Mr. P. Throckmorton had produced during his research in the Aegean. Unfortunately most of these plans are uncompleted and often without clear enough lines.

(**) There is no mention of a scale on some plans and in this case the measurements are in the actual size of the plan. In this case the aim of the table is the % of the measurements.

(***) It is not clear from the drawings whether the keel is included in the measurements of the depths or Vert.Proj.

FUNDAMENTAL DIMENSIONS (F.D.) Table.no.29

Source: Throckmorton's collection and "Sakoleva" from Paris,A.E. (1882-6, plt.91)

Identity of vessel	no.18 Agh. Gingos		no.20 Birginia		Sakoleva (1835)	
Type of vessel	Varkalas		Varkalas(*)		Varkalas	
	1:25		no scale			
	m	%	m	%	m	%
L.Keel	11.25	(100)	39.30	(100)	09.03	(100)
Hor.Stem Proj.	00.85	(007)	02.70	(007)	02.18	(024)
Hor.Stern Proj.	00.78	(007)	01.80	(004)	00.70	(008)
L.O.A.	12.88	(114)	43.80	(111)	11.91	(128)
M.B.	04.90	(043)	18.85	(046)	03.55	(040)
M.D.	02.67	(024)	07.30	(018)	01.41	(016)
Vert.Stem Proj.	03.78	(034)	11.70	(030)	02.00	(022)
Vert.Stern Proj.	03.00	(027)	10.00	(025)	01.85	(020)
Differ. between fore & aft draught	00.00		00.00		00.00	

(*) The classification of "Varkalas" has been used on all boats of this collection which have a transom board on the stern (2.3.1 Varkalas) apart from that the other features of the vessels vary.

FUNDAMENTAL DIMENSIONS (F.D.) Table.no.30

Source: Throckmorton's collection

Identity of vessel	no.11&13 scale 1:20	no.5 no scale	no.19&4&16 no scale	no.17(*) Half model
Type of vessel	double ended(**)	double ended(***)	Trechadiri no scale	Trechadiri
	m %	cm %	cm %	cm %
L.Keel	08.48(100)	59.20(100)	78.50(100)	27.80(100)
Hor.Stem Proj.	02.02(024)	06.40(011)	31.60(040)	09.80(035)
Hor.Stern Proj.	00.48(006)	05.20(009)	13.60(017)	06.80(035)
L.O.A.	10.98(130)	70.80(120)	123.70(157)	44.40(170)
M.B.	03.24(038)	22.80(038)	41.20(052)	15.60(056)
M.D.	01.04(012)	08.40(014)	20.70(026)	08.00(029)
Vert.Stem Proj.	01.80(021)	13.20(022)	29.20(037)	10.20(037)
Vert.Stern Proj.	01.76(021)	11.00(018)	28.00(036)	12.50(045)
Differ. between fore & aft draught	00.00	00.00	00.60(001)	00.00

(*) This plan has the notes "half model of Savas Vikas, Trechadiri 1935". There is only one sheer line of the model mentioned on the plan and the depths are measured from this sheer line to the rabbet of the keel as it appeared on the drawings of the model.

(**) The form of this boat is similar to Tserniki or Gagava.

(***) The form of this boat is similar to Botis. A certain classification is impossible due to the missing parts on the plans.

FUNDAMENTAL DIMENSIONS (F.D.) Table.no.31

Source: Throckmorton's collection

Identity of vessel	no.9 no scale	no.10 no scale	no.14(*) scale 1:25		
Type of vessel	:double ended Perama		Perama		
	%	%	m %	m	%
L.Keel	: -(**)	53.20(100)	14.50(100)		
Hor.Stem Proj.	: -	09.50(018)	02.05(014)		
Hor.Stern Proj.	: -	07.50(014)	01.52(010)		
L.O.A.	: 21.50	70.20(132)	18.07(124)		
M.B.	: 07.60	-(***)	05.90(041)		
M.D.	: -	-	03.00(021)		
Vert.Stem Proj.	: -	15.20(027)	04.37(030)		
Vert.Stern Proj.	: -	15.20(027)	03.90(027)		
Differ. between fore & aft draught	: -	00.00	00.00		

(*) On the sheer plan of this vessel there is only one point which indicates the level of the keel. All measurements concerning depths from the keel are taken from this point.

(**) No sheer or body plan is available of this recorded model.

(***) There is no body plan or half breadth plan of this vessel.

FUNDAMENTAL DIMENSIONS (F.D.) Table.no.32

Source: Adoniou,A. (1969) and recorded mould of a boat from Hydra

Identity of vessel: no.78 Boat from Hydra (fig.108)(*)

Type of vessel : Varkalas from Hydra

	m %	m %	m %	m %
L.Keel	: 06.20(100)	04.57(100)	04.72(100)	04.88(100)
Hor.stem Proj.	: 00.00(000)	-	-	-
Hor.stern Proj.	: 00.00(000)	-	-	-
L.O.A.	: 06.20(100)	04.57(100)	04.72(100)	04.88(100)
M.B.	: 02.64(042)	01.65(036)	01.67(035)	01.70(035)
M.D.	: 01.25(020)	00.62(013)	00.63(013)	00.64(013)
Vert.Stem Proj.	: 01.36(022)	-	-	-
Vert.Stern Proj.	: 01.48(024)	-	-	-
Differ. between fore & aft draught	: 00.00	-	-	-

(*) Recorded patterns by K.Damianidis

FUNDAMENTAL DIMENSIONS (F.D.) Table.no.33

Source: Kazakopoulos' Trechadiri, recorded boat from Chanea and survey of "Phaneromeni"

Identity of vessel	Kazakopoulos(*)		Boat from Canea (fig.27)		Phaneromeni (18a, b and c)	
Type of vessel	Trechadiri		Small transom		Perama	
	m	%	m	%	m	%
L.Keel	06.88	(100)	04.42	(100)	10.40	(100)
Hor.stem Proj.	01.01	(015)	00.70	(016)	02.48	(024)
Hor.stern Proj.	00.55	(008)	00.52	(012)	01.04	(010)
L.O.A.	08.44	(123)	05.65	(128)	13.92	(134)
M.B.	02.90	(042)	01.95	(044)	04.62	(044)
M.D.	00.99	(014)	00.58	(013)	01.64	(016)
Vert.Stem Proj.	01.36	(020)	00.84	(019)	02.66	(026)
Vert.Stern Proj.	01.43	(021)	00.80	(018)	02.60	(025)
Differ. between fore & aft draught	00.00		00.00		00.00	

(*) Damianidis,K. and Zivas,A. (1986)

Table.no.34

	min.	average	max.
Trechadiri (number of available examples: 17)			
M.B./L.Keel	0.37	< 0.45.5 <	0.58
	(tab.18,boat.30)		(tab.16,red boat)
M.D./L.Keel	0.12	< 0.18.1 <	0.29(*)
	(tab.18,boat.30)		(tab.30,boat.17)
Perama (number of available examples: 7)			
M.B./L.Keel	0.38	< 0.43 <	0.50
	(tab.24,boat.47)		(tab.24,boat.48)
M.D./L.Keel	0.13	< 0.17.7 <	0.22
	(tab.27,Labraki)		(tab.24,boat.48)
Karavoskaro (number of available examples:8)			
M.B./L.Keel	0.23	< 0.33.8 <	0.41
	(tab.22,boat.22)		(tab.26,Ageliki II)
M.D./L.Keel	0.12	< 0.16 <	0.20
	(tab.26,Naftilos)		(tab.23,boat.29)
Varkalas (number of available examples:9)			
M.B./L.Keel	0.31	< 0.41.2 <	0.52(**)
	(tab.28,boat.15)		(tab.28,boat,1&2)
M.D./L.Keel	0.12	< 0.21.2 <	0.30
	(tab.28,boat.15)		(tab.28,boat,15)
Liberty (number of available examples: 6)			
M.B./L.Keel	0.33	< 0.38.8 <	0.45
	(tab.17,Black Boat) (tab.23,boat.51)		(tab.17,Brown Boat)
M.D./L.Keel	0.12	< 0.15.7 <	0.19
	(tab.26,Fishing)		(tab.23,boat.49) (tab.23,boat.52)

(*) The boat Trechadiri in table.no.25 has the ratio M.B./L.Keel equal to 0.32. However since the lines of this vessel were taken from a boat model we exclude this measurement from the table.no.34 (see note (*) in table.no.25)

(**) The boat Varkalas in table.no.25 has the ratios M.B./L.Keel equal to 0.54 and M.D./L.Keel equal to 0.37. However they are exeluded from the table.no.34 for the same reason as in the previous not (see table.no.25).

Table.no.35

Trechadiri (number of available examples: 17)

	min.		average		max.
Hor.Stem Proj.	0.16	<	0.25.5	<	0.37
	(tab.18,boat.30)				(tab.20,boat.18)
Hor.Stern Proj.	0.09	<	0.14.9	<	0.23
	(tab.18,boat.31)				(tab.16,Red Boat)
Vert.Stem Proj.	0.12	<	0.18.1	<	0.37
	(tab.18,boat.30)				(tab.30,boat.19&4&16 and boat.17)
Vert.Stern Proj.	0.18	<	0.25.9	<	0.45
	(tab.18,boat.30)				(tab.30,boat.17)

Perama (number of available examples: 8)

Hor.Stem Proj.	0.14	<	0.19.4	<	0.24
	(tab.24,boat.47)				(tab.33,Phaneromeni)
Hor.Stern Proj.	0.09	<	0.11.6	<	0.16
	(tab.24,boat.47)				(tab.24,boat.48)
Vert.Stem Proj.	0.18	<	0.24.6	<	0.30
	(tab.27,Labraki)				(tab.31,boat.14)
Vert.Stern Proj.					
	0.18	<	0.24	<	0.27
	(tab.24,boat.47)				(tab.31,boat.10) (tab.31,boat.14)

Karavoskaro (number of available examples: 8)

Hor.Stem Proj.	0.08	<	0.16.3	<	0.27
	(tab.22,boat.22)				(tab.22,boat.22)
Hor.Stern Proj.	0.07	<	0.16.4	<	0.24
	(tab.22,boat.24)				(tab.22,boat.24)
Vert.Stem Proj.	0.17	<	0.21.6	<	0.32
	(tab.26,Two Mast) (tab.26,Naftilos)				(tab.23,boat.29)
Vert.Stern Proj.	0.16		0.18.8	<	0.24
	(tab.22,boat.22) (tab.22,boat.26) (tab.22,boat.27) (tab.26,Naftilos)				(tab.23,boat.29)

Varkalas (number of available examples : 9)

Hor.Stem Proj.	0.03	<	0.15.7	<	0.24(*)
	(tab.28,boat.6)				(tab.29,Sakoleva)
Hor.Stern Proj.	0.03	<	0.14.6	<	0.50
	(tab.28,boat.6)				(tab.28,boat.15)
Vert.Stem Proj.	0.17	<	0.28.2	<	0.34
	(tab.28,boat.6 and boat.8,)				(tab.29,boat.18)
Vert.Stern Proj.	0.16	<	0.25.5	<	0.38
	(tab.28,boat.8)				(tab,28,boat.15)

Liberty (number of available examples: 6)

Hor.Stem Proj.	0.11	<	0.21.3	<	0.34
	(tab.26,Fishing)				(tab.23,boat.52)
Hor.Stern Proj.	0.12	<	0.16.8	<	0.21
	(tab.23,boat.51)				(tab.17,Brown Boat)
Vert.Stem Proj.	0.14	<	0.21.7	<	0.28
	(tab.23,boat.51)				(tab.17,Brown Boat)
Vert.Stern Proj.	0.16	<	0.21.8	<	0.27
	(tab.26,Fishing) (tab.23,boat.51)				(tab.17,Brown Boat)

(*) The boat Varkalas in table.no.25 has the ratios Vert.Stem Proj./L.Keel equal to 0.44 and Vert.Stem Proj./L.Keel equal to 0.45 (see note (*) in table.no.34).

5.2 The moulding method

Nine of the twenty boatbuilders interviewed are still building their small boats by means of moulds. This method is still considered by them as more practical than any lofting technique ([2]-Kornidaris, [5]-Dardanos, [7]-Chilas, [4]-Korakis, [8]-Chalaris, [9]-Chilas, [10]-Binos, [17]-Chatzinikolaou).

Historical references to moulding methods in the Aegean go back to the second half of the 18th century (Nikodimos,K. (1862, p.70), Kostandinidis,T. (1954, p.115)). A Greek mould, however, had been recorded by the end of the 16th century (Barker,R.A. (1983)).

From the interviews and the available bibliographical sources we can distinguish several variations of the moulding method which were used in the Aegean during the last two centuries.

5.2.1 "Master frame and Ribbands"

Poulianos, A. (1977, p.545) describes a method by which only the shape of the middle pair of frames and two of the fore and aft frames (not those adjacent to the middle pair) were determined by means of moulds. When these six frames were set upon the keel, ribbands (Φούρμες) were placed and nailed on both sides of the set frames and on the stem and stern posts. The upper ribband was located on the level of the sheer line of the boat and the rest around the level of the turn of the bilge. These ribbands were used to determine the shape of moulds for the rest of the frames. Each new frame was set on a station previously cut on the keel. The frames on the stem and the stern post (Ριπίδια) consisted only of futtocks placed on the stations without using floor timbers. When they had set all the frames on the keel and the posts, they secured their positions by means of stronger ribbands (Σκορτσάδες). Then they determined the bevel angle of each frame using laths at the positions where the planks of the hull were to be placed later. Unfortunately we have almost no information from interviews about this method of moulding. There is, however, a bibliographical reference to a similar method. Sarsfield J.P. (1988) refers to a report by Lee, N.J (1978), of a boat which has been built somewhere in the Aegean using a similar moulding technique (fig.81). Sarsfield,J.P. (1988) identifies this process of moulding as a "Master frame & Ribbands" method and gives evidence of the use of the same method today in Brazil. He also refers to other places where the same or similar method has been used (Spain, France, Newfoundland, Nevis W.I., Granada W.I., Bequia W.I., Antiqua W.I. Les Iles des Saintes W.I., Bahamas, W.I.). In the description from Lee, N.J, (1978) he mentioned no more than the two middle frames as determined before setting the ribband (as in the Brazilian case). This process however is not exactly the same as the one described by Poulianos, A. (1977 p.545), so the two sources refer to two different variations of the "Master frame & Ribbands" method. Sarsfield, J.P. (1988) mentions in his description the appearance of "the same (as in the Brazilian case) straight stick placed of the forward end of the keel to facilitate the alignment of the ribbands at this section". We have evidence from the interviews ([11]-Polias, [17]-Papastephanou) that there was a frame close to the scarph of keel to stem post which consisted of almost straight pieces (ribs). [11]-Polias also gave the name of "Πρωτοβαθικό" for this rib, and he mentioned that its shape was often determined before setting the ribbands. However he was not able to give more information about this moulding process because he never used this method. But the existence of this frame with straight pieces was common on boats built by any of the other moulding methods ([17]-Papastephanou).

Another description of this method has been published by Basch, L. (1972 pp.36-7) and it contains a photograph of moulds from the Island of Syros and photographs of the skeleton of a boat under construction from Marathokampos (Samos). However I am totally convinced that the moulds and the construction process that appears in these photographs are not actually elements of the "Master frame and ribbands" method. The moulds from Syros are like elements of the moulding with adjustable template methods. The photographs from Marathokampos show the eight frames which had been shaped by moulds, the ribbands which are used to adjust these eight frames as well as to determine the shape of the rest of the frames, and some of the fore frames which were determined by means of the ribbands.

Furthermore we can mention here the information from the interviews ([17]-Papastephanou) where the use of the master frame and the "πρωτοβαθικό" frames together with the ribbands were set initially on the keel during the moulding with adjustable templates method. In this way the boatbuilders control the final decision about the distances between two successive stations and the final position of the group of the moulded frames on the keel (7.3 Framing up)(fig.82).

Therefore what is included in Basch,L. (1972, pp.36-7) can be the above mentioned part of a moulding with adjustable templates method.

Sarfield, J.P. (1988) poses the dilemma raised by the historical relation between the "Master frame & ribbands" methods and "the more elaborate lofting methods, such as: Mediterranean Moulding, the Gabarit de St. Joseph, and Whole Moulding". The material from the field work in the Aegean and the rest of the bibliographical sources give us the opportunity to suggest some possible solutions to this dilemma at the end of this chapter and in the conclusion of this thesis.

For the moment let us examine the more elaborate methods of moulding recorded during field work in the Aegean.

5.2.2 Moulding with Adjustable templates (The term is used with the same meaning in Taylor,D.A. (1982, p.91) and in Sarsfield,J.P. (1988).

Several versions of this method were recorded during the field work. First we will present the most intricate of them. The simple versions will then be described by comparing and contrasting them with this intricate version.

The Greek name of all the versions of moulding is "Μονό-Χναρο", which in English means "single-mould". The definition that most of the boatbuilders give to this name is that by means of a "single-mould" the boatbuilder can form the shape of all the ribs of the middle part of a boat (fig.82). The most sophisticated of all the versions is the one which was recorded in [14]-Chatzinikolaou's boatyard on the Island of Rhodes. [14]-Chatzinikolaou learnt the method forty years ago when he was apprenticed to an old shipwright on the Island of Symi. This moulding method differs from all the others in consisting of five aids, rather than three. These aids are as follows (fig.83) (the term "aids" is borrowed from McKee,E. (1983) in order to identify the components of "Whole moulding").

5.2.2.a The rising table (Πινακίδι)

During the assembly of the moulding system this piece represents the keel of the boat. The sirmarks on the table indicate the rising for the ribs of the middle part of the boat. The mark Φ is for the midship rib. The numbers: 1,2,...,7 are for the seven ribs forward of the midship rib. The Greek letters: A,B,...,H are for the seven ribs aft of the midship rib. The mark K indicates a notional origin on centre line against which to set the sirmarks of the floor breadth mould.

5.2.2.b The floor breadth mould (Μάνα)

This is the basic aid which supports all the other parts. The only part of this aid which actually forms part of the moulded frame is the fraction FR (fig.83). The sirmarks on the mould indicate the breadth of the floor timbers. The numbers and the letters of the sirmarks correspond to the numbers and letters of the rising table (fig.83).

5.2.2.c The hollow mould (Δύβολτο or Αξινίστροφο)

This is to provide the shape of each floor-timber as in the following example: to form the shape of the 4th-fore-floor-timber (fig.84) the mark K of the rising table is set up against the sirmark 4 of the floor breadth mould. The mark F of the hollow mould is set on the mark F of the floor breadth mould. The other end of the hollow mould is set on the rising table so that the edge of the hollow mould bearing the mark F is placed exactly above the sirmark 4 of the rising table(1)(fig.84). The line 4-F(2) of the hollow mould and F-FH of the floor breadth mould form the shape of the floor-timber of the rib number 4.

5.2.2.d The futtock head breadth table

The sirmarks on the table indicate the breadth of the futtock head forward of the midship rib (fig.85). All the moulded futtocks aft of the midship rib correspond to the mark Φ on the table.

5.2.2.e The futtock mould

This is the mould for all the futtocks. In order to explain the use of this aid as well as the use of the whole method, I will continue to use the example of forming the 4th-fore-rib (fig.84). In order to form the shape of the futtock part of the rib, the mark R of the futtock mould is set on the mark R of the floor breadth mould. The other end of the futtock mould is placed on the futtock head breadth table so that the edge with the mark R is placed exactly above the sirmark 4 of the futtock head breadth table.(3) The lines 4-R of the futtock mould and R-FF of the floor breadth mould form the shape of the futtock-part of rib number 4. In this way the line 4(4)-F-R-4(5), as it has been set by the Hollow mould/Floor breadth mould/Futtock mould, determines the shape of the 4th-fore-rib of the boat (fig.84). By means of these five moulding aids Mr [14]-Chatzinikolaou forms the shape of the fourteen ribs of the middle part of a boat (fig.83). A short report of the same version of moulding is mentioned in Adoniou, A. (1969) but without any details.

All the other recorded versions of moulding consist of three aids: the rising table, the floor breadth mould and the hollow mould. [17]-Papastephanou, [4]-Korakis and [5]-Dardanos used the sirmarks on the rising table and on the floor breadth mould in the same way as Chatzinikolaou did. [9]-Chilas and [10]-Binos used an even more simple version where the two groups of sirmarks on the rising table were equal to the two others on the floor breadth mould. [9]-Chalaris used only one group of sirmarks on the rising table and another one on the floor breadth mould. This last version had the effect of producing symmetrical forms of the moulded frames on the aft and fore parts respectively, equidistant from the midship pair of frames. This last version has been briefly presented in Heidelberg, P.K. (1985). The method given in this source was recorded on the Island of Symi in 1981.

Often the same aids of the moulding methods were applied to produce slightly differently shaped boats. These were achieved by using different groups of sirmarks for each boat shaped ([5]-Dardanos, [8]-Chalaris, [7]-Korakis, [9]-Chilas). Also it was very common to form the four or the six middle frames identical to the midship pair of frames, in order to extend the beamier area of the vessel. This was done to produce either a beamier form of boat than usual or a longer form of boat than the moulding usually can provide. An account of the process of assembling the moulded frames has been included in the chapter on 7. Construction (7.3 Framing up).

5.2.2.f Determination of the groups of sirmarks marked on the five aids of the method.

The illustrated moulding method (five aids-version) was for a boat with a transom stern of 6.70m. length, 2.40m beam. To find the shape and all the marks and sirmarks of the moulds [14]-Chatzinikolaou drew a simple lines plan of the boat at the begining of the boatbuilding process (fig.85). He calls this lines plan "Saleto" and it is worth noting that the Greek name for lofting floor was "Sala". This lines plan included only the deck line, the water line and the profile of the boat. The shipwright intended to mould the shape of only those ribs which lay between the lines which he calls "MASTORI"(6)(fig.85). In order to do this he measured the distances: A,B,C,D,E,F as they were shown in the fig.85. The sirmarks were derived from these measurements as follows:

Φ7 of the floor breadth mould=A

Φ7 of the futtock head breadth table=A-B

Φ7 of the rising table=C

ΦH of the floor breadth mould=D=E

ΦH of the rising table=C

These measurements were the basic elements for all the sirmarks on the moulding aids. To define each group of sirmarks the boatbuilder drew the "METZAROLA" plan (fig.86). With his sweep and using as radius each measurement Φ7 or ΦH he drew five "METZAROLA" plans, one for each of the moulding aids. The "METZAROLA" plan in fig.86 is for the sirmarks 1,2,...,7 of the floor breadth mould. In order to find all the other sirmarks of the group which were included in the line Φ7, he divided the arcs Φ0 and 07 into seven equal parts. Then he drew lines to connect the corresponding dividing points along the two arcs. These lines are the distances of the other sirmarks from the sirmark 7 of the group. Using the sweep he marked all these later elements on the basic element Φ7 (fig.86). In this way he defined all the groups of sirmarks and he marked these on the moulding aids.

In the other recorded versions of moulding the determination of the basic elements Φ7 or ΦH was not made in this sensible and analytical way. [17]-Papastephanou calculated by rule of thumb the rising and the narrowing of the frames and in this way determined the basic measurements of his "METZAROLA" plans. His method was still sensible but without the analytical method of the "SALETO". [9]-Chilas and [10]-Binos defined the basic element of the "METZAROLA" diagram on the floor breadth mould as equal to the measurement of the distance between two successive frames. Then they chose a slightly shorter or longer measurement for the "METZAROLA" of the rising table. The difference in length depended on the desired rise of the sheer line of the boat. We can not really accept that this way of determining the basic measurement of a "METZAROLA" is sensible. The distance between two successive frames had nothing to do with the narrowing of the frames of the boat. However, for Trechadiri boats shorter than 20m, the results do not in practice deviate from those which are determined by [14]-Chatzinicolaou's or [17]-Papastephanou's methods. So this last version seems to be an abstract simplification in order to make the use of a "METZAROLA" diagram more practical than in the two previous instances. However there is the question of whether with this rather obscure simplification an overall control of the boat form was actually achieved.

Although [4]-Korakis and [8]-Chalaris still produced moulds for their boats, they suggested that they determined the location of the sirmarks on the moulds totally by rules of thumb without the use of any "METZAROLA" plan. [2]-Kornidaris, [5]-Dardanos and [7]-Chimonas did not know how to make moulds and they either used their fathers' moulds or built boats from boat-plans.

Similar methods of moulding with "adjustable templates" have been recorded in various other countries. Taylor, D.A. (1985, pp.87-100) describes the contemporary use of whole moulding by boatbuilders of Trinity Bay (Newfoundland). The system that he explains consisted of three aids (similar to the Aegean method using three aids) and by contrast with the Greek version there are groups of sirmarks on all of these three aids. Furthermore he mentions (p.91) that by the time he recorded the method "no one in Winterton uses the three-piece adjustable templates in the original fashion. Instead of using them to describe all of a boat's timbers, the templates are now used only to form the shapes of the three principal timbers: the fore hook, the midship bend and the after hook. After these timbers have been installed on the keel, ribbands running from stem to stern are tacked to them in horizontal rows in order to approximate the shape of the eventual hull". It is clear from this description that the method of moulding with adjustable templates has been simplified to the "Master Frame & ribbands" method. This fact makes us pose a question about the relation of these two methods in the Aegean tradition. This North American ethnological evidence leads Sarsfield,J.P. (1988) to suggest as a possible hypothesis that the "Master frame & Ribbands" method was a vestigial version of the more sophisticated methods of moulding.

Nevertheless Sarsfield, J. P. (1985) describes very carefully a method of moulding with adjustable templates which was still in use in Brazil. The method consisted of the use of three aids with groups of sirmarks only on two of them. They actually used the same groups of sirmark on the floor breadth mould and on the rising table for the forward and the aft frames from the midship pair. The method seems very similar to one of the recorded methods in the Aegean ([9]-Chalaris) except in the way that the boatbuilders determine the distances between the sirmarks of each group of them. Here another geometrical solution was used, instead of the "METZAROLA". This is the "Graminhos" diagram and consists of a half circle divided into equal parts in the same way as a "METZAROLA". Sarsfield, J.P. (1985) explains that the same geometrical method of "Graminhos" had been described in Portuguese manuscripts from the late 16th and early 17th century (Barata, 1965).

Vence,J. (1897, pp.25-31) gives a description of the "Gabarit de Saint-Joseph" which appears as another version of moulding with adjustable templates. The conception was again the same but here there are only two aids: "Le gabarit du maitre-couple" as the floor breadth mould and "La tablettes des acculements" as the rising table. These are the only components of the method. In fact the floor breadth mould was adjustable for both the position of the floor breadth and the hollow mould. The main difference from the Greek moulds is that according to Vence, J. the profiles of the aids of the moulds and the position of the groups of sirmarks were taken from some sort of boat-plans instead of any of the above mentioned geometrical methods.

Finally Mckee, E. (1983, pp.122-125) describes another version of moulding for the use of which we have evidence in Britain during the 18th century. This is the "whole moulding" method which consisted of three aids. Sirmarks were marked on all of the three aids (like the Canadian version) and no indication of any geometrical method for determining the sirmarks was mentioned. The main difference, however, between this "whole moulding" and the Greek version was that the former was used, according to the source, to determine the shape of even more frames on the fore and aft part of the boat than the latter.

Returning to Greek moulding, bibliographical sources suggest that moulding techniques were used at least as early as the middle of 18th century.

Konstandinidis, T.P. (1954, p.118) mentions that the moulding method was improved in the Aegean after 1770 and more pieces of moulds were used to determine the shape of each component of the skeleton. After 1780, ship-plans were introduced in the Aegean shipyards.

Unfortunately he does not give more details about this modernization of moulding after 1770. However he seems to exaggerate the capacity of the new moulds to determine the shape of "each" component of the skeleton. If by this expression he means each of the crucial components of the skeleton then he leads us to think about an evolution from a method similar to "Master frame & Ribbands" to that of moulding with adjustable templates.

Nikodimos, K. (1862) mentioned that before the end of the 18th century shipwrights on the Island of Psara used moulds to determine the shape of the floor timbers on the middle part of the vessels. According to his description this was a method with adjustable templates applied only on the floor timbers of the vessels. Then they used ribbands to set the futtocks above the turn of the bilge. This is an interesting account of moulding which does not seem to have survived. On the part below the turn of the bilge a moulding method with adjustable templates was used while on the part above the turn of the bilge a "Master frame & ribbands" method was applied. If this is the meaning of Nikodimos' description then we can possibly detect an intermediate stage between the "Master frame & ribbands" method and the more sophisticated moulding techniques.

In my opinion this impressive variety of moulding with adjustable templates together with the worldwide use of the method indicates the possible existence of even more evidence from other countries through historical or ethnographical sources. Therefore one obvious question which arises from all this material is whether there is a connection between these versions of moulding. And this is possibly related to the origin of the moulding with adjustable templates. Usually such widely used techniques come from times and places in which social and economical situations, I think, required their establishment. As we will see later in this chapter, historical evidence leads us to suggest that moulding with adjustable templates was possibly widely established during the Renaissance in the Venetian Arsenals.

For the moment let us examine more closely the "METZAROLA" method considered as a geometrical aspect of the moulding method.

5.2.2.g Analysis of a "METZAROLA" diagram

1) At first sight a "METZAROLA" plan provides a series of lines: Φ7,11,22,...,66 the lengths of which do not seem to bear a regular orderly relationship to one another.

2)Studying two "METZAROLA" plans (fig.87) we can prove that the lengths of corresponding pairs of lines from the two plans always have the same ratio. In other words, the following relation applies between two groups of sirmarks provided by the same method: Φ7:Φ'7=76:7'6'=75:7'5'=...=71:7'1'

In practice this means there is a constant relationship between successive sections of a body plan or two water lines, derived from the moulding method where the sirmarks of the moulds were produced from "METZAROLA" plans.

3)The relations between the lines of the same "METZAROLA" plan are very close to the classic golden section relation between two lines (fig.88a) (Le Corbusier (1949)).

4)In order to examine the exact relation between the lines of the sirmarks I used trigonometry on a "METZA-ROLA" plan (fig.88b). The result is the following series of measurements:

Φ7=R	
11=R x $\sin 9a^o : \sin 11a^o$	[Where R=Φ7 and a^o are the
22=R x $\sin 7.5a^o : \sin 11.5a^o$	equal arcs:71,12,23,...,60.
	In our example this arcs
....	are a^o=60:7 =8.571^o]
	(fig.130)
66=R x $\sin 1.5a^o : \sin 13.5a^o$	

From this function we can suggest that the "METZAROLA" diagram provides part of a kind of sine curve.

5) By applying this method to the plan in fig.89 we can see more clearly the actual relationship between the measurments from the diagram and the boat lines. On this plan there is a schematic representation of the middle part of the body plan and half breadth plan of a boat which are determined by means of the moulds which were recorded in [14]-Chatzinikolaou's yard (moulding with five aids).

By reference to the way that they used the moulds, we can suggest that the fore part of the water line "I" has been determined by the "METZAROLA" on the rising table and the "METZAROLA" on the floor breadth mould (both respective to the fore part). The aft part of the water line "I" has been determined by the respective "METZAROLA" for the aft part on the same moulds as before. The fore parts of the water lines "II" and "III" are determined by the same diagrams as those for the water line "I". However because of the different levels of the intersections between the frames and the water lines these three parts of the water lines "I", "II" and "III" are not parallel to each other. The aft part of the water lines "II" and "III" are determined by the "METZAROLA" on the futtock head breadth table and by the other two on the rising table and on the floor breadth mould. We can see on these last parts of the water lines how the additional diagram of a "METZAROLA" changed dramatically the shape of the two water lines. As we mentioned, these moulds correspond to the lines of a boat with a transom on the stern post. This is the reason for the differences between the fore and the aft parts of these water lines. Possibly for a double ended boat this additional "METZAROLA" on the futtock head breadth table was not necessary since these sorts of dramatic differences between the fore and aft parts of the water lines did not occur. This statement leads us straight to the other recorded version of moulding in [17]-Papastephanou's yard. This is the case of moulding with three aids and four groups of sirmarks, and it can be seen as exactly the same version as the first one adapted for a double ended boat. The rest of the recorded versions of moulding in the Aegean are in fact simplifications of the two previous ones and they provide water lines of boats which have obviously less diversity of form.

However, I think that the two versions of moulding first described exhibit clearly the possibility of producing an impressive variety of water lines by means of moulding with adjustable templates. The synthesis of the results of more than one "METZAROLA" diagram (as in the case of the water lines in fig.89) can provide a substantial number of curves capable of determining the middle part of any traditional type of vessel. I am convinced that a shipwright with a good knowledge of moulding with adjustable templates could use the method to control the lines of a vessel of a considerable size. This extensive flexibility provided by the moulds indicates that the method originated during periods when this kind of sophisticated application of practical geometry occured.

5.2.2.h Elements of a Historical study of the diagrams used to provide the group of sirmarks on moulding with adjustable templates.

The oldest and best known method of moulding with adjustable templates (or early lofting technique) was used in the Venetian Arsenals during the 15th and 16th century (Aderson,R.C. (1925), Bonino,M. (1981), Concina,E. (1987), Lane,F.C. (1934)).

In order to focus on the method which was used to determine the group of sirmarks on the moulds let us follow the description by Lane, F.C (1934, pp.94-95) about the use of the "MEZA-LUNA" diagram (fig.90a).

" Two diagrams which might be employed to determine these measures, and show them all in one drawing, are pictured in some notes on Venetian shipbuilding written about the middle of the fifteenth

century(7). The way in which they were to be employed is explained by Crescentio, a Neapolitan writer a century and a half later. The diagram whose application Crescentio explains most fully is that shown in figure XVII [(fig.90a*)*], *and called at Naples the meza-luna, the "half-moon". A half circle was drawn using as radius the extent by which the tail-frame was narrower at the base than the midship frame. This half cicle was divided into two quadrants by the radius AB. The length of that line accordingly equals the total amount of narrowing to be effected. It is to be divided into eight progressively smaller fractions. The frames set up from midship frame to tail-frame will then each be made narrower than the preceding by the amount of one of these fractions. In order to divide the line AB into these unequal fractions the two quadrants CA and DA were divided into eight equal parts. Lines were drawn connecting these dividing points along the quadrants, and these lines divided the radius AB in the desired eight fractions of the total. The divisions of the line AB thus obtained were then marked off on a rule and the rule placed on the model midship frame, the point A being put at the middle point of the floor. The marks were transferred from the rule to the base of the midship frame. In designing the first of the frames forward from the midship frame the shipwright narrowed it at the base an amount equal to the smallest of these divisions, namely, that marked on the midship frame nearest to the mid-point of the floor. He narrowed the second frame forward by the amount of the two smallest of the divisions, that is, the distance from the mid-point of the floor to the second mark, and so on until he reached the tail-frame which was narrowed by the whole length of the line AB. Thus the ship carpenter was able to find in one pattern or model all the measures to be used in narrowing the frames and did not need to make a separate calculation for each(8)."*

The description obviously shows a very close relation to the method that has been recorded in ethnological material from the Aegean Sea. Let us now examine "MEZA-LUNA" diagram and point out some of the similarities with the Aegean diagram.

Using Trigonometry to express the measurements of the lines provided from a "MEZA-LUNA" plan, I reached the following form:

7'1'=R x sin6a^{o}

7'2'=R x sin5a^{o}

7'3'=R x sin4a^{o}

....

7'6'=R x sina^{o} (see fig.90b)(9)

This function which occurs between the elements provided by the diagram, has the graphic appearance of a simple form of part of a sine or harmonic curve (Eagles,T.H. (1885, pp.305-6)).

Both systems, "MEZA-LUNA" and "METZAROLA" plans, have a trigonometrical order of measurements. Although they do not provide the same function we can investigate a number of similarities (fig.90b).

1)The sweep is obviously the tool used in both systems to draw the plans.

2)Linguistic similarities exist between the names "METZAROLA", and "MEZA-LUNA" plans.

3)We can expect that the same practice is used in both plans to divide arcs into certain numbers of equal parts.(10)

4)In both systems we can recognize the idea of marking equal arcs which provide, in a geometric way, the same number of "progressively smaller fractions" (fig.90b).

5)The measurements of the narrowing of the beam of a certain frame from the midship frame are in both systems the basic radius on the plans (see "Saleto" plan in fig.85 and the description by Lane,F.C. (1934 p.94) "*A half circle was drawn using as radius the extent dy* *which the-frame was narrower at the base than the midship frame."*).

7)Both diagrams, as we proved, provided sine curves, but based on different functions. In fig.91 there is a simplified representation of the results from a "MEZA-LUNA" and a "METZAROLA" diagram in order to support a comparative study of the curves produced. The two diagrams appear with the same basic element, the same number of eight divisions of the arcs, and the same distances between the hypothesised frames with a simplified reduction.

The first point of interest is that the maximum deviation between the two curves is located on the area between the frames numbered 4 and 5. The second, is that the tangents to the curves at frame number 8 are two lines with different orientations. Let us assume that the two curves "A" and "B" are water lines at the same level of the hulls of two different boats "A" and "B" respectively. We can suggest then that the boat "A" (line by "METZAROLA") had a roomier form on her middle part than the boat "B" (line by " MEZA-LUNA") but without having a different maximum beam. Additionally, because of the different orientations of the tangents to the curves at the point 8 we can suggest that the extensions of the lines further fore or aft on the boat were smoother and more subtle on boat "A" than on boat "B".

Using these similarities and differences, we can assume that the two curves produced by the diagrams are so close to each other that each one of them can equally be the initial version of the other. In fact it is astonishing that such delicate differences can be the reason for an evolution from one to the other.

However by examining the possibility of an early evolution from one diagram to the other, we might cast some light on two small publications in the form of notes. Bloesch, P. (1983) and Sarsfield, J.P. (1984) speculate about another method (sufficiently different from those of "MEZA-LUNA" and "METZAROLA") of determining the group of the sirmarks on Venetian moulds. This later method was suggested by Crescentio in his book "Nautica Mediterranea", (Rome, 1607), because it could provide more a "regular and continuous form than the method of MEZA-LUNA". The relevance of this evidence for our study is that it indicates that shipwrights from as early as 1607 were looking into improvements of the "MEZA-LUNA" diagram in order to provide more regular and continuous forms. So possibly the same demand was served by this subtle improvement from the Venetian diagram to what, in the Aegean is known as "METZAROLA".

However we can draw on other pieces of evidence to support the hypothesis that the two diagrams existed contemporaneously. Lane, F (1934, pp.30-31) and Anderson, R.C. (1925, pp.149-150) mention that in addition to the "MEZA-LUNA" another three different methods were used to determine the group of the sirmarks, and all four methods were called "PARTISONI". In fact Lane, F. (1934, p.30) states the following: "It is my conclusion that all four of these ways of modifying the shaping of the frames were worked out by geometrical diagrams like the meza-luna ...". Therefore there is certainly a possibility that one of these "PARTISONI" was that recorded in the Aegean "METZAROLA".

On the other hand the lack of evidence of this diagram in the 15th and 16th century requires that these suggestions remain hypothetical. Moreover there is no lack of historical evidence about the use of similar diagrams in later periods.

Barata, J. da G.P. (1965)(11) contains the publication of the Ms."Livro Primeiro da Architectura Naval" by Joâo Baptista Lavanha (codex 63, Salasar Collection, Library of the Real Academia de la Historia (Madrid)). The date of this Ms. is uncertain, it is thought to be between 1598 and the end of the first quarter of the 17th century. This source gives the diagram of "MEZA-LUNA" but with the name of "GRAMINHO"(12). However in other later Portuguese sources

"GRAMINHO" appeared as the general name for all the methods of producing elements with successive increments in lengths, and the name of "MEIA-LUA" or "BESTA" was given to the familiar diagram. But none of the other diagrams illustrated in these sources seems similar to the "MEIA-LUA", the "MEZA-LUNA" or to the "METZAROLA" (Barata,J. da G.P. (1965), Barker,R. (1988)[1]).

In an early publication by Dudly (1661) "Arcano del Mare" a similar diagram appears in order to provide successive narrowing of certain elements (fig.92). The diagram is very similar to the Venetian diagram except for the fact that its basic shape is an arc of a circle instead of a half circle. At present it is difficult to decide whether this is another "PARTISONI" or "GRAMINHO".

In Anderson, R.C. (1942, p.246) the plans of the ship "The Royal Louis" of 1692 are given. Next to the body plan of this ship there are geometrical diagrams labelled with the inscriptions "Figure for the aft part" (fig.92) and "Figure for the fore part" (translation by Anderson, R.C.). On this diagram, in addition to elements similar to those of a "MEZA-LUNA" diagram, there is a certain number of other lines which seem to be haphazardly placed. Although it is very difficult to investigate the purpose of these lines, we can note a few points. On each of the two diagrams there is a group of numbered lines equal to the group of elements produced by the "MEZA-LUNA" diagram and equal too to the number of diagonals which appeared on the body plan. I don't like to put a conjecture but it seems to me that the naval architect who used these diagrams was trying to get more out of them than his forebears. In my opinion the diagrams seem to give some explanation for the lofting process for the vessel. This is something similar to the explanatory sketches which are often included in the plans made by civil engineers. Possibly the actual scale of the diagrams is not the same as the scale of the included ship plans. However it is unique for this geometrical diagram from moulding practices to be included in naval architectural plans. Can this be considered as an early step from "designing" methods using moulds with "adjustable templates" to the use of naval architectural plans?

Half a century later we still find naval architectural plans in which similar geometrical diagrams were included. In Grimm, K. (1972) there is a group of plans for a vessel from the middle of the 18th century (printed in Göttingen). In one of these plans some schematic profiles of the components of the skeleton of the boat are included, together with a familiar geometrical diagram (fig.92, diagram 5). Unfortunately there is no specific explanation about the use of this diagram given by the author. This is the oldest diagram that I have found which is very similar to the Greek "METZAROLA". It consisted of two arcs of 60° each and the basic element. The arcs were again divided into equal parts (not though on their entire length) and new successivlly smaller elements were produced. Again the fact that this diagram was placed next to the schematic representation of skeleton components might indicate that the actual use of it was made on the lofting floor, rather than in the naval architect's plan. Furthermore if we think practically it seems impossible to have accurate shapes of all the frames of a wooden vessel on a scale equal to the scale of any naval architect's plan. Therefore it is possible that this naval architect gave further technical details by suggesting the way that the distances between two successive frames can be determined. Moreover, I must point out here the use of a diagram almost the same as "METZAROLA" rather than the better established "MEZA-LUNA". So this diagram was not just a Greek adaptation of the original Venetian one isolated to the Aegean sea.

I am grateful to Dr.Robert Prescott who kindly let me study some of his unpublished material from his research on the British vernacular maritime tradition. This is the use of another two versions of diagrams which were used by an old mast maker in the port of Bristol (1989). The first was similar to "MEZA-LUNA" and the second was similar to "METZAROLA" diagram. Both were used to provide elements which were applied as successive diameters on the masts and on the spars. The mast maker mentioned that the second diagram was used to provide more gentle curves than the first. This is the only recorded material about some comparison between the two diagrams.

I do not believe that the use of the "METZAROLA" diagram in these three pieces of evidence from different European countries is a mere coincidence. Although the conception and the use of the two diagrams are practically the same, the actual geometrical construction of the "METZAROLA" is distinct from that of the "MEZA-LUNA". This fact makes it very difficult to accept the assumption that the "METZAROLA" was an adaptation of the original diagram which accidentally occurred in three different areas. I suggest instead that the "MEZA-LUNA" and the "METZAROLA " were two different "PARTISONI" or "GRAMINHO" worked out more or less during the same period. Unfortunately at the moment I do not have any further evidence capable of providing any conclusive support for these hypotheses. Since, however, both diagrams have such distinctive geometrical forms it seems worth paying more attention to their geometrical properties.

5.2.2.i Some comments on the geometrical properties of the diagrams

Looking again at the application of these two diagrams in shipbuilding it seems to me that something is missing from the whole scene.

Although boatbuilders considered moulds as practical tools directly applicable during the boatbuilding process, the method of moulding with "adjustable templates" seems more abstract than any other task of this trade. Diagrams involving geometry of a rather complicated nature for the contemporary technology (early Renaissance) were applied in boatbuilding as a key for the assembly of the skeleton work. I believe that this method of moulding, including the diagrams for the sirmarks was based on some kind of geometrical analysis of the object, which is a vessel, and some sort of synthesis which produced the moulding with adjustable templates. It is hard to consider that this analysis was carried out by a person with a practical mind like any shipwright. I am sure they would be quite capable of improving any method but it is very difficult to accept that a shipwright invented this method.

It seems to me that behind all these diagrams there is a special geometry studied and used by a rather intellectual mind in order to provide more predictable control over the shipyards' production. If this is an early renaissance engineer, an example of the "RENAISSANCE MAN", then he must be considered as the father of the moulding with adjustable templates methods and, why not, the father of the whole lofting technique.

The puzzle is undoubtedly very interesting and although a few arguments are already presented in several publications (Concina,E. (1987, p.402) and in Barker,R. (1988)[2]) let us give some more ideas.

First of all it is plausible, I think, to suggest that before the first quarter of the 15th century the knowledge of geometry in Western Europe was remarkably limited. In addition to the lack of mathematical innovation in the 14th century the outstanding earlier figures, such as Bradwardie (1290-1349), Nicola Oresme (around 1360), Leonardo Fibonacci of Pisa (ca.1180-1250) and his contemporary Jordanus Nemorarius provide us either with translations of Classical and Arabic books or with some crucial but preliminary treatises. Even most of the more advanced treatises follow the paths of Classical mathematics (Boethius, Aristotle, Euclid, Archemedis) or the relativlly new field of Algebra (Al-Khowarizmi, Thabit, Al-Karkhi). Obviously geometry was not one of their favoured topics and the new treatises on this field were very few indeed (Smith,D.E. (1923, pp.230-42), Coolidge,J.L. (1987, pp.88-9, 106-7, 116-28) and Boyer,C.B. (1968, pp.249-322)).

There is no point in speculating more about the knowledge of geometry possessed by scholars of this period. It is enough for present purposes to point out that this was limited to the framework of classical Greek geometry. This suggests that any further analysis of the diagrams that we are examining must also be limited to the same framework. In fact the same suggestion can occur to any one who studies the early accounts of these diagrams (Barker, R. (1988)[2]).

We have described so far five different versions of diagrams as they appeared in fig.92. Based on them we can suggest that the diagrams no.1, no.2 and no.3 appeared to be produced by means of the same approach as that used to determine the sirmarks. We can suggest the same remark for diagrams no.4 and no.5. In this case we have two distinctive groups which can be represented by diagram no.1 and diagram no.4. The first question which arises in connection with an examination of these diagrams is whether any relation can be introduced between the two groups in the framework of classical geometry. Indeed studying the "METZAROLA" diagram we find the demonstration which appeared in the fig.93. With this representation together with proposition no.2 in the analysis of a "METZAROLA" plan, we can prove that the successive elements provided by a "METZAROLA" plan on a basic element AB are equal to the successive elements provided by a part of a "MEZA-LUNA" plan with diameter equal to twice the element AB. This is very useful because in this case we can convert the study of each one of the diagrams on fig.92 to the study of the diagram no.1.

As we proved earlier, the trigonometrical representation of the elements provided by a "MEZA-LUNA" plan can be illustrated as part of a sine curve. However without the use of trigonometry the curve "B" (as it has been identified in fig.91) can be constructed as in fig.94.

The cylinder in fig.94 contains the whole circle of the "MEZA-LUNA" plan as base. Its height is equal to the length of the respective part of the vessel where the elements provided by the "MEZA-LUNA" will be applied. The curve "W" in this figure is the representation of the curve which can be provided by the previously described application of the "MEZA-LUNA" plan (the curve "W" is the same as the curve "B" in fig.91). However in fig.94 the "W" is given as an orthogonal projection of the curve "C" on the level "A". This later curve " C" is a curve in three dimensions located on the surface of the cylinder.

Therefore the initial curve is the curve "C" and this might be provided by a sophisticated designer which intended to represent part of a vessel.

Before further speculating on the constructive analysis of the curve "W" let us focus on another interesting aspect of this analysis. Let us accept that the construction so far described of the curve "W" was part of the conception which provided the "MEZA-LUNA" plan. Therefore we must be puzzled about the identity of this very advanced designer who produced this concept.

We do know that by the middle of the 15th century a "RENAISSANCE MAN" like Leonardo Battista Alberti (1404-1472) might have been capable of providing an abstract approach to the contemporary problems of shipbuilding technology. And possibly "NAVIS" the lost work of Alberti on ships (Concina, E. (1987, p.402)) contained the answer to this puzzle. But if we look nearer to the beginning of the 15th century the possibility of the existence of this kind of "RENAISSANCE MAN" was very limited. According to the available sources the first known account of the "MEZA-LUNA" diagram comes from as early as 1410 (Lane, F.C. (1934, p.25) and Barker, R. (1988)[2]). In the opinion of historians of mathematics the first decade of the 15th century is more likely to be similar part of the dark period of the 14th century than of the early Renaissance (Smith,D.E. (1923, pp.242-55) and Boyer,C.B. (1968, pp.297-9)).

Barker, R. (1988)[2] too suggests, some substantial arguments for the possibility that this diagram could have been invented long before the 15th century.

There is no known account of any of these diagrams before 1410 and so we must accept these ideas only as possibilities. Furthermore it is true that the few known treatises of "Practica Geometria" (Victor, S.K. (1979, pp. 1-73), Clagett,M. (1980) and Boyer,C.B. (1968, pp.278-295)) can substantially represent the most advanced pieces of applicable geometry during the period of the Middle Ages. The content of these works has nothing to do with the kind of constructive geometry that we illustrated earlier on. It is unlikely that the invention of the "MEZA-LUNA" diagram can be placed during the period of the Middle Ages. In this case, if we accept the possibility that the invention of this diagram was not contemporary with the early accounts in which it is found then research on the origin of the "MEZA-LUNA" diagram must concentrate on a much earlier period than the beginning of the 15th century.

Barker, R. (1988)[2] seems to suggest that there are no grounds for extending research on the origin of this diagram beyond the first evidence of the "skeleton first" technique (11th century A.D., Serçe Liman). However there is no evidence that this kind of diagram was necessarily related only to the "skeleton first" technique. It is true that we do not have evidence that in the classical "shell first" technique any similar diagram was applied. This is the reason why students on ancient shipbuilding maintain silence about any application of constructive geometry to shipbuilding during Greek and Roman times. Nevertheless because of the sophisticated "shell first" and "carvel" technique which was applied during Classical times it seems very sensible that some kind of abstract control on the shipbuilding occurred.

5.2.2.j Some remarks on the origin of the diagrams

Historical sources give us evidence that the construction of curves was a familiar subject to Classical Greek geometers at least from the second half of the fifth century B.C. (Boyer, C.B. (1968, p.75) and Coulton, J.J. (1977, p.109)).

Evidence of the application of projective geometry to curves is available for the middle of the fourth century (Menaechmus (fl. ca. 350 B.C. in Coolidge J.L. (1940, p.268)). (similar illustrations as fig.94 concerning problems of theoretical geometry appeared in Maddalena, A. (1954 pp.215-216) and in Heath, T. (1949 pp. 265-266)).

The most relevant point for our study is that these works on constructing curves were extensively applied to civil architecture. There is a remarkable number of studies on the geometry and refinements of Classical architecture, even from the last century.

The same forms of curves that are produced by the diagrams on fig.92 were applied to parts of the classical temples as refinements. We can mention here the "concavity of a straight - tapering column", known as ENTASIS, and the upward curvature of the stylobate (Dinsmoor,W.B. (1950, pp.166-169)). In particular the use of a diagram which is practically the same as diagram no.2 on the fig.92 is illustrated in several sources for ENTASIS (fig.95) (Mauch,J.M. von and Lohde,L. (1875, pl. T.XXXVII), Leveil,J.A. (n.d. pl.LX), Cordingley,R.A. (1951, pl.8-9), and Fletcher,B. (1948 p.134)).

In fact it is Vitruvius who provides us with the earliest record of the use of this diagram in order to determine the curve of ENTASIS on columns (Morgan,M.H. (1960 pp.86-87)).

The history of the "Greek refinements" is not very clear. There are different suggestions about their purpose and origin. It is clear that there are three distinctive periods of the application of refinements. The early period contains very pronounced curves (for example, in the temple of Hera at Paestume, sixth century, and in the temple of Apollo at Corinth, c.540 B.C.). In the Periclean period, delicate curves appeared (for example, in the Parthenon, 447-432 B.C.). Again ENTASIS is noticeable during the Roman period (Coulton,J.J. (1977 pp.109-113)).

Although the purpose of the use of civil architectural refinements is irrelevant to our studies, the geometrical diagrams which were applied to determine the curves during the last two periods were practically the same as the diagrams of the early Renaissance on ship moulding techniques.

Therefore knowledge of the construction of curves by means of these diagrams and practical application of this knowledge in civil architecture were well established in Greece possibly during the second half of the fifth century B.C. (fig.95).

If we are convinced by this conclusion then we cannot reject outright the hypothesis that the same or similar geometrical constructions of curves applied in naval architecture too.

Let me draw our attention, one more time, to the representation in fig.94. And let us try to relate each one of the curves "W" and "C" to any boat line of the hypothetical vessel that the constructed curve "W" is supposed to have been applied to. Because of the use of the successive elements to provide the curve "W" in the moulding with adjustable templates, we can obviously suggest that curve "W" represents schematically part of a water line. It is not easy though to trace what is supposed to be represented by the initial curve "C". In my opinion, the shape of the curve "C" is closer to the hypothetical line of a ribband than any other boat line (7.3 Framing up). This can be seen more easily if we replace the base of the cylinder with an ellipse or, even better, with a curve representing part of the middle section of the hypothetical vessel. From this schematic demonstration it seems that the key to the moulding with adjustable templates lies in lines which represent the form of ribbands rather than any other skeleton component of the vessel.

If we agree with the suggestion that the early invention of moulding with adjustable templates should be considered to be based on the logical process of geometrical analysis and synthesis, then we must accept that this had to start from the form of the shell of the vessels. Furthermore, from the schematic demonstration in fig.94 we can suggest that it was some hypothetical ribbands which represented the form of the shell in this process. But then the form of the ribbands was nothing more than the form of the later placed planks of the shell. We can then see that with a suitable modification of the method we might be able to build up another moulding method with adjustable templates which can provide the position of planks on the shell of a vessel instead of frames. This can bring the whole concept of the application of these diagrams back to the times of classical "shell first" technique. Possibly this was the origin of the moulding method with adjustable templates.

I do not think that we can go any further with this study without an extensive analysis based on the conjectured design of the proposed hypothesis. It was only two years ago that Richard Barker (1987) mentioned this possibility as a wild hypothesis: " ... we may even wonder whether the basic design techniques for forming skeleton hull shapes derive directly from the Classical world". Now after the geometrical analysis of these techniques we do have some new evidence which supports this idea. Until further research and new Archaeological evidence cast some new light on the subject, I propose as very likely the hypothesis that some diagrams respective to those from early Renaissance times were applied in classical shipbuilding technology.

5.3 Lofting methods

Three methods of using a lofting floor to determine the shape of a boat have been recorded during this research in Greece. In the first method the boatbuilder chalked the lines of the boat in full size straight on the floor. In the second after having built a half model he transferred the lines onto the floor. And in the third he first produced the boat's lines plans on paper before transferring them onto the floor for lofting.

5.3.1 Laying out the lines of a boat straight on the lofting floor

The earliest evidence we have about the use of a lofting floor on the Greek Islands comes from Nikodimos,K. (1962. p.72) where he mentioned that "during the end of the 18th century the boatbuilding on the Island of Psara became more advanced. Thanks to Mr.Stamatis(13), an illiterate shipwright from the Island of Chios, who came across from the Turkish naval arsenal(14) where he used to work as a carpenter. He reformed the boatbuilding practice on the Island. For example in order to build a boat, he first made a floor (Σαλα) and then he chalked the lines of the boat on the floor. From this drawing he made patterns for each frame and he found the shapes of all the frames of the boat. In this way he built the whole boat as our shipwrights use to build the boats today."

According to this description of the method Mr.Stamatis introduced in the boatyards of Psara Island, it was the first method which he was using, where the boatbuilder chalked the lines of the boat in full size straight on the floor. This method has been recorded during this research in [1]-Mavrikos' boatyard on the Island of Syros(15). Patterns for a boat with a transom stern lofted from a floor from Hydra are recorded and included in this work (fig.108)(16).

The lofting shop (Σαλα) in Mavrikos' boatyard is situated at the N.W.

corner of the yard (fig.96). This is separate from the main work-shop and the assembly ground. Its surrounding area was used for drying timbers. The dimensions of the structure were 14x4.20m and its outside height started from 1.90 to 2.10m. The floor is carefully built of planks 0.10m wide (light pine imported from Roumania). Beams supported the planks every 1-1.20m and they were based on stones arranged to provide an horizontal level for the whole floor. Moreover the rest of the structure is very simple and cheap. A light skeleton of posts and beams covered with sheet-iron and old thin planks served obviously only as a protection for the inside space from the rain and the strong summer sun. The North and East sides of the structure were open in order to provide enough fresh air for the inside area. On the other two sides lots of patterns, used for lofting, were hanging nailed on the walls (fig.97).

During our visit the room was full of dry timbers for boatbuilding and a lot of other stored items. That happened, according to the owners, because that time they had too many dry timbers in the yard which had to be protected from the strong sun (September). This lofting floor is 10 years old and it is exactly on the same site as the previous one. That former floor was about 25 years old and they had demolished it because it was too rotten. During those 25 years they repainted it three or four times and they rechalked new boat-lines on it.

On an old photograph (fig.98) another lofting floor appeared. Although the location of the place and the date of the picture are unknown we can tell from the surroundings that the place was Perama, close to Pireaus, about 1950[17]. Here the lofting floor was unsheltered, it had almost the same dimensions as the one recorded on Syros, it was about one hundred metres away from the sea and surrounded by olive trees which could provide some shade during the hottest hours of the summer days.

In Gourgouris,E.N. (1983, p.469) the use of a lofting floor has been mentioned in Galaxidi as early as the middle of the 18th century.

Fig.10 shows a photograph of an unsheltered old lofting floor from the Island of Samos. This lofting floor was used by [13]-Kontatos' father.

On the recorded lofting floor from Syros nine boats were laying on it. Seven of them were chalked on it with oil colours and two were pencilled (fig.99). These last two were small Trechadiria but unfortunately it was not possible to record them because they were not outlined clearly enough on the floor.

The seven coloured boats have been recorded and are included in this thesis:

1)The red boat was a fishing Trechadiri, 11m long (fig.100).

2)The blue boat was a Trechadiri, 10.30m long (fig.101).

3)The green boat was a gri-gri Trechadiri, 13m long (fig.102).

4)The yellow boat was a Trechadiri, 13m long (fig.102).

5)The small red boat was only the body plan of a Trechadiri, (fig.99).

6)The brown boat was a fishing Liberty, 11.65m long (fig.103).

7)The black boat was an Anemotrata (kind of long fishing net) Liberty, 16.20m long (fig.104).

(The F.D. of all these boats together with the F.D. of "Evaggelistria" (fig.105a,b,c) which had been built in the same boatyard are included in the tables. no.16,17)

The process of laying the lines of a boat on the floor started with the definition of the fundamental dimensions of the boat as they have been described in previous sections of this chapter. The boatbuilder marked the length of the boat divided into the length of the keel and the lengths of the posts on one of the two "keel" lines placed parallel to the long sides of the floor in a distance of 8cm from them. Often the length of the whole boat could not fit on the length of the floor. In this case the boatbuilder divided the length of the boat in two equal parts and chalked the half breadth plan of the one part on top of the other part (fig.101,103,104) ([1]-Mavrikos, [12]-Kozonis, [15]-Vrochidis).

Then he chalked the projections of the frames on the half breadth plan, which were straight lines perpendicular to the "keel" line. He named these lines with numbers which corresponded to the projected frames, starting with the midship frames which were named with the letter M (Μέση). The distances between these lines were equal to the distances between the stations of the frames of the boat and they have been determined according to the length of the boat. These distances came to 32cm for the red and blue boat, (fig.100,101) 35cm for the yellow and green boat (fig.102) and 41cm for the brown and black boat (fig.103,104).

Then the profiles of the rabbets of the posts were layed down on the floor. Since for these lines only the two end-points were known from the fundamental dimensions they were marked on the floor. The rest of this line was a matter of the boatbuilder's choice based on his experience and on the required form of the boat (3. MORPHOLOGY) ([1]-Mavrikos).

When he had finished with the lines of the rabbets of the posts he started to draw the top-side line on the half breadth plan. This work required great experience in the form of the deck of the boat because this line was not cross-checked with its projection on the sheer plan. The next step was to transfer this top-side line from the half breadth plan to the body plan and to start shaping the line of the midship frames. For this work all the measurements were taken on a thin straight lath which was one of the main tools in lofting, together with pencils, rules and bevel gauges (4.3 Measuring - Marking - Moulding - Lofting) ([1]-Mavrikos).

Gourgouris,E.N. (1983, p.470) mentioned, however, the use of a marking line in order to determine the lines on a lofting plan (4.3.10 Marking line).

To find the final shape of the midship frames the boatbuilder makes small changes to its shape so as to reach the shape which he believed was most appropriate. The shape of the midship frames together with the shape of the top-side line were the most crucial lines which the boatbuilders had to form. These were used as guides for the rest of the lines ([1]-Mavrikos).

The shape of the midship frames would be repeated four or six times on the rest of the middle frames of the boat. The six projections of frames on the half breadth plan under the mark "M" were related to the six frames with the same shape of midships frame (fig.100, 101, 102, 103 and 104).

The next group of lines to lay on the floor were the shapes of the "Μαγκιόρες" frames as they call them. These were on the blue, the red and brown boats the frames no.4,8 and 12 and on the green, the yellow and black boats the frames no.5,10 and 15. The idea was to divide the whole length of the boat which was to appear on the body plan as frame sections into 7 main sections. With those main sections (Μακγιόρες) a first overall control of the lines of the vessel was achieved ([1]-Mavrikos). We should mention here that this method of lofting provided for the boatbuilder only a certain number of midship frames. The remaining 4 or 5 on the fore or aft ends of the boat will be formed in the same way as in the method with moulds.

When all these basic lines were completed the work came to the step where the "diagonals" should be layed on the body plan. We call them simply "diagonals" although they were not the same thing as the diagonals which were on a conventional boat lines plan. These lines were usually four and their main function was to provide the shapes of the four ribbands on each side of the boat (their name was "Φούρμες" which is the Greek name for ribbands) ([1]-Mavrikos).

The highest of those lines was the projection of the deck line (the edge between the deck and the hull of the boat). This line runs almost parallel to the top-side line on the body plan. In the double ended boats (blue ,red, green and yellow boat) the aft and fore part of those lines were curved and had intersections on the axis of the boat. On the boats with an counter or transom form of the stern (black (fig.104), brown (fig.103) and the boat with transom from Hydra (fig.108)) the fore and aft part of those lines hadn't intersections on the axis of the boat.

We can think of two reasons for this difference. Firstly, this line as a deck and not a diagonal line had not to have inter- sections on the axis of the boat. Furthermore the stem and stern heights on the Trechadiria on the floor were equal while those on the Liberties were different (see F.D.tables.no.1,2). Secondly, as we mentioned at the beginning of this description, the boatbuilder did not expect to have the shapes of the 4 or 5 last fore and aft frames from the lofting floor. And in this case it was not necessary for him to find the intersections of the top-side line and the deck line with the axis of the body plan. After the deck lines the other ribband lines were determined on the plan (CH,DI and EJ in fig.106). In addition to the equal fractions BC, CD and DE the curved line GJ is divided into almost three equal parts: GH, HI and IJ. This was a practical rule to determine the position of the ribbands on the body plan. However, it was the projection of those lines on the half breadth plan which provided their true shape. To mark this projection the boatbuilder transferred the intersections between ribbands and frames from the body plan to the half breadth plan. This was done by measuring the fractions NK, OL, PM and QH and transferring them onto the correspondent frames of the half breadth plan (fig.106) ([1]-Mavrikos).

The ribband lines were used also as guides for the form of the strakes on the hull of the boat and the angle of their intersection with the frames on the half breadth plan provided the bevel of the frames on the level of each ribband. When they had chalked all the ribbands they started filling up the gaps between the main frames which were already marked. They chalked all the remaining frames and checked their intersections with the ribband lines on both the body and the half breadth plans.

When the plans were ready for lofting they consisted of the lines of 13-20 fore frames and the same number of aft frames, the top-side line, the deck-line, the three ribbands lines and the lines of the rabbets of the posts. All these lines were presented on their projections on the body and the half breadth plan. Only the lines of the rabbets of the posts appeared as projection on the sheer plan (fig.100, 101, 102, 103 and 104).

As I mentioned at the beginning along with the coloured plans of boats there were some pencilled lines layed out on the floor. Some of them served as modifications of the lines of the coloured boats in order to adapt then to some new requirements. The recorded examples of this way of adapting old lines to new requirements were the green and the yellow boat on the floor (fig.102). The green boat had been drawn 10 years ago and it was a fishing Trechadiri. This kind of fishing required a less beamy boat than the ordinary way of fishing. The middle beam (M.B.) of the green boat was 5.00m and her O.A.L. was 17.60m. In order to find the lines of another boat with the same length but more beamy they kept the same longitudinal dimensions of the green boat and they developed the body plan of the yellow boat. The boat thus created had the same length as the green one and the middle beam came to 5.75m. The ribbands of the yellow boat had the same projection on the body plan as the green one but their projection on the half breadth plan was wider than those of the green boat. This development of the yellow boat from the longitudinal dimensions of the green one shows that this method of finding the lines of a boat was based on a simple system of projections and intersections of the lines which provided the ability to develop changes of shape to new requirements.

When all the lines of a boat had been layed on the floor they were ready for lofting. In the lofting shop on Syros the following six kinds of patterns were used for lofting (fig.107) ([1]-Mavrikos).

1) The stem rabbet pattern which consisted of more than three pieces nailed together. The whole shape of the stem post was developed practically from this pattern. The intersections with the ribbands were marked on this pattern.

2) The stern-post pattern consisted of a single piece or two nailed pieces. Here too the intersections of ribband-lines with the stern-post were marked.

3) The floor timbers patterns. These consisted of a basal piece and two arms formed symmetrically to the axis of the boat.

4) The patterns of the middle part of the frames. On these patterns the intersections of the diagonals were marked. Often an indication of the vertical was added to the pattern (fig.107) and this provided one of the ways to check the vertical position of the frame when it was mounted on the skeleton.

5) The futtock patterns. The intersections of the top-side line, the deck-line and the ribbands-lines with the frames were marked on these patterns.

6) The ribband-line patterns. Often these were used as real ribbands on the structure. In this case they were strongly built and consisted of three or more pieces with reinforcements. Some intersections of the ribbands with the frames have been marked to provide a check on their proper position when they were mounted on the structure. Finally on a small wooden board all the bevels were marked with reference to the numbers of the frames. Patterns appeared on the

picture of the lofting floor from Perama (fig.98). Although it is difficult to ascertain whether all 6 types of patterns existed in this boatyard it is clear that the same kind of patterns were in use. In the case of the lines of the boat with transom stern from the Island of Hydra the lofting method varies (fig.108). Here the symmetry of the floor timbers was achieved by means of a wooden triangle symmetrical to the axis of the boat. The intersections of the frames were marked with the two equal sides of the triangle. The patterns represented half of the floor timber of each frame. They were placed between the marks representing the intersections of the frames with the triangle and the axis of the triangle in order to generate the shape of each floor timber (fig.1o8). The repetition on the other symmetrical side provided the full form of the floor timber. These floor timbers extended as far as the mark of the lower ribband line.

The patterns of the futtocks had an overlapping part with the floor timbers including the marks of the lower ribband. In this way the patterns of the futtocks can be placed on the patterns of the floor timbers and provide the shape of the whole frame. The remaining intersections of the ribbands and the top-side line with the frames were marked on the patterns (fig.108). The patterns were made from hard-paper instead of wood or plywood.

These patterns from Hydra showed a way to create the lines of a certain size of boat providing at the same time patterns for the same kind of boats but of different sizes. On the triangular component has been written the note that these patterns provided the lines of boats with 15 or 15.5 or 16feet length. For this reason to either sides of the marks of the axis of the triangle were other marks 3cm distant to the axis. By the use of these latter marks instead of the former ones they determined the lines of a new boat with 16ft. length and 6cm wider than the previous one. In the same way the marks on the inside of the axis of the triangle provided the lines of a boat 6cm thinner which correspond to the 15ft. length boat(18). This was a way to receive an arrangement of the patterns which could provide at least three sizes of the same kind of boat.

From the representation of the lines of the boat which provided the patterns from Hydra it becomes clear that the method for finding the lines of the boat was the same as on the lofting floor from Syros.

If we like to compare this method of planning a boat with the known naval architectural plans, we will see that a lot of lines from the standard plans are missing on the plans from Syros (Ester,H.C. (1918, pp.87-98), Vaitses,A.H. (1980) and Mckee,E. (1983, pp.128-9)).

On these recorded plans we find uncompleted sheer plans. Only the projections of the rabbets of the two posts appeared on a sheer plan level without composing any form of a sheer plan. Water lines were not used at all on these plans. Also there are no other miscellaneous lines like bow and buttock lines and bearding lines. Even the lines which appeared as diagonals were in fact the projections of the ribbands. One of the reasons for the absence of these lines was that no checks for fairness of the structural lines occurred on the plans. The whole process was straightforward without any special technique to check the fairness of the lines exept the checks between the different projections of the structural lines.

The main case though for this form of the lines was that it was made to serve certain requirements in the boatbuilding process rather than to present the full record of a boat's lines. It seems that the main demand which these plans served was the form of the frames. These lines were the only true representation of structural components. The rabbet lines were only indications for the actual profile of the posts and ribbands were in practice used to fair the frames rather than to form any structural component.

With this method the Greek boatbuilders improved the symmetry of the hull of their boats and achieved better fairness of the frames and of the form of the hull. These problems were not obvious on small boats but when any of these boatbuilders faced the demand for bigger boats the variations of the old method of moulding were not sufficiently adequate to serve the requirement of symmetry and fairness on the bigger boats. For this purpose they adopted the new method of laying the lines of a boat upon a floor and lofting them. As the method was adopted to match certain problems in the boatyards it was developed towards this end and not in regard to the possibility to determine on the lofting floor as many structural components as possible.

5.3.2 Forming a model method

Three boatbuilders were interviewed who used a model (half or whole) method to determine the lines of a boat. [15]-Vrohidis used to work in Perama. He learned the method from his father who was working as a shipwright in Russia. Mr.Vrochidis came to Perama when he was nineteen years old (1924) and he was one of the first boatbuilders using models at that time.

[6]-Arvanitis was the first boatbuilder who introduced this method in Chalkis. He learned to use full models during his service in the Navy. According to him the older boatbuilders used half-models, but none of the boatbuilders is using half models today.

The third was [18]-Kastrinos from the Island of Kalimnos who again started to use this method in the Navy.

In addition to these three people two drawings of half models have been recorded in this work. These come from Peter Throckmorton's collection and both seem to be Trechadiria. For the first of these it is not clear whether it has a horizontal or a raked keel (fig.109)(7). For the second though no sheer or body plan has been recorded (fig.110)(8).

From these sources it seems that the model method was introduced in

Greece first as a half-model method, possibly last century, and in the 20th century as a full model method.

The usual scale of a model was 1:20 and the method could provide any of the traditional types of boats. First they selected about seven very straight planks of 1, 1.50 or 2cm width ([15]-Vrochidis, [6]-Arvanitis,[18]-Kastrinos).

Then they nailed these planks together and started shaping them. They started with the fundamental dimensions of the boat, the outline of the stem and the stern post and the outline of the horizontal projection of the deck-line. Then they continued with the determination of the water-lines starting from the bottom to the upper one. At the end they faired the hull of the boat by trimming the vertical edges of each of the water lines levels ([6]-Arvanitis, fig.142b).

When the model had its final form, they took it apart into its constituent horizontal slices and they recorded them on the floor or on a piece of paper. Then they marked the stations of the frames with lines perpendicular to the water level lines. On both of the recorded models there were two of these station lines specially marked (with the numbers 0 and 20). These lines had to be marked in advance on the model in order to be used as guides when the water levels were laid dawn.

The main advantage of this method was the opportunity to ensure the client's satisfaction with the form of the boat, with the aid of the model, before the boat was laid out on the lofting floor ([6]-Arvanitis, [15]-Vrochidis).

This advantage of displaying the form in advance was not provided by the previous method of laying the boat-lines straight on the floor. The main technical difference though between the two methods was the use of water lines on the models instead of the ribband lines which were used in the straight lofting method. In the method with models the analysis of the boat lines into projections on three perpendicular plains was more developed than in the other method. This means that although both methods were applied on a lofting floor they were based on different analytical conceptions of the shape of the boat. We can accept that the models were practically independent from the actual boatbuilding process (whereas the straight use of a lofting floor was not really independent from it) and they could be used even if the boat was finally not built (for example, during the arrangement with a client). The three dimensional representation of the boat in advance was the main requirement which this method served. This provided a better expression of a boatbuilder's conception of the boat and the clearest arrangement with the client about the form of the boat. It is not clear though whether the introduction of this method in the Greek boatyards was a matter of serving additional technical requirements of the other traditional methods (moulding and straight use of lofting floor) or an influence from other boatbuilding practices adopted in this country.

Another new feature being introduced with this method was the use of a scale in the construction of the model. This new feature required a theoretical knowledge of using scale representation.

5.3.3 The use of boat lines plans

[3]-Stilianou kindly offered me copies of his plans of boats which had been built in the past. His father was a boatbuilder on the Island of Spetses and he taught Mr.Stilianou all the technical background of this art. Mr.Stilianou though learnt to make and use boat lines plans in the arsenal of the Navy from 1917 until 1922. He was one of the few traditional boatbuilders who started by making plans of the boats.

He started the plans by determining the fundamental dimensions of the boat and marking them on the paper. Then he drew the deck line and the profile of the two posts. He determined the draft of the boat and marked the water level. Then he used the diagonals AB and AC (fig.111,112) to find the shape of the midship frame. Having drawn the deck line and the water level line on the half breadth plan he continued with the other lines of the plans ([3]-Stilianou).

This process of drawing the lines of the boats seems rather empirical without the common checks and fairness of the lines. This seems to be closer to the conception of the use of a model than to the use of naval-architectural plans. The plans of this method were similar to the model's lay out plans though without the use of a model.

5.4 Comments on the evolution of the designing methods

The "master frame and ribbands" and the moulding with adjustable templates methods have been suggested in some publications to be very old methods of designing (Steffy,J.R. (1982), Barker,R. (1987), Basch,L. (1972), Rith,E. (1984), Sarsfield,J.P. (1988), Heidelberg,P.K. (1985)).

The processes of determining the shape of the ribs by these two methods seem to have some common features (the ribbands, the midship frame, the "tail-frame" (Lane,F.C. (1934)) or "πρωτοβαθικό" ([11]-Polias) or "terço de vante" (Sarsfield,J.P. (1988)) or "fore and aft hook" (Taylor,D.A. (1982)), the flexible wire or similar flexible material to form the shape of the remaining frames).

Sarsfield,J.P. (1988) mentioned the difficulty of concluding which of these methods was the older one. From a first examination the "master frame with ribbands" seems to be the initial method rather than the moulding with adjustable templates. However, the case of the Newfoundland example where the former was a simplified modification of the latter method suggests that the moulding with adjustabe templates was the original method in this area (Taylor,D.A. (1982, p.91).

Furthermore as we have examined earlier on, there are sufficient grounds for tracing the origin of the moulding with adjustable templates method to early classical times (5.2 Moulding methods). Therefore it is unlikely that moulding with adjustable templates was generated from the "master frame and ribbands" method. Even more, the only evidence we have suggests the other way around.

According to [17]-Papastephanou's description, moulding with adjustable templates contained in practice a part of the "master frame and ribband" method. So an apprentice in the boatyard could only copy in his mind the practical parts of this process. If the boatbuilder did not let him know the geometrical generation and use of the "METZAROLA" plan then, wanting to build a boat by himself, he would have generated some kind of "master frame and ribband" method.

We have to admit that the knowledge of working by means of "METZAROLA" or "MEZA-LUNA" or any of the other sophisticated geometrical compositions was one of the main secrets of this work. Therefore any copy of the moulding with adjustable templates method without the knowledge of a "METZAROLA" plan could easily be reformed to a "master frame and ribbands" method.

In any case the small double ended or transom stern boats in the boatyards of the islands could easily be formed by either of these two methods. The "master frame and ribbands" method was inconvenient when the boatbuilders had to face the building of big boats. The easily handled small boats had not the same requirements about more systematic determination of their shape than the bigger ones.

Therefore it is our suggestion that before the last quarter of the 18th century two levels of boat designing were in use on the Islands of the Aegean. The moulding with adjustable templates was used on the bigger boats and in the more organized boatyards while the "master frame and ribbands" method was applied on small boats built in the more primitive boatyards.

The material in Nikodimos,K. (1862, p.70) offers an additional suggestion to this hypothesis. According to his description the boatbuilders on Psara (during the second half of the 18th century) set only the floor timbers ("έδρες") on the keel by means of a moulding with adjustable templates method. This was obviously the most critical part of framing in respect to the successive narrowing and rising of the floor timbers. Then the boatbuilders completed gradually the futtocks and the top timbers by means of the "master frame and ribbands" method (7. CONSTRUCTION). In this second stage they followed the predetermined narrowing and rising of the floor timbers only by rule of thumb.

This method had the same name as the moulding with adjustable templates in the 20th century ("Μονόχναρο") and it was used on the big vessels which were built on this island. However, the use of the "master frame and ribbands" as part of the moulding with adjustable templates method's was more recognizable in this early account than in the later description from the interview ([17]-Papastephanou).

Therefore the above mentioned suggestion that the "Master frame and ribbands" was a simplified modification of the moulding with adjustable ribbands method seems more likely during the second half of the 18th century.

However Konstadinidis,T.P. (1954, p.118) suggests that improvements in the moulding technique occurred after 1770 in the Aegean without giving any evidence or reference for this suggestion.

By the end of the 18th century the new method of laying the lines of the boats on the lofting floor was introduced at least in the boatyards of Psara (Nikodimos,K. (1862, p.72)). We suggest that certain requirements forced the boatbuilders to introduce this modernization in their boatyards. We will examine them in the table. no.36.

The new method was gradually influenced from the old method of moulding with adjustable templates. As we have shown in the section on lofting, some of the details of this method were simpler than in other lofting practices (the existence of only the outline of the sheer plan, the lack of water lines, the lack of the 4-5 fore and aft frames, the lack of bow, buttock and bearding lines). Despite the frames the only additional lines on the plans of the lofting floor were the ribbands lines and the rabbet lines on the keel and the post (fig.100, 101, 102, 102, 103 and 104). The reason for this simple form of lofting was the boatbuilders' familiarity with the use of ribbands thanks to the moulding with adjustable templates method.

However the introduction of the lofting floor occurred in only a few boatyards during the last years of the 18th century. So the other boatyards had to combat the new technique by means of improving the old moulding with adjustable templates method. We suggest that the most sophisticated versions of moulding, like the one that [14]-Chatzinikolaou used, were introduced in the boatyard through this technical competition (the use of the simple "saleto" drawing could be evidence for this suggestion).

Therefore we find mutual influences in the evolution of these two methods from the end of the 18th century until today.

Since both methods survived in Greece until the 20th century, they have been used especially on two respective groups of boats. Moulding was used often for less than 15m length and double ended or transom stern boats and the lofting floor method was used for bigger boats and especially for boats with counter stern.

Most of the boatbuilders who used a lofting floor could work with moulds as well but none of those who used to work with moulds could lay down and loft the lines of a boat. Later the arsenal of the Greek Navy apparently produced a new generation of boatbuilders who used to work with models and plans of boat lines.

Studying the evolution of practical design in the Aegean boatyards we can see certain requirements which forced the establisment of the new methods. At the same time some of the new methods were introduced by boatbuilders who came from other shipbuiding traditions ([15]-Vrochidis and 1. HISTORICAL INTRODUCTION) and their techniques have been welcome in the boatyards.

In table.no.36 we present the requirements or the advantages which determined the evolution of design including both the old and the respectively new methods.

Table.no.36

METHODS OF SHAPING IN RESPECT TO REQUIREMENTS

"master frame and ribbands"

The method was used on boats with limited size.
The boats built by this method often lacked a symmetrical hull

Moulding with adjustable templates used on floor timbers and "master frame and ribbands" method used on futtocks and top timbers (Nikodimos,K. (1862, p.70)).

The method was used to build bigger boats than the previous ones. The hull of these boats had shown signs of asymmetry like the boats built by the former method (Nikodimos,K. (1862, p.70)).
However, by this method the boatbuilders started to keep the moulds of successfully shaped boats in order to improve the forms of the later built boats

Moulding with adjustable templates for the whole middle frames of the vessels (version with three aids).

This method provided better symmetry about the middle part of the hull. The size of the boats built by this method was as limited as by the previous method.

However, by this method the boatbuilder could keep the moulds of a successful boat as a record of the whole middle part (floor timber, futtock, top timber) and was able to reproduce her easily another time. This was a further improvement from the previous method.

Lay out the lines of a vessel on a lofting floor without plans or models

By this method sufficient improvement of the boats' symmetry was achieved. More frames than in the previous methods were determined. The size of the boats that could be built was increased by this method. Additional tests of the longitudinal fairness of the hull were available by lofting. The new method provided the ability of building new types of hull with a more complex form than the old types.

Moulding with adjustable templates (version with five aids)

The method was an improvement of the previous moulding methods in order to meet the requirements of more flexibility in the determination of the boats' shape by the traditional way of moulding. The main advantage of this version of moulding was the ability to provide different forms on the fore and the aft part of the boats.

Making models before the use of the lofting floor

During modelling the decision of the final form of the boat was under convenient control and negotiation with the client. The new test of horizontal fairness of the lines was introduced through this method. The method of modelling provided the ability to predetermine the shape of more structural components of the boats (the more extreme fore and aft frames the curves of the deck beams and the measurements for the planks of the hull).

<u>Using boats lines plans before the use of the lofting floor</u>

With this method some accurate tests of the fairness of the lines had been introduced by water lines, bow and buttock lines and bearding lines.

The method was associated with the introduction of the naval architect's post in the shipyard and the modern ideas about ship-designing.

Therefore as we can see on the above table.no.36 two basic periods can be identified in the evolution of boats design during the last three centuries in the Aegean. The first started in the second half of the 18th century until the introduction of making models or plans before the use of the lofting floor. In this period the main requirement which influenced all the changes of the old methods and the introductions of the new methods was the improvement of the form of the boats (symmetry and fairness). The second period contained the introduction of the predetermination of the boats lines on models and plans. In this second period the main requirement was the better management and the overall control of the boatbuilding process by the new figure of the naval architect.

notes:

(1)The mark 4 of the rising table, in our example, is actually the point where the rib number 4 of the boat meets the side surface of the keel (this point is on the rabbet line).

(2)[14]-Chatzinicolaou uses this side of the hollow mould for the ribs which correspond to the sirmarks 1,2,3,4 and A,B,G,D and the other side of the hollow mould for the ribs which correspond to the sirmarks 5,6,7 and E,Z,H. This second side of the mould provides more curvature for the floor timbers (fig.83).

(3)The futtock head breadth table must be kept horizontal. It is nailed on the floor breadth mould at one side and it can only move around this nail (fig.83).

(4)Sirmark on the rising table

(5)Sirmark on the futtock head breadth table

(6) However Kanellopoulos, H.Ph (1890 p.35) calls "MASTORIS" the midship pair of frames and without necessarily relating them with the moulding method.

(7) Original note number (12) in the book, Anderson, "It. Nav. Arch.", p.154.

(8) Original note number (13) in the book, Crescentio, pp. 14-18. The measure of system for narrowing here described is called by Crescenzio the "brusca" , by Drachio the "partisone del fondo" , by Theodoro simply "partisone". Anderson, "It.Nav.Arch.", p.154, says the radius of the circle was the half-beam, although there is written along it: "questo e el morelo de la partison", i.e., "this is the measure of the partison". I presume Anderson thought the length of the partison to be the same as the half beam, but such is not the case in Theodoro or Drachio.

(9)In order to compare the two systems more directly, I have changed the division of the line AB of the "MEZA-LUNA" plan from eight to seven "progressively smaller fractions" (fig.90b).

(10)In order to divide the whole arc into seven equal parts the Greek shipwright uses the sweep on which he measures by eye and marks one seventh of the arc. This is achieved by trying to do that several times each time, using slightly different distances on the sweep as one seventh of the arc. We can expect that the same practical method was used in the case of the "MEZA-LUNA" plan in so far as this division into equal parts was not derived from bisection of the arc: ie. dividing the arc into 2 or 4 or 8 or 16 and etc. equal parts.

(11) A translation of this work into English has been kindly provided for me by Richard Barker.

(12) It is interesting to note that Lavanha, J.B. (early 17th century) mentioned the Greek origin of the word "GRAMINHO"

(13) Tzamtzis,A. (1976) mentioned that the name of this boatbuilder was Mr.Stamatis Kofoudakis. When the Turkish navy attacked the Island of Psara Mr.Stamatis Kofoudakis emigrated to the Island of Andros. There he continued to build boats together with his son Mr.Gianis Kofoudakis. Later his grandson, another Mr.Stamatis Kofoudakis, became one of the chief shipwrights on the Island of Syros.

B.Kardasis,V.A. (1987) in his book mentioned Mr.Tzani Kofoudaki as one of the most famous boatbuilders on Syros from 1832 to 1857, who possibly was the son of Mr.Stamatis Kofoudakis.

The owners of the lofting floor which we recorded, Mr.Aris and Mr.Nireas Mavrikos, mentioned that their father from whom they learn this craft used to be an apprentice in Kofoudakis' boatyard.

(14) Bekiaroglou-Exadaktylou,A. (1988) mentioned that French and Italian naval architects used to be the chief shipwrights in the Turkish arsenals at that period.

(15) The lofting floor has been fully recorded by Dr. Robert Prescott and Mr.K. Damianidis, in September 1987, in order to be included in this thesis.

Mr.P.Throckmorton included in his article "Pantano Logarini", Nautical Archeology, vol.2, 1973, a photograph of the previous lofting floor in Mavrikos' yard on Syros.

(16) The patterns belong now to the Hellenic Institute for the Preservation of the Maritime Heritage which kindly offered them to me for recording and studying. They had been used in a boatyard on Hydra and they formed the body plan of a boat with a transom stern. This is according to the records of the Institute a "Varkalas from Hydra" (2.3.4 Varkalas from Hydra).

(17) The photograph comes from the BENAKI MUSEUM from the negative no.B9277 and it was taken by Mrs.Βούλα Παπαϊώανου. The railways on the background together with the clothes of the people determine roughly the date and place of the picture. Furthermore other negatives from the same person in the Museum have dates between 1940-1950.

(18) On the same triangle there is another note which describes the way to form the lines of a boat 16.5ft. length. The note is not clear enough but we can read that in the case of a boat 16.5ft length in addition to the wider form of the "keel" the.....word missing...must be 2cm wider than in the previous boat.

6. BOATBUILDING TIMBER

Before studying the boatbuilding process we will pay attention to the several kinds of boatbuilding wood and their properties. As we have seen in the chapter on 4. TOOLS a number of them were especially adapted to working with forms and properties of boatbuilding wood. Furthermore we studied in the chapter on 3. MORPHOLOGY some elements of the boat's form which were determined by the properties of wood (curves of the hull below the turn of the bilge and curves of the stem post).

The interviews also made it obvious that timber properties were important factors both for the duration of a boat's life and for successful boatbuilding. The study of wood prior to the boatbuilding process will provide us with further material from which we will take advantage to extend the study of some parts of the next chapter.

Wood was a very popular material in the techniques of the past. The easy access to this material and its constructive properties were appreciated by lots of different craftsmen. In the modern Greek tradition wood was one of the first structural materials used on buildings or in other constructions. Some of the examples from traditional craft-work in wood show some developments of special techniques which had common elements with boatbuilding. In Fei-Stamati,E. (n.d.) the technique of building a wooden stock-saddle is included. In this technique steaming was used to bend some timber. The technique of building the wooden part of a windmill in the Islands of the Aegean was similar to boatbuilding (e.g. the methods of measuring and marking curved pieces of timber).

However, there is no doubt that boatbuilding was one of the most complex and skilful works in wood. The boatbuilders took advantage of some properties of the wood in order to improve the strength, the curved shape of the components and the duration of the boats' life.

Table.no.37

Boatbuilders Interviewed	Location of Boatyards	Places where timbers come from
[1] Marrikos	Syros	Samos, Lesvos, Athos, Asia Minor
[2] Karnidaris	Lephkas	Lephkas, Aitoloakarnania
[3] Stilianou	Spetses	Samos, Evia, Thasos, Spetses, Czechoslovakia
[4] Kovakis	Spetses	Samos, Lesvos
[5] Davdanos	Evia	Evia
[6] Arvanitis	Evia	Evia, Samos, Thasos
[7] Chimonos	Evia	Evia
[8] Chalavis	Santorini	Samos, Athos
[9] Chilas	Kalymnos	Samos, Lesvos, Rhodos
[10] Binos	Lemnos (Pevama)	Samos, Skiathos, Thasos, Lesvos, Evia, Athos, Asia Minor
[11] Polias	Symi	Asia Minor, Rhodos, Symi
[12] Kozonis	Samos	Samos
[13] Kontatos	Samos	Samos
[14] Chatzinikolaou	Rhodos	Rhodos
[15] Vrochidis	Perama	___
[16] Kritikopoulos	Perama	Samos, Lesvos
[17] Papastephanou	Perama	Samos
[18] Kastvinos	Kalymnos	Samos, Lesvos, Rhodos
[19] Bilias	Salamis	___
[20] Giamougianis	Lesvos	Lesvos

The special name for boatbuilding wood was "Κερεστές" (Kerestes) ([11]-Polias, Kanellopoulos,H.P. (1983, p.50) and Gourgouris,E.N. (1983, p.459)).

This study comprises two parts. In the first we study the different kinds of wood used in boatbuilding and their basic elements. In the second we pay attention to the properties of wood which have been mentioned by boatbuilders as important elements in their work.

The lack of any convenient previous work on boatbuilding wood from the Aegean makes it necessary to include in this work some fundamental information on the subject.

6.1 Kinds of boatbuilding timber

In addition to the properties of wood required for its use in boatbuilding the other main factor which determined the choice of the kind and the area where this wood came from, was the availability of it. This is I believe the explanation of the fact that all the kinds of wood used in Aegean boatbuilding normally grew close to the coasts. Kardasis,V.A. (1987, p.184) mentioned the argument of the boatbuilders from Syros (1856) about the necessity for roads in the forests in order to gain access to the inland parts of them.

There is evidence of imported wood for boatbuilding from the Balkans ([1]-Mavrikos), Asia Minor ([1]-Mavrikos, [10]-Binos, [11]-Polias, Zouroudis,G.I. (1974, p.162)), Europe (?) (Tzamtzis,A. (1987), [3]-Stilianou). It is rather difficult to identify the species of the imported wood used in boatbuilding. The following presentation contains the native Greek wood used in boatbuilding.

The extensive use of oak is mentioned ([1]-Mavrikos, [3]-Stilianou, [6]-Arvanitis, [8]-Chalaris, [10]-Binos, [11]-Polias, [17]-Papastephanou, [20]-Giamougianis) and elm ([1]-Mavrikos, [8]-Chalaris, [10]-Binos, [11]-Polias, [17]-Papastephanou) and among the other hard woods mulberry has been mentioned by [6]-Arvanitis and

[10]-Binos and Eucalyptus by [5]-Dardanos.

Soft wood was more suitable for used in planking and decking. Pine has been mentioned by all the twenty boatbuilders interviewed as the best native timber for boatbuilding (even for structural components). [2]-Kornidaris, [8]-Chalaris, [10]-Binos and [11]-Polias mention the use of cypress wood in boatbuilding.

Bekiaroglou-Exadactylou,A. (1988, p.24) mentions oak, pine, beech, fir and cypress as the boatbuilding wood which was used in the Turkish arsenals in the 17th and 18th century.

Denham,H.M. (1986, p.285) mentions the use of the tall fir (?) trees from the small Island of Othoni, in order to produce pole masts. He notices the information about the "Pyramidal tree, 50-70m tall with smooth whitish bark ... growing in the mountains of N. Greece" (Huxley and Taylor (1977), Flowers of Greece and the Aegean).

However no information about the use fir in boatbuilding is available from the interviews of this thesis.

6.1.2. <u>Hard wood</u>

6.1.2.a Oak (Quercus sp.) (Δρύς)

[1]-Mavrikos, [6]-Arvanitis, [8]-Chalaris, [10]-Binos and [20]-Giamougianis mention the use of oak in the past for strong structural components in boatbuilding (knees, "ντουφέκι", keel, "σκορπιός"). Other boatbuilders mention the shortage of native oak during the last years and that it was therefore very expensive to obtain oak through the market ([5]-Dardanos, [14]-Chatzinikolaou, [17]-Papastephanou).

There are a lot of different species of oak growing in Greece, e.g: Q.pedunculata, Q.pedunculiflora, Q.aegilops, Q.macedonica, Q.infectoria, Q.cerris, Q.coccifera. It seems difficult to distinguish which of these species have been used in boatbuilding. Information from old boatbuilders about the origin of these timber and the required properties of them can give us some idea about the species of Greek oak used in boatbuilding. The species of oak growing close to the coasts are: Q. pedunculiflora, Q.aegilops, Q.infectoria, Q.coccifera. Furthermore, Q.aegilops and Q.infectoria are growing on the Islands where most of the wood for boatbuilding comes from (Samos, Lesvos, Rhodes, Thasos, etc.) (Tsoumis,G.T. (1972, p.317)) (fig.113).

Of these last two, Q.aegilops is a tree of 10-25m height with thick boughs, whereas Q.infectoria is a sort of tree less than 3m high with thin boughs (Tsoumis,G.T. (1972, p.133, 139)).

Both grow in hot and dry climates without requiring special conditions of soil. From this description it is likely that Q.infectoria provides better dimensions for the construction of the skeleton.

Most of the boatbuilders used scrub oak (Πουρνάρι or Αγριοξυλεία) for the strongest and short parts of the construction (knees, "Ντουφέκια", "φουρνιστή"). Even small pieces of this wood were used to make treenails ([1]-Mavrikos, [8]-Chalaris, [10]-Binos).

The hardness of this wood, according to Brunell, is between 9-20 degrees while for the other oak species about 3-6 degrees. This sort of oak is Q.coccifera and possibly Q.infectoria (Simopoulos,K (1985, p.187)). Q.coccifera is one of the species which grows on Samos (Anastasiou,A. (1987, p.139)).

"Oak can reach a height of 35-40m and a radius on the low part of its bole of 1.00-1.20m. This tree can become as old as five centuries. Oak has a high strength ability and a middle degree of shrinkage and swelling. The kind of oak used on boatbuilding has wide annual rings. This kind of oak is hard and heavy (specific gravity 900mgr/m3 on 15% moisture). The main defect of oak wood is shakes." (Simopoulos,K. (1985, p.187)).

Oak wood was extensively used during the last century and at the beginning of the 20th century. In addition to boatbuilding, oak was a favourite wood for other structures and even for burning. This extensive use had caused the shortage of oak trees which makes it difficult today to obtain oak wood from the Islands or from the mainland of Greece (Simopoulos,K. (1985, p.186)).

All the species of oak, mentioned above as likely to be used in boatbuilding, are kinds of white oak (Simopoulos,K. (1985, p.186)). There is an interesting description of the white oak from North America used in boatbuilding, which gives information for this wood although from other parts of the word: "white oak has a better combination of properties which meet the principal requirements of ships and boat parts than any other native wood. The heartwood of white oak ranks moderately high in decay resistance, holds fastenings well and is one of the stronger and stiffer native woods. It is an excellent bending wood and can be satisfactorily bent to curvatures required in boatbuilding...

A number of hardwoods compare favorably with white oak in most of the required properties' except decay resistance. Red oak, hickory, white ash, rock elm, beech, yellow birch and hard maple are domestic woods that are equal or superior to white oak in bending strength, shock resistance and ability to hold fastening. Because of their low decay resistance, however, they are unsuitable for ship and boat use without thorough preservative treatment..." (US.Dep. of the Navy (1957, p.194)).

6.1.2.b Elm (Ulmus campestris) (Φτελιά or Καραγάτσι)

Elm is known as a shipbuilding wood from Classical times (Meiggs,R. (1982, p.118)).

[1]-Mavrikos, [8]-Chalaris, [10]-Binos and [11]-Polias mention the use of elm in boatbuilding. Native elm as well as oak was difficult to obtain in the market ([5]-Dardanos, [17]-Papastephanou).

According to Tsoumis,G.T. (1972, p.148) "elm is a tree of 20-30m height, rarely as high as 40m. It grows on rich and wet soil and it needs to grow under light shade. Wood is middle hard and heavy (specific gravity o.65gr/cm3), flexible and it is used on structures in the water...

In Greece it is grown in the Peloponnese and northern...

Some times it was imported from Yugoslavia and Turkey. The strength of elm is lower than that of oak. It weighs 600- 850kgr/m3. It is resistant to splitting...

Its sapwood has low decay (fungi) resistance whereas the heartwood has high decay (fungi) resistance. It grows easily and fast. Lumber from elm needs care in order to avoid twisted forms of timber from shrinkage and swelling." (Tsoumis,G.T. (1972, p.155)).

6.1.2.c Mulberry (Morus sp.) (Μουριά)

Mulberry wood is known as a shipbuilding wood in Classical times (Meiggs,R. (1982, p.118)).

[6]-Arvanitis and [10]-Binos used mulberry wood in boatbuilding.

There are two species of mulberry in Greece: Morus alba L. and Morus nigra L. Although both Tsoumis,G.T. (1972, p.155) and Simopulos,K. (1985) do not mention any difference on the strength of these two species, [11]-Binos used only morus nigra because "this wood is stronger and harder than the light coloured mulberry" (M. Alba L.). This is possibly a matter of the locality of this wood rather than its general property of strength.

"Tree of 6-10 m high. It needs a warm climate...

The wood is middle hard and middle heavy (0.60gr/cm3).

Morus alba L. has been introduced in Greece during the 12th century from China. Morus nigra L. has been introduced in Greece during the ancient times from N. Persia." (Tsoumis,G.T. (1972, p.155)).

6.1.3 Soft wood

6.1.3.a Pine (Pinus sp.) (Πεύκο)

Pine was used in shipbuilding as early as Classical times (Meiggs,R. (1982, p.118)).

All of the boatbuilders interviewed used pine extensively for planking and for most of the skeleton components. The differences between the pine used by boatbuilders was in respect to the area where this wood was coming from
(table.no.37).

There are lots of different pine species in Greece. The most numerous of them are: P.nigra, P.pinea, P.halepensis and P.brutia. Pinus nigra is growing in the mountains of the mainland and its commercial name is mountain pine. This wood is both heavy (0.60-0.80 gr/cm3) and long enough for constructions (17-35m) (Simopoulos,K. (1985, p.185)).

This pine did not grow on the coasts and on the Islands and it is unlikely that they used it in boatbuilding in the past.

Pinus pinea grows on the coasts but not on the islands. Its wood is strong enough for construction. The sapwood has low resistance against sapstain (blue stain). It is workable and can be well seasoned (Simopoulos,K. (1985, p.185)).

According to Asteriou,S.Z. (1977) P.pinea was used in Classical times in shipbuilding.

P.halepensis and P.brutia have the same structure of wood and it is difficult to distinguish them as different types of wood (Davis,P.H. (1965, vol.1, p.75), Simopoulos,K. (1985, p.185)).

Moreover these two species seem to grow in two different areas in Greece (see map in fig.114). P.halepensis grows on the Peloponnese and southern mainland whereas P.brutia can be found on the Aegean Islands (Samos, Lesvos, Thasos, Crete, Rhodes, etc.) and in Asia Minor (Tsoumis,G.T. (1972, p.312), Davis,P.H. (1982, vol.1, p.73, 77), Papaioanou,I.K. (1954, pp.104-5)).

Both species grow close to the coasts. P.halepensis provides wood with middle weight 0.41-0.84 gr/cm3 (Tsoumis,G.T. (1972, p.28-30)). P.brutia is usually heavier and harder than P.halepensis (0.65 -0.84gr/cm3). It has a lot of wide resin ducts (Simopoulos,K. (1985, p.185) and Papaioannou,K. (1954, p.104)).

As we will see later for most of the boatbuilders the high content of resin in the pine wood was a considerable advantage (table.no.38) which imparted some decay resistance to the wood in the water.

It is not clear if P.brutia contains more resin than P.halepensis. Although according to Papamichael,P. (1970[1], p.74), P.brutia contains more resin than the P. nigra. Other sources suggest that during extraction of resin P.halepensis provides sufficiently more resin than any of the other species (Kossenaki,G. (1954, p.94), Papaioannou,I.K. (1954, p.111)).

Tsoumis,G.T. (1972, p.30) mentions that the high content of resin makes both species suitable for boatbuilding.

P.brutia provides straight timber (Davis,P.H. (1982, vol.1, p.74)) with a length of 15-20m and occasionally 30m, by contrast P.halepensis has usually twisted or curved boles (Tsoumis,G.T. (1972, p.29, 32)). This in practice can be a sufficient advantage of P. brutia in order to be used in planking or decking.

P.brutia and P.halepensis have brown heartwood and yellow sapwood. There is a description for the southern yellow pine (U.S.A.) which seems to have similar properties as these two species (specific gravity of southern yellow pine is 25-43p/f3=561-705kgr/m3). "Douglas-fir and Southern Yellow-Pine are softwood with the best combination of the properties required for structural parts in ships and boats.

The dense heartwood of these two species of wood is generally a little less decay resistant than the heartwoods of white oak. As is common to all woods, their sapwood is not decay resistent. The principal difference in strength between these softwood species and white oak is hardness, shock resistance, sheer strength and ability to hold fastenings. When compared with the two soft woods, white oak is from two-fifths to four-fifths harder and about one-fourth higher in shock resistance, holds fastenings better, has higher sheer strength, resists splitting, wears less and bends more easily. However, because douglas-fir and south yellow-pine are lower in shrinkage and swelling resist warping and stay in place better and are lighter in weight and more available than white oak, they are often specified for such ship and boat applications as planking, decking, deck beams and other uses where their strength properties are satisfactory..." (US.Dep. of the Navy (1957, p.195)).

Almost all the Greek boatbuilders agree that the best Greek pine for boatbuilding came from the Island of Samos (table.no.37). The other common places for boatbuilding wood were Lesvos, Rhodes, Thasos and Evia.

On Samos 85% of the pine in the forests is P.brutia and the rest 15% P.nigra which is located on the highest altitudes in the area (Anastasiou,A. (1987, p.139)).

On Lesvos 98% of the local pine is P.brutia and only 2% P.nigra (Seraidis,P. (1987, p.145)).

On Thasos P.brutia covers 71,5% of the whole forest area of the island and it is growing from sea level up to 500m above the sea (Makedos,G. (1987, p.153)).

The only place mentioned above where P.brutia is not the dominant species is Evia (fig.114). However, we should mention here that three of the boatbuilders who mention the pine from Evia are actually located on this island ([5]-Dardanos, [6]-Arvanitis, [7]-Chimonas). At the same time other boatbuilders mention the use of their local pine ([2]-Kornidaris, [3]-Stilianou, [11]-Polias, [12]-Kozonis, [13]-Kontatos, [14]-Chatzinikolaou, [20]-Giamougianis). So the availability (and possibly the price) of pine from Evia persuaded some of the boatbuilders to use this wood.

Pine from Karpathos was used before 1815 for shipbuilding there and on Kassos (Papavasiliou-Petritis (1936)). Tzamtzis,A. (1987) gives the information that the frames of a vessel built on Syros in 1832 were made of wood from Karpathos. The species of pine on Karpathos is P.brutia as on all the S.eastern Islands (Davis,P.H. (1982, vol.1, pp.73-4)).

From the above mentioned evidence it is clear that P.brutia was more popular in boatbuilding than any other species of pine in Greece, the pine from Samos in particular. Unfortunately there is not any work available on the special properties of P.brutia from the Island of Samos. But according to the specialists from the Institute of Forest Research in Athens it is quite conceivable that the wood of P.brutia from areas like the Island of Samos might have some special properties which give better performance in boatbuilding. We should mention here that P.brutia is growing in areas of Asia minor from where wood for boatbuilding used to be imported to Greece.

P.brutia is the most numerous species of pine on Cyprus (Papaioanou,K. (1954, p.105)). According to Meiggs,R. (1982, p.118) some advantages of the species of pine from Cyprus for use in boatbuilding were known in Classical times.

6.1.3.b Cypress (Cupressus sp.) (Κυπαρίσσι)

Cypress was extensively used in shipbuilding during antiquity on Crete (Zachari,A.S. (1977, p.41,44,69 and 97)).

There are two main species of cypress in Greece. The first with straight upward boughs (Cupressus sempervirens var.pyramidalis) and the second with horizontal side boughs (Cupressus sempervirens var.horizontalis). Both species provided hard and middle heavy wood (0.60gr/cm^3) (Tsoumis,G.T. (1972, p.55)).

The differences between these two species of cypress are rather on their form than on their strength or other properties. From the first kind only the bole could be practically used for boatbuilding and the second kind provides some bent timber from its main boughs. In Grispos,P. (1963, p.111-2) there is an explanation given about how the old boatbuilders from Sfakia in Crete cut cypress trees for boatbuilding: "they used to cut the straight bole of a cypress about 1-2m above the roots. This is used for a straight component of the boat. From the remaining bole, above the roots, two or more new boughs are going to grow. These new boughs will form the desirable curved shape for ribs of boats. After some years the new boughs will be ready (5-10) to cut".

The species C.sempervirens var.horizontalis is growing on Samos (Anastasiou,A. (1987, p.139)).

Cypress was often used for boatbuilding in the Ionian Islands (Corfu, Lefkas, Ithaki) and on the West coast of the Peloponnese (Patre, Kalamata) ([2]-Kornidaris, [8]-Chalaris, [10]-Binos, [11]-Polias).

6.2 Properties of boatbuilding timber

6.2.1 Grain

Most of the boatbuilders mention the form of the grain as the most important feature which effects the strength of timber (table.no.38).

Grain is the line of the fibers of the wood which appear on the surface of a longitudinal cut timber. The form of the grain of a timber depends on the form of the fibers of the tree. Most of the cells of a tree are located along the directions of its fibers. According to Simopoulos,K. (1985) more than 90% of the pine's cells are located parallel to the direction of the bole. These long cells determine the cylindrical form of the cellular structure of the trees (annual rings). This cellular structure gives strength along the

Table.no.38

Boatbuilders interviewed	main properties on boatbuilding wood
[1]-Mavrikos	the natural curves high content of resin the form of grain on the timbers minimum of other defects
[2]-Kornidaris	________________
[3]-Stilianou	the natural curves green when coming into yard without knots or other defects
[4]-Korakis	the natural curves
[5]-Dardanos	the natural curves without defects
[6]-Arvanitis	strength high content of resin trees to be felled in January
[7]-Chimonas	________________
[8]-Chalaris	trees to be felled in January seasoned for a year before coming into boatyard
[9]-Chilas	the natural curves without knots and other defects trees to be felled and cut in a way providing suitable shapes for boatbuilding the seasoning in the forest
[10]-Binos	the natural curves the long boles for the planking without knots and other defects
[11]-Polias	the natural curves the timbers for the planking must be seasoned for more than a year
[12]-Kozonis	the natural curves the high content of resin without defects
[13]-Kontatos	the natural curves the high content of resin without defects
[14]-Chatzinikolaou	the high content of resin green timber for the skeleton seasoned for the planking
[15]-Vrochidis	________________
[16]-Kritikopoulos	the natural curves the high content of resin without defects
[17]-Papastephanou	the natural curves the high content of resin the form of the grain on the timbers without defects
[18]-Kastrinos	________________
[19]-Bilias	________________
[20]-Giamougianis	the natural curves the high content of resin without defects

fibers or along the grain. "The strength of wood differs greatly in the two principal directions, along and across the grain. Strength parallel to grain is 10 or more times greater than that perpendicular to grain." (US.Dep. of the Navy (1957, p.15)).

According to Simopoulos,K. (1985, p.34) the strength on compression is higher on the direction parallel to the grain, and it is 4-5 times lower perpendicular to it. All the timber on boats have the grain parallel to their long direction or to the direction where the highest strength is required. This is an axiom among all boatbuilders. The naturally curved trees which provide curved timber with grain following this curve are valuable in boatbuilding. From these timber the strong curved components of the skeleton of a boat were formed (stem posts, knees, waterways, etc.). Further more it seems that the natural curve of a timber determined sometimes the final shape of a component of the boat ([6]-Kritikopoulos). This is the reason for the different shapes of stem-posts between two boats of the same type made in the same boatyard. During the same period we have some examples where boatbilders take advantage of natural phenomena in order to obtain naturally curved trees (Grispos,P. (1963, p.111-2)).

[10]-Binos mentions that the boatbuilders from Limnos used to go and cut trees which had grown on steep slopes of the hill of the island. The curved boles of these trees were used to form stem posts, knees and ribs.

According to Anastasiou,A. (1987, p.139) the majority of the pine trees on Samos are growing on the slopes of the hill (angle to the horizon 25%-80%).

[11]-Polias mentions that in the past the boatbuilders on Symi used to go and cut trees in the forest of the island by themselves. [12]-Kozonis, [13]-Kontatos and [20]-Giamougianis had access to the forests on Samos and Lesvos in order to obtain boatbuilding timber by

themselves.

However, as we mentioned in the chapter on 4. TOOLS (4.2.6 Axe) there were boatyards without suitable forests close to them. In this case specialized woodcutters were providing the boatyards with boatbuilding's timber. These woodcutters were able to cut the trees at the right parts of the boles in order to provide the desired shape of timber used in boatbuilding ([9]-Chilas, [12]-Kozonis, [17]-Papastephanou).

Grispou,P. (1963, p.20-5) describes how the woodcutters used to determine five or six years earlier the formation of the trees' boles which were to be cut. Mechanic tension in respect to the direction of the wind was used for this reason.

In Weshington Patrignani (n.d. p.57) an old Italian sketch is included where the different parts of trees are related to different components of the skeleton of a boat (no date of the sketch is given in the reference).

In Gourgouris,E.N. (1983, pp.460-6) we find some contracts between woodcutters and boatbuilders or owners of boats. These date from 1841 until 1903. These contracts mention in great detail all the skeleton components with which the woodcutters had to provide the boatyard. So the woodcutters had to know very well the right shape of each one of these components.

After all this evidence there is no doubt that the availability of naturally curved timber was very important. However, these natural curves of the boles were nothing more than naturally curved grain of the respective timber.

In addition to the direction of the grain some boatbuilders ([1]-Mavrikos, [17]-Papastephanou) mention as a further advantage of a timber the even formation of the lines of the grain. This is nothing more than a regular and even formation of the annual rings of the tree. Each annual ring is formed from the springwood and later in the season from the summerwood. Springwood is often denser than summerwood (US.Dep. of the Navy (1957, p.15)).

Between two annual rings most of the volume of wood is springwood (Simopoulos,K. (1985, p.34)). On this structure, if the distance between two annual rings is wider than the average distance between the other annual rings, the wood between them is denser than the rest wood of the tree. This destroys the homogeneous strength of the timber and makes it unsuitable to be used as a strong component of the boat.

6.2.2 Decay resistance

Wood should recieve some treatment in order to avoid early decay effects. The main problem of all the external wooden structures is the decline of their strength because of decay effects. Decay processes starts sooner if the wood is within a high-moisture environment. "All forms of decay and many kinds of stain as well, are caused by primitive plants called fungi that grow in the wood. Fungi are made up of fine threads (hyphae) invisible to the naked eye, unless they are massed together." (US.Dep. of the Navy (1957, p.33)).

The fungi need high moisture in their environment to grow. "Where it is practicable, the most economical way to protect wood from decay is to keep it dry. Wood may contain enough moisture internally to decay even if the surface looks and feels dry; but for rapid decay, its moisture content must be more than 30 percent of the weight of the oven-dry wood. Decay never takes place if the moisture content of wood remains below 20 per cent...

On the other hand, too much moisture is unfavourably for most fungi; They depend on the presence both of air and water, and the common decay fungi are unable to work in wood that is completely waterlogged or submerged in water. In boats constantly in the water, the keel and other members below the usual bilgewater level would be expected to be too wet for decay and in actual experience are rarely damaged by fungi. Most decay fungi can make progress at temperatures between 40 and 100F with fastest decay in the neighbourhood of 75 to 85F. [(these are the common temperatures in Greece during spring, summer and autumn)]. It is the universal experience that there is more rapid decay in fresh than in salt water" (US.Dep. of the Navy (1957, p.45)).

The Greek boatbuilders think that three main elements are the most important requirements for decay resistance.

6.2.2.a Seasoning of the lumber

[8]-Chalaris, [9]-Chilas, [11]-Polias and [17]-Papastephanou suggest that the lumber for planking should be seasoned for over a year before being brought into the boatyard. Then this lumber would have additional seasoning for at least two months in the boatyard ([5]-Dardanos, [11]-Polias, [8]-Chalaris, [12]-Kozonis, [14]-Chatzinikolaou).

[3]-Stilianou, [11]-Polias and [14]-Chatzinikolaou mention that the timber for the skeleton of the boats should be green when they are brought in the boatyard. First they sawed them and later they left them for seasoning. These timber received additional seasoning after they set them onto the skeleton and before planking started.

6.2.2.b High content of resin

As we can see in table.no.38 most of the boatbuilders point out that boatbuilding wood had to contain as much resin as possible. So far there is no special study provided about the advantages of high content of resin of wood in shipbuilding. However, this critical point has been mentioned sporadically whithout any further comment or explanation (Adoniou,A. (1969, p.94) and Tsoumis,G.T. (1972, p.31)).

It is beyond the aims of this work to study the chemical effect of resin on the decay resistance of pine wood. However, we can mention few further remarks which will give some evidence about the species and the origin of the boatbuilding pine.

Greece used to be the fourth most resin-producing country in the world before the Second World War (after U.S.A., France and Spain). The best species for resin extraction were P.halepences and P.brutia (Chinopoulos,D. (1962, p.148)).

On 25% of the forest areas with these two species resin extraction was undertaken (all these figures come from the decades of '40 and '50) (Chinopoulos,D. (1962, p.150), Kossenaki,G. (1954, p.93), Andreopoulos,Ch. (1959)).

The islands of Lesvos, Chios (Papaioannou,I.K. (1954, P.104) and Rhodes (Papamichail,P.M. (1970[2], p.10) were offering a considerable part of the extracted resin. According to Papamichail,P.M. (1970[2], p.10) resin extraction was even more extensive on the island before the decade of '50. So if the content of resin in the wood was so critical in boatbuilding the boatbuilders had to find forests of pine (P.brutia or P.halepensis) where no resin extraction was undertaken.

It is very interesting to mention here that, despite such extensive work of resin extraction on the above mentioned islands, on Samos forty years before (1899) the local government established law no.933 which prohibited resin extraction from any pine tree on the island (Schitza,P. (1928, p.7)).

We do not know the reason for this prohibition but in the same source the felling of pines to be used in shipbuilding is mentioned several times (Schitza,P. (1928, p.3, 7)). Therefore it is likely that on Samos some protection was established in order to maintain the quality of the wood for construction and shipbuilding. We need further evidence to suggest the importance of any relationship between this situation on Samos and the preference of pine from this island by the boatbuilders. However, there is no doubt that the fact that no resin extraction of the pine took place on Samos, has influenced the reputation of this pine as the best of the area for boatbuilding ([12]-Kozonis, [13]-Kontatos).

Papamichail,P.M. (1970^2, p.10) suggests that during the Second World War fire destroyed lots of the P.brutia forests. The remaining P.brutia forests were mainly providing boatbuilding timber.

6.2.2.c Coating the timber with red lead

This measure applies after seasoning in order to reduce the influence of the humidity on the timber's moisture and gives additional decay resistance (7. CONSTRUCTION) ([1]-Mavrikos, [12]-Kozonis).

6.2.3 Shrinkage and swelling

On boats more than on any other wooden structure shrinkage and swelling of the timber was a very important element especially on the planking. This influenced the whole process of caulking and it was another reason for the necessity of seasoning the planks before setting them onto the skeleton.

"Lumber is not like any other material in regard to the cause of dimensional changes. Lumber changes dimensions with a gain or loss of moisture content. This moisture gain or loss depends mostly on the relative humidity of the air not on the temperature, which is responsible for the dimensional changes of most other structural materials. This is the reason why expansion joints are not needed for timber structures and part of the reason why timber structures will withstand extremes of heat without collapse. Various wood species shrink or swell at different moisture rates, but no wood species shrink or swell until the moisture content is below 30 percent (fiber saturation point). Below 30 percent, the lumber swells with an increase and shrinks with a degrease in moisture content." (US.Dep. of the Navy (1957, p.84)).

It is clear now that seasoning is not only necessary to provide decay resistance but it causes as well shrinkage of the timber. This causes the joints of the structure to reinforce and to fit firmly when the timber of the boat in the water swell because of the new moisture from the sea.

Tsoumis,G.T. (1983, pp.155-77) mentions the moisture, the specific gravity, the cellular structure, the chemical content of wood and the mechanical conditions, as factors which influence the shrinkage and swelling of the timber.

Another control of the effects from dimensional changes are the different ways to saw the lumbers from the tree. "The greatest dimensional change is in the direction parallel to the annual growth rings (tangential). About one-half to two-thirds of this amount occurs in the direction perpendicular to the annual growth rings (radial). No appreciable change occurs in the direction of the grain (longitudinal)..." (US.Dep. of the Navy (1957, p.84)).

The seams between planks of different strakes of the hull are seams between tangential directions of grain. Because of the "greatest" swell of the planks on this direction after seasoning the seams tend to close. Thanks to the advantage of this natural swelling of the planks caulking was sometimes not necessary ([1]-Mavrikos, [7]-Dardanos, [14]-Chatzinikolaou) (7.5.4 Planking, 7.6 Caulking).

The joints between planks and other members of the boat, like keel or waterway etc. are joints between tangential and radial direction of grain. In this case the swelling is not sufficient enough to close the seams and caulking became necessary. Finally the joints between planks of the same strakes (sokora) are joints between longitudinal directions of grain. In this case almost no swelling occurs and careful caulking (even double caulking) was indispensable. We can now understand that a proper seasoning of the planks was really important for boatbuilding. This could cause considerably less work in terms of caulking (7.5.4 Planking, 7.6 Caulking).

Additionally the boatbuilders did not like to have too many effects of shrinkage or swelling on the planks when the humidity of the environment was changing. This is one of the reasons why pine was favoured for planking instead of oak or elm which are favoured for the skeleton of the boat (see diagram of shrinkage in pine wood fig.115) (Tsoumis,G.T. (1983, fig.46)).

The best way to confine the moisture of the planks of a boat to a constant level is to water them often with sea water and keep it around the fiber saturation point.

6.2.4 Strength

The first requirement for boatbuilding wood is undoubtedly strength. In addition to the specific strength property of each species of wood there are elements of wood which are directly related to its strength.

"Since the specific gravity of a piece of wood is an excellent index of the amount of wood substance the piece contains, it is also an index of the strength properties...

Locality of growth, within the normal range of growth of a species, has relatively little effect upon quality of lumber. Far greater differences in weight, strength and other properties are found in trees growing side by side." (US.Dep. of the Navy (1957, p.45)).

From the table of the specific gravity of greek wood for boatbuilding (table.no.39) (Adoniou,A. (1969, p.93)) we can see that among pines from different areas the pines from the Island of Samos is heavier than any other pine and oak is heavier than any other species of wood mentioned on this table.

Adoniou,A. (1969, p.92) mentions that the test pieces of the species in the table.no.39 were taken from various boatyards, with the dimensions 20x2x2cm. The period of the seasoning varied from one to four years. In this table only the pieces with the same percentage of moisture can be accurately compared.

Seasoning also effects the strength of the timber. "Most of the strength properties of wood improve as it dries. The increase in strength varies with the property. Values for compression parallel to grain of small clear pieces increase about twice and those for stress in extreme fiber about two-thirds in drying from the green condition to 12 percent moisture content." (US.Dep. of Navy (1957, p.158)).

[6]-Arvanitis and [8]-Chalaris mention the relation between the strength of the timber and the period when the trees had been felled. The same kind of information comes from North European shipbuilding traditions : "...felling would take place during the winter when there was the least sap flowing in the tree..." (Frost, T. (1985, p.2)).

In contrast we have the following explanation on this point which disagrees with this belief: "an old belief still given wide currency is that winter-cut lumber is based on the erroneous assumption that in winter, "the sap is down" while in the summer, "the sap is up" in the living tree. Actually, tests have demonstrated conclusively that standing trees contain about as much sap in winter as in summer. The only sound objection to summer-cut lumber is that logs are more likely to deteriorate if left exposed to high summer temperatures that may accelerate checking and attack by insects and decay fungi. Reasonable precautions, particularly prompt sawing after felling and good piling and seasoning methods, remove the danger of such damage to summer-cut material." (US.Dep. of the Navy (1957, p.39)).

I can not agree definitely with the opinion that this belief is based on "erroneous assumption", but in the case of the Greek timber it is true that the cut trees are often left exposed to the forest weather conditions for more than six months (Simopoulos,K. (1985, p.16).

In this case and especially during the older times, winter-cutting was really important in order to avoid deterioration of the cut wood.

Hausen,J. (1982, pp.271-3) suggests that the mechanical properties of the wood are different corresponding to the direction of grain, the type of wood, the way that the timber were cut or sawn and how beams and planks are assembled within the ship's structure. Often the lack of experimental tests on some species make any strength calculation of beams made of these species extremely difficult. The same source states the influence of the mechanical properties of wood by additional factors like the age of the tree, the environmental conditions (climate, nature of ground), moisture content and the number of limbs or branches.

In my opinion the relation between strength and the grain of the timber is the most important one. This relation is already mentioned in the section on grain. In respect to this relation we can understand the emphasis given by the boatbuilders on the way that timber used to be cut or split by hand tools along the direction of the grain. The combination of the frame saw and the wooden wedge was recommended for this task in order to provide strong pieces of timber ([10]-Binos, [11]-Polias, [19]-Kritikopoulos) (4.2 Splitting - Cleaving - Cutting).

We are going to study further the strength of the wooden components of boats at the end of the chapter on 7. CONSTRUCTION.

Table.no.39
"Properties of Greek boatbuilding wood" (Type of wood, origin, respective moisture, specific gravity)
From Adoniou,A. (1969, p.93)

'Αριθ. Δοκιμίου	Εἶδος Ξυλείας	Προέλευσις	'Υγρασία (Σχετική)	Εἰδικόν βάρος
1	Πεύκη	Εὔβοια	13.0%	0.645
2	"	"	13.0%	0.675
3	"	Σκίαθος	12.5%	0.663
4	"	Σάμος	10,0%	0.700
5	"	Σάμος	15 %	0.745
6	"	"	16 %	0.835
7	"	"	14 %	0.730
8	"	"	16.5%	0.89
9	"	"	13.5%	0.765
10	"	"	13.5%	0.760
11	"	'Αττική	12.75%	0.600
12	"	Μυτιλήνη	9.75%	0.582
13	"	Θάσος	11.5%	0.683
14	Μωρέα	Τρίπολις	10.25%	0.670
15	"	"	9.80%	0.620
16	Δρῦς	Ἤπειρος	17.0%	0.940
17	"	"	16.0%	0.645
18	"	"	16.0%	0.680
19	"	Δράμα	10.5%	0.890
20	Πτελέα (Καραγάτσι)	Ἄρτα	11.5%	0.610
21	Δρῦς	Δράμα	13.0%	0.736
22	Κυπάρησσος	Ξάνθη	12.0%	0.560
23	Εὐκάλυπτος	Τρίπολις	11.0%	0.610
24	Μελία (Δεσποτάκι)	Φλώρινα	10.75%	0.790
25	"	Ξάνθη	12.0%	0.775
26	Καστανέα	Ἅγ. Ὄρος	10.0%	0.755
27	Φηγός (ὀξυά)	Δράμα	11.0%	0.660

7. CONSTRUCTION

7.1 Preparation

When the wood was sufficiently seasoned, they brought it into the boatyard. The boles still possessed their outer bark protecting them from damage (Poulianos,A.I. (1977, p.525)). First, they selected the straight boles for the keel and the keelson and the curved one for the posts and the ribs.

Two or three trees might have been used in order to make up the length of the keel and the keelson respectively.

The number of these trees for the keel and the keelson was a matter of the length of the boat and the length of the available straight trees. The grain of these trees had to run along the length of the keel (6.2.1 Grain). They calculated, first, by a plumb line, the thickness of the keel or the keelson at the two ends of the boles. Then they linked these marks with the aid of a marking line (4.3.10 Marking line).

When the marking of the boles was completed, they sawed them with the frame saw. [11]-Polias mentions that the maximum two apprentices could manage to saw timbers was a length of one hundred meters per day. Sawing by frame saw and splitting the timbers by means of wedges did not damage the fibers of the grain as much as the electric saw does today ([11]-Polias, [16]-Kritikopoulos) (4.2.7 Wooden wedge). [10]-Binos mentions that sawing planks by this means finally produced planks with different widths (5-10cm). Later, in order to form the surface of the hull as smoothly as possible, they had a lot of dubbing to do with an adze or a small adze or the "surface" planes (4. TOOLS).

Then, the keel and the keelson were laid aside in the shipyard for up to fifteen days for additional seasoning ([11]-Polias). The length of this additional seasoning period depended on the weather conditions and on the previous seasoning of the trees. The timbers were not directly exposed to the strong sun during the hot summer period ([1]-Mavrikos, [17]-Papastephanou). The curved trees underwent the same process. The curved sides of the posts, the knees and the ribs, were determined by patterns which were produced either by the lofting or moulding. The main feature of curved trees is the natural curve which provides the desired curved grain. Often, the shape of the available curved trees decided the final shape of the stern or the stem post of the boat (6.2.1 Grain). The timber for the planking of the hull were left in the yard for about two months. All of the boatbuilders mentioned that these planks had to be seasoned for a longer period of time than the skeleton timber. The total amount of timber depended on the size and the type of the boat and, also, on the desired weight of the structure. Usually boats with an counter stern needed more timber than the double-ended boats ([1]-Mavrikos, [3]-Stilianou, [6]-Arvanitis). According to [6]-Arvanitis, a boat with a counter stern which had a carrying capacity of 60-70 tonnes and a keel of 40-60 feet required about 70-75m^3 of wood, whereas a Trechadiri (double ended boat) with the same capacity required about 5-6m^3 less wood. According to the same boatbuilder, by increasing the volume of wood on a boat he could increase the capacity of this boat. He gave the following example of this point: "some years ago I built a Perama which was supposed to have planking 5.5cm thick and a 250m^3 capacity. Because I left the planking as thick as 6-7cm the final capacity of the Perama was 275m^3". [1]-Polias suggests that the volume of timber used on frames when the boats were sailing was greater than today. This was brought about by building the whole length of the frames with double timber and reducing the distance between the frames by 1-2 cm. [1]-Mavrikos suggests that for a Trechadiri 10m long an amount of 15m^3 wood was required. [9]-Chilas, however, gives the estimation that for a Trechadiri about 10m long

(L.O.A.) an amount of $6m^3$ was required for the skeleton of the boat and about $8m^3$ for the planking. [3]-Stilianou, on the other hand, gives the general rule that for each ton weight of boat a volume of one cubic meter of wood had to be ordered.

According to Adoniou,A. (1969, pp.88-90), the amount of wood required differed in respect of the function, the tradition of the boatyard and the choice of the owner, rather than in respect of the type of hull. He suggests that the amount of wood which was ordered for a boat was 25%-35% more than the final weight of the structure (sometimes even 50% more). These figures also varied in respect to the curves of the hull and the waste of wood to form them.

7.2 Keel, stem and stern post

7.2.1 Double ended vessels

7.2.1.a The keel (Καρένα)

When the preparation and seasoning of the timber for the keel was completed, the boatbuilder checked the dimensions in order to correct any shrinkage or swelling. For this purpose, he left a few centimetres at the first sawing. The scarphs (Παρέλα or Ματησιά) of the keel were then cut (fig.116).

They used a small cross saw to cut the scarphs. Even today they use this saw in some boatyards for that specific task. [16]-Kritikopoulos suggests that they could not easily cut the scarph joint using the saw-mill. This work was performed when the keel board was still green. The explanation was that forming a scarph joint on a dry board sometimes caused splits which could be avoided if the scarphs had been formed when the timber was still green ([1]-Mavrikos, [11]-Polias). [1]-Mavrikos, [7]-Chimonas and [17]-Papastephanou mention that they had sometimes driven small wedges of hard wood into the joints in order to stiffen the joint.

When the keel boards had been seasoned for a few days they were joined to form the keel. Most keels less than 8m long consisted of a single keel board. Keels within 8-16m length usually comprised two keel boards ([5]-Dardanos). The scarph joint between these two boards was always placed on the aft-part of the keel. Gourgouris,E.N. (1983, p.471) suggests that the keel on the biggest vessels consisted of no more than three pieces. When the keel consisted of two or three pieces particular care was taken to avoid the location of a scarph-joint at the middle of the keel (this was because hogging of the boat caused more tension on the middle of the keel than on the two ends) ([4]-Korakis). Poulianos,A.I. (1977, p.534) suggests that the bolts through the scarph of the keel should always have their heads extended on the upper side. According to [8]-Chalaris a Trechadiri 8 to 10m long had the keel about 7x20cm in cross section. [5]-Dardanos,by contrast, suggests that a Trechadiri about 10m L.keel had 8cm or 8.5cmx19cm cross section. According to Poulianos,A.I. (1977, p.534) the width of the keel for "caiques" was more than 10cm. Adoniou,A. (1969, p.61) mentions that the ratio of the cross section dimensions of the keel were from 1 to 1.5. "Evaggelistria" had a keel cross section 18x32cm.

When the keel was assembled, they often trimmed it by forming a very smooth upward bend on either end in order to protect it from later hogging ([11]-Polias) (fig.18a). In the past, it was common to place, under the keel, the counter keel board (Κοντρα-καρένα). That was a timber made of oak (or any other hard wood available), having the same width as the keel, which ran along the whole length of the keel. Its depth came to 3-5cm ([1]-Mavrikos). It saved wear on the keel.

Tzamtzis,A. (1987) published the contract for building a vessel in 1832 where it is stated that the keel for the vessel (length about 21.944m, possibly L.O.A.) should comprise two pieces, and that the thicker one should be square in cross section with a side of about 22cm. [11]-Polias and [1]-Mavrikos suggest that the keel consisted of two layers (fig.116). The upper piece (Πανινό) (about 5-6cm high) had the frame-stations and the upper side of the rabbet and the lower piece had the lower part of the rabbet and the main body of the keel. This arrangement was specially made to provide an easy replacement of a new lower keel piece in the case of damages (fig. 116.) Kanelopoulos,H.P. (1983, pp.37-8) informs us that the keel of the biggest ships was made up of the following three pieces: the upper keel (ακράπι της καρένας), the main keel (καρένα) and the counter keel (κόντρα καρένα).

The stations of the frames were marked on the keel and were then cut out. The length of the fractions between two stations depended on the length of the boat. Giannoulellis,G.N. (1985, p.3) calls the cut of a station on the keel "χαραξιά". [17]-Papastephanou says that before they marked and cut the stations of the keel they had first to test the positions of the frames and to work out the final distances between two successive stations (7.3 Framing up). On the bottom line of the frame-stations the rabbets were formed on each side of the keel (by the rabbet planes). The distances between the station of the frames were generally equal along the whole length of the keel. However, Tzamtzis,A. (1987) gives evidence that the distances between two successive frames of a boat built on Syros (1832) were shorter in the bow and the stern than in the middle part.

7.2.1.b The stern post.(Πρυμιό ποδόσταμο)

The first post fitted on the keel of a Trechadiri was the stern post. This was accomplished before the keel was laid on the keel-blocks. The post was driven in the scarph of the keel from one side of the keel. This joint provided extra strength on this part of the post against both forward and backward pressure. On the internal face of the post, and at the joint with the keel, a knee was placed to reinforce the scarph joint (Μπρατσόλι or Σκορπιός or Αγκών). This knee was bolted on the post and on the keel. In the case of double ended boats longer than 15m a piece of deadwood was often placed between the keel and the knee of the stern. Another timber was later placed on the external edge of the stern (Αρκάς). This provided enough space for the toe iron of the rudder to be nailed on the post and, also, displaced the rudder further aft, thus leaving space for the propeller. There are examples where the same idea of internal and external boards as on the keel has been used in order to make repair work easier ([11]-Polias). Finally, a rabbet was formed on the stem and met the rabbet of the keel (fig.116).

The keel and the stern post were placed on the keel-blocks which were located on the area where the boat was to be built. The keel-blocks were usually pieces of old keels or other old timbers. They were placed in a line with distances of about two metres from one to another. A line was used in order to set all the keel-blocks at the same height. This was 50-60cm in order to provide enough space to work on the lower part of the boat and to facilitate the launching process.

7.2.1.c The stem post. (Πλοριό ποδόσταμα or Στειρα)

The stem post consisted of only one piece on boats less than 6m long ([5]-Dardanos, [8]-Chalaris). On bigger vessels it comprised at least two pieces with a scarph joint between them. The lower-one occupied the fore end of the keel and also the lower part of the post (ποδόσταμα) (fig.116). The upper piece was fastened on the lower by a simple plain scarph which was placed 50-60cm above the upper side of the keel (κοράκι).

The different types of joints used along the stem post - keel - stern post were generally related, firstly, to the different tensions along these components and, secondly, to the different angles with which these components met. But there are records of two different arrangements of the scarph joint between the upper and the lower stem post timber (fig.116).

Poulianos,A.I. (1977, p.536) suggests that, if the stem post was made up of three pieces, then the middle one was called τσούντα. Gourgouris,E.N. (1983, p.470) gives the information that the upper piece of the stem post was called ταλιαμά.Giannoulellis,G.N. (1985, p.12) gives the name of "γκάγκα" to this upper piece of the stem post.

Often, a small timber was fitted on the top of the upper piece of the post in order to carry the decoration of the head of the post ([8]-Chalaris calls that "Κοράκι"). The distinctive curve on the head of the Trechadiri's post was formed on this timber which was connected to the rest of the stem by a simple plain scarf. But [17]-Papastephanou suggests that, on big Trechadiria boats (carrying two masts), this decoration of the head of the post was omitted in order to provide good support to the bow sprit (fig.12).

Some shipwrights working with the moulding method used predetermined moulds to find the shape of the whole stem post ([8]-Chalaris, [10]-Binos). The boatbuilders who worked out the lines of the boats on the lofting floors used lofted patterns both for the stem and the stern post.

When they assembled the keel and the posts, they first placed this preliminary structure in its the final position before setting the reinforcing knees. It was placed on the blocks ("παλος") and supported on the sides by the poles ("ποντέλι" and "αντιλῆχτρες") (4.4 Holding - Grasping) ([11]-Polias, Poulianos,A.I. (1977, p.541)). At that stage the main task was to test the vertical position of all components by a plumb and a plain line. Then they readjusted the poles to determine the vertical position of the structure ([11]-Polias, Poulianos,A.I. (1977, p.541)).

Above the joint of the stem with the keel a reinforcing knee was placed next (Ακράπι). Long bolts were used to fasten all three pieces together (fig.116). Finally, the rabbet (Αοός) was formed on both sides of the post. This rabbet was broken off for 4 or 6cm at the level of the waterway and then was continued as far as the level of the end of the gunwale (fig.116).

7.2.2 Boats with a transom stern

On boats of this kind, the keel and the stem had the same structural arrangement as the double-ended boats. The only example of a different form of keel for this type of boat is given in [4]-Korakis' interview; a schematic sketch has been included in the index of the interviews (fig.141d). The main difference of this type was in the stern post, which was formed to accommodate the transom component. They are two different forms of stern boards, as mentioned in the chapter on 2. CLASSIFICATION (2.3.1 Varkalas).

7.2.2.a Old form of transom

In this form, the transom was placed on the external edge of the stern post. This post was almost identical with that of double ended boats. The only difference was the form of the transom station on the aft edge of the post (fig.161). Another timber was placed on the external surface of the transom in order to support the rudder of the boat. This timber was bolted through the transom to the stern post.

On most of the older examples of boats with this kind of stern the transom board was placed at a considerable height on the stern-post. On the Skaphi, from Symi, the transom was placed above the half-height of the stern post (fig.25). On the fishing boat from Hydra the transom was also placed above the half-height of the stern and it extended higher than the stem post (fig.16, 108). On the boat from Chania, the transom component was placed only on the height of the three upper strakes of the hull (fig.27). On the boats which were identified as Booarda in the typology of hulls a similar location of the transom feature can be recognized (fig.24a,b). In all these examples the transom arrangement was apparently designed to provide extra space on the after part of the deck rather than more room in the inside after part of the boat.

7.2.2.b New form of transom

In the second form, the stern post consisted of two timbers. The lower one had the form of an upside-down knee which formed the space of the propeller and, also, the station for the transom on the end of its upper edge. On top of the low timber, the upper one was placed to support the transom on its after edge. The two pieces were bolted together (fig.117). In this kind of arrangement the transom board was usually deeper than on the previous one. Bigger boats with this stern structure often had another version of this arrangement: the two pieces of the stern post were not directly connected. Instead, a pair of beams were placed on the sides of the two post timbers and bolted to them. In this version a hole was left between the beams and the upper and low post timber. This provided a vertical passage for an internal rudder (fig.117).

On both, old and new forms of stern, the transom consisted of horizontal planks. All the planks were nailed on a frame which supported the whole transom component. Internal knees reinforced both stern post/ keel and stern post/transom joints.

7.2.3 Boats with round stern (Liberty)

The shape of the stern post of liberty boats was the same as that of the new form of stern with transom. The only difference was the shape of the upper timber of the post which, instead of the straight form and the station for the transom, was curved with the rabbet on the two sides. On the example from Spetses Island, the stern post of a small Liberty consisted of a single timber (fig.118) ([4]-Korakis).

This simple arrangement of a single stern post, reinforced with an internal knee, seems to have been the standard form which was used on all kinds of small boats. This post was drilled at two points in order to form the hole for the stern tube and the hole for an internal rudder. On bigger Liberties (more than 10m long) the lower piece of the stern post had the simple form of a straight post scarph joined on the keel. Two pieces of deadwood reinforced the stern to keel joint. The upper edge of the upper deadwood has a rake of 15-20 degrees. The rest of the structure had the same arrangement as the second version of the second kind of stern with transom.

Another, more complicated, form appears in the photograph of fig.119. On this form the lower post consists of two pieces lengthwise. The deadwood and a knee reinforce this lower part. The upper part consists of three parallel boards. The central is scarph-joined on one board of the lower part of the post and the other two side-board were bolted on the central-board, on one piece of the lower post and on the knee. The after edges of these side-boards form the rabbet on the central-board.

7.2.4 <u>Boats with counter stern (Karavoskaro)</u>

The stern of a karavoskaro consisted of a low stern post and a deadwood (fig.120). The stern post supported the whole structure of the stern skeleton of the boat which was built separately from the skeleton of the boat and was fitted afterwards on the stern post (7.3.1. Framing up the stern of a Karavoskaro). The hole between the upper and the lower stern boards, which we described for the new form of transom appeared, on this kind of boat too. The only difference was that the upper stern-board on this type of boat was an integral part of the structure of the stern skeleton rather than part of the stern post (fig.120).

According to [3]-Stilianou and [1]-Mavrikos, on the Karavoskaro boat, the joint between the lower stern-board and the keel was often formed by the mortice and tenon joint. The same mortice and tenon joint was used some times in the stern post structure of other types of hulls (fig. 122d).

7.3 Framing up

The frames were worked out either by the moulding with adjustable templates or by the lofting floor method.

For the "master frame and ribband" method we had no information from the interviews. Therefore we are at present not able to add anything to what has already been said in the chapter on 5. designing and the bibliography belonging to it (Poulianos,A. (1977, p.545), Lee,N.J. (1978), Basch,L. (1972, pp.36-7)).

According to both these former methods a certain number of frames were preassembled. Each timber of a frame had been coated with primer (water solution of red lead) and after assembly the frames were left in the boatyard for about two or three weeks to season. These were either all frames which were determined by the moulding method or a number of middle frames determined by the lofting floor ([4]-Korakis, [5]-Dardanos, [8]-Chalaris, [10]-Binos, [14]-Chatzinikolaou, [17]-Papastephanou). [1]-Mavrikos suggested that these frames were the six or eight middle frames which had the same shape as the midship pair of frames (5.3 Lofting methods).

But there are some examples where the frames were not totally coated with primer before they were set on the structure (fig.120).

The simplest frames comprised three pieces for boats less than 8m long. However, in this case the pieces of the frames had to have sufficient natural curvature while their cross sections were about 7-9x4.5cm on the floor timber and about 5-6x4.5cm on the top timber. The floor timber was called <u>έδρα</u> and the top timber was named <u>σκαρμός</u> or <u>σταμίν</u> ([8]-Chalaris, Damianidis,K. & Zivas,A. (1986, p.47)).

Boats from 8 to 15m L.O.A. had either 5 or 7 timbers in each frame. We have examples of longer boats in which the frames consisted of 9 timbers ([1]-Mavrikos, [4]-Korakis, [16]-Kritikopoulos) (fig.122a).

The general idea of assembling a frame was to keep both the symmetry of the shape and the symmetrical balance of the weight. All the joints between the pieces of each frame were overlapping and nailed or bolted in the following way:

All the frames on the fore part of the boat (from the midship pair of frames to the stem) had the first futtock piece overlapping the floor timber on the fore side of it. The frames on the aft part of the boat had the first futtock piece overlapping the floor timber on the aft side of it (fig.121).

In respect to this order of assembling the frames they nailed or bolted the single pieces of the frame from the directions which appear in fig.142c ([11]-Polias).

Marks provided by the moulds or by the patterns from the lofted frame-lines were used on the pieces of the frames to indicate the right position during assembly (στήβα) ([1]-Mavrikos, [5]-Dardanos, [14]-Chatzinikolaou, [17]-Papastephanou).

Poulianos,A. (1977, p.542-3) states that each frame was made up of five pieces ("εδρα", two "στραβόξυλο" and two "ριπίδι") and that all four joints between floor timber/futtock and futtock/top timber were covered with four other small pieces, the "καπάκια" (covers). It is worthwhile noting that Poulianos,A. (1977) minimized the purpose of the four pieces by identifying them as covers. In fact the model of frame he presented was more similar to the frame with nine pieces rather than to a five one, such as mentioned above.

The way of assembling the frames on the fore and the aft part of the boat and the way of nailing the different pieces which form the frames was related to the main tensions which occurred on these parts of the boat. The buoyancy on the middle part of the boat determined the fore and aft direction of these main tensions on the fore and aft part of the boat respectively.

[5]-Dardanos suggests that on a Trechadiri 10m L.Keel the futtock cross section was 14x19cm (this consisted of two pieces with cross section 7x19cm). The floor timbers in the same boat were deeper than

the futtocks.

Tzamtzis,A. (1987) gives the information that on Syros in 1832 the frames on a vessel of about 21.944m (possibly L.O.A.) had futtock sections comprising two pieces each of which being 11.4cm wide.

"Evaggelistria"'s frames (fig.122a) consisted of nine pieces. All the frame cross sections were made up of two pieces and each one of them was 12x12cm. Only the top timber was a single piece 12x12cm.

When the longitudinal part - keel/posts/knees - had been completed the middle couple of frames was placed on the keel. These frames had false beams in order to secure their symmetrical form. The frames were placed on the middle pair of stations on the keel and often they were formed with a rectangular check cut out of the floor timber which was going to meet the check on the keel. This check was about 2-3cm deep.

The right position of the frame was confirmed with the aid of a plumb-line. This line was dropped from the middle point of the false beam. If the frame was in the right symmetrical position on the axis of the boat, the plumb-line should have pointed to the middle of the floor timber and the middle of the keel. The same plumb-line was used to check the vertical position of the frame by dropping it from some other points of the false beam. When the middle frames were placed in the right position they fastened them firmly by means of side poles (ποντέλια or μπουτέλια) but they did not bolt them yet.

To set up the rest of the frames two different processes were in use. If the frames were formed by using the moulding method the next step was setting up the whole group of moulded frames (5.2.2 Moulding with adjustable templates). This group of frames covered the middle part of the whole length of the boat which varied in length from 1/4 L.O.A. to 1/2 L.O.A. depending on the moulding method ([5]-Dardanos, [8]-Chalaris, [10]-Binos, [14]-Chatzinikolaou, [17]-Papastephanou).

Fitting each frame they always checked the symmetry and the vertical position of it with the same method as on the middle frames. When the whole group of moulded frames was set upon the keel, ribbands were placed on both sides of them (these ribbands only extended across the middle part of the boat - they do not stretch as far as the stem and sternposts). At this stage of the construction a new check on the symmetry took place. Now the symmetry and the smoothness of the ribbands as false-planks were at test.

On boats less than 15m length (L.Keel) normally 3 ribbands were fixed on one side. The upper one was on the level of the deck line, the middle one was on the level of the turn of the bilge and the lower one below the upper end of the floor timber ([8]-Chalaris, [10]-Binos, [17]-Papastephanou).

When the whole group of moulded frames was finally positioned with the three ribbands nailed on each side of them, the boatbuilder started to set up the fore and aft ribbands which connected the middle section of the boat to the stem and stern posts. These were three pairs of flexible laths (Φουρμες) which could be positioned to form three sheer sections of the desired shape of the hull. Lots of experience was required to determine the position of these ribbands. The only possible check for the right placing of them was their symmetry about the axis of the boat and their fair shape. However, [17]-Papastephanou says that in order to check the right position of these ribbands he used to test the shape of some of the frames which were determined from these ribbands. Furthermore he mentions that there was a certain frame, usually above the scarph of the keel and post, which should have an almost straight profile. The form of this frame was used as a key for the form of the ribbands ([17]-Papastephanou). These straight profiled frames were probably what [11]-Polias calls "πρωτοβαθικό" (5.2.1 "Master frame and ribbands").

Only when these fore and aft ribbands were in a satisfactory position could the boatbuilder find the shape of each of the remaining frames of the boat. The boatbuilder placed a flexible, non-elastic wire (which holds its shape when bent) on the inside face of these ribbands. To find the shape of each of the remaining frames he set the wire on a station of a frame and formed it in a way to be a tangent to the inside faces of the ribbands. In fact there were only three points on the form of each of these frames (these were the points where the ribbands cross the frames) which could be checked with the whole shape of the hull at this stage. The rest of the shape of the ribs depended simply and solely on the boatbuilders' experience ([8]-Chalaris, [10]-Binos, [17]-Papastephanou).

When he found the shape of the frame with the wire, he copied it on a timber and in this way he produced the forms of the frames fore and aft of the group of moulded frames.

According to [10]-Binos this process of framing up with ribbands and wire occurred only on one side of the boat and symmetrical copies were made for the other side of the boat. In this way three ribbands were attached to one side of the boat but only two of them to the other side (fig. 123).

[17]-Papastephanou describes a very interesting task which was undertaken before any framing up started on the keel. During the moulding with adjustable templates he tested the position of the frames and also the free space between two successive frames in the following way. He set the midship pair of frames and then he set only the last fore and aft moulded frames on the keel. Then he used ribbands to test whether these four frames were on the proper location on the keel. If he was not satisfied with the form of the ribbands he corrected it in two ways. One was to add another two frames identical and next to the midship pair. The other was to readjust the positions of the last fore and aft moulded frames by moving them slightly ahead or astern. Having applied these

corrections he measured the distance between the last fore and the last aft moulded frame and by dividing it with the number of moulded frames he determined the final distance between two successive frames on the middle part of the boat.

We are going to study the use of the ribbands further at the end of this chapter in the 7.7 Comments on construction.

The final fore and aft frames which were set on the posts or the knees had a special name of βαθικό. They represented a simple structure of two or three timbers and their shape often stemmed from a special mould for this purpose ([8]-Chalaris).

According to [5]-Dardanos the distance between two successive frames remained the same throughout the whole length of the boat. He even suggests that these free distances between the frames were unrelated to the length of the boat. For this reason he presents the dimensions of frame, deck-beam and free distance on a cross section from two boats, one 10m and the other 7m long (fig.142a). In his opinion the size of the boat definitely influenced the width of the frames but not the free space between them.

However, Adoniou,A. (1969, p.66) mentions that the distance between two successive frames varies according to the size of the boat. He adds that the rule applied by boatbuilders was that the distance between two successive frames should be equal to the width of the frames of this vessel.

"Evaggelistria" had 42 frames and her L.O.A. was equal to 18.90m (fig.122d) (she doesn't obey Adoniou's prescription).

Tzamtzis,A. (1987) mentions the number of 50 frames for a vessel from 1832 with (possibly L.O.A.) equal to 21.944cm. There is suggestive evidence from the same source that the free distance between frames on the bow and the stern was shorter than in the middle of the boat.

However, it is interesting to note that the ratio of the number of frames to the L.O.A. was on the vessel from 1832 equal to 43.88cm (according to the figures in Tzamtzis,A. (1987) and on "Evaggelistria" (1939) was equal to 45cm. If we subtract from these figures the thickness of the frames (22.8cm on the vessel from 1832 and 24cm on "Evaggelistria") we realize that the free distance between two frames were equal to 21cm on both vessels. This result supports [5]-Dardanos's statement about the free space between two frames (see above).

[7]-Chimonas mentions that a different method of checking the symmetry of these frames took place, when the frames were set up as two individual pieces (we call these ribs). In this case a plumb-line was dropped from an upper point of the rib and the distance between the plumb-line and the keel below the rib was measured. Repeating the same process on the rib of the other side the boatbuilder should have come up with the same distance between plumb-line and keel.

Zouroudis,G. (1974, p.164) suggests that on the biggest vessels they first set on the stations of the keel the floor timber which was connected only on its one side with the futtock and the top timber. After that they set on the other side of the boat the other futtock together with the top timber.

The early description of Nikodimos,K. (1862, p.91) indicates some other aspect of the framing up process. He mentions that first the floor timbers of the middle part were determined by moulding with adjustable templates before using ribbands to determine the floor timbers on the bow and the stern. Later additional ribbands were placed on the level of the futtocks in order to determine the shape of the futtocks of the frames. Finally to determine the shapes of the top timbers they had to introduce other ribbands further than the previous ones. We can see that in this technique the frames were not assembled before their erection on the keel. The assembly of the frames was done gradually during the framing up process on the keel and the posts. This framing up process can be identified as moulding with adjustable templates on the lower part (floor timbers) and "master frame and ribbands" on the upper part (futtocks and top timbers).

The framing up on the boat on the left of fig.123 appeared without any false beam on the frames and with three ribbands nailed on each side of the structure. This construction is most likely one of the sort mentioned above ([7]-Chimonas, Zouroudis,G. (1974, p.164)) where the ribs were not initially erected as solid frames.

Another process of framing up a Greek vernacular boat was used in association with the lofting method (5.3 Lofting methods). Using one of the lofting methods the boatbuilder had completed on the floor almost 3/4 of the whole number of frames for the boat. Usually with this method the middle pair of frames was repeated on the next two or three frames fore and aft of the midship frame.

[1]-Mavrikos describes the framing up process on a boat when their lines had been lofted as follows. Beginning from the middle frames the boatbuilders completed first the whole fore or aft part of the framing up work and then continued the work on the other part. Usually it did not matter with which of the two parts (fore or aft) they started as long as the shape of each frame was available from the lofting floor. Although in the case of a Karavoskaro boat, because of the special structure of the aft part of the boat, it was often easier and more convenient to complete the fore part of the boat first.

7.3.1 Framing up the stern of a Karavoskaro

The framing up of a Karavoskaro hull required a different process from that of other types. The middle part ond the bow frames were assembled in the same way as in other boats with lofted frames. The stern of this boat however was built as a separate structure. The final frames to be set on this skeleton were those which linked the stern structure with the rest of the boat (fig.120). At first they assembled the stern post with the upper stern timber and with two ribs. These two ribs are the last aft on the boat which can be considered as a solid frame (<u>αρέτα</u>) structure. The joint of the upper stern timber with the stern post was similar to the one described in the structure of the new form of stern with transom (7.2.2.b). Scarph joints were used between the two ribs and the stern post. The whole structure was finally reinforced by means of internal knees. The second step was to form the waterway timber on the stern and fasten it on the two ribs (αρέτα) and on the upper stern timber. That was likely the most crucial part of the structure and was the main component which required lofting technique. This waterway timber usually had the form of "χαραχτό" than "τριπιτό" as they are described later on (7.4.2 in the structure of the deck beams) ([1]-Mavrikos, [3]-Stilianou). When the waterway timber was permanently fastened on the rest of the structure additional ribs were erected further aft of the two initial ones (αρέτα). These were usually three or four on each side of the stern structure. Later the whole stern structure was erected on the keel of the boat and a mortice and tenon joint was formed. A considerable amount of deadwood was required to reinforce the structure. Finally additional small frame pieces were used to complete the after part of the structure and stanchions were erected to support the gunwale on the stern.

A similar structure is described in Frost,T. (1985, pp.16-9, 26). However we can point to some differences between the Karavoskaro and the wooden steam drifter structure. The ribs on the stern of the steam drifter were not fastened perpendicular to the upper stern piece as in the case of the Karavoskaro. The structure on the steam drifter had these ribs on a radial position and they were all fastened to the stern post on the same position. Furthermore the lower stern post in the case of the steam drifter was extended upwards to the level of the deck beams while on the Karavoskaro it ended at the scarph with the initial ribs (αρέτα).

7.4 Reinforcements of the skeleton

By finishing the framing up of the boat, almost half of the skeleton of the boat was completed. The rest of the skeleton structure comprised longitudinal reinforcing components and the structure of the deck beams. We can suggest a further distinction by saying that in the previous phase priority was given to the determination of the boats's form while in this phase priority was paid to reinforcing the structure.

7.4.1 Longitudinal reinforcing components of the skeleton

Although the frames were now in their final position they were still not permanently fastened. The ribbands were now to be replaced by permanent components of the skeleton. The keelson (Σοτρόπι) was always the first longitudinal timber to be inserted in the construction. It was placed on top of the joints between frames and keel. It started from the last floor timber (κούτσα) which was set on the knee of the stem and it ended on the first floor timber which was seated on the knee of the stern. To fasten the keelson they drilled holes through every second floor timber and the keel. Then they drilled the respective holes on the keelson and bolted all three pieces together ([1]-Mavrikos, [5]-Dardanos, [16]-Kritikopoulos). The dimensions of the cross section of the keelson depended on the available timbers and the length of the boat. [5]-Dardanos suggests that for a Trechadiri 10m L.Keel the keelson could be 4.5x19 or 22cm (depending on the available timbers). According to Kanelopoulos,H.P. (1983, p.39) the keelson on wooden vessels had a square cross section. In "Evaggelistria" this timber was 30x30cm in cross section (fig.122a,b,c,d). [8]-Chalaris suggests that on small caiques (about 8m L.O.A.) the keelson was not smaller in cross section than 5x20cm. The width of the keelson was often more beamy at the middle of the boat (22cm) and narrower at both ends (16cm) (boat built in [5]-Dardanos's boatyard). Moreover the shape of the keelson was always symmetrical about the axis of the boat. The keelson was usually made from a single piece of timber (Damianidis,K. & Zivas,A. (1986, p.57).

The next component of the skeleton which was set upon it was the <u>lower gunwale timber (Κατινή κουπαστή)</u> (fig.124,125). This was a timber placed on top of the ribs and it formed the upper edge of the whole skeleton structure. To set this timber on top of the frames they first marked the gunwale line on the frames. These marks were generated by the moulding with adjustable templates method on the moulded frames (5.2.2 Moulding with adjustable templates). The marks on the whole length of the boat were determined by nailing a lath on the outside face of the frames representing the top side of thr gunwale. The boatbuilder formed the profile of this line by rule of thumb. Because of the crucial form of this line, great attention was paid to the final position of this lath. Later they would replace this lath with the upper plank of the gunwale (απανου-ζώναρον) (Giannoulellis,G.N. (1985, p.8).

According to [4]-Korakis the way he used to determine the position of this line was the following: once the frames had been erected he nailed this lath temporarily on the frames at the positions of the marks on the moulded frames. Then he observed the shape of the lath from different angles and from a distance of 30 or 50m. During this task he was correcting any unfairness until he was completely satisfied by the position of the lath. Once this lath was on the final position the line of the lower gunwale timber (the sheer line of the gunwale) was marked on each rib and the ribs were sawn on a bevel on these lines. On top of them the lower gunwale timber was nailed. This timber will keep constantly the distancies between the frames until the end of the skeleton construction process

([7]-Chimonas).

The next timber to be placed was the first plank below the waterway timber as an external shelf (Τσάπες or Ζονάρια or Αστάρια or βοῦρδος (on Symi)). This was the only external component of the skeleton (belonging to the hull). It was placed to reinforce the skeleton at this stage and to help find the shape of the other components (fig.124,125). In fig.128 the Perama hull on the middle and back this external shelf seems to be thicker than the rest of the planks. This feature is abandoned today. Today most of the boatbuilders do not place the lower gunwale timber at all, they start straight from the first plank below the waterway. This is to accelerate the whole process and in this case most of the purposes of the lower gunwale timber have been overtaken by the first plank below the waterway timber and the upper plank of the gunwale ([7]-Chimonas). To find the position of the external shelf on the ribs, they measured a certain vertical distance below the lower gunwale timber and they marked it on the ribs. The upper edge of this plank should be placed on these marks. Using the stantsola (Σταντσόλα) and mastari (Μασταρί) tools together with the marking line (4.3.11 Marking line) they transferred the measurements from the ribs to the timber for the external shelf. The method was exactly the same as that used later for the planks of the hull (7.5 Planking up). This external shelf determined the height of the gunwale, the level and the sheer of the deck as well as the shape of the seams between the later placed planks of the hull.

[4]-Korakis notices that although in order to determine the position of this external shelf he used the plumb line as described above, an additional check on the position of this component was carried out. As in the case of the lower gunwale timber he used to observe the boat from a distance of about 50m. If the external shelf component was placed at the right position then it should appear to run parallel to the lower gunwale timber on the whole length of the boat.

In case of any lack of fairness in these two parallel components he readjusted the position of the external shelf despite the previously taken measurements. The whole process of testing these components was straightforword by rule of thumb. The height of the gunwale was related to the size and the function of the boat (later in the section of planking the gunwale, we present the available information about the height of the gunwale).

The next step was to set the clamps (Στραγαλιές) on the inside face of the frames. The layers of clamps were as many as the number of joints between the different pieces which formed the frames of the boat. The clamps covered and reinforced the inside face of these joints (Στραγαλιές were serving both the purpose of a clamp as a cover on the joint between the frame pieces and the purpose of a stringer as a longitudinal reinforcing component). Only the joints between the futtocks and the top timbers were covered by the shelves later on.

Thus on a boat with frames of 5 pieces there was one clamp on each side whereas on a boat with frames of 7 or even 9 pieces 2 or even 3 clamps were required (fig.122a,b,c,d). Again with the addition of a flexible lath the line of the upper edge of each clamp was formed. Then using the same method of stantsarola and mastari (4.3.6 and .7) the final shape of each clamp was determined. When the skeleton was derived from the lofting method of shaping (5.3 Lofting method), clamps followed the lines which appear as diagonals on the body plan ([1]-Mavrikos).

In the case of a skeleton derived from a moulding method (5.2 Moulding methods) the lines of the clamps were formed in relation to the form of the external shelf ([4]-Korakis, [8]-Chalaris). In practice on the middle part of the boat the vertical distances between these clamps and the external shelf were almost equal on each one of the frames. [5]-Dardanos suggests that the planks of the clamps were thicker than the planks of the hull. He mentions that for a Trechadiri with 10m L.O.A. the clamp was a single strake with a cross section about 3 or 4x14cm. Usually on bigger vessels aboout 16m L.O.A. each clamp was made up of two or three strakes. In the case of "Evaggelistria" there were three layers of clamps. The two upper ones consisted of two strakes and the lower one consisted of three strakes. All of them were 7cm thick and their width was about 20cm (fig.122a,b,c,d).

Tzamtzis,A. (1987) gives the information for the boat of 21.944m L.O.A.(?) from 1832 that the clamps (probably 3 in number) of each side consisted of six strakes. Two of these six strakes were formed with checks in which the frames were morticed. The first clamp layer of this boat was 11.4cm thick and the two lower were 7.6cm thick. The clamps ended on the third or the fourth frame before the posts. This was because there were no joints on these frames (simple frames consisted of two or three pieces). Sometimes the clamp strakes were wider in the middle of the boat than at the bow and the stern ([11]-Polias).

When the clamps were set on the structure the <u>shelves (Λούρος or κάτω κουρζέτο or ζυγοδοκη or παναστάρι (on Symi)</u>) were placed on both internal faces of the frames (fig.122a,b,c, 129). On Lesvos these planks had the same name as the clamps (στραγαλιά) (Giannoulellis,G.N. (1985, p.17-8)).

Their position was 5-8cm below the strakes below the waterways. This distance depended, in fact, on the height of the deck beams which were later seated on these shelves. The form of the shelves was controlled in the same way as we described for the other longitudinal components of the skeleton. They were fastened on the ribs with a pair of nails on each rib.

Tzamtzis,A. (1987) informs us that the boat which was built on Syros in 1832 had shelves running along the whole length of the boat from stem to stern. On the side facing the frames they were checked to receive each frame.

"Evaggelistria" had shelves consisting of three strakes with cross sections 7x20cm each of them (fig. 122,a,b,c).

The longitudinal components of the middle part of the skeleton were completed at this stage whereas the reinforcements of the bow and stern part were still to be placed.

In boats about 10m L.O.A., it was common practice to set a timber on top of the floor timbers which were seated on the stem (Σώψωμο) (fig.126) (Damianidis,K. & Zivas,A. (1986, p.59)). This in fact appeared as an extention of the keelson above the stem. It started from the floor timber where the keelson ended (κούτσα) and it covered finally all the floor timbers until the first simple frame on the stem. Its cross section was the same as that of the keelson on the aft end and it became narrower as it ran along towards the head of the post. Bolts were used to fasten it to the floor timbers and the stem post ([5]-Dardanos, [8]-Chalaris).

The most crucial components of the skeleton of the bow and stern areas were three timbers connecting strongly the fore and aft parts with the middle one. They formed a sort of extensive knee. There were various forms of the same structure and it could be seen on the stern of small boats (less than 12m long) or on both stem and stern areas of bigger double ended boats. This consisted of two long timbers (Ντουφέκι), like the arms of a knee, and a wooden plate (Φουρνιστή), with trapezoid shape, fastened on top of the convergent ends of the long timbers. The whole structure was placed horizontally on the posts (fig.126). The convergent ends of the long timbers together with the plate above formed a triangular structure which was firmly attached to the post. The plate was also bolted to the post. On the long timbers there were checks in which the frames were morticed. These timbers were extended as far as the first frame which landed on the keel. There were at least a couple of frames to which both the long timbers of this structure and the clamps were fastened ([8]-Chalaris, [10]-Binos).

On vessels with a L.O.A. about 20m there were two or three of these triangular structures on the stem post. This kind of reinforcement was placed on the stem post on that area where a scarph joint was located (Zouroudis,G.I. (1974, p.166)).

Sometimes the two components were replaced by a single horizontal knee or breasthook. This breasthook ("φουρνιστή") was made from a naturally curved timber especially selected for this purpose (Grispos,P. (1963) (fig.127)).

Another form of structure appeared on some boats built usually before the Second World War. In this form the wooden plate (φουρνιστή) was replaced by a naturally curved wooden knee. In this case the two long timbers (Ντουφέκι) served as extentions of the arms of the knee on the frames (Poulianos,A. (1977, p.548)) (fig.126).

"Evaggelistria" had two of these breasthook on the stem. One below the deck and the other on the level of the upper clamps. The same boat had a triangular structure with "φουρνιστή" and "ντουφέκι" at the level of the middle clamps (fig.122b,c,d). On the stern she had two breasthooks at the level of the shelves and at the level of the lower clamps and one triangular structure at the level of the middle clamp. This last structure was located on the scarph joint of the stern post (fig.122d). Kanelopoulos,H.P. (1983, p.42) suggests that in the middle of the 19th century these components were placed not only on the stem and the stern posts but often on the keel, being fastened onto the clamps. These components (αστράβη or φουρνιστή) were placed to reinforce the scarph joints of the keel and the heel of the mast.

7.4.2 The structure of the deck beams

The deck beams (Καμάρια) were set on top of the shelves and nailed on both the shelves and the ribs. Usually a vertical angle half-check was formed on each end of the beams in order to accommodate the ribs. Rectangular checks were often cut on the shelves to accommodate the beams. Each frame corresponded to a beam of the deck. The cross section of the beams according to [8]-Chalaris was 4x6cm on a boat 10m long. The same section according to [5]-Dardanos was 4x10cm on a boat with 10m L.Keel. Most of "Evaggelistria's" deck beams had a cross section of 8x20cm (fig. 122d). The short side was always vertical and the longer side horizontal. According to Adoniou,A. (1969) there are two explanations for this arangement: the reduced height of the beams provides more space underneath the deck and the wider form of the horizontal dimension of the beams provides more area for the nailing of the deck planks. [5]-Dardanos suggests that the depth of the deck beams should be just enough to cover the whole length of the nails from the deck planks. The free space between the deck beams was related to the free space between the frames of the boat (fig.142a).

The distinctive feature of these beams was their curved shape in order to determine the desired shape of the deck. This curve was dependent upon the length of the boat as well as the type and its function (3. MORPHOLOGY). Moreover this curve used to be sharper in older times to form an easier way for the water to run off the deck (fig.128). The deck beams were made from naturally curved timbers. Nowadays the height of this curve on the middle beam of a 10m L.Keel fishing boat is about 15cm. It gets less as we move fore or aft from the middle of the boat ([5]-Dardanos). Adoniou,A. (1969, p.70) says that vessels with a considerable curve on deck had a maximum height of this curve equal to 1/50 - 1/20 of the M.B.

[17]-Papastephanou mentions the use of moulds in order to establish the curve of each deck beam. The bevel gauge with the long arm was used on the deck beams to determine their bevel (4.3.2 Big bevel

gauge).

Half beams were placed where openings in the deck were intended. The rectangular framing of these openings was constructed of two beams wider than the other deck beams and two carlings parallel to the axis of the boat timbers. The half beams supported these two carlings (fig.128). If the structure was too heavy one or two posts or stanchions on either fore and aft side of the opening supported the beams of the opening and were stepped on the keelson. There were certain types of double ended boats (2.2.1 Trechadiri) where a kind of step was formed on the fore or on the aft part of the deck. To form this step they had to add another pair of shelves above the normal shelves of the boat on these areas. The beams of the deck were now fastened on the new shelves and they were about 18cm higher than the other beams of a 10m long boat. The first of those beams was about 22cm high in order to fill the gap between the two levels of the deck (fig. 121).

Hanging knees(Μπρατσόλια or Αγκων) were placed underneath the beams to support them. These were nailed on the ribs and their arms were 30cm long for a boat 10m L.Keel ([5]-Dardanos). These knees were again formed from naturally curved timbers.

On "Evaggelistria" there were 10 hanging knees on the middle part of the boat and they were placed underneath every second deck beam. Their arms were about 60cm long (fig.122a,d).

On top of the joint between rib, deck beam and shelf the waterway timber (τριπιτό, κουρζέτο, ταρακλαμάς (in Symi)) was placed (fig.129) (Damianidis,K. & Zivas,A. (1986, p.58)). This was a timber of 3x20cm in cross section for a boat 10m long.

According to [5]-Dardanos the cross cection of the waterway timber for a Trechadiri 10m L.Keel was 4.4x22cm or 4.2x28cm (depending on the available cross section of timbers).

On "Evaggelistria" this timber had a cross section of 8x40cm (fig.122a,b,c). The waterway consisted of three or more pieces, one after the other all the way from stem to stern. These pieces of timbers had simple scarph joints. The purpose of the form of these joints was to provide enough space for each timber to be securely nailed on the lower deck beam. The most distinctive feature of the form of the waterway was that rectangular holes were cut in it. Fitting the waterway on the structure, each rib should pass through one of these rectangular holes. In this way each rib was passing through a hole of the waterway which was finally fastened on the deck beams and the strake below it. This was the main arrangement to keep the distances between the frames constant. There was a special method to cut these holes by using the stantsola and mastari method.

First they nailed the σταντσόλα on the deck beams beside the place where the piece of the waterway timber was going to be placed (fig.30). Then, with the trapezoid piece (μασταρί), they made marks on the stantsola which corresponded to the cross section of each frame. In fig.130 these marks are identified with different numbers which correspond to the frames. Thus the first frame corresponded to mark "1", the second to mark "2" and so on. Later, by means of the same tools, they marked the outlines of these cross sections on the waterway timber (fig.130). Finally they cut holes following these marks using the small cross saw. In this way they formed the shape of the waterway timber and drove it onto the structure ([10]-Binos). When the whole construction of the boat was completed the waterway was visible from the outside of the boat as a narrow strake projecting about 2cm.

For boats bigger than 20m it was difficult to make the waterway of only a single timber in width. In this case a pair of timbers formed the waterway component of the boat. The holes for the ribs were now rectangular cuts on the inside part of the external timber (χαραχτό) . The internal timbers were placed straight to the inside part of the ribs ([7]-Chimonas, [11]-Polias, [17]-Papastephanou).

In the case where the waterway was a single piece of timber, to fit it into the skeleton they had to remove the lower gunwale timber in order to drive the ribs through the holes of the waterway. When the waterway finally took its position the lower gunwale timber was replaced. But before its replacement mortices were cut on the side below in order to hold steadily the heads of the ribs ([7]-Chimonas).

Another common structural timber which does not appear anymore on boat structures today was the along the axis of the boat deck beam (πικεριά) (fig.28). It was common on vessels bigger than 10m L.Keel and was placed underneath the deck beams at the middle of the deck. Often two additional πικεριά were placed underneath the beams and further to the sides of the deck ([7]-Chimonas, [11]-Polias). Poulianos,A. (1977, p.556) mentions the posts or stanchions (σανταρόλια) stepped on the keelson which sometimes supported the πικεριά component.

"Evaggelistria" had a πικεριά with a cross section of 6x20cm and three posts or stanchions σανταrόλια (fig.122d).

These were the main components for the reinforcing of the frame-skeleton of the boats. As we have seen there were two basic groups of these components. Those which reinforced the structure along the axis of the boat and those which reinforced each single frame and deck beam structure. At the end of this chapter we will study further these two groups of pieces of the skeleton.

7.4.3 The rudder

Poulianos,A. (1977, p.554) points out that the rudder consisted of two parts. "φτερό", the lower and wider part, and "αδράχτι" which was the upper and narrower part. Both however were parts of the same piece of timber. The rudder was supported on the stern post by three sets of pintles and gudgeons which were located in cuts formed on the rudder.

[19]-Bilias gives the information that when the boats were going to sail under lateen or sprit sail, the rudder could be extended below the keel. This adjustable draught of the rudder was achieved by supporting it with two chains fixed on the deck or on the gunwale.

7.5 Planking up

When the skeleton of the boat had been completed, the next phase was planking up. This consisted of the following steps. If the boat was going to have internal ceiling planking it was often placed first. The next step (or the first on boats without ceiling planking) was to place the planks of the deck. Subsequently the whole structure of the gunwale was formed. And finally the planking of the hull of the boat would start.

7.5.1 Ceiling planking (Φόδρο)

Using the same method of planking as on the hull the builders inserted the internal planking of the boat. First they filled the area between the clamps with planks. On big boats the clamps comprised two or three strakes and the area between two layers of clamps was not extensive (fig.122d). So usually 2-4 strakes were placed between these layers ("Φάρσα" in Poulianos,A. (1977, p.548) and "φάρσομα" in Giannoulellis,G.N. (1985, p.19)). Usually they did not plank up the areas above the shelves and between the beams of the deck. These gaps were left to provide ventilation for the internal face of the planks and the ribs ([1]-Mavrikos, [11]-Polias). However "Evaggelistria" had planks and filling pieces in these places (fig.122d). Ceiling planking was placed only on the middle part of the boat. The bow and the stern were never internally planked ([1]-Mavrikos, [11]-Polias) (fig.122d).

Above the keelson and the floor timbers the floor planks were placed ("Πανιόλα"). These were either short planks across the axis of the boat or planks about two meters long which were placed along the axis of the boat. Both kinds were laid on the lower pair of clamps or on a pair of timbers specially placed on the frames to support the floor planks.

The floor planks were easily removable in order to allow access to keelson and floor timbers for repair work. "Evaggelistria" had internal planking of 3cm thickness. In this boat some floor timbers were extended above the rest of them in order to support the floor planks (fig.122d).

7.5.2 <u>Deck planking (Κατάστρωμα or Κουβέρτα)</u>

Planking the deck started with the plank on the axis of the boat. The dimensions of the planks depended on the dimensions of the available timbers. On boats less than 15m the deck planks were usually 6-10cm wide and 2-3cm thick ([1]-Mavrikis, [6]-Arvanitis, [10]-Binos) (on "Evaggelistria" the thickness of the deck planks was 3cm, fig.122a).

The first plank placed on the axis of the boat used to be thicker than the other planks (4cm on a boat 15m long). That was because this plank supported part of the weight of the mast when the boat was sailing ([10]-Binos).

Moreover this plank in relation to the longitudinal beam (Πικεριά) underneath the deck beams formed a pair of timbers which supported some of the lengthwise tension of the deck. When this middle strake was completed they continued planking symmetrically about the axis of the boat.

The seams of the planks were always parallel to the axis of the boat and each strake (for a boat 15m long) consisted of 2-4 planks. The seams between the planks of the same strake (butts) were placed above the deck beams. Care was taken to form the seams between the deck planks and the waterway. The method of stantsola and mastari was used to find the shape of the last side planks of the deck (next to the waterway timber) (we are going to study the use of these tools later in the planking of the hull).

The deck planking followed the curves of the deck beams. Along the length of the boat an upward curve on the deck was formed. According to [5]-Dardanos the fore and aft ends were about 20cm higher than the middle of the deck of a fishing boat 10m long. This curve was sharper on sailing boats in the past (3.1 The influence of function).

7.5.3 Forming the gunwale (Παραπέτο or δρύφρακτο)

In some boatyards they used to set the planks of the gunwale before planking the deck (fig.128). In this way they secure the position of the frames and the deck beams before they start any deck planking ([4]-Korakis).

According to [5]-Dardanos on boats about 10m long the gunwale was usually 30-40cm high. [7]-Chimonas mentions that the height of the gunwale was more than 80cm on boats about 20m L.O.A. or more. [19]-Bilias suggests that the height of the gunwale of a Karavoskaro was between 60cm and 80cm. "Evaggelistria" had a gunwale 75cm high (fig.122a) while "Phaneromeni" had a gunwale of 40cm height (fig.18b).

Adoniou, A. (1969, p.79) suggests that the height of the gunwale for boats 10m, 12m L.O.A. was 34cm and 40cm respectively while for bigger boats it came up to 50cm or more. First they set the internal strakes of the gunwale on the boat (Μπακαλάρι or Μορφωτάρι). These planks were nailed on the internal faces of the ribs and they covered only the upper half of the side of the gunwale. Lane,F.C. (1934) suggests for the word "bachalari", used by the Venetians, the following meaning: "bachalari were the timbers which rose from the end of the deck beams to support the "posticcia" on which the oars rested". On top of both the internal strakes and the lower gunwale timber (Κατινή κουπαστή) the upper gunwale timber was placed (Κουπαστή). This was a timber with trapezoid shape having long sides about 10cm and narrow ones about 3cm. The final shape of this timber was oval with the long side placed horizontally. To achieve this shape they used to dress the timber with planes. That was possibly the reason for placing this timber first and the external planks of the gunwale later. The external surface of the gunwale was made up of two or three strakes (Αστάρι) which were placed between the upper gunwale timber and the waterway. In order to maintain the vertical distance between the upper gunwale timber and the waterway throughout the length of the boat the fore and aft parts of the gunwale were wider than the middle part ([4]-Korakis, [20]-Giamougianis).

Because the gunwale was wider on the bow and stern area the "key plank" was placed on one of the two ends of the gunwale. This was a small wedge shaped plank starting from the stem or the stern post and pointing to the middle of the boat ([17]-Papastephanou). The shape of this "key plank" as well as the shapes of the other planks of the gunwale were created by the use of stantsola and mastary tools and the marking line.

On the lower strake of the gunwale, scupper holes (Μπούνια) were drilled next to the ribs and on the level of the deck. When there was no raised part of the deck on the bow of the boat (to form a step) a horizontal timber, like a thwart (Πραγκάτσα), was placed (fig.121). This ran across the axis of the boat and linked the two gunwales, about one metre abaft the fore end of the deck. The joints of this timber with the gunwale were reinforced with horizontal lodging knees (fig.2.2.1 Trechadiri).

Poulianos,A. (1977, p.557) mentions another component of the gunwale which appeared only on big vessels. That was an additional plank of about 20cm width placed on top of the upper gunwale piece (Μπαστιγάγιο). At the external upper corner of this component they formed a groove where the side canvas on the top of the gunwale was going to be accommodated. At the same time this arrangement provided extra height to the gunwale.

Giannoulellis,G.N. (1985, p.8) mentions a plank placed on top of the seam between the upper gunwale timber and the upper plank of the gunwale under the name "Ϛουνάρ".

7.5.4 Planking of the hull (Πέτσωμα)

The planks for the hull were seasoned both in the forest (for about a year) and in the yard (for at least two months) before any planking took place. In contrast to the skeleton components some of the boatbuilders did not coat the planks with red lead before setting them on the frames.

For a Trechadiri hull of 10m L.Keel long the plank of the hull had a cross section 2.5x12cm or 2.5x13cm ([5]-Dardanos). For a Karavoskaro hull with a L.O.A. 40-60feet the planks had to be 5-5.5cm thin ([6]-Arvanitis).

[6]-Arvanitis gives an example how the thickness of the planks (therefore the volume of the wood) might influence the carrying capacity of a vessel: "some years ago I built a Perama which was supposed to have 250tons capacity. Instead though of building her with planks 5.5cm thick, I made the planks about 6-7cm thick. Because of this additional wood on the planking the boat finally had 275tons capacity".

"Evaggelistria"'s planking had a thickness of 5cm (fig.122a).

The first planks of the hull were placed below the clamp strake (Τσάπα or Ζονάρι). The planks form strakes which were located parallel to the clamp-strake (on a plan this can be represented with sheer-lines). When the strakes consisted of more than two planks they first nailed the end-planks, which ended on the rabbets and later the middle plank. Fashioning this middle plank, care was taken to form the butts on a strake as tight as possible. For this reason the edge of the middle plank which was going to form the last butt on a strake was sawn on site by means of a small cross saw. In this way they achieved extra-tight butts between the planks of the same strake.

The projections of the top and bottom edges of each strake onto a bow and buttock section of the boat remained more or less parallel throughout the length of the boat. This form was for the planks of the upper part of the hull (fig.131). This means that the width of each strake varied along the length of the boat on the body section. At the same time as the builder was cutting out planks of various widths, he had to ensure that they would form seams with adjacent strakes as narrow as possible. This dual requirement, varying plank width with close-forming seams, was achieved by a special way of measuring and marking each plank of the hull. They used for one more time the stantsola and mastari method ([4]-Korakis) (fig.132).

The flexible plank was temporarily nailed on the ribs at that position where the plank after the next one was to be located. They usually had in stock a variety of differently shaped flexible planks which they used as stantsola according to the differently curved areas of the hull. Then they placed the trapezoid piece on it and pointed one of the two narrow angles of it to the edge of the plank above at the point where the sides of the ribs met the plank (fig.132). When the trapezoid piece was exactly in the right position they marked the outline of the other narrow angle of it on the flexible plank. By repeating the same thing at several points of the plank they could then record the edge. This was a practical way to record the edges of the already placed planks. Then in a similar way they transferred the recorded points to the next plank. Linking these points by the marking line they marked out the shape of the upper edge of the next plank and it was ready to be sawn. The bottom edge of each strake was marked at the same time on the bottom edge of the stantsola by rule of thumb while, nevertheless, following the above mentioned rule for the projections on a bow and buttock plan ([1]-Mavrikos, [4]-Korakis).

Nikodimos,K. (1862, p.73) mentions that this method of plank recording was introduced in the yards of Psara by Mr.Stamatis at the end of the 18th century. However, Koukoule,F.I. (1950, p.281) gives evidence of the use of the marking line in the boatyards in the Aegean during the 12th century. So we do not know at present how old this method of recording, measuring and marking planks of the hull might be. Before they nailed the plank on the ribs they trimmed them to form the necessary bevel angle.

The actual process of dubbing out a portion of a frame in order to form the desired surface for the corresponding plank was described by [4]-Korakis. The main point of this work was to find the bevel angle on the frame and to form it by dubbing out to this bevel. They used a line fastened on the stem and the stern post running as a hypothetical edge of a plank. Given that the next plank above was already placed the boatbuilder had to form the bevel on the parts of the frames where the next (hypothetical) plank was going to be fashioned. The determination of the bevel angle was given by the line which was running as the edge of the next plank. Dubbing (Συμπελέκισμα) was carried out on big boats by the adze and on small boats by the small adze ([14]-Korakis, [8]-Chalaris, [17]-Papastephanou). The bevel angle could be measured straight from the lofting floor or the drawings of the boat if they were used. In the case of moulded frames the above mentioned process was followed.

It was common to plank both sides at the same time in order to avoid any inequality in the symmetry of the boat and to save time ([1]-Mavrikos, [5]-Dardanos). However, I have seen small boats planked first from one side and later turned over to be planked from the other side (Damianidis,K. & Zivas,A. (1986, fig.75).

The planking stopped half way below the clamp-strake. Then they started planking above the keel. The first three strakes above the keel had special names: Πιστρόφι,(garboard) καβαλάρης, and κόντρα καβαλάρης. I have no straight answers from the interviews about the need for these special names. Nonetheless there are some details

which might provide us with a probable answer (fig.133 and 122h,i).
Poulianos,A. (1977) and Giannoulellis,G.N. (1985, p.18) suggest the name "τουρέλο" for the garboard strake. These strakes had the strongest tension across their grain because of their twisted form. Table.no.40 includes the suggestions of the boatbuilders about the treatments the planks should receive before fashioning them. We can see that there are four different kind of suggestions containing one or two of the following treatments: soaking the planks in sea water, heating the planks and setting the planks by accurate measuring and marking without any of those treatments. Despite the different suggestions all of these boatbuilders mention the difficult area of the garboard and the two planks above. Furthermore all of them recommend these three planks to be heated up or soaked or both. So these three planks were a critical point of the planking. [8]-Chalaris, [13]-Kontatos, [14]-Chatzinikolaou mention that these planks should be measured and marked more carefully than the other planks. These determined the form of all the higher strakes in the hull, including the key plank.

The lowest edge of these three strakes was the straight line of the keel's rabbet and the highest was formed on a certain angle to the seams of the upper part of the hull in order to provide the final shape of the key plank (fig.122f,g,h,e).

This progressive change of the plank's edges from a straight line to a certain curved line obviously demanded more skill than the other planking.

In addition to all these features of the garboard strake and the two strakes next to it, [8]-Chalaris mentions that all of these strakes were measured, sawn, soaked or heated before any of them were placed in the final position. So indeed to determine the shape and the twisted form of these strakes should have been something special during the boatbuilding process. Poulianos,A. (1977, p.550) focuses

Table.no.40
Treatments of planks before fashioning them

Boatbuilders	Treatment
[1]-Mavrikos............	"If the grain of the planks was formed properly, soaking or heating was not necessary."
[5]-Dardanos............	"Before they set the planks onto the frames they soaked their inside face and heated up their outside face. After this process the flexibility of the planks was sufficiently increased and fashioning them was easy. The garboard (Πιστρόφι) and the two strakes above it required longer time of soaking of about one hour."
[6]-Arvanitis...........	"The planks should be set on the skeleton without soaking or heating at all. However if the planks for the garboard and the two strakes above were not flexible enough we might heat them up for a while to curve them."
[9]-Chilas..............	"The planks which were going to be set on the sharper curved areas of the hull should be heated up from the one side and soaked on the other side with sea water."
[11]-Polias.............	"If the planks were going to fashioned on a very curved shape they should be soaked before in the sea. The sharper was this curved shape the longer the time was that these planks were left in the sea."
[12]-Kozonis............	"Before they soak the planks in the sea they coat them with red lead for protection. For the garboard and the two other planks above it, as well as for some planks for the bow and stern area of the hull, a period between two or three hours was necessary in the sea. The rest of the planks required a period of less than half an hour in the sea. They did not heat up the planks but they used to leave them for additional seasoning after they had fashioned them onto the skeleton. Often they avoid planking during winter because of the bad weather for seasoning."
[13]-Kontatos...........	"They soak the planks in the sea for one hour. The garboard and the other two planks above it need more time of soaking."
[14]-Chatzinikolaou.....	"In addition to the seasoning if your measuring and marking of the planks were accurate enough heating or soaking was not necessary. Only sometimes you can not avoid to soak or even to heat the garboard and the other two planks because of their twisted form."

on the importance of the garboard strake without explaining why. However, he mentions that this plank was thicker than the rest of the planks of the hull, being selected from the best quality timbers available.

Giannoulellis,G.N. (1985) looking into the etymology of the word "τουρελλο" mentions that a similar Greek term is used for a thick plank.

Planking upwards from the keel will eventually meet the lower plank of the upper planked area (downwards from the clamp- strake). The key plank (Καταφραή) will be placed in the remaining gap between the two planked areas (fig.122f,e and 133). This plank had a triangular shape and both edges were measured and marked with the previously described method.

There are however examples were this particular key plank was measured and marked by a pair of sweeps (Damianidis,K. & Zivas,A. (1986, fig.73)).

We have described so far the task of forming seam-lines fair and parallel in projection seam-lines between the strakes of the hull (fig.122f,g,h,e). In fig.122e appears the key strake of "Evaggelistria"'s hull which consisted of two triangular shaped planks.

Let us now examine closer the cross sections of these seams. There were two basic forms of seams on these sections. Those above the key-plank were formed with a narrow angle (bevel) above a line perpendicular to the outer face of the rib (fig.134a). The others below the key-plank were formed with a narrow angle (bevel) below the perpendicular to the outer face of the rib (fig.134c). Finally the key-plank had a wedge-shape with the upper edge formed as the upper seams and the lower edge as the lower seams (fig.134b). This arrangement of the seams between the strakes provided a coherent strength in the hull.

When the seams were well formed in the above way and the planks were carefully measured and formed, caulking was not necessary. However, this was the case only on boats less than 10m long , since on the bigger ones caulking, at least partly, was unavoidable. Caulking was necessary in any case, on the rabbets and on the butts (vertical seams) between the planks of the same strake ([5]-Dardanos, [9]-Chilas, [10]-Binos, [14]-Chatzinikolaou).

Another detail was the special cross section of the planks which were located on the more curved parts of the ribs (fig.134d). Since the radius of these curves was perpendicular to the grain of the planks shakes were liable to occur after they had nailed them on. In order to avoid these defects in the planks they trimmed the inside of them forming a curved surface across the length of the plank (fig.134d).

This was done by means of the across-bound "surface" plane, or by the most capable boatbuilders by means of the adze ([1]-Mavrikos, [5]-Dardanos, [11]-Polias, [17]-Papastephanou).

This treatment provided for some small boats an extremely light hull (e.g. 2.3.4 Varkalas from Hydra).

[1]-Mavrikos mentions that in the past they fastened the planks of the underwater hull usually with treenails if the owner wished a better fastening arrangement for this part (that was more expensive than the fastening with ordinary nails). Gourgouris,E.N. (1983, p.472-3) mentions that the combination of two treenails and one iron nail was used to fasten the planks on each of the frames.

One of the features of the hull which does not appear any more today was the strengthening of a couple of strakes below the waterway by using thicker planks. n an old photograph from a boatyard in Kavala a perama hull appears with a thicker plank on the hull than the rest of her planks (fig.135) (Archaeological Museum of Kavala). The boat in fig.135 was undergoing repair work on the gunwale and the upper strakes of the hull. However we can study in addition to the thicker planks of the fifth remaining strakes of the hull, the formation of the seams between the upper strakes as they are analysed in fig.135 earlier on. It is worth noting in the same boat the extremely pronounced sheer line on the bow.

The butts between planks of the same strake were always placed on the top of frames in order to nail the ends of the planks on the frames.

When planking up was finished they started smoothing down the hull. In this work a group of planes of different shapes were used (4.8 Scraping) in order to rub down all the parts of the hull with different curvatures. Smoothing by planes always took place along the grain of the planks. Today the whole job is performed by means of electric tools.

In the past it was common to smooth down the underwater part of the hull with an adze (this work was done by boatbuilders who were specialists on using the adze) whereas for the upper part, planes were used to produce a smooth surface. That made good sense because on the rough surface of the underwater part (produced by the adze-treatment) the application of tar-coating was easier and more effective than on the smooth surface of the upper part ([10]-Binos, [11]_Polias).

Another kind of work to be done after planking was the treatment of the nails. This was done by using a sledge hammer (Ζουπάς) and some punches of the same size as the heads of the nails. By hammering a couple of times on the nail these were driven about 1cm further into the planks (Poulianos,A. (1977, p.551)). At the end they filled the remaining hole with tar. For more expensive constructions and on visible parts of the boat they usually placed a wooden dowel on the top of the nails ([1]-Mavrikos).

Zouroudis,G. (1977, p.168) states that the marks and the measurements on the planks were taken out by the shipwright. Then the apprentices fashioned the planks on the skeleton without paying a lot of attention to fastening them properly. Finally, the specialized group of mallet users (Πουργουδζής) completed all the final nailing work.

7.5.5 Planking on boats with a transom stern

This type of boat was planked in the same way as the double- ended boats. The only difference was that, caused by the wider area of planking on the stern, another "key plank" was introduced. It was placed lower than the main "key plank" and by contrast to the main "key plank" it was located right aft on the hull. That new "key plank" was also wedge shaped (fig.137).

7.5.6 Planking on boats with a counter stern (Karavoskaro)

[17]-Papastephanou mentions the different way of planking for most of the Karavoskaro hull. Because of the available profile of the frames on the lofting floor, measurements sometimes were taken for the width of the planks. With these predetermined widths of planks no "key" plank was necessary and all the strakes ended on the stem post or at the butt which was located on top of the stern post. It was not necessary for this planking to end on the middle of the hull and usually it started with the first strake below the waterway timber. Moreover the sharp curves on the stern area required some kind of the above mentioned treatment for further flexibility in the planks (fig.136).

7.5.7 Comments on planking

Let us summarize all the aspects of planking mentioned and assess their effects on the hull of the boats.

The strong edges of the planking area, the form of the strakes of the hull, the key-plank structure and the form of the seams between the strakes were decisive for a strong wooden hull.

The practical method to record the edges of the planks, the clamp-strake as a starter for the planking and the treatment for more flexible planks determined the fair form of the hull. The treatment to form a curved inside of the planks, the avoidance of caulking by tight seams and the flexibility of the timbers made it possible to build a light hull.

The high content of resin, the sea-water soaking and the coating with red-lead provided some decay resistance.

I think that the most important feature of the planking process on the hull was the fair and tight seams. This seems one of the fundamental features of carvel construction. We do not know for certain when and where all these details of forming the seams of a carvel hull were introduced for the first time. But undoubtedly the problem of fair and tight seams must have been one of the shipwright's problems from the earliest times of covering a skeleton structure with carvel planking.

Steffy, J.R. (1982, pp.29-33) published some notes about the planking in the preliminary report on the reconstruction of the 11th century Serçe Liman vessel. These notes as a preliminary report did not include a suggestion about the whole planking process. However, there are two remarks which can be studied in respect to the material about the above traditional method of planking. According to Steffy,J.R. (1982, p.29) in this earliest example of a "skeleton first" boat the two curious details of the planking were the shape and the fastening of the garboard plank together with the next two planks above it and the formation of the planks at the area of the turn of the bilge. It is worth including here the "schematic diagram of the portside planking. Not to Scale" from Steffy,J.R. (1982, fig.10) (fig.138).

There is not much to add concerning the first three strakes above the keel exept that for both the boatbuilders in the 11th century and the traditional boatbuilders in the early 20th century this part of the planking was one of the most critical points. This preliminary report of the 11th century vessel does not include details which would allow further comparisons on this point. However, the question remains whether the special names of these three strakes in the recent Aegean

tradition (without any straightforward reason) and the puzzle about the way which these three strakes had been fashioned on the 11th century Eastern Mediterranean vessel was simply mere coincidence.
Studying fig.138 we can see that this, what Steffy, J.R. (1982, p.30) suggests as the "curious" area of the middle part of the planking, appears to be very similar to the same formation in the same area on traditional Aegean vessels (fig.122e). We can notice the dominant and important feature of the middle "key plank" and the form of the three strakes below this "key plank" which smoothly provided the "key" gap at the end of the planking. In respect to the evidence for the use of the marking line in the Aegean boatyards in the 12th century (Koukoule, F.I. (1950, p.281)) we might wonder if we can trace some evidence from this recent Aegean tradition in order to reconstruct the earliest known examples of the "skeleton first" boatbuilding technique.
A final point which we can suggest here is the difference in "key planking" structure between double ended boats, boats with a transom stern and boats with a counter stern. The double ended boats appeared with a very clear "key plank" structure which can have roots of origin as early as the 11th century (Steffy,J.R. (1982, pp.29-30)). The "key plank" structure on the boats with a transom stern appeared as a modification of the previous one by introducing a second "key plank" on the hull. By contrast, the absence of a "key structure" in Karavoskaro planking suggests the likely different technical origin of this type.
We can see that in the case of the double ended boats the problem of fair planking the great area of the middle part and the smaller areas of the two ends of the hull was solved by the "key plank" structure. On boats with a transom, the stern area of the hull was no longer considerably narrower than the mid-ship section. In this case the old tradition of planking had to be modified by introducing a second "key

plank". Finally the new technique of lofting the lines of a Karavoskaro solved the similar problem of this type of hull by a new technique of planking up.

Therefore we can notice that technical evolution in the boatyards during the last two centuries, as suggested in the previous chapters, influenced also the planking up techniques.

7.6 Caulking

When the whole building process had been completed the caulkers (Καλαφάτης) were called in to work on the boat. On some boats full caulking work was not necessary. A typical example of this was the transom-stern boat from Hydra (2.3.4 Varkalas from Hydra). [5]-Dardanos, [9]-Chilas and [14]-Chatzinikolaou mention that on the small boats (less that 10m L.O.A.) built in their boatyards the seams between the strakes were so tight that caulking was not necessary. Nevertheless, caulking was always indispensable in the butts between planks of the same strake and in the rabbets of the keel and posts. And on boats of considerable length caulking was unavoidable on all the planking.

To begin with, the caulkers treated the seams to make them wider. Using the appropriate iron (Κοφτερό), they cut off a part of one edge of the seam. This cut is on the lower edge of the seams above the "key plank" (Καταφραή) and on the upper edge of the seams below the "key plank" of the hull. In fact, this arrangement followed the direction of the seam bevels of the hull. On big vessels the first part of caulking was undertaken with a special kind of cord (Τρισήλιο) of about 3-4mm. According to [10]-Binos this cord was used in order to clear up the inside part of the seams. On smaller vessels, which did not require this prior caulking, the caulker used a wet cloth just to clear up the seams. Gourgouris,E.N. (1983) mentions "τρισήλιο" as the name of the thicker oakum which was driven in the wider and crucial seams of the vessels (rabbet, butts).

The actual caulking started from the upper part of the hull because often the smoothing down and the finishing of the hull was still being carried out on the lower part ([10]-Binos). By contrast, Gourgouris,N.G. (1983, p.480) suggests that only the lower part of the hull was caulked at the point where the vessel was built. After launching the upper part of the hull was caulked while the vessel was afloat.

On small boats, less than 15m long, they caulked each seam twice. In the first instance (Προστούπι) with the single iron and after that (Δεύτερο στουπί) with the double iron (4.9.7 Double iron). On bigger vessels they caulked each seam three times. Tree-nails were caulked also. In Gourgouris,N.G. (1983, p.481) a contract between a caulker and boatbuilder from the late 19th century is included. In this contract it is stated that the hull should be caulked twice (διπλά φυτίλια), the gunwale with the deck planks only once (μονά φυτίλια), and that in the rabbets they should drive "Τρισήλιο".

Only at the end of this caulking the hull did they caulk the rabbet seam of the keel. This was because filling the seam of the rabbet with oakum caused pressure on the first plank above the keel. Under this pressure the next seam, if not already caulked, could be damaged. The seam of the rabbet of the keel and posts, and often the first seam above the keel, were filled with oakum several times. For this job the caulkers used the big mallet (Καταράφα) ([10]-Binos) (4.9.14 Big caulking mallet).

When the caulking of the hull was completed, the next step was to caulk the scarph joints of the keel fore and aft (Παρέλα or Ματισιά). First, they fitted two treenails (Καβίλια) (as stowater pins) through the scarph at each corner of it. Then they caulked the seam between these two treenails. They split the treenails vertical to the seam and caulked them as well. The caulking of the keel was important for

waterproofing the hull. Usually, they caulked the seam between the keel and the counter keel board, if there was any.
After finishing the caulking of the hull and keel, they started the deck caulking. The main difference between the deck and the hull caulking was the depth to which the oakum was driven into the seams. In the case of the deck the seams were tar-coated with very special care and economy just to seal the top of the seams. Since the heat of the summer could easily soften the tar they minimized the exposed area of tar by increasing the amount of tar which was placed into the seams of the deck. This treatment required at least 5mm free-depth of the seam on top of the oakum. In order to form this free-depth in the seams of the deck they fitted the oakum deeper than 5mm.
Sometimes the underwater part of the hull was completely coated with tar whereas the part above the water was puttied and painted. [10]-Binos mentions that some owners of new vessels prefer to have the upper part unpainted and only the seams between the planks were coated carefully with tar. In this case they coated first the seams of the upper hull with tar and then the underwater parts (using the 4.9.17 Brush for tar, "Μαλαχτάρι") ([10]-Binos).
On both parts of the hull there was no reason for a free-depth in the seams. The oakum was driven 4-5mm into the seams of the hull (except on boats bigger than 20m where the planks of the hull were 4-5cm thick and the oakum was driven 8-10mm into the seams). Big cracks on the planks were cauked as well where ever this seemed to be necessary.
It was common in the past to leave the part of the hull above the water unpainted and the seams visible without putty. ([10]-Binos, Gourgouris,N.G. (1983, p.480).
All the caulking work was performed from left to right. It should be commented here that the caulking work started on the seams between the futtocks and the waterway ([10]-Binos). This was undertaken

before the gunwale was placed. According to [10]-Binos, in additon to the oakum, pieces of lead were driven in the futtock and waterway joints. These pieces of lead swelled under water into the seams and provided sufficient waterproofing. The difficulty of achieving seams on these joints as tight as on the planks possibly explains this treatment.

Additionally, the timbers of the futtocks and the waterway showed less swelling and shrinking than the planks of the hull and deck because of the different direction of the grain on these components (6.2.3 Shrinkage and swelling). Any increase of the timbers' moisture caused less swelling on the futtocks and the waterway than on the planks. This difference between the two timbers could be covered by the swelling of the pieces of lead placed in the futtock and waterway seams. Gourgouris,N.G. (1983, p.480) mentions briefly this special caulking with pieces of lead in the boatyards of Galaxidi, during the middle of the 19th century.

[7]-Chimonas mentions that after caulking they used to scorch the hull until a very thin surface of ash covered the part of the hull below the water level. This ash surface served as a protection against penetration of the wood by the sea worm.

Coppering was not common in the boatyards in the Aegean. Konstadinidis, T.P. (1954, p.119) suggests that coppering was never undertaken in the Greek boatyards. Instead of coppering they used "Παλάμισμα" or "Ρετσινοπαλάμισμα" which was coating with a mixture having as basic ingredients resin, animal fat and tar (Kanelopoulos,H.P. (1983, p.55)). This treatment was repeated every year together with careening (Καρενάρισμα) and caulking or planking repair work (1.5 Aspects of the working environment). Gourgouris,N.G. (1983, p.483) mentions that during the middle of the 19th century only two vessels in Galaxidi had copper sheathing but they had not been built in the local boatyards. In the Admiralty Mediterranean

Pilot (1918) it is mentioned that "uncoppered wooden vessels can be repaired" in the boatyards of Rhodes.

7.7 Comments on construction

Studying the construction of boats in the Aegean we can distinguish two basic phases, the phase of the construction of the skeleton and the phase of planking. Furthermore, in the skeleton phase we can separate two groups of components. The shapes of the timbers of the first group were determined by the desired form of the boat but at the same time they were functional parts of the skeleton (keel, stem post, stern post, frames). The main properties of these components, in relation to their structural function, were the dimensions of their cross sections and the advantages of the wood of which they were made (6. BOATBUILDING TIMBER). The second group of structural components had their shape determined by their structural function rather than by the form of the boat (horizontal knee, vertical knee, ντουφέκι, φουρνιστή, deadwood).

As we have seen, there are two critical aspects of the shaping of the frames and their erection on the keel and posts: the method of designing and the use of ribbands. In chapter 5. Designing, we looked at some elements of the initial practical analysis of the intended form of the boat. Some of these were learned by a boatbuilder from personal experience (the form of moulding aids, the basic elements of "METZAROLA", the crucial lines on the lofting floor and the water lines on the models) but the foundation for applying these methods (especialy those of moulding) was a matter of "know-how" passed from one generation to the rest. By contrast the use of ribbands was directly associated with the boatbuilders' experience of the forms of the traditional Aegean vessels.

Barker,R.A. (1988)[2] suggests that the concept of using ribbands to determine the form of boats was one of the main evolutionary factors since early "skeleton first" construction. Steffy,J.R. (1982, p.28) suggests that external non-structural planks were used to control the position and the shape of ribs in the earliest "skeleton first" structure, the 11th century Serçe Liman vessel. Are these planks a kind of ribband like those we have studied in the modern Aegean tradition?

It is not within the scope of this work to study this early evolution of boatbuilding methods. But we can reasonably conjecture that, in the case of the Aegean boatbuilding of the last three centuries, the use of ribbands controlled the form of most of the structural components of the first group (frames, clamps, shelves, waterway, gunwale components) in addition to the strakes of the hull. Furthermore, as we have seen in chapter 5. Designing, the use of ribbands was so familiar to the Greek boatbuilders that it was introduced as a local adaptation into the new method of designing on a lofting floor. So the use of ribbands was one of the traditional "key" tasks for Aegean boatbuilders during the last three centuries.

We can see the extensive use of ribbands as early as the second half of the 18th century in the account of Nikodimos,K. (1862, p.91) (7.3 Framing up). Therefore in respect to the pre-18th century boatbuilding in the area (1.1 HISTORICAL INTRODUCTION), we can suggest that the use of ribbands was a likely part of the early techniques either under the "master frame and ribbands" method or under "moulding with adjustable templates".

A final point on the use of ribbands can be made in relation to their identification as false strakes (5.2.1 "Master frame and ribbands"). In fig.123 by comparing the two vessels represented we can see another example of this statement. So the experience and the confidence of boatbuilders about the form of boats was applied by the use of false strakes which represent the sheer lines of some strakes of the hull. No water lines or body-plan lines were considered during the boatbuilding process. The sheer lines of the strakes of the hull as they have been studied in planking up (seams between strakes) were one of the most crucial aspects of these techniques during skeleton assembly as well as during planking up.

At the end of the construction of the skeleton the first group of structural components determined the surface (frames) and the edges (keel, posts, waterway timber, lower gunwale) where planking would be placed. However, as we have seen earlier on, planking made its own contribution to the strength of the whole structure. The thickness of the planks, the "key" plank structure, the form of the seams between the strakes, the properties of the wood for planking all provide evidence for this.

To further analyse the structure of the vessels which have been built in the Aegean yards we can distinguish two main sections of study: the longitudinal strengthening components and the repeated frame plus deck-beam structure across the axis of the boat.

7.7.1 The longitudinal strengthening components

Hausen,J. (1985, p.271-2) proposes that strength calculation on wooden boats is always influenced by timber being a "non-convenient anisotropic material". He points to the different mechanical properties of wood corresponding to different types of load (tension, pressure, bending), the angle between fibre flow and the direction of load and the way that the timber is cut or sawn (6. BOATBUILDING TIMBER).

Adoniou,A. (1969, pp.94-5) claims that the results from the strength calculation on the structure of many boats were above the expected limits. So these boats could have had weaker timber cross sections than those which were given by traditional boatbuilders.

Therefore, we suggest that the structural arrangements of these boats was more important for their strength than any strength calculation on their components. We can here make some remarks on these structural arrangements on the vessels (139a). Along the axis of the boat a number of structural components supported most of the tension which occurred in the boat from this direction. These components were formed in a way which provided unbroken strengthening lines linking the fore and the aft end of the boat (fig.139a). These lines were:

1) The stem post, the keel, the stern post and the reinforcing knees on the joints between these components.

2) The "φουρνιστή", the "ντουφέκι", the clamps (so the clamps were more like stringers) and the breasthooks.

3) The Breasthook on the stem post, the waterway timbers, the shelves and the breasthooks on the stern posts.

4) The deck beams along the axis of the boats ("πικεριές"), and the frame beams of the openings in the deck.

However, the torsion which occurred in the hull was counteracted by the planks of the hull and the deck rather than by any other structural component.

7.7.2 <u>The frame/deck beams structure across the boat axis</u>

The frame and the deck beams were the main structural components across the axis of the boats. However, these components would be useless without the reinforcements on their joints (fig.122a).

In fact the crucial parts on these across structures were the following arrangements of the joints:

1) The joint of the keel, the floor timber and the keelson,

2) The joint of the floor timber, the futtock and the clamp,

3) The joint of the futtock, top timber and the shelf,

4) The joint of the top timber, the deck beam, the waterway timber the knee and the shelf.

The hanging knees between the frames and the deck beams provided the required stiffness of this transverse structure.

Since the main components of these transverse structures (frames/deck beams) were assembled in a triangular form, additional diagonal reinforcements were not necessary against distortion.

The last remark which we can point out in this study is that when we look closer at any of the joints between components of the boat's structure we can identify combination timbers with different grain directions (e.g. keel-keelson-frames, frames-clamps, frames-waterway timber-deck beams, stem or stern post-breasthooks, stem post-"φουρνιστή"-frames). This cross-grained arrangements provides additional strength to the joint (6.2.1 Grain).

7.7.3. Remarks on the evolution of the structure

There is a number of old structural features on the boats which are abandoned today. We can notice the following examples which are mentioned either in the interviews or in the bibliographical sources:

1)The keel consisted of two pieces in addition to the counter keel board ([1]-Mavrikos, [11]-Polias, Kanelopoulos,H.P. (1983, pp.37-8)).

2)The lower gunwale timber ([7]-Chimonas).

3)"Φουρνιστή" made by a naturally curved hard wood (Poulianos,A. (1977, p.548), Grispou,P. (1963, p.20-5)).

4)"Φουρνιστή" on the scarph joint of the keel (Kanelopoulos,H.P. (1983, p.42)).

5)"Πεκεριά" deck beam along the axis of the boat ([7]-Chimonas, [11]-Polias).

6)The deck strake on the axis of the boat being thicker than the rest of the deck ([10]-Binos).

7)The external shelf being thicker than the rest of the planking of the hull (Tzamtzis,A. (1987) and fig.128)).

8)The thicker strake on the middle of the hull (fig.135).

9)The garboard strake being thicker than the rest of the hull planks (Poulianos,A. (1977, p.550), Giannoulellis,G.N. (1985, p.18)).

10)The use of treenails both on the skeleton and on the planks of the hull ([1]-Mavrikos).

11)Treenails or small wedges driven through the scarph joints of the keel as stopwater pins ([1]-Mavrikos, [10]-Binos, [7]-Chimonas, [17]-Papastephanou).

12)The form of the seams between the strakes of the hull ([8]-Chalaris, [10]-Binos).

From the above features we can see that the structure of boats was stronger in earlier times than today. According to some boatbuilders, technique declined after the Second World War in the Aegean and this is probably the time when most of these features were abandoned ([3]-Stilianou, [6]-Arvanitis, [7]-Chimonas, [8]-Chalaris, [11]-Polias, [15]-Vrochidis, [17]-Papastephanou, [19]-Bilias). Moreover early evidence from bibliographical sources supports the suggestion that some of the above features were used on boat structures as early as the middle of the 19th century (Kanelopoulos,H.P. (1983), Tzamtzis,A. (1987), Grispou,P. (1963)).

Looking again at the above mentioned features of the early structures we can notice that all of them are directly related to the longitudinal axis of the vessels rather than to the transverse axis (with the exception of the treenails perhaps). Furthermore we have some pieces of evidence where the transverse components were not respectively stronger on the old structure than the new one. We have seen that the free space between the frames was the same on the "Evaggelistria" and on the vessel from 1832 (Tzamtzis,A. (1987)). In Poulianos,A. (1977, p.542-3) we have seen the minimized structural purpose of some pieces of the frame assembly. Finally the absence of any additional component of transverse stiffening in the frame structure is noticeable from the early accounts of boatbuilding. Thus, whereas longitudinal structural members seem to have become lighter with the passage of time, transverse structural members do not sem to have changed.

In fig.140 some pieces of an abandoned boat appear in which were we can notice the wide cross sections of the longitudinal components.

The same observation arises from the few early accounts of cross-section dimensions of structural components (Tzamtzis,A. (1987), Kanelopoulos,H.P. (1983).

We can not suggest that these differences between old and new structures were in respect to the different length of vessels; since the old examples of vessels (both in the references and in the illustrations) do not appear particulary large in comparison to those of today. Therefore the differences between the two structures were in relation to different approaches to strengthening them. Undoubtedly the old boatbuilders paid more attention to reinforcing the structure lengthwise than athwartships. The frames were not among the stronger components of the skeleton and they were mainly supported by the internal or external lengthwise components (keels, clamps, shelves, external thick planks).

In respect to the methods of determining the shape of the frames (5.2 Moulding methods) we might even wonder if these components were more important for the formation of hull shape than for strengthening the skeleton structure.

8. CONCLUDING REMARKS

At the end of this work we can see clearly that traditional boatbuilding in modern Greece still provides the ground for ethnographical study of the evolution from early "skeleton first" and "carvel" techniques to relatively modern methods. The last three centuries has been an unbroken period for which we have some pieces of evidence about boatbuilding techniques.

In the HISTORICAL INTRODUCTION we drew an outline of the historical background of the period and we saw how some historical and economic aspects influenced the process of evolution in boatbuilding. We reviewed the evidence earlier than the last three centuries and we have seen that a boatbuilding tradition existed in Greece before the period studied in this work. The late 18th century and the second half of the 19th were the periods (during the last three centuries) when the fastest technical change was taking place. The first was associated with new methods in boatbuilding, the second includes the first experiments with steel boats and the beginning of the decline in wooden shipbuilding. Throughout the period of the last three centuries (until the 1940's) we can detect the coexistence and synthesis of the old traditional techniques and the relatively new ones in wooden boatbuilding. This was first due to the capability of both the old and the new techniques to supply the local client with adequate boats. The simultaneous existence of the old and the new techniques was justified by some differences between the boats they produced. These differences were often associated with different types, the different uses of boats and different sizes.

To classify the types of boats as they appear in most of the old boatbuilding traditions is a difficult task. However the study of the evidence provided by the interviews and the other sources (bibliography, old photographs, recorded fieldwork) enables us to offer some remarks on the relationship between types of boats and boatbuilding techniques. We discovered that the introduction of new methods in the Aegean boatyards during the late 18th century enabled the Greek boatbuilders to build a new type of hull, with a counter stern (Karavoskaro). This new type of hull was justified by the increasing trading during the same period. We can understand that since trading was the new reason for this evolution some influences came from other techniques and types of hulls which already existed in other areas. At the same time boatyards with a demand for fishing and diving boats continued to build boats by the old traditional patterns of boatbuilding. These were double ended and transom stern boats. It is worth noting that although our evidence about techniques does not provide any remarkable difference between local construction traditions in the area, we do have evidence about the existence of local types of boats. We noticed that we can distinguish some differences in the fundamental dimensions between the old types of hull (double ended and transom stern vessels) and the relatively new types of hull (round stern and counter stern). We focused especially on the differences in the ratio M.B./L.Keel. Furthermore we have seen that this last difference was associated with the type of rigging. Especially the Polacca type of rigging was used extensively on transom stern or double ended boats. The lateen and the sprit sail was very common only among the old types of hull (1/2>M.B./L.Keel) or =1/3) while counter stern boats (1/3>M.B./L.Keel> or =1/4) were rigged usually with mizzen gaff sail and square fore and top sails (Brig and Goélet). We mentioned that the old boatbuilding techniques were able to assimilate the type of Karavoskaro (laying out and lofting technique) in order to produce the new type of Liberty (moulding with adjustable templates technique) even after the Second World War. This clearly indicates the extensive use of the old methods in the beginning of the second half of this century.

From the study of boats CLASSIFICATION we realized that the form of hull was not totally controlled by the specific type of hull. Aspects like the use of the boat, the kind of propulsion and the concept of fair lines influenced, sometimes dramatically, the final form of the boat. These kinds of influences were studied in the chapter on MORPHOLOGY. Evidence from the interviews made it necessary to distinguish the vessels into trading, fishing and diving boats in respect to their use. These different distinctions as to the use of boats influenced the shape of a number of lines on the hull of the boats. This influence occurred on most of the types of hull studied. The evolution from the great area of sprit or lug sail together with the top square sails, to the smaller area of the gaff sail and later to the abandonment of the sails had an equivalent effect on the shape of the lower part of the hull. The depth of the draught was reduced gradually along with this evolution of rigging. One of the parts of this work which might be related to local traditions is the concept of fair boat lines among the boatbuilders. There is a number of suggestions on this subject from the interviews which provide us with the ability to propose some explanations for a few features of the boats' form. With the aid of these suggestions the evolution of the shape of the stem post of the sailing Trechadiri to the modern one can bear some explanation. Furthermore the same suggestion was used to justify the genesis of the distinctive form of the Perama bow. Most of the types of hulls had a relationship with particular areas in the Aegean or Ionian Sea. There are examples in which this relationship was in respect to local activities (Skaphi from Symi). However the 20th century evidence through the interviews and the rest of the field work was insufficient to provide us with specific remarks on these geographical relationships. The study of boats morphology is not so familiar to the students of the maritime traditions. But MORPHOLOGY has been provided this work with material concerning the control of the form of the hulls without direct relation to the type of the boats. This part of the present work cast more light on the importance of the traditional designing as that part of the boatbuilding process in which all the decisions about the final form of the boat have to be made.

The nature of the boatbuilding techniques influenced most of the tools of this craft. There were special groups of hand used tools (Measuring - Marking - Moulding - Lofting, Smoothing, Caulking) which were related to particular phases of the boatbuilding process. This relationship of groups of tools with phases of boatbuilding reflects the most specialized tasks of this craft (shipwright, boatbuilder or carpenter, caulker). Furthermore we identified the group of fundamental tools of this craft which usually were the initial subject to develop other specialized tools. On the ability to use and manufacture these fundamental tools depends some part of the boatbuilders skill and confidence to control the most difficult parts of their work.

The boatbuilding process started with the traditional methods of designing the shape of the vessels. In this work we recorded two basic designing techniques: the old method of moulding and the new method of lofting (evidence from the end of the 18th century). Moulding was one of the most important of the old techniques. It was difficult to identify the evolution between the three main moulding methods studied in this work ("master frame and ribbands", moulding with adjustable templates consisting of five aids and moulding using three aids). However there is no lack of evidence about the origin in a period earlier than the last three centuries. In fact the earliest evidence comes from Venice in 1510 where the use of the "MEZA-ROLA" diagram is reported. This diagram was similar to one which has been recorded during the present field work under the name of "METZAROLA". The study of the geometry as an integral part of these methods permits us to formulate some thoughts about the early origin of these diagrams of the moulding methods. First we detected the possibility to have the innovation of these diagrams in the early times of the 15th century. The contemporary knowledge of geometry does not convince us of this hypothesis. The most advanced constructions during the Middle Age were the Gothic Cathedrals. Here the applied geometrical constructions were considerably different from the construction of conic sections or harmonic curves such as we have studied in the case of the moulding diagrams. The possible location the date when this geometrical conception of the diagrams was first carried out brought us to the Classical and Roman times. During these times constructive geometry and conic sections or harmonic curves were subjects with technical applications. Furthermore we studied the same use of the moulding or lofting diagrams to provide curved components in Classical civil architecture. Therefore the main question from this study is whether similar diagrams were used in classical times on ship designing. The "shell first" construction of the excavated vessels from this period adds an additional problem since moulded frames were not a significant part of this technique. A probable answer to the above question comes from further justification of the concept of these methods through their geometrical analysis. This suggested that the starting point for this conception was the shape of some hypothetical ribbands which represented false strakes of the hull. Therefore the required shape of some kind of sheer lines was the starting point of the concept of the moulding diagrams. We suggest that this concept either derived from a "skeleton first" technique or from a "shell first" technique and it can be modified in order to be used on "shell first" technique as well as on "skeleton technique". This suggested hypothesis extends the limits of the study of the origin of these moulding methods much earlier than the oldest known example of "skeleton first" construction (11th century). At the same time this hypothesis introduces another approach to the study of the technical evolution from the "shell first" to the "skeleton first" and "carvel" boatbuilding. Further archaeological and historical evidence is necessary to carry this study into more specific results.

The boatbuilding timber was significant to the construction. The boatbuilders had a specific preference for the use P.brutia from the Eastern Aegean for the planking of the hull. The differences between the properties of this species of pine and the other species, particularly P.halepencis, were difficult to identify. That makes us think that this choice was based on an old tradition since evidence suggests that this species has been favourable for planking since Classical times. Cypress was used sometimes for planking and oak, elm and mulberry for some structural components. The most important properties of timber were: the adequate formation of grain, the decay resistance, the control of shrinkage and swelling and strength. These properties were often critical aspects for the use of some tools and for some structural arrangements both on the skeleton and on the planking of the hull.

The boatbuilding process followed the standard patterns of the "skeleton first" and "carvel" construction. The differences in construction between the old double ended and transom stern types, and the relatively new counter stern type reflect clearly some old and new parts of the boatbuilding process (moulding and lofting techniques, the use of the ribbands, the structure of the stern, the key-plank and the non key-plank structure on the hull).

By focusing on the old parts of this structure we identified some details on the assembling of the frames which provide some links between the "master frame and ribbands" and the moulding with adjustable templates methods. We observed the evolution of the size and strength of the longitudinal components of the skeleton from the early evidence on traditional modern Greek boatbuilding to the recent evidence from the interviews. Additionally we have seen the abandoning of some of these components at the end of the period studied. Thus evolution in the structure can be identified as a result of this study. This is first in respect to the skeleton in which more emphasis was given, in the past, to the strength of the longitudinal reinforcements than to the frames and the other athwartship components (with the exception of the hanging knees). Second in respect to the planking, where more attention was paid in the past to the seams between the strakes, to the thickness of some strakes (thicker garboard strake and the two strakes above it, thicker strake on the middle of the hull and thicker external shelves, all on the old version of the structure). Furthermore, additional careful work was undertaken in caulking during the years before the decline of the craft.

In the old construction process the frames of the boats were undoubtedly an integral part of the structure but not among the main strengthening pieces of it. Frames as structural components of this tradition were mainly used to provide the intermediate connection between the planked external surface and the internal longitudinal reinforcements. At the same time they provided the joining structure between the planks of the hull and a good supporter of the seams and the butts between the planks.

If the frames cannot be justified as critical strengthening components of the skeleton, then they possibly serve a fundamental purpose in deciding the boat's shape. This kind of justification of frames can be associated with their distribution in the various moulding methods which are studied in this work. However, we already suggested that the starting point of these methods was some hypothetical false strakes (ribbands) and only the transmission of this concept to the construction of the boat was carried out by means of the shape of the frames. Thus the longitudinal components, either planks of the hull or internal structural reinforcements, were the crucial parts of the old structure both during designing and constructing the vessels.

As a final concluding remark we can pose the following hypothesis and question. By assuming that the main conception of the use of the frames in this structure was related neither to the decision about the form of the boat nor to the main strengthening parts of the structure, then how we can explain the innovation of this kind of structure at the beginning of the "skeleton first" and "carvel" techniques? Was any other non-structural reason (economical or social reasons perhaps) responsible for the introduction of the "skeleton first" techniques at the beginning of these methods?

The material of this work is not enough to give any positive answer to the question of the genesis of these techniques. But it is certainly enough to provide in the future the ethnographical contribution to a wider study of the subject in addition to new archaeological and historical evidence.

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