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Task n° 1.1	THE INDISSOLUBLE FOREST-BOATS BOND DURING THE SERENISSIMA REPUBLIC OF VENICE
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Introduction

The development of the civilisation (es. explorations, trade, conflicts) has always been linked to forests-wood-navigation; governments and peoples thus needed to ensure that wood resources were readily available, so they had to plan its supply and manage forested areas in mountains and valleys.

A significant example was the Serenissima Republic of Venice: during the period of Venetian domination wood was one of the main economic resources of the Veneto region. Venice is a city built entirely on water and depended heavily on wood from the hinterland for many of its strategic activities, in particular for the construction of the naval fleet on which it based its mercantile and military power. Given the need to ensure the supply of wood, the Serenissima tried to safeguard the forest heritage of its hinterland, protecting its exploitation with specific laws and reserving the best forests for its purposes. The main forests "protected" by the Serenissima were: the larch and fir forest of Somadida, from which the masts of the ships were obtained; the Caiada forest and the beech forest of Cansiglio, from which the oars of the galleys were obtained; the oak forests of Montello and Montona (Istria), which provided the wood for the structure and planking of the ships.

Throughout the modern age, an innovative forestry plan was implemented in the territory dominated by the Serenissima and a wood supply chain developed that connected the mountains and the plains, the hinterland and the Adriatic coast along the rivers, including the Isonzo, the Tagliamento, the Piave, the Brenta, which constituted the main transport routes for wood to the Lagoon.

Over the centuries, the Serenissima built up a wealth of traditions and knowledge covering forest management, floating and uses of timber, plus artefacts, construction techniques (e.g. border milestones, dams, slides, wooden buildings) and sophisticated production chains which connected distant territories and built a strong relationship between natural resources and their sustainable use.

1 Serenissima Republic of Venice and the forest management

1.1 Venice, a bit of history

Venice was founded on a myriad of small islands in the middle of the Venetian lagoon, an inhospitable environment of shallow waters, outcropping terrain and narrow shores. A shortage of fresh water, farmland and raw materials naturally led Venice to exploit its only real resource: the sea. Venice, however, soon broadened its horizons and undertook a commercial adventure that led it to trade raw materials and processed products with gold and spices from the Byzantine and Arab worlds, thus establishing an extensive network of contacts and ports throughout the Mediterranean.

The production and political structure of Venice was organized around trade and its power grew rapidly, so much so that the city became the main warehouse in the Mediterranean. Between the Middle Ages and the Renaissance, it was one of the most populated cities in the world, with 150,000 inhabitants.

Starting from the 15th century, the growing threat from the Ottoman Empire led Venice to bolster its merchant fleet with a highly efficient navy. From that moment on, the supply of timber in large quantities became even more of a strategic necessity for the Serenissima.

Consequently, in 1548 Venice banned forest activities in Cansiglio Forest, sequestering it for its own exclusive use. The wide beech forest made it an invaluable source of material for the construction of

oars, a fundamental part of lagoon navigation. Oars were above all a key part of naval warfare as they afford ships greater flexibility and speed of manoeuvre than sailing. The Serenissima had become a naval power, both commercial and military, thanks to its knowledge of the forests and the natural timber properties of trees which covered lands between mountains and the lagoon. The basic production chain that oversees the creation of a boat therefore starts from the sustainable management of the wood resource, from knowledge of the use of wood and waterways.

1.2 Forests and the Serenissima

1.2.1 Forest management by the Serenissima

Venice implemented lot of regulations and laws for the sustainable management of forest resources, ensuring a continuous supply without depleting available resources, involving a high numbers of forest guards to monitor and control the forest exploitation.

The Serenissima approached forest management with scientific rigor and solid experimental principles, developing good forestry practices tailored to the needs of the Republic and forest ecology. For the Arsenale's activities, high-quality timber from mature forests was required. To ensure the sustainable productivity of these forests and prevent destruction from indiscriminate cutting, forestry was progressively adapted to the Republic's needs. By the late 1700s, Venice had reached a forest management level as the modern naturalistic silviculture.

The Arsenale required each year over 20,000 cubic meters of high-quality timber, especially of conifers, for military and commercial needs.

The rational exploitation of the forest heritage was organized by the Serenissima (1405-1420) according to the production needs of the Arsenal, reserving the almost exclusive use of the forests to guarantee the supply of the necessary wood.

Throughout the 14th century, the Serenissima mainly exploited the possessions of the hinterland, from the entire Alpine arc to the Adriatic and Mediterranean coastal emporiums, while from the 15th century it tended instead to rationalize and enhance the resources present in the mainland areas of which it had full availability.

The vast forest reserves were located in the Belluno territories (Cansiglio-Alpago, Cadore-Comelico, Agordo and Feltre), in the Vicenza area (Altopiano dei 7 Comuni and the Monti Lessini) up to the Monte Baldo area in the Verona area. These are the main forests of the Veneto mountain area, mainly beech and coniferous, to which should be added about fifty, but of modest size, in Carnia, Ampezzo and Tarvisio, also mixed but with a clear prevalence of beech and fir trees.

The Veneto and Friuli Venezia-Giulia plain, originally covered by extensive forests, is today mainly occupied by buildings, infrastructures and intensive cultivations, in an inextricable and often confused intertwining of different land uses. The progressive contraction of the original lowland forest reached its absolute minimum at the end of the 1980s with the presence of very small surfaces, often severely compromised and isolated within the highly anthropized territory.

Bosco di Carpenedo (VE)

In Carpenedo there were several wooded areas as early as 1300; also represented on a Habsburg map of 1820, they were white hornbeam woods, hence the toponym, present in the current urban area of Mestre. The Bosco di Carpenedo, the last relic to have reached us, today consists of about 10 hectares, the remains of the ancient oak-hornbeam forest that originally covered the Venetian hinterland (Habsburg map of 1820).

Bosco di Olmè (Cessalto, TV)

The Bosco is located in the eastern Veneto plain, between the Piave and Livenza rivers. With a current surface area of about 24 ha, it extended for about 66 ha between the 16th and 19th centuries, thanks to its splendid regularly registered oaks. The oak and hornbeam forest represented one of the most significant expressions of the forests of the lower Veneto-Friuli plain. The Bosco is subject to hydrogeological constraints of a forest type and is today recognized, despite the heavy transformations of the last 100 years, as one of the most important relict forests of the Veneto plain.

Bosco del Montello (TV)

Since 1471 the Serenissima Republic of Venice has been directly concerned with the Bosco del Montello and proclaimed the law of the "bando" with which the entire surface became a forest reserve of the Arsenale, guarded by special and constant surveillance to avoid illegal cutting and theft of wood and to avoid grazing in the forest.

During the entire period of the Serenissima, the greatest care was given to the oaks, so much so that special pruning was practiced capable of shaping the trunk, adapting it to what it was supposed to become, that is, a curved part suitable for being cut for the creation of specific components of the hulls of ships. In all the years between the 16th and the end of the 18th century, laws and decrees alternated to guarantee the integrity of the forest; to facilitate forest management, the forest was divided into sockets and delimited by boundary stones. After the fall of the Republic of Venice, the laws protecting forest areas were no longer in force and in a short time in the Montello area the oaks began to be freely cut down without worrying about the maintenance of the forest. Having lost its former appearance, the overall forest is now dominated by black locust/Robinia pseudoacacia, poplars/Populus alba and Popolus tremula, elms/Ulmus glabra, and Ulmus minor, maples/Acer campestre Pseudoplatanus, chestnut/Castanea sativa; here and there there are some plane

trees/Platanus hybrida, wild cherry/Prunus avium, beech/Fagus Sylvatica and finally very rare oaks/Quercus Petraea and Robur, while in a small and isolated area there remains an almost pure relict oak grove, which remains as a testimony to the old Venetian dominion.

Bosco del Sacil (Roncadelle di Ormelle, TV)

In the 15th century it had a perimeter of about 3 km and contained 1462 Trevisan perches and 1829 oaks. In 1726 it was declared an exclusive reserve of the Serenissima while now it has completely disappeared.

Bosco di Lison (Portogruaro, VE)

Privately owned forest of about 53,000 square meters, reachable via a dirt road closed by a barrier, inside the agricultural crops; it is mainly composed of oak, ash, hornbeam and elm.

Bosco Zacchi (Cinto Caomaggiore, VE)

In ancient times the territory of the municipality of Cinto between the Tagliamento and Livenza rivers was covered by the large lowland forest, as attested by the various toponyms. During the period of management by the Serenissima Republic, the woodlands were requisitioned, destined exclusively for the cultivation of oak wood given the presence of valuable trees and marked by boundary stones with the effigy of San Marco.

Bosco di Cavalier (Gorgo al Monticano, TV)

Today private property of about 9 ha, characterized by a multi-layered forest whose origin was an old coppice with English oak trees, white hornbeam, common alder, opium maple, common ash, flowering ash.

Bosco di Basalghelle (Mansuè, TV)

This relict lowland forest of about 14 ha (Pearl oak, White hornbeam, Common elm and Black poplar) is the last remaining strip of the ancient "Bosco delle Vizze" which until the mid-19th century extended over a surface of about 90 ha; today it is evolving into a multi-tree forest. The area is part of the Natura 2000 network (SIC IT3240006 "Bosco di Basalghelle") and represents one of the very rare strips of lowland forest remaining in Veneto.

Bosco Zacchi (Gaiarine, TV)

The Bosco Zacchi (S.I.C. and Z.P.S. insert code), until the mid-19th century of about 100 ha, is today a relict lowland forest located within the territory of the spring belt, which has survived repeated human interventions and is now private property. It is a high forest of uneven age with an adjoining neighboring area of about 1 ha affected by a reforestation plant; among the tree species there are English oak, European hornbeam, Southern ash, Opium maple, Common elm.

Mountain forests: Cansiglio

The Cansiglio forest, also known as the great San Marco rowing forest, was identified by the Serenissima as a main place from which to draw the wood supply for the construction of the oars for the fleet, given the high presence of beech trees. In order to guarantee the Serenissima the exclusive pre-emption of the beech wood (1548), the forest was banned and fenced off and was periodically

checked and measured to ensure a constant supply. In this way the Serenissima managed to preserve the Cansiglio forest heritage, more than 4000 hectares of forest, still present today: the Venetians implemented a careful forestry policy during the 3 centuries of domination and many studies were carried out to try to improve the quality and yield of the forest and find the most suitable cutting solutions. Subsequent governments tried to preserve the forest in the state in which it was found and with the Unification of Italy, the Cansiglio became (1871) a National Forest and in 1930 the first formal planning document for the forest was drawn up.

From the Cansiglio forest to Venice, the wood was gradually transported along the mountain slopes and concentrated along the waterways, a very expensive method of transport, but one that guaranteed the integrity of the largest and most valuable pieces. For the floating of the wood, systems of dams or barriers were also used along the streams to create temporary artificial basins and use periodic floods to move the wood along the rivers, where navigability was better and using the logs assembled in large rafts up to the ports. The rafts arrived in Venice where they were dismantled and the wood taken to warehouses and workshops for seasoning.

Today, the Cansiglio Forest is a node of the Natura 2000 Network (IT3230077 Cansiglio Forest), rich in species and biodiversity. The current planning of the territory occurs thanks to the application of a forest management plan and the subdivision of the forest into productivity classes: beech forest, mixed forest, conifer forest, protection forest and regenerating forest.

Mountain forests: Somadida (Auronzo, BL)

The Somadida Natural Reserve represents one of the most important forests of Cadore and the Belluno Dolomites; called “Vizza di S. Marco” it represented an important reserve of valuable strategic wood for the naval fleet of the Serenissima, thanks to the iron discipline of management and

protection applied to the forest, in order to be able to obtain the masts for the naval fleet. After the fall of the Venetian Republic (1797) the possession of the forest was exploited by the French authorities and then, after various dominations including the Austrian one, with the Unification of Italy it became property of the State that declared it inalienable (1877).

Mountain forests: Cajada (BL)

It is now located within the Belluno Dolomites National Park and was historically controlled and exploited for a long period by the Serenissima as a supply of wood for the Arsenal's uses

Mountain forests: Ampezzo (UD)

In this area of Friuli there are some of the most beautiful mixed forests and pure spruce forests of Carnia, partly used by the Serenissima for its exclusive use and reserved for the needs of the Arsenal or for other public uses. After the period of Venetian domination, the forests were heavily exploited but the situation of degradation was easily overcome over time thanks to the good management of the local administration, favored by the isolation of these forests compared to other more easily accessible wooded areas.

Mountain forests: Carnia (UD)

This is a large territory whose woods, at the end of the 16th century, had been proclaimed the exclusive reserve of the Republic of Venice for the supply of wood necessary for the needs of the arsenal, with the exception of wood for the reconstruction of houses and other artifacts destroyed by floods and fires.

Mountain Forest: Lessinia-Asiago Plateau; Valbrenta-Calà del Sasso-Valstagna (VI)

For these territories, wood was a precious resource given the high demands from the large cities of the Venetian plain. To quickly deliver the wood to its destination, the trunks were brought down the valley along mountain roads, with mules and horses and then tied to form rafts up to 30 meters long for floating along the rivers.

Mountain forests: Monte Baldo/Garda (TN)

Venetian domination lasted a long time on both the eastern and western slopes of Monte Baldo. After the annexation of Veneto to Italy, however, much of the woods were destroyed to make room for meadows and pastures.

Istrian and Motovùn forest

There were many forests in Istria, used both by Venice and by private individuals; among these, the Corneria forest (Kornarija) in the Municipality of Grisignana, near the village of Marussici (Marušići) should be mentioned: today its surface area amounts to about 160 ha, while the area delimited by the ancient stone markers is 79 ha; the vegetation of the Corneria forest is mainly made up of downy oak with oriental hornbeam or black hornbeam. Other forests are found in Leme (Kontija), Vidorno (Vidorna), Mompaderno (Baderna), Siana near Pula and Lisignamoro (Ližnjemoro).

The forest that rises in the Motovun Valley, in Istria, was chosen by the Serenissima for the supply of wood both for the Arsenal and for firewood. It was controlled by special officials who also had the task of surveying the state of the resources, verifying the borders also with the installation of boundary stones; a regulation for the management of the Istrian forests and the Motovun forest was also drawn up in 1777 in Italian and Croatian.

From Motovun you could reach the sea through the Quieto (Mirna) river up to the Baštija port (palada della Bastìa, Grisignan –Grožnjan), while with smaller vessels you could even get to the Pietrapelosa/Kostel castle, almost under the fortified town of Pinguente/Buzet.

After the domination of the Serenissima (1797) the forest was administered by Austrian, French, Italian, Yugoslavian and Croatian foresters, successfully overcoming the world wars and the projects of drastic reduction of extension. Today the state forest measures about 1,200 ha of which 292 are fully protected where only phytosanitary cuts are foreseen. It is a forest with high plant and animal biodiversity and represents an irreplaceable biogenetic oasis in the center of Istria.

1.2.2 The Venetian land registers and the planning of wood cutting

The Serenissima Republic of Venice lay out detailed forest land registers to monitor the quantity and quality of available timber. Careful estimation and forest planning were essential to avoid deforestation from compromising constant timber supplies. For efficient management of forest resources of the Serenissima, a decision was made to survey and register, starting with the oak forests of Veneto and Friuli, all trees useful for the Arsenale and the city. Each tree belonging to Venetian forests was recorded in a dedicated book (so-called "catastico"), noting the condition and value of the forest assets and meadows. This cadastral system allowed for the strict enforcement of laws prohibiting unauthorized cuts and damage to trees.

The first census of the forest initiated in the public forests of the Friuli and Veneto land during the 16th century (1548) and it was repeated many more times as the specific redaction of land registers (eg. the Surian land registry in 1569) and the Contarini land registry in 1740), culminating in the last census around the mid-18th century, progressively perfecting the technique and the management significance of the property.

The forest management planning of the Serenissima aimed to supply the Arsenale and the city of Venice with the necessary timber. Venetian forest laws were based on the best principles of forestry science, focusing not only on the conservation of the woodlands but also on their continuous renewal and expansion. The Republic specifically protected the most valuable species, such as oak and beech, as well as the conifers needed for shipbuilding.

In fact, to ensure the supply of raw materials that Venice needed, especially wood, permanent magistrates for the protection and management (so-called “Provveditori sopra le legne e boschi”) were established already in the 15th century; in this way a more effective control and rational exploitation of the forest heritage was possible, reorganizing the management of the subject territories also in function of the production needs of the Arsenal and "banishing" (that is, reserving to the State the pre-emption or exclusive use) of the forest reserves that guaranteed the tree species required for shipbuilding.

This process tooks place in a European context where, elsewhere, forest legislation was often non-existent or solely oriented toward feudal or fiscal interests, perpetuating a system of privilege. In fact, Venetian laws reflected ancient local traditions, particularly in the highlands, emphasising the need to safeguard the land. Cutting methods were established to allow the shoot growth in coppices, to maintain soil stability and to protect the snowpack in mountain forests.

These principles became more and more strict, heavily impacting agricultural practices and, especially, the management of communal forests left in use by the original inhabitants of the area.

To apply a long-lasting forest management, Serenissima needed of land register and maps and direct controls of properties by “forest captains”; then, other objectives and basic concepts for the Venetian forest management are the natural forest regeneration by seeding or planting, the ordinary coppice regime and the maintenance of all the species (e.g. oaks) useful for shipyards in clearings and

transitioning from simple coppice to high forest. All these approach are nowadays the pillar of a sustainable governance of a territory.

1.2.3 Defending the lagoon began with defending mountains

There is a strong relation between mountains, rivers and lagoon: Venice feared the siltation of the lagoon (and therefore the loss of its hegemony as a city-state) so it was indispensable to protect lagoon and implement a hydrographic supervision to defense both the lagoon and rivers and mountains/plains (pasture/agriculture).

In fact, the survival of Venice was inseparable from that of the Lagoon and therefore for the Serenissima the protection of the hydraulic balance of the Lagoon was always the top priority. In short, this balance meant preventing both the increase in the quantity of fresh water with the consequent spread of marshes and malaria, and the silting up and reduction of the seabed, to obtain a balance of the tides that guaranteed a continuous exchange and cleaning of the seabed, and to allow adequate internal navigation.

Throughout the history of Venice, the Lagoon was the primary source of food resources: with fishing, with the products of the estuary gardens (radicchio, artichokes), with hunting in the mudflats even if to a lesser extent, until the 15th century it also meant the production and trade of salt.

From a military point of view, the Lagoon was an insurmountable defense and the size that Venetian warships could reach depended on the depth and width of the navigable canals, a limitation particularly felt with the advent of galleons and vessels.

In the 16th century Venice was a city of over 150,000 inhabitants and one of the industrial centers of Europe, and therefore large quantities of both basic necessities and raw materials were needed, and

in particular there was the Arsenal, at the time the largest factory in Europe, with its needs for various types of wood, coal for the forges, semi-finished and iron products, wood and coal.

Having no physical connection with the mainland, the supply of most of these goods depended on the navigability of the rivers, especially the Brenta and Piave, and the internal canals of the Lagoon.

The constant excavation of the lagoon to eliminate sand and mud was an ancient practice in Venice and for a long historical period the excavation and recovery of mud had been functional to the growth of the city itself: the spaces of Venice, its very solidity, were the result of a slow but powerful reclamation work.

Rivers were therefore enemies of the health of the lagoon, especially from the 15th century, when the increase in mountain deforestation and agricultural clearing favored the dragging of stones, mud, and sandy material downstream.

To counter the process of continuous silting up caused by the rivers, Venice devised a strategy both for managing internal waters with daily cleaning work and for major river diversion works, in order to eliminate at the root, the sources that fueled the silting up. A process of territorial delimitation began, the so-called “lagoon contermination”, the barrier line, marked by stone pillars, which would extend from Chioggia to its northern border, a process that lasted a few centuries, with which Venice distanced the rivers that previously flowed into the lagoon, and separated the salt water from the mainland.

Regarding the interventions of the Serenissima on the rivers, it should be considered that until the end of the 14th century the mainland domain reached a few dozen kilometers from the coast (Treviso), so the possibility of intervention was limited to the immediate edge of the Lagoon, where significant interventions were still carried out, even if with poor results. In the 15th century, however, the Serenissima expanded into the mainland [in 1405 Padua, Vicenza and Verona, 1420 definitive

dedication of Cadore and the Patria del Friuli] and therefore could, and must, begin to address the problem of the hydrogeological management of the territories upstream of the Lagoon, and large-scale and long-lasting engineering interventions were possible already on the mainland. The 16th century was the golden age of Venetian hydraulics, but perhaps more for the theoretical elaboration of principles and for studies than for the execution of programs; the merit of 16th century hydraulics was to have established the interdependence between the problems of river regulation, the internal regime of the lagoon and the port and coastal system. The major works were then carried out from the 17th to the 18th century around the great arteries of the Brenta in a south-east direction and of the Sile-Piave in a north-east direction, and ensured the development of a system that guaranteed the functionality of the modern lagoon.

However, river diversions were very expensive operations and characterized by several failures and not always positive consequences; for this reason, it was necessary to act at a preventive level to solve the problem at the source. At the beginning of the 17th century the Paolini Code was drawn up, a document that explains the rules for a good global management of the territory, from the mountains to the sea. The Paolini Code was an example of this, even if it was not applied at all, however it demonstrates the aptitude of the Serenissima to intervene globally on the mountains, whose protection is considered by the Venetian administration as a priority for the protection of the lagoon balance. It can be considered that Paulini's proposal contributed decisively to orient the territorial policy of the Serenissima in this area in a new way.

2 The river system and timber transport

2.1 The transport of timber

Rivers and canals have been used since ancient times as the most natural and safest routes for the transport of timber, goods and passengers. Venice was no different, the dense network of river crossing its territories along the Adriatic coast, and its vast fleet of modern boats influencing the development of social and economic relations.

For the operations of the Venice Arsenale, it was essential to have high-quality timber from mature forests. The process of felling and preparing the trees was carried out by woodsmen, who used specialized tools to move the cut and debarked logs.

Log transportation downstream was facilitated by natural and artificial slides, known locally as "risine". The risine allowed natural obstacles to be bypassed and covered long distances. These channels were made of sections of logs, stabilized with poles driven into the ground. In autumn and winter, the risine were cleared of snow, which, once frozen, facilitated the sliding of the logs.

The timber was then gathered in storage points located on dry streambeds in front of the stue. The stue, closed structures built in narrow sections of the valleys, created water reservoirs to facilitate log floating. These structures could be either permanent or temporary, set up specifically for the logging season. The woodsmen specialized in log floating, monitored the movement of the timber along the waterways, ensuring that the logs did not get stuck in narrow sections. They used poles with pointed irons to push and pull the moving logs.

The arrival point of these transport lines were lakes and the big rivers such as the Piave, Livenza, Tagliamento and others. The best logs continued their journey as rafts, which were loaded with timber cut into planks by local sawmills and others goods, ensuring a continuous and sustainable

supply of essential raw materials for the Arsenale and other activities of the Serenissima. The rafts, made up of 15-18 logs each were joined in "trains" of 3-6 units, reaching a length of about 30 meters. These rafts, articulated like the wagons of a train, could be up to five meters wide and over twenty meters long.

2.2 The river system: waterways, rivers and water pipes

River navigation has played a crucial role in the development and economic growth of many countries. Defined as the practice of transporting goods and people via rivers and inland waterways, river navigation has historically been a backbone of commerce, trade, and connectivity.

The significance of river navigation extends beyond mere transportation. It encompasses historical developments, economic impacts, technological advancements, and environmental considerations. The evolution of river navigation reveals a dynamic interplay between human activity and the natural environment, reflecting the broader historical and economic trends that have shaped the region. Understanding the history and current state of river navigation provides valuable insights into its future potential and the ongoing efforts to balance economic development with environmental sustainability.

Veneto region

River navigation is certainly very ancient; evidence dating back to prehistoric times is given by the discovery of a pirogue in Ponte di Piave, a type of vessel made from a single trunk of oak, the farnia variety (Quercus robur L.), the most suitable for this use being particularly robust and potentially able to reach considerable dimensions (about 30-50 m in height and 2 m in diameter).

In the past, river transport, both for people and goods, has often been a safer, more direct and less dangerous means of transport than other modes of land transport. Although many waterways had a torrential regime, or the period of autumn floods and the swelling of rivers with the spring thaw made this method of movement complicated, even against the current, knowing how to manage this variability of situations navigating waterways has constituted the basis for the agricultural, economic and social development of communities.

The critical issues of river transport were well known at the time of the Serenissima and in particular by the operators who used the hydrographic network for the transport of wood so much so that they were also obliged to guarantee at their own expense the proper functioning of these river routes on the lands managed by the Serenissima.

The need and diffusion of this method of transporting goods was so evident that, even in the documents describing and planning the exploitation of the woods, the distance from a navigable waterway was always expressed - or from the so-called "cargadori", i.e. locations with characteristics suitable for loading the goods.

All the Venetian mountain forests of the Serenissima that guaranteed the wood for the arsenal had the possibility of relying on a river network connecting with Venice. For example, the Cansiglio forest had two main river transfer axes, chosen based on the type of wood: for the assortments intended for the production of beech oars, the journey started from the Treviso side, passing through Cappella Maggiore and, through the Meschio river, reached Sacile, where it flowed into the Livenza and from there to Portobuffolè to reach the sea at Porto Santa Margherita; the other axis, the one that mainly concerned the conifers for naval masts or working wood, from Cansiglio (Palughetto) reached Bastia and the lake of Santa Croce then, through the Rai river, the port of Cadola sul Piave, where the “rafts”

that reached Venice were set up. The total time from Cadola to Venice foreseen by the contracts was 45 days in winter and 35 between April and September.

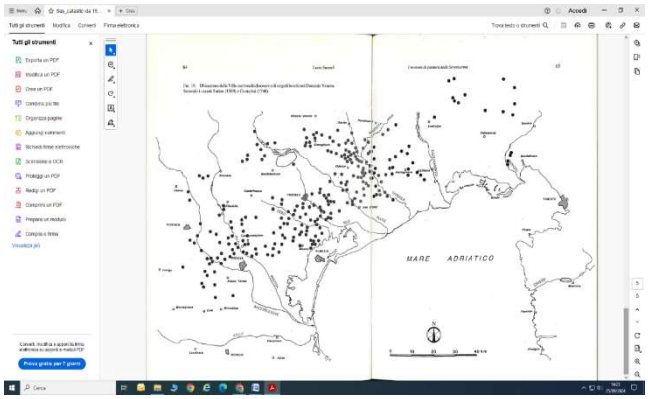
Also for the Somadida Forest the main route to reach Venice was the Piave River and, before that, the Ansiei torrent. Similarly, for the Cajada Forest, much further downstream, today included in the Dolomiti Bellunesi Park, the natural route to reach the coast was the Piave River.

Moving further north-west, and involving the current Trentino Alto Adige, the wood coming from Caoria and Primiero, passed respectively along the Vanoi and Cismon torrents, into which it flowed, to enter the Brenta River, at the confluence with the Valsugana, up to the sea.

Similarly, the wood coming from the Asiago Plateau, through an artificial stone conduit (Calà del Sasso) cancelled out a difference in height of 800 meters, to compose the rafts of 18-20 trunks, which through the Brenta river would then descend to Venice.

Wood and timber from Monte Baldo and Lessinia, instead, reached the Serenissima through the Adige river.

All the wood, mainly oak, which was instead produced by the hundreds of "villas" scattered across the Veneto-Friuli plain, similarly made use of plain rivers including the Bacchiglione, the Sile and the Zero.



Main river courses of the Veneto-Friuli plain and location of the Villas with oak woods and individual woods in the Veneto Dominion (Surian (1569) and Contarini (1740) land registers.

Croatia

The use of rivers for transportation and trade in Croatia dates back to ancient times. Rivers were the lifeblood of early civilizations, providing a natural means of transport for people, goods, and ideas. From ancient times through the mediaeval period to the modern era, river navigation in Croatia has evolved significantly, shaped by technological advancements and economic developments. The major rivers—Danube, Sava, Drava, and Kupa—have been vital to the country's transportation and trade networks, supporting economic growth and regional integration, being essential arteries for movement and commerce.

Understanding the historical background of river navigation in Croatia provides valuable insights into its current state and future potential, highlighting the enduring importance of these waterways in the country's development.

In Croatia, the major navigable rivers –the Danube, Sava, Drava and Kupa, have facilitated the movement of goods and people for centuries, linking inland regions with the broader European market and providing essential routes for trade and communication.

These rivers play vital roles in the country's navigation network, contributing uniquely to the economic, historical, and cultural landscape of Croatia. Understanding the significance of these rivers and addressing the challenges associated with their navigation is crucial for leveraging their full potential in the country's development.

However, it is important to emphasize that all rivers in Croatia that can be navigated belong to the continental part of the country. In the area of interest for ToFoLa project, mostly coastal shipping was developed with little small scale river traffic, usually around tributaries.

The Istrian Peninsula and the Kvarner region, known for their stunning coastal landscapes, also possess a rich history of river shipping that has significantly contributed to the area's development.

While these regions are more renowned for their maritime activities in the Adriatic Sea, the role of river shipping cannot be overlooked, particularly in the context of local trade, transport, and economic activity.

In ancient times, the rivers in Istria and Kvarner were integral to the local economy. The Raša River in Istria, for instance, played a significant role in the transportation of goods. The Romans, who settled extensively in the Istrian Peninsula, utilised the Raša River for the movement of agricultural products, timber, and stones. They built infrastructure to facilitate river navigation, including small ports and loading points along the riverbanks. The Raša River, flowing through central Istria and emptying into the Raša Bay, was a vital route for transporting goods from the interior to the coast. This river enabled the movement of Istria's rich agricultural produce, including olives, grapes, and grains, to coastal towns for further shipment across the Adriatic and beyond. During the medieval period, the Raša River continued to serve as a crucial trade route, supporting the local economy and connecting inland settlements with the thriving coastal trade hubs.

The Mirna River, another important waterway in Istria, facilitated the movement of goods, particularly during the mediaeval period. Flowing from central Istria to the Adriatic Sea near Novigrad, the Mirna River was essential for the transportation of timber, which was a significant resource in the region. The dense forests along the Mirna River provided ample supplies of wood for shipbuilding and construction, supporting local industries and trade.

The early modern period saw continued use of Istrian and Kvarner rivers for shipping, albeit on a relatively smaller scale compared to maritime activities. The rivers remained crucial for transporting goods from the interior to the coastal ports, where they were loaded onto larger vessels for international trade.

The Raša River gained particular prominence for the transport of timber and coal. The exploitation of Istria's natural resources intensified, with timber and coal becoming significant export commodities. The river facilitated the efficient movement of these resources from inland mines and forests to the coastal ports of Raša Bay, from where they were shipped to various destinations across the Adriatic and Mediterranean.

More towards the south, Lika River and its tributaries were important for local connectivity.

To support the increased river traffic, infrastructure developments were undertaken. Improvements to riverbanks, the construction of small docks, and the establishment of storage facilities along the rivers enhanced the efficiency of river transport. These developments were crucial for maintaining the flow of goods from the interior to the coastal ports. In the modern period, the role of river shipping in Istria and Kvarner has diminished, overshadowed by the development of road and rail transport, as well as the continued dominance of maritime shipping. However, the historical significance of river navigation remains an important aspect of the region's heritage.

Today, the rivers of Istria and Kvarner are appreciated for their cultural and historical significance. They offer insights into the region's economic history and the evolution of transport and trade practices over centuries. Efforts to preserve and promote the historical sites along these rivers contribute to the region's cultural tourism.

Modern environmental considerations have also influenced the use of rivers. Conservation efforts aim to protect the natural ecosystems of the Raša and Mirna rivers, balancing the historical use of these waterways with the need to preserve their ecological integrity.

While the rivers of Istria and Kvarner may not be as prominent as the major navigable continental rivers of Croatia, their historical role in local trade and transport is significant. From ancient times through the mediaeval period and into the modern era, rivers like the Raša and Mirna facilitated the

movement of goods, supported economic activities, and connected inland areas with the coast. Understanding this aspect of the region's history enriches our appreciation of Istria and Kvarner's diverse and dynamic past.

Friuli Venezia Giulia Region

The Friulian rivers, such as the Tagliamento and the Livenza, were crucial for the transport of timber to Venice. The Serenissima invested in the construction of canals and hydraulic infrastructure to facilitate this transport to the sea and the lagoons.

In the Friulian region, the Tagliamento-Fella river system was the most important, and its journey ended at the ports of Latisana or Pertegada, from where the timber continued to other locations, primarily Venice. In western Friuli, however, timber from the Prealps and the Cansiglio, mainly firewood, was transported along canals and partially by cart. From the Torre and Natisone valleys, firewood reached the Friulian market, with Udine absorbing most of it. From the Musi mountain range, the timber was transported by carts and cables to the Torre stream and from there ferried to the port of Molins near Tarcento. Additionally, boats transported timber from the Friulian plains' forests to Venice and Trieste, while large hardwoods were used in the Precenicco shipyard near the mouth of the Stella River.

Ports and stone structures were continuously distributed along the Friulian rivers: ports in Cimolais, Claut, Sequals, Villa Santina, Moggio, and dams on the Lumiei and Arzino streams, in Val Aupa, and on all waterways useful for timber transport. Amaro and Ospedaletto had ports with canals and dams; some of these, with widened riverbeds and excavated stones, could accommodate thousands of logs and allow countless rafts to pass through. The management of these ports, often subject to complex transactions and speculations, could be very lucrative.

3 Venice Arsenal, shipbuildings and "botteghe" (artisan shops)

3.1 A brief history of Venice Arsenal

The Arsenal (from the Arabic darsina'a = house of industry) is a gigantic construction in which the merchant and military fleet that for centuries made the fortune and greatness of Venice was set up. Founded around 1104, it was progressively expanded with new and more suitable buildings until it occupied a vast area of Venice, between canals and surrounded by high walls and square towers with the emblem of the winged Lion. The Arsenal is the typical expression of the maritime interests of the Serenissima, not only as an urban complex composed of shipyards, warehouses, homes, which Venice flaunted to all the authorities visiting the city, but above all as political and economic management: the Arsenal represents the place where the Serenissima looked after and followed the evolution of its interests on the sea for eleven centuries. This complex has its own organicity where a functional rationality is always found; in fact, covered or uncovered constructions for shipbuilding are always connected to storage and supply activities, distributed according to their own precise logic. The structure of the Arsenal evolved following a succession of expansions, both following fires, but also above all progress in construction and logistical techniques (e.g. laboratories, warehouses and rooms for artillery and gunpowder) and historical events and foreign dominations.

After the various foreign dominations, the Arsenal was also used by the Italian government and some giants of the Italian navy set sail from its docks (e.g. the Francesco Morosini); during the First World War (1915-18) it was an important strategic hub of the Adriatic fleet and was subject to continuous threats of enemy incursions, being stripped of much of its machinery to prevent it from falling into enemy hands; after Austria was defeated, the centuries-old activity of the Arsenal ceased in the 20th century.

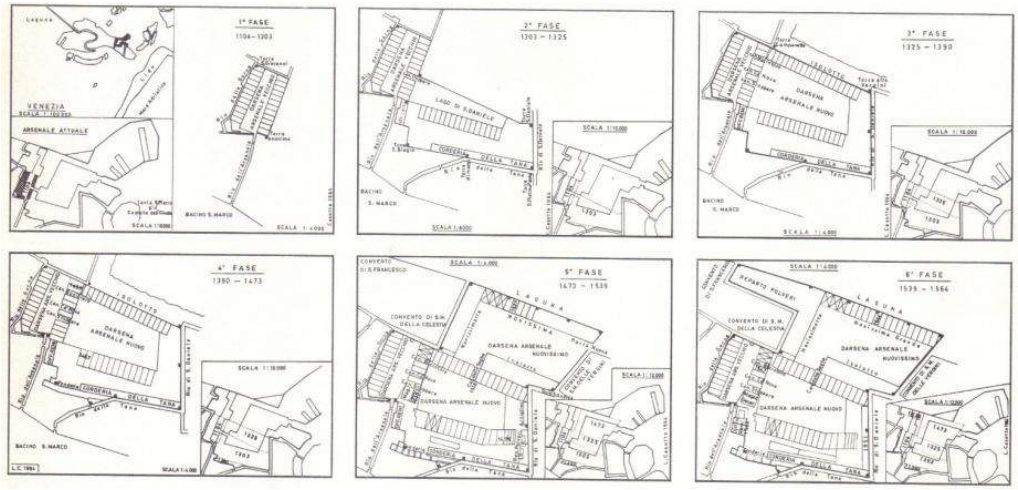


Fig.: Historical sequence of the successive expansions of the Arsenal up to 1564.

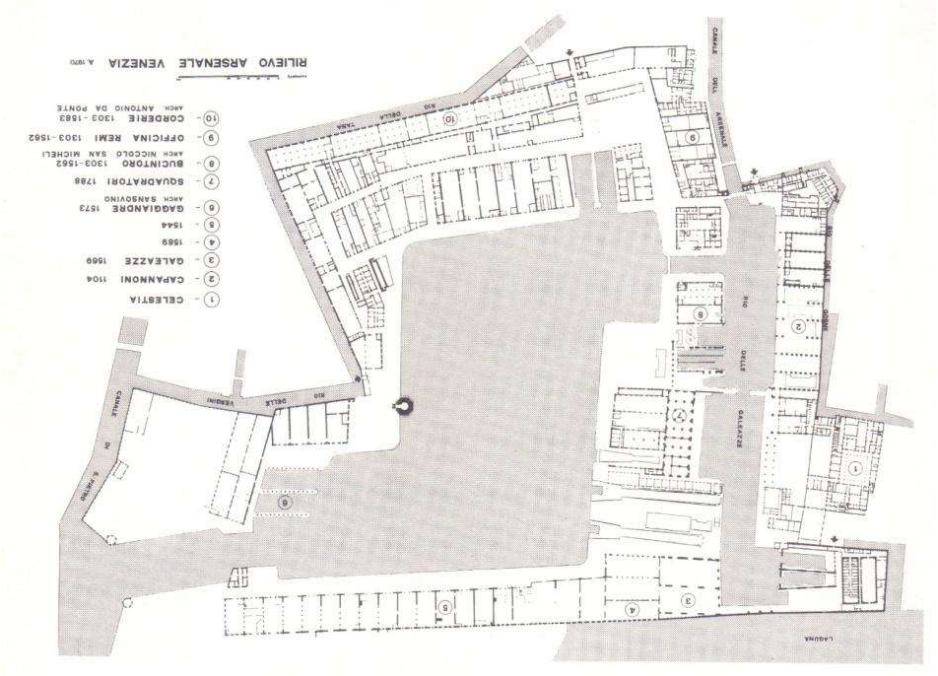


Fig.: The Arsenal today

Venice Arsenal complex was configured, already at the beginning of the 1600s, as it appears today. Today it is owned by the State Public Property, in concession to the Navy Property. Its surface area covers 318,240 square meters of which 90,000 square meters of water from the internal dock.

On the eastern bank, we find the "Bucintoro" building (1547), a construction with a water gate and internal dock for the doge's boat, still used today for boat storage.

On the Arsenal Canal we find the so-called "Officina dei Remi", built around 1303 and rebuilt in 1562; the building is now in disuse but it is made up of three very large structures side by side, with wooden shed roofs.

In the southern part, we find the large "Corderie" building rebuilt to a design by Antonio Da Ponte (1583) today used for events and demonstrations. In the original closing part of the Arsenal towards the lagoon, the walls of 1476 still extend and, towards the interior, the interesting sequence of roofs, called the "Novissima Grande", built in 1527-1544.

Since Venetian power was based on its ships, the availability of wood to supply the Arsenal became a strategic factor and its availability was one of the major concerns for the Republic. As the fleet and the city grew, the need for wood supplies increased in parallel. The few forests in the surrounding areas ran out and so the Venetians began to import wood from Istria and Romagna but, above all, from the Alpine and pre-Alpine arc of Trentino and Belluno. In 1548, the Serenissima went so far as to ban the Cansiglio forest, that is, to reserve it for the exclusive use of the Arsenal, as had already happened with the oaks of Montello: Cansiglio therefore became one of the forests of San Marco. Wood was also the main source of sustenance for the local populations, who specialized in the individual production phases, from felling in the impervious tall forests to transport by carts and sleds, from sawing to rafting. The wood for the manufacture of oars was mainly beech and, later, fir. In Cansiglio there was an initial division into the so-called "stele da remo", a longitudinal sections of

the trunk. Once in the Arsenal, the "stele" was worked by the oar workers who roughed it out and planed it until they reached the finished oar.

3.2 The building of ships

The Galea

The "Galea" or "Galera" is the term that indicates a type of Venetian ship both for war and trade that was used in the Mediterranean for over three thousand years and that can be considered the evolution of the ancient Greek ships, with largely similar shape and functions although smaller in size. Over time, oars arranged in multiple rows (tiers) were used in the galley, thus increasing the number of rowers. The elongated and streamlined shape (its name also derives from the Greek galeas, swordfish) allowed for greater speed, ideal for shortening times in commercial transport, but conferred instability; these boats were therefore used for routes along the coasts, also because there was little internal space to load food and water, which had to be continually replenished.

The Arsenal began to organize itself for the construction of the Galleys starting from the 12th century and soon became the largest production complex in the Mediterranean, up to 20,000 people worked there, becoming a true industrial center in the modern sense, with a real assembly line.

The galley was 5 to 9 meters wide and 15 to 25 meters long. The number of rowers ranged from 10 to 200. The so-called thin galley was more suitable for war, while the large galley was used for commercial voyages. In any case, the presence of sails, even if small in size, was considered an important element that increased, sometimes significantly, the propulsive force of the oars.

After the battle of Lepanto in 1571 against the Ottoman Empire, the decline of the Republic of Venice began and commercial interests gradually shifted from the Mediterranean to the Atlantic routes

towards America, favoring the European countries on the Atlantic coasts, especially England and Spain.

The galley was quickly replaced by the galleon, larger in size and with many sails, more suitable for the open sea and with a large load capacity, while in the Mediterranean the galley was used until the 17th century.

According to a list from 1500, the following wood was needed to build a galley:

– oak wood (rovere): 380 curved beams obtained from trunks 8.5 to 10 feet long and 4 to 5 feet in circumference, for the sides, the bow and the stern wheel;

– 150 straight beams, 24 to 29 feet long, for the keel, the shock absorber, the belt, the floorboards, the upper sleeper, the deck beams;

– 280 boards 1/4-foot-thick sawn from trunks 24 feet long and 4 to 5 feet in circumference, for the planking;

– larch wood (làrese):

– 35 beams 40 feet long and a foot and a hand's breadth in circumference, for the internal sleepers, the false ones and the lanes;

– larch and fir wood (albeo):

– 50 small pieces for the deck equipment, friseti, morti, colomele, portavedi and perteghete;

– 300 planks for the interior and deck;

– elm wood for capstans and mast tops;

– cornel wood (cornial), for the pegs (caece);

– walnut wood for the rudder;

– beech trunks for the oars.

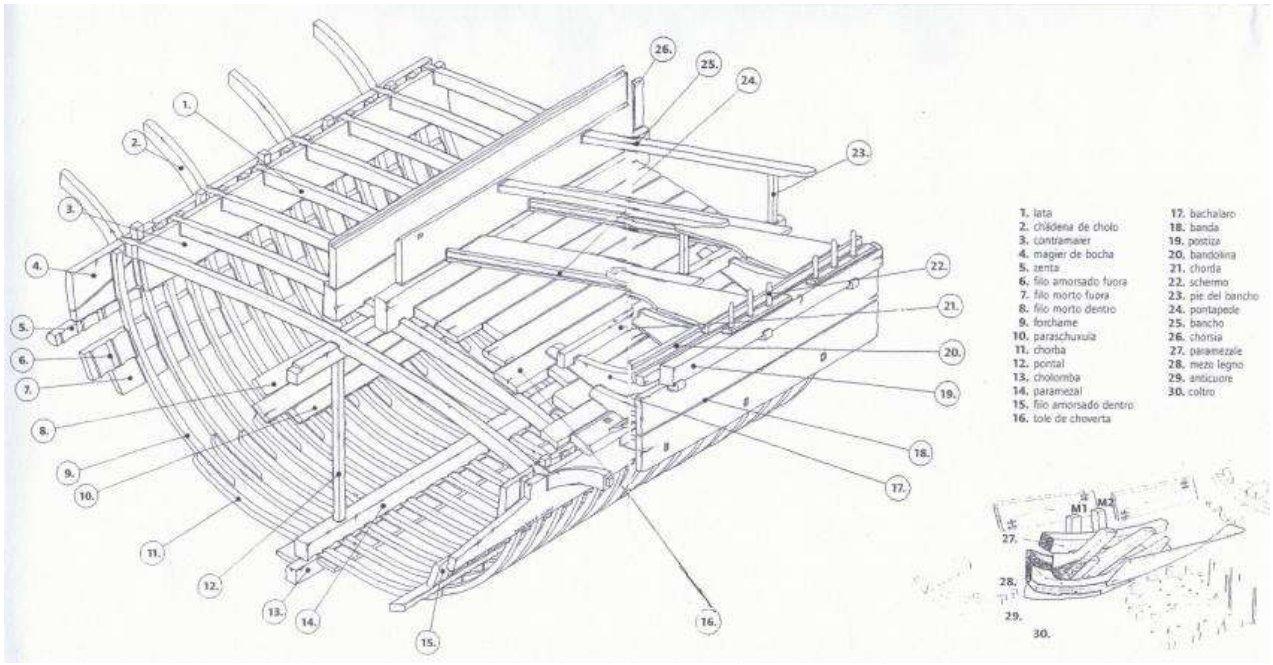


Fig.: components of a Galea
1. lata, 2. chadena de cholo, 3. Contramaier, 4. magier de bocha, 5. Zenta, 6. filo amorsado fuora, 7. filo morto fuora, 8. filo morto dentro, 9. forchame ,10. paraschuxula, 11. chorba, 12. pontal, 13. cholomba, 14. paramezal, 15. filo amorsado dentro, 16. tole de choverta, 17. bachalaro, 18. Banda, 19. Postiza, 20. bandolina, 21. chorda, 22. schermo, 23. pie del bancho, 24. pontapede, 25. bancho, 26. chorsia, 27. paramezale, 28. mezo legno, 29. anticuore, 30. coltro

The rascona

The rascona was a transport vessel, approximately 23.60 m long and 6 m wide, which was used for river and lagoon navigation, but which could also travel short stretches of sea to pass from one river mouth to another. In this vessel, the stern and the bow were slender upwards, almost equal to each other. A characteristic of the rascona was its lightness which allowed, even with a considerable length, to limit the draft to one metre, a fundamental factor when having to navigate on shallow waters.

The rascone were very active in the transport of cereals which took place up the Po to Mantua and Pavia (the rascona was also called the Pavia ship) reaching Milan via the canals. In thirty days these boats covered the route from Mantua to Venice on a navigable canal which, behind the Adriatic lagoons, connected Veneto, lower Friuli and Trieste in a capillary manner. In its movements the rascona was aided when there was wind with small sails; otherwise, like the burchi, it was towed by horses. It was only partially decked and at the stern it had a cabin with a semicircular roof for the crew's accommodation. In 1867 in Venice there were still 80 registered rascone, but at the time this type of vessel was already in decline, so much so that it disappeared at the beginning of the 20th century. With regard to river use, the most immediate reference for the Boccalama model concerns the Brenta, which flowed not far from the island, near which, therefore, a good part of the traffic connecting the river and the lagoon had to pass.

3.3 Construction of oars and "botteghe" (artisan shops)

The oars for the galleys were not made in Cansiglio, but at the Arsenale in Venice: in Cansiglio only a rough semi-finished product (stela) was made, obtained by splitting the trunk lengthwise, into 4 or 8 parts, with the use of wedges.

The oars were generally made from a single piece, although sometimes the roundel (handle) was assembled with the other elements (knee and blade) to make the most of the best trunks and cope with the high demand for material in an emergency. .

For the construction of oars, it was preferable for the trunks to be free of knots and with straight fibres along the entire length, otherwise the oar would bend or break under stress. The diameter of the trunks had to be at least 50 cm: the Venetians spoke of brazzadura, that is, a measure of at least 5 feet (about 174 cm) of trunk circumference measured at the height of a man's chest (about 130 cm

from the ground) to thus obtain for each trunk up to 8 stele, that is, the corresponding planks, in length and thickness, to the rough semi-finished oar to be completed in the Arsenal. Often, however, the average yield of stele per trunk was lower, obtaining about 4 stele per beech, with beech trees that had to be about 120-140 years old.

The oarsmen were those who worked on the stele (slices of beech trunk) to obtain oars of various sizes and blade widths. Some oarsmen built long oars for the ships of the Serenissima, others worked in dozens of workshops scattered around the city for smaller boats, in particular those used for transport in the lagoon (gondolas). The oarsmen in Venice were united in corporations since 1307 (so-called Mariegola) which defined their rules.

In addition to trade, the other great wealth of the city was in fact the artisans who, with their work, transformed raw materials into fine products destined for export throughout Europe.

In Venice the artisan professions were organized into corporations to protect the interests of the members, safeguard the quality of the products, guarantee the State a certain control over any market imbalances. The arts had a headquarters, the school, and a statute, the Mariégola. The latter was a document of capital importance because it defined the rules that all members had to respect: for example, avoiding unfair competition or revealing secrets about specific processes. It also established at what age one could begin the profession and after which tests of skill it was possible to access the qualifications of worker and then master.

Other Venetian arts linked to shipbuilding in addition to the remeri were the marangoni (carpenters), the calafati and the segadori or sawyers; however, the remeri were the most important.

In 1307, the statute proposed by the representatives of the remèri, the craftsmen responsible for making oars and oarlocks, was approved. The legally recognized art of the remèri would last exactly half a millennium: in 1807, in fact, with the Napoleonic domination, all the trade corporations – like

monasteries, convents and brotherhoods – were suppressed and their assets annexed to the state property.

3.4 The types of wood used to make boats

The shipbuilding of a galea is a big project, each naval component was made with a specific wood (oars, spars, curved parts, hull, etc.) from a specific territory.

In the shipyards of the Venice Arsenale, timber was used to build both warships, such as galleys, and merchant vessels. The construction of a single galley required approximately 500 cubic meters of oak wood, 50 cubic meters of conifer wood, and several hundred beech trunks. At the beginning of the 16th century, to maintain its naval power, the Arsenale required more than 20,000 cubic meters of high-quality wood annually, mainly oaks of specific sizes and shapes, as well as several thousand cubic meters of conifer wood. The amount of timber needed for a galley was therefore significant. Oaks were essential for the hull planking and the ship's frame, while larch, fir, and pine were used for the superstructures and the masts. It is estimated that the construction of a galley required over 500 oak boards, both curved and straight, for the frame, nearly 300 planks for the hull, around 50 planks for the interior and deck, 50 fir beams for the deck fittings, and 300 planks for the coverings. Additionally, fir was used for the masts, beech for the oars, and walnut for the rudder.

In any case, given the importance of the forest and the plants for the Serenissima, nothing was wasted. Excluding the most valuable parts of the tree, in terms of size and quality, for the construction of oars, the other wood waste was used not only for minor carpentry work and masonry work, but also as firewood, while the leaves were used to make litter for the animals that were raised by the Venetians also for work (e.g. horses and oxen for the heaviest work also in the Arsenal). As evidence of how careful the Serenissima was in choosing the materials used to build its naval fleet, a table was

found in the documents kept in the State Archives of Venice, which reported the various types of wood and their main uses during the construction of the galleys, and how much material was needed for each type of wood.

So, there were several main types of wood used for the construction of galleys:

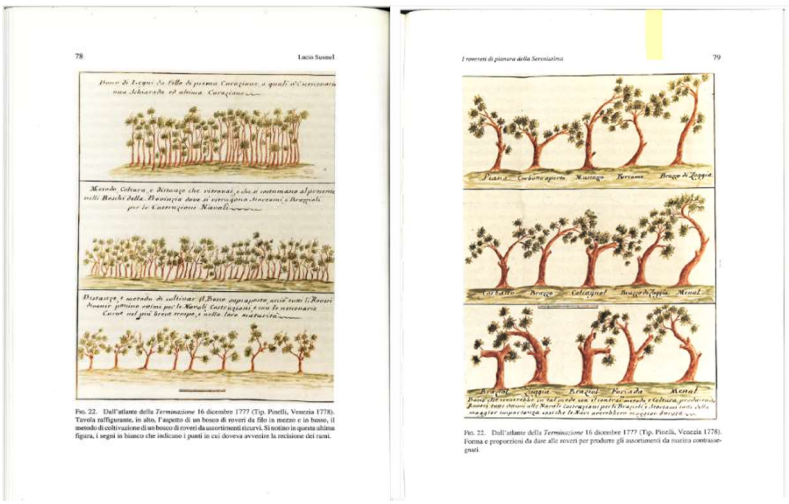
- SILVER FIR (Abies alba), the wood is whitish and with evident annual rings and was used for ordinary carpentry work. The best trunks are used for beams and sometimes the trunks were used for naval masts. Nails for nailing the hull of ships were also obtained from this wood, as in contact with water it increased in volume and the nailing was more tenacious.
- SPRUCE (Picea abies), has whitish wood with evident annual rings and straight grain. It seasons quickly and well and is easy to work. It is not suitable for outdoor use because it is not very durable and difficult to impregnate. It was used for the masts and interiors of ships.
- LARCH (Larix decidua), is a reddish-brown wood, resistant and heavy and provided an exceptional quality wood with good mechanical and aesthetic characteristics. Due to its resistance to atmospheric agents it was used in Venice both outdoors, for building constructions, fixtures, doors, furniture, but also for the beams for ship decks. It also produces an excellent resin known as Venetian turpentine, from which turpentine and essence of turpentine are obtained by successive distillations. The conifers for making the masts and naval antennas came mainly from the forests of Veneto (Somadida BL) and Friuli.
- CASSIA (Cassia), is a type of yellowish wood, very hard even when immersed, but it can easily flake lengthwise. It is usually used for mooring piling.
- MOUNTAIN MAPLE (Acer), has whitish wood with a silky appearance with excellent mechanical characteristics and easy workability. It was used for the interiors of boats.

- DOGWOOD (Cornus mas), is a very hard but light wood. It was used for lathe work or to make tools subject to heavy wear. The entire plant has dyeing properties (yellow) and was used for painting hulls.
- BEECH (Fagus sylvatica), has a light-coloured wood. In its natural state it is not very durable, so it is usually subjected to vaporization, a procedure that makes it less alterable and gives it a darker and reddish colour (evaporated beech). It was widely used, and still is today, for the construction of the shaft of oars which makes it very soft and easier and lighter to row.

The beech trees came mainly from the Cansiglio forest, also known as the San Marco rowing forest, and Montona (Croatia).

- PEPPER and OAK (Quercus sp.), are woods that are difficult to distinguish, both very valuable and durable. It is a warm brown wood that darkens over time. It is long-lasting, beautiful, hard, heavy and elastic, highly sought after for shipbuilding. It is still used today for shipbuilding and hulls. There are seven types of oak wood, but they all have the same function: the use for the hulls of ships and smaller vessels.

The oak trees came mainly from the Montello and lower venetian land.



The drawings of an Atlas of 1777 illustrate the structure of an oak forest in which the plants have already been bent to obtain curved hulls for ships.

- WALNUT (Jugland regia), is a beautiful brown color, often with dark and irregular streaks. It is a wood of great value for its mechanical characteristics, easy to season and good workability. It is used for furniture, but in Venice it was and is used for the construction of oarlocks, or rowlocks, for boats, as it is long-lasting, resistant, moves little and can be bent, but above all it does not damage the oars when rubbed.
- FIELD ELM (Ulmus minor), is a reddish-brown wood and is considered among the most valuable woods. It is easy to work, has good resistance and durability, even if it tends to twist during seasoning. It was used in the shafts (tagliamare) of ships, for rudders and it is still used today by the squeraroli in the construction of gondolas and
- PINES (Pinus sp.), Domestic pine is also soft and resinous, resistant to humidity and it is used in shipbuilding and pile-building. Maritime pine, very similar to the domestic one, is mainly used for the resin, from which turpentine is extracted; Black pine is soft and resinous, resin can be extracted from turpentine. It was used for piling.
- ROBINIA (Robinia pseudoacacia), has a bronze-coloured wood, dense, hard and elastic, very durable and resistant. It was used for poles, fences, ladders and ships, floor strips in blankets and wooden nails.
- LIME (Tilia cordata), coming from mixed mountain forests, has a light-colored wood, white-yellow with reddish-brown shades. Easy to work and plane, lime wood was the favorite material of sculptors, carvers and turners and was used for the creation of interior and decorative parts of ships.