

Navigational Practices and the Use of the Leeboard on Shallow-Draft Riverine and Coastal Craft in the Yangtze and Rhine Estuaries

A Short Essay in Comparative Nautical History

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Abstract

Both in the shallow Yangtze and Rhine deltas, flat-bottomed sailing craft made use of leeboards to prevent the drift of the ship when reaching or sailing close-hauled. Without a doubt, the leeboard was invented earlier in China, but contrary to what is often suggested, the Dutch leeboard was not adopted from the Chinese example. Its invention should be considered an independent act, a case of convergence.

The leeboard was introduced in the Low Countries simultaneously with the adoption of the fore-and-aft 'jib and spritsail' rig and the transformation from narrow to broader ship hulls during the late Middle Ages. Over time the Dutch leeboard was further refined in form: deep and narrow leeboards for seagoing fishing vessels en round and shallow leeboards for the sailing barges and pleasure craft on lakes, canals, and rivers.

Introduction

Geography may influence human life, but it does not determine it. Human life is determined by the ways in which humans avail themselves of the physiographical conditions to improve their standard of living. This common observation is proved by the ways in which the navigators of the shallow estuaries of the Yangtze and Rhine rivers handled their aquatic natural environment. They did so by designing and building various kinds of versatile sailing craft that were suited

to an aquatic environment where transport via rivers and canals was faster, more economical, and more convenient than transport over land. The curiously shaped Chinese junks with their wing-like battened sails as well as the no less characteristic round-bowed, curvy, flat bottomed sailing vessels of the Netherlands with their fore-and aft rigs were each in their own way products of the river deltas in which they originated. While the Low Countries still treasure a large number of, often carefully restored, traditional sailing craft, over the past decades the traditional sailing junks have vanished from China's water world.¹

In traditional Chinese literature, all kinds of vessels are referred to and described, but illustrations are generally rather superficial in execution and tell us little about the many interesting details of the Chinese junks of yore. Apart from observing the moon with a cup of wine on a lake, or visiting flower boats for other moments of leisure, the Chinese literati were not interested in the daily life of the floating world as such. Fortunately, not all is lost. Various foreign mariners gained more in-depth knowledge of China's rich maritime heritage when it was still afloat. They collected and commissioned Chinese ship models, or drew pictures of or photographed all types of Chinese junks they encountered.² In addition to this documentation, elderly Chinese shipwrights, treasurers of age old shipbuilding skills, have recently been commissioned by the newly established Chinese shipping museums in Quanzhou, Ningbo, and Shanghai to build scale models. Life-size replicas have even been constructed or are under construction. China

1 Overviews of Dutch ship types can be found in the classic Cornelis van Yk, *De Nederlandsche scheepbouwkunst open gestalt* (Amsterdam 1697) and in recent works like: T. Huitema, *Ronde en platbodem jachten* (Amsterdam 1973); P.J.V.M. Sopers, *Schepen die verdwijnen* (Amsterdam no date); J. van Beylen, *Schepen van de Nederlanden. Van de late Middeleeuwen tot het einde van de 17^e eeuw* (Amsterdam 1970).

2 I note in passing G.R.G. Worcester, a former inspector of the Chinese Maritime Customs, whose books contain well-executed plans made by his Chinese collaborator Chang Ter Tsing. Unfortunately they show but few construction details; the *Musée maritime* in Paris preserves the *cahiers manuscrits* of Etienne Sigault, a treasury of sketches and notes which still awaits publication, see Eric Reith, 'Les cahiers manuscrits d'Etienne Sigault. Jonques et sampans chinois', *Techniques & Culture, Revue semestrielle d'anthropologie des techniques* 35-36 (2001) 141-174. The Maritime Museum of Rotterdam published the notes of the nineteenth-century French naval officer L. Audemard, *Les jonques Chinoises* (Rotterdam 1970); a very useful overview of Chinese civil engineering and nautics is given by Joseph Needham in his *Science and civilisation in China*. Volume 4, Physics and physical technology. Part III: Civil engineering and nautics (Cambridge 1971); and sublime photographs by D.W. Waters of Chinese junks can be found in: You Zefeng 尤泽峰 and Jiang Bo 姜波 (eds), *The Sampan Girl smiles* 舢板女孩的微笑, (Shanghai 2018), see note 14.

is actually in the process of rediscovering and appreciating its own rich maritime past.³

Traditional modes of propulsion

Before the introduction of engine propulsion, there were basically two ways to propel a vessel: either by animate energy (animal or human) or by wind power. This choice means that ships were moved forward either by tracking (towing) them by a cable from the shore, by quanting (punting) with long poles, by pulling and pushing oars and paddles, or by setting sails to catch the wind. Boatmen and sailors of course also availed themselves of the downward flow of rivers, along with the in- and outgoing tidal movements in the estuaries. In the days of sail, seamen would always heed the tide and, in case sufficient wind was lacking, often anchor during the spell that the tide ran counter to their plotted course.

The Yangtze and the Rhine have served as important arteries of transportation in China and Europe. The higher reaches of the Yangtze river were notorious because of their rapids, but from Wuhan down to the sea the river runs almost flat for 1,000 kilometers until it meets with the coastal waters. This course means that on the lower stretch of the river most water transport was driven by sail or human power. The longitudinal profile of the navigable part of the Rhine River (about 900 kilometers) from Switzerland until the North Sea coast, however, has enough slope to provide descending barges with a bit of speed over the water without any propulsion as far as the Netherlands. This so-called downhill *stevelen* enabled the Rhine skippers to move their ships or rafts four to five kilometers faster than the current of the river. Large rudders and sweeps enabled them to keep the ship on course in the meandering river bends. Yet with the prevailing western winds in the Low Countries, sailing craft could also sail against the river current as far as Cologne.

3 Leonard Blussé, 'Oceanus resartus: or, is Chinese maritime history coming of age?', *Cross-Currents, East Asian History and Culture Review* 25:December (2017) 8-25. (<http://cross-currents.berkeley.edu/e-journal/issue-25>)

The leeboard, a unique invention

Considering that a sailing vessel needs a keel to prevent it from drifting when sailing close to the wind, flat-bottomed sailing vessels theoretically speaking can only properly navigate having the wind abaft. Thanks, though, to the application of leeboards or centerboards instead of a keel, they can also sail close to the wind. The invention of the movable leeboard therefore dramatically improved the navigational capabilities of the flat-bottomed sailing vessels that navigated the delta regions of the Jiangnan region and the Low Countries. This unique contrivance is called *zijwaard* (side-sword) in Dutch and *pishuiban* 披水板 (splitting the water board) or *yaoduo* 腰舵 (hip rudder) in Chinese.⁴ During the Qing dynasty the leeboard was also commonly called *tou qiao* 头樵 (head – i.e., front – sledge). These wooden boards, which are bolted to the hull, can be raised and lowered along the sides of the flat-bottomed vessels. Whenever a ship is sailing close to the wind, the board is lowered on the leeside of the hull to reduce leeway. While tacking, the board on the luff- or windward side, is pulled up to avoid unnecessary drag. The function of the leeboard as a drift reducing device is well expressed in the nautical terms that are used in southeast England and northern France where the board was introduced from the Netherlands: *leeboard* and *semelle de dérive*.

Now that the wooden sailing junks have disappeared in the Yangtze estuary, leeboards have also vanished from Chinese waters. In the Netherlands, however, they still can be seen on traditional yachts and on restored sailing cargo barges and fishing vessels that have been converted into passenger-carrying pleasure craft. While various articles and research notes have been devoted to the use and the particular shape of leeboards in the Low Countries, little has been written so far about the Chinese leeboard.⁵ Because of this lack, it would seem useful to discuss by way of comparison Chinese and Dutch leeboards and to assess their history and their use.

4 The flat-bottomed Thames barge of course derived the use of leeboards from its Dutch sisters.

5 In none of the Chinese maritime journals that I know of has anything been published about the origins, the construction, the typical shape, or even the practical utility of the leeboard in the shallow waters of the Yangtze estuary.

The introduction of leeboards in the Low Countries

How is it that leeboards were only commonly used in China and Holland? Several authors have sought to solve this conundrum by suggesting that the leeboard may have been transferred from China to Europe in the late sixteenth century, when it came into popular use on Dutch waters. The question of convergence (i.e., the independent evolution or invention of the leeboard in the Netherlands) or of diffusion (the Dutch adaptation of the Chinese example) is indeed an interesting one: it has led to heated debates between advocates of the two different processes.⁶ The first documented Dutch visitor to Chinese waters, who according to adherents of the “diffusion theory” would have played an instrumental role in the introduction process, was Dirck Gerritsz Pomp, characteristically nicknamed ‘Dirck China’ by his contemporaries. This native from the port town of Enkhuizen served during the 1580s as a *constabel* (gunner) on board a Portuguese galleon that sailed from Goa in India via Macao to Japan and back. His travel account was included in Jan Huyghen van Linschoten’s famous *Itinerario* published in 1596.⁷ Yet nowhere in his narrative does Pomp mention that he witnessed Chinese junks with leeboards during his stay at Macao. This absence is not surprising because leeboards were not in use in the deep waters of the Pearl River estuary. Junks provided with leeboards could only be witnessed some thousand miles to the north in the shallow river deltas of the Yangtze and Yellow River estuaries. For this reason it is unlikely that Pomp could have acted as a link of practical knowledge about the use of leeboards.

In addition to this, the critical factor of time also would seem to refute that diffusion of knowledge concerning the use of leeboards actually occurred between China and the Netherlands. The first depiction of Dutch sailing vessels with leeboards can already be found on a printed map of the city of Gouda in the famous atlas of cities *Civitates Orbis*

6 On diffusion see: Edwin Doran, ‘The origin of leeboards’, *Mariner’s Mirror* 53 (1967) 39-53; André W. Sleeswijk, ‘Dirck Gerritsz. Pomp and the introduction of the leeboard in Holland’, *The Mariner’s Mirror* 70 (1984) 435-437. On convergence see: A.J.H. Prins, ‘Dutch maritime inventiveness and the Chinese leeboard’, *Mariner’s Mirror* 56 (1970) 349-353; Anton Wegman, ‘Zijzwaarden. Een zestiende-eeuwse innovatie’, *Scheepshistorie* 7 (2009) 56-59; Anton Wegman, ‘De eerste zijzwaarden in Nederland, een innovatie in de zestiende eeuw’, *Spiegel der Zeilvaart* 5 (2012) 7-11.

7 J.H. van Linschoten, *Itinerario: Voyage ofte Schipvaert van Jan Huygen van Linschoten naer Oost ofte Portugaels Indien 1579-1592*. Amsterdam: Cornelis Claesz 1596. John Huighen van Linschoten, *his discours of voyages into y Easte & West Indies*. London: John Wolfe 1598.



Illustration 1 Dutch ship with leeboard. Painting View on Dordrecht, by Pieter Bast 1596
(source: Rijksmuseum Amsterdam, <http://hdl.handle.net/10934/RM0001.COLLECT.75856>)

Terrarum by G. Braun and F. Hogenberg.⁸ This city map must have been drawn several years earlier than 1585, the year of publication, that is, years even before Pomp returned to the Netherlands from Asia. Taking all this evidence in consideration, the invention of leeboards in the Netherlands should therefore be considered an independent act, a case of convergence.

It would now seem logical to turn straight to analyzing more in detail the function of leeboards on sailing ships, that is, the capacity to reduce drift while a vessel is sailing close to the wind. That move, however, would be cutting corners, because in Holland and China leeboards were not merely used on sailing barges but were also used on tow barges to keep them on course parallel to the shore, as will be explained below.

8 R.A. Skelton, Braun & Hogenberg, *Civitates Orbis Terrarum 1572-1618*. Amsterdam: Theatrum Orbis Terrarum, 1965. Vo.II, Parts 3/4, Gouda; Anton Wegman, 'De eerste zijswaarden in Nederland', 8.

Three types of propulsion

In the pre-engine period both in the Netherlands and China, all ways of propulsion – punting, tracking pushing, rowing, and sailing – were often used simultaneously on the same vessel. Let us therefore briefly recapitulate the three ways of propulsion by animate energy (humans and draught animals) which were used in the past.

Tracking or towing along the shore

Along the creeks, canals, and rivers of both the Rhine and Yangtze estuaries, barges were towed by animate energy: in the Netherlands most often horse power was used, while in China the application of abundantly available manpower was standard practice. Here we shall not address the extraordinary dexterity of the Chinese trackers in towing junks through the gorges and whirlpools of the upper Yangtze, but solely focus on the lower reaches of the great river in eastern China. The well-known *Along the River during the Qingming Festival* scroll from the city of Bianjing (today's Kaifeng) in the Yellow River region, executed by the Song dynasty painter Zhang Zeduan (1085-1145), portrays in detail how river craft of all type was towed, punted, and rowed.⁹ On this Song scroll, no leeboards are shown yet, but in another celebrated painting, depicting the *Qingming* festival in the Jiangnan city of Suzhou some 600 years later, a similar prospect is shown, and this time various river craft (with and without sails) are depicted sporting leeboards.¹⁰ Why barges without sails still would be provided with leeboards has to do with the fact that a tracked vessel is much easier to steer and to maneuver thanks to its *yaoduo*, 'hip rudder' (lee- or sideboard), which helps it to keep a straight course parallel to the shore, because it moves the hinge point of the ship forward from the rudder.¹¹ Kurt Schwarz in his historical study of ship types of the Rhine River shows that such side boards were also in use on the Rhine during the Middle Ages.¹²

9 Yang Dongsheng (ed.), Zhang Zeduan, *A riverside scene at Qingming Festival* (Tianjin 2008).

10 Yang Dongsheng (ed.), Chen Mei a.o., *A riverside scene at Qingming Festival by Qing-dynasty court artists* (Tianjin 2008).

11 In Holland during the seventeenth century, special canals (*trekvaarten*) were dug for the purpose of towing sleek, well-designed, easy-to-pull vessels 'for fast passenger and postal traffic' between cities, the so-called *trekschuiten*. Some of these canals still exist although they have lost their main function after the introduction of the railroads and highways for automobile traffic in the nineteenth and twentieth centuries.

12 Kurt Schwartz, *Die Typenentwicklung des Rheinschiffs bis zum 19. Jahrhundert* (Cologne 1928) 34.

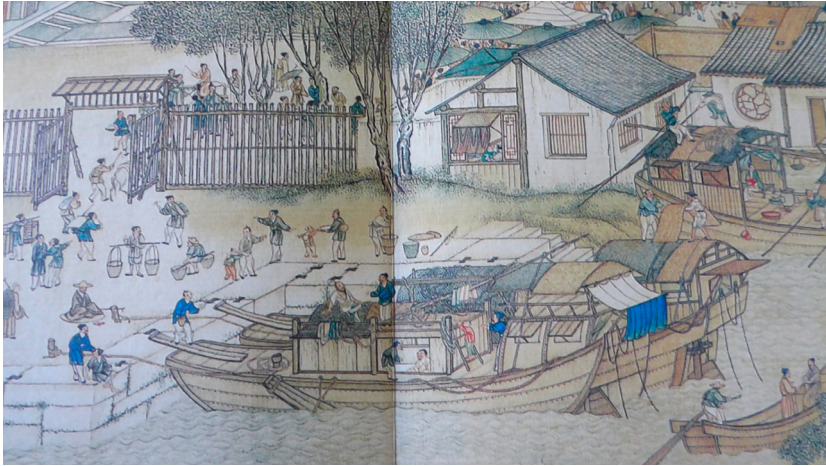


Illustration 2 Qingming scroll ship with leeboard, in: Yang Dongsheng (ed.) *A Riverside Scene at Qingming Festival (Tianjin 2008)* 66.

In the Netherlands, the same aim of keeping small barges on a parallel course in narrow canals, but this time without a leeboard or even the assistance of someone manning the rudder, could be achieved by pushing the *wegering*, a horizontal crossbeam on the foredeck with a pole, while walking on the shore. This so-called *wegeren* technique was practiced by Dutch vegetable growers in the Westland polder region, who used to *push* their flat-bottomed lighter pram, loaded with vegetables along the narrow canals on the way to the auction hall.

Propulsion by punting, rowing, or sculling

Propulsion by punting the ship forward with long poles was and is practiced in the same way in China and the West. The Chinese rowing and sculling techniques are quite outstanding, however. Europeans row their craft in a seated position and, while doing so, rather inconveniently look backwards in the direction of the stern of the boat. They hardly use leg power. The Chinese boatman, however, stands while rowing and actually pushes the oar instead of pulling it. And what is more: he looks forward over the bow and thus observes clearly where he is heading. While in the West only the blade of the oar of a rowboat tips into the water, in China the blade and the oar itself is planted deeply in the water. As a result Chinese manpower is used much more efficiently by the combination of legs, arms, and body weight.¹³ G.R.G. Worcester,

¹³ G.R.G. Worcester, *The junks & sampans of the Yangtze* (Annapolis (MD) 1970) 45, 46.

who devoted part of his working life to the study of Chinese river navigation, draws attention to another rather unique Chinese manner of propulsion. In his engaging book *The Junkman Smiles* he tells that ‘in the good-old-days’ the boatmen of so called ‘foot boats’ – sampans that were used for passenger traffic in the creeks near Hangzhou and Shaoxing – used hands *and* feet at the same time, by rowing in a seated position, using one foot and paddling with both arms.¹⁴

Another special feature of manpower propulsion is sculling. Here again, Worcester points out that the traditional Chinese sculling technique is superior to the European one. Like the Venetian gondolier, the Chinese boatman handles a long oar, the so-called *yuloh* (yaolu 搖櫓), which pivots on the stern and is steadied by a rope connected to the deck. He dexterously moves it like the tail of a fish: ‘the man or woman at the yuloh holds the rope in one hand, and with the other [hand] works the yuloh back and forth in a circular manner.’¹⁵ The traditional European sailor sculls with both hands looking backwards, without using a rope to steady his oar.

Sailing

Both the Dutch and Chinese showed much ingenuity in designing flat bottomed sailing craft fit for use in the shallow waters, varying from freshwater creeks, lakes, and canals in the river deltas to tidal river mouths and saltwater bays. A great variety of typical fishing vessels and freight barges were constructed for special purposes quite often within remarkably restricted geographical parameters, so that one could immediately discern the local origins from their external appearance. In and around the former Zuiderzee, the Dutch inland sea, one could easily count more than a dozen different types of sailing fishing vessels.¹⁶ The same went for the junks of the lower Yangtze area, where C.R.G. Worcester and the French navy officer L. Audemard identified more than a hundred different types of river and coastal craft!

Although designed for the same purpose of navigation in shallow waters, the hulls and the styles of rigging of the flat-bottomed Dutch and Chinese sailing vessels were completely different in appearance and construction. Chinese barges generally derived their longitudinal

¹⁴ Idem, *The junkman smiles* (London 1959).

¹⁵ Idem, *Sail and sweep in China. The history and development of the Chinese junk as illustrated by the collection of junks models in the Science Museum* (London 1966) 12.

¹⁶ Just to name a few: Botter, kwak, schokker, blazer, Wieringer aak, Lemmer aak, schouw, hengst, pluut, Staverse jol, Enkhuizer bol, and so on.

strength from a thick keel plank and five heavy strakes or wales (split poles) on both sides, while transverse strength was derived from bilge frames and bulk heads that served as semi-watertight compartments. Chinese sternpost rudders took shape at a very early date, as a further development of the stern sweep or yuloh. The rudders on the larger Chinese junks in the Yangtze estuary were constructed in a mobile fashion, so that they could be hoisted by means of pulleys and winches when entering shallow waters. As Worcester has remarked, there existed an amazing number and variety of rudders and steering arrangements, each designed for a special kind of use.¹⁷ In Europe, rudders hanging on pintles to the transom also were a later development of the steering oars, but those rudders did not appear until the middle of the thirteenth century, many years later than in China.

Different types of rigging

Both in China and in the Netherlands, the application of leeboards on sailing ships was directly connected with the introduction of fore-and-aft rigs instead of the square sails that since ancient times were used while running free, or as the Dutch say 'met ruime wind', that is, the wind nearly on the quarter, or having the wind abaft. In China, the typical Chinese lug rig, with about 1/6-1/3 of the matted sail before the mast was developed, while in the Netherlands, the combination of jib (foresail) and spritsail or gaff sail came into dominant use. These rigs allowed ships to tack and to sail much closer to the wind than was possible with the original square sails. This capability is exactly what a seventeenth century Dutch introduction to shipbuilding comments: 'Ship swords, perhaps named so because these are carried like a side arm on the side of the ship, serve the ships, that are sailing close to the wind in order to keep them from drifting sideways.'¹⁸ The first pictures of Dutch ships rigged with jibs and spritsails date from the 1490s. They are depicted on one of the choir stalls of the *Oude Kerk* in Amsterdam.¹⁹ In the past, before the introduction of cotton cloth, Chinese sails were generally made of mats attached to rattan battens, while Dutch sails generally were made of flax. The Dutch fore-and-aft rig dating from the Middle Ages consisted of a jib and a spritsail. During the sixteenth

¹⁷ Worcester, *Sail and sweep*, 23.

¹⁸ Van Yk, *De Nederlandsche bouwkunst open gestalt*, 122.

¹⁹ Thanks to Menno Leenstra who pointed this out to me.

century, the spritsail was increasingly replaced by the gaff sail with a small gaff, which could be hoisted and lowered, or by the gaff sail with a long 'standing gaff' (*gaffelaar*), which generally remained in its standing position. In this case, the main sail was like the sprit sail clewed up against the mast when in port or at anchor.

The function of leeboards

For all its advantages to be able to transport heavy loads in shallow waters, a flat-bottomed vessel without a proper keel does not sail well. Due to the absence of sufficient lateral surface under water, it cannot sail close to the wind, because without any lateral grip on the water, it will drift sideways and become unmanageable. Therefore the keel or the leeboard (or centerboard) are indispensable components for a proper sailing ship because they provide the necessary vertical plane of resistance. The draught that keel and leeboard provide permits the sideward movement of the incoming force of the wind in the sails to be translated into a forward movement.

The Dutch *zijzwaard* (side-sword) originally was hung like a single moveable wooden "sword" on the lee side of a small sail boat, but crew members had to remove it and hang it on the other side of the boat after tacking (going about), when the wind would come in over the other side of the bow. This means that the board was always lowered at the leeside, hence the English term leeboard. From there it was a small step to change from *one* single board that had to be moved from one side to the other of the boat to the installation of *two* boards permanently fixed on pintles on either side of the ship. When in the late sixteenth century the leeboard was introduced on sailing barges in the Netherlands, the shape of the hulls of these cargo barges also changed. Originally sharp and narrow river craft were dramatically widened. The sharp bow and stem became rounder, and the ship itself was widened in order to increase the carrying capacity.

Depending on the depth of the water and the size of the waves, different shapes of leeboard were developed in Holland. Fishing vessels sailing in open and deeper water possessed long narrow leeboards, but in the lake districts and on the rivers and canals more roundly shaped boards were used that drew less deeply. Generally speaking the length of the leeboard was equal to twice the depth of the hold of the ship. Over the years, the shapes of the leeboards were improved and more or



Illustration 3 Shanghai Shachuan with leeboard
(source: Matsuura Historical Museum, Hirado, Japan.)

less started to look like bird wings, slightly hollow on the outside and rounded on the inside. On Dutch sailing craft, leeboards are placed at a slight angle of 3-5 degrees alongside the ship to create a lifting effect. Depending on its shape and size, the Dutch leeboard is fashioned from several rectangular planks of oak.

In China, leeboards were introduced possibly as early as the Song dynasty and used as well on sailing junks as on barges that were towed along the shore, hence the interesting term 腰舵 (hip rudder). The Chinese leeboard was made up from several rectangular planks of hardwood, made of *choumu* 桐木 (lithocarpus), *limu* 栗木 (chestnut), or *jumu* 榉木 (beech).²⁰ A ubiquitous type of flat bottomed junk sporting leeboards was the two-masted *shachuan* 沙船, which appeared in various subtypes, such as the *Hangzhou trader* 杭州湾商船, and *Shaoxing trader* 绍兴船. For *Shachuan*, the leeboards were positioned on both sides of the hull slightly in front of the main mast, that is, at two fifths of the whole length from the stern. Various Japanese scrolls

²⁰ The following data I derive from the beautifully illustrated book by You Zefeng 尤泽峰 and Jiang Bo 姜波 (eds.), *The Sampan Girl smiles* 舢板女孩的微笑, 27. The photographs in this book were all made during the 1930s by a British Navy officer, David Willie Waters, whose collection is treasured in the National Museum in Greenwich, UK.



Illustration 4 Traditional Tjotter Yacht with leeboard (photo by the author.)

dating from the seventeenth and eighteenth centuries depict *shachuan* with leeboards among the numerous types of Chinese junks that were sailing the South and East China seas. Apparently the *shachuan* with leeboards from Shanghai were considered seaworthy enough to make the short crossing to Japan. As can be seen from the photographs made by D.W. Waters, the leeboards of the Shaoxing trader were rather crudely fashioned in rectangular shape devoid of the further refinements of their Dutch counterparts.²¹

In conclusion

Much more could be said about the various ways in which the often very heavy leeboards of the larger ships were raised and lowered by hand with the help of ropes and pulleys, or about the various ways in which they were hinged to the hulls of Dutch or Chinese vessels, yet this would lead us away from the basic point that this comparative essay purports to make: the *zizwaard* and *pishuiban* were invented independently of

²¹ Wolfgang Asbach, *Das Shaohsing Ch'uan. Ein traditionelles Schiff in China* (Brilon-Gudenhagen 1991).

one another, and both of them played an important role in optimizing and facilitating the riverine and coastal transport of the Yangtze and Rhine deltas.

About the author

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