

Principles in East Asian Shipbuilding Traditions

by Jun Kimura

Thesis submitted in the fulfilment of the requirement of the degree for
Doctor of Philosophy

Department of Archaeology
Faculty of Education, Humanities and Law
Flinders University

Contents

Abstract	iii
Declaration of Candidature	v
List of Figures	vi
List of Tables	xv
Acknowledgements	xvi
Chapter I - Introduction	1
I-1 Problem orientation	1
I-2 Research aims	4
I-3 Research methods and data collection	4
I-4 Significance of study	5
I-5 Chapter Structures	6
Chapter II - Contexts of East Asian shipbuilding research	9
II-1 Precursor's approaches and resources for understanding the theme	9
II-2 Bulkheads as a hull component of East Asian oceangoing ships	18
Chapter III - Underlying theory and background	29
III-1 Underlying theory on the development of shipbuilding	29
III-2 Environmental condition of seafaring in the <i>East Asian ocean</i>	39
Chapter IV - Shipwrecks and ship remains in East Asia	63
IV-1 Technologies and materials of East Asian watercraft before the tenth century	63
IV-2 Inventory of the shipwrecks and ship remains in East Asia	73
Chapter V - Quanzhou ship	122
V-1 Site background	122
V-2 Overall hull dimension and hull form and basic structure	125
V-3 Cargo stowage	126
V-4 Details of the hull structure	127
V-5 Perspectives the hull construction	149

Chapter VI - Shinan shipwreck	152
VI-1 Site background	152
VI-2 Overall hull dimension and volume of the ship	156
VI-3 Cargo stowage	156
VI-4 Details of the hull structure	158
VI-5 Perspectives on the hull construction	179
Chapter VII - Ship remains from the Takashima underwater site	181
VII-1 Site background	182
VII-2 Previous study of the ship timbers from the site	184
VII-3 Bulkhead remains from the Takashima underwater site	184
VII-4 Anchors	191
VII-5 Other ship timbers recovered from the site	195
VII-6 Characteristics of ship timbers from the Takashima underwater site	196
Chapter VIII - Thematic studies on the excavated ships	200
VIII-1 Hull sturdiness	200
VIII-2 Ship nails	206
VIII-3 Timber analysis	225
Chapter IX - Discussion of hull components	248
IX-1 Elements of hull components of East Asian ships	248
IX-2 Diffusion of East Asian shipbuilding tradition into Southeast Asia	256
Chapter X - Conclusion	263
X-1 Perspectives on East Asian shipbuilding technologies	263
X-2 Principles in East Asian shipbuilding traditions	264
Appendix I	271
Appendix II	272
Appendix III	283
References	286
Glossary	303

Abstract

The archaeological study of excavated ships has significant potential to contribute to the realm of past seafaring and maritime activities in East Asia. This research assesses ship structure and construction methods, highlighting technological innovations identified in thirteenth and fourteenth centuries' ship remains in China, Korea, and Japan. The existence of diverse shipbuilding traditions has been noted within the region. Endemic features in shipbuilding, however, have been understood as a linear evolutionary development. Innovations generate from not only endogenous growth but also exogenous factors. Technological hybridization concerning the use of a hull component from different traditions is a principle involved in shipbuilding technologies.

One such hull component that has been identified by archaeologists and historians in East Asia is the bulkhead. This component has been linked to technological innovations and its importance needs more study. This research pursues the bulkhead in the structure of oceangoing ships in relation to technological innovations, diffusion, and hybridization which formed regional shipbuilding traditions with other factors, such as environmental elements and material availability. The examination of these factors contributes to a wider understanding of the formation of shipbuilding traditions identified as a "Yellow Sea shipbuilding tradition," an "East China Sea shipbuilding tradition," and a "South China Sea shipbuilding tradition." This framework is developed through reviewing primary and secondary historical resources and sites' reports and studies and archaeological investigations, producing a database of excavated ships in the region.

The "Yellow Sea shipbuilding tradition" is primarily identified in ships showing flat bottoms, operating in the northern waters of the Yellow Sea, yet constructed using two different types of transverse components. The early utilization of bulkheads is archaeologically evidenced in the riverine ships dating back to the Tang Dynasty (618-907 A.D.), compared to early East Asian coastal traders using beams in nearby coastal traders of the Goryeo Dynasty (918-1392 A.D.).

Three case studies of archaeologically recovered East Asian ship remains are the focus of this research: the Quanzhou ship, the Shinan shipwreck, and disarticulated ship timbers from Takashima underwater site. Their structure and construction methods are reviewed in detail. The archaeological examination extends to the assessment of their longitudinal and transverse structure, and the type of timbers

and iron nails used for the hulls. The identified technological innovations on these excavated ships suggest an “East China Sea shipbuilding tradition”, which generally shows v-shaped bottoms, keels and bulkheads, and multiple-layered hull planking. Those ships built according to this tradition actively came to be used in seaborne activities within and beyond the region of East Asia and Southeast Asia.

The “South China Sea shipbuilding tradition” has been defined and is reiterated in this research as a type of hybrid ship integrating East China Sea shipbuilding traditions into Southeast Asian (Austronesian) shipbuilding traditions. While the idea of hybrid ships has been presented in previous research, this study traces the formation of such ships as they evolved from, and related to, adjacent shipbuilding traditions including the “Yellow Sea shipbuilding tradition” and the “East China Sea shipbuilding tradition.”

Declaration of Candidature

'I certify that this thesis does not incorporated without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person expect where due reference is made in the text.'

Singed by Jun Kimura

A handwritten signature in black ink, consisting of the Japanese characters '木村淳' (Kimura Jun) followed by a long horizontal stroke.

01/December/2011

List of Figures

Figure 1-1	Location of ships remnants dating to the late thirteenth and early fourteenth centuries, and important areas and cities in this research.	2
Figure 2-1	Prehistoric Viet Khe dugout in the National Museum of Vietnam History. <i>Photo by author</i>	20
Figure 2-2	Cross-sections of the Quanzhou ship (above) and the Shinan shipwreck (bottom). <i>Produced by author</i>	25
Figure 3-1	Historical scroll paint depicting a red seal ship known as Araki bune, sailing to Vietnam. <i>Courtesy of Museum of Maritime Science</i>	38
Figure 3-2	Geographical feature of East Asian waters. <i>From ASTER GDEM</i>	41
Figure 3-3	Image of Sha-chuan depicted in <i>Wu Bei Zhi</i> . <i>From Xi et al</i>	45
Figure 3-4	Scroll paint, <i>Tosen no Zu</i> depicting merchant chips including Nanjing ship (top left), Ningbo ship (top right), Ningbo ship anchoring (middle left), Fuzhou ship built in Fuzhou, departed from Nanjing (middle right), Taiwan ship (bottom left), Guangdong (bottom right). <i>Photo by author, Courtesy of Matsura Historical Museum</i>	46
Figure 3-5	Fuzhou ship built in Fuzhou departed from Guangdong (top left), Guangnan ship (top right), Amoi (Xiamen) ship (middle left), Siam ship (middle right), Calapa (Batavia) ship (bottom left) in the <i>Tosen no Zu</i> . <i>Photo by author, Courtesy of Matsuura Historical Museum</i>	47
Figure 3-6	Nanjing ships depicted in <i>Tosen no Zu</i> (top photo by author) and Kiyo Tojin yashiki Zukei (middle from <i>Oba (ed.) 2003</i>), and drawings of Hanzhou Bay Traders. <i>From Sokoloff 1982</i> (left), <i>Donnelly 1930</i> (right)	48
Figure 3-7	The Punjulharjo ship discovered in Java Province. <i>From Manguin 2009, Courtesy of Ministry of Maritime Affairs and Fisheries</i>	62
Figure 4-1	Reconstructed planked-up dugout canoe at the Osaka Maritime Museum (bottom part consists of a hollowed log). <i>Photo by author.</i>	66
Figure 4-2	Metal fastenings evidenced in the ship remains used as a coffin discovered in the Sui Dynasty's tomb of Zhongshanwang, and the reconstructed ship lines of the ship. <i>From Xi 2000</i>	68
Figure 4-3	Plan of the Rugao ship. <i>From Wang 2000</i>	71
Figure 4-4	Plan and cross section of the Shiqiao ship. <i>From Xi 2000</i>	71
Figure 4-5	Plan of the Dazhi boat. <i>From Ji 1987</i>	75
Figure 4-6	Plan and cross-section of the Yuanmengkou ship. <i>From Xi 2000</i>	76
Figure 4-7	Plan and cross-section of the Fengbinyang Bay ship and its photograph showing the use of a bracket fastening the hull planks and bulkhead planks together. <i>From Wang 2000.</i>	78

Figure 4-8	Plan of the Fashi ship and its photographs showing the limber and the brackets fixed onto the bulkhead planks. <i>From Xi, Yang, et al. 2004</i>	79
Figure 4-9	Plan and photographs of the Heyilu ship. <i>From Gong, C., Ding, Y., et al. 2008</i>	80
Figure 4-10	Plan and cross-section of the Ningbo ship and cross sections, and a photograph of the exposed hull. <i>From Green 1997</i>	83
Figure 4-11	Underwater photograph from the top view of the Huaguang Reef No.1 shipwreck. <i>Courtesy of the Research Centre for Underwater Archaeology, in China</i>	83
Figure 4-12	Plan of the Nankai River ship. <i>From Wang 2000.</i>	88
Figure 4-13	Plan of the Penglai ship No.1 and diagrams showing the use of metal brackets to secure hull planks and a bulkhead plank, a hook scarf of the hull planks, and two different nails (the skewed and edge driven nails) fastening the hull planks. <i>From Xi 1989 and Cultural Relics and Archaeological Institute of Shandong Province, Yantai Municipal Museum, et al. 2006</i>	89
Figure 4-14	Cross-section of the Liangshan Ming Dynasty ship. <i>From Xi, Yang, et al. 2004</i>	92
Figure 4-15	Plan and cross section of the Xiangshan Ming Dynasty shipwreck. <i>From Xi, Yang, et al. 2004</i>	94
Figure 4-16	Plan of the Penglai ship No.2 <i>From Cultural Relics and Archaeological Institute of Shandong Province, Yantai Municipal Museum., et al. 2006</i>	95
Figure 4-17	Plan of the Penglai ship No.3 <i>From Cultural Relics and Archaeological Institute of Shandong Province, Yantai Municipal Museum., et al. 2006</i>	96
Figure 4-18	Plan of the Penglai ship No.4 <i>From Cultural Relics and Archaeological Institute of Shandong Province, Yantai Municipal Museum., et al. 2006</i>	99
Figure 4-19	Cross-sections of the Wando ship (the end 11th - early 12th century), Sibidongpado ship (the end 11th - the early 12th century), and Talido ship (13-14th century).	104
Figure 4-20	Plan and cross section of the Wando ship. <i>From Green 1989</i>	105
Figure 4-21	Plan and cross section of the Sibidongpado ship and photographs of the bow planks' remains. <i>From National Maritime Museum of Korea 2005b</i>	107
Figure 4-22	Drawing of the remains of the Taean ship. <i>From National Maritime Museum of Korea 2009</i>	108

Figure 4-23	Drawing of the remains of the Daebudo ship. <i>From National Maritime Museum of Korea 2008a</i>	109
Figure 4-24	Drawing of the remains of the Talido ship. <i>Courtesy of the National Maritime Museum of Korea</i>	110
Figure 4-25	Plan and the cross section of the Anjwa ship, diagrams showing the butts of the bottom and side strakes, and photographs showing bow and stern structure. <i>From National Maritime Museum of Korea 2006, Shiplines drawn by author</i>	112
Figure 4-26	Structure and construction methods of the 20th century Korean fishing ship recorded by Horace H. Underwood. <i>From Underwood 1979</i>	113
Figure 4-27	Scale model of the Sekibune that was made based on historical and iconographical resources. <i>Photo by author, Courtesy of Matsuura Historical Museum</i>	116
Figure 4-28	Image of the early 19th century Bezaisen and drawing and photograph of the remains of the rudder post. <i>Produced by author</i>	118
Figure 4-29	Drawing of the remains of the timber discovered from Nishihama in Ngasaki city. <i>Produced by Kashiwagi Kazuma from Kimura 2010c</i>	118
Figure 5-1	Discovered location of the Quanzhou ship at the Houzhu Harbour. <i>From Museum of Overseas Communication History 1987</i>	123
Figure 5-2	Exposed hull of the Quanzhou ship during excavation. <i>Courtesy of Museum of Overseas Communication History</i>	124
Figure 5-3	Reconstruction of the dismantled hull of the Quanzhou ship at the Kaiyuan temple. <i>Courtesy of Museum of Overseas Communication History</i>	125
Figure 5-4	Plan of the Quanzhou ship. <i>Courtesy of Museum of Overseas Communication History</i>	126
Figure 5-5	Stern of the current hull. <i>Photo by author</i>	128
Figure 5-6	Stern of the Quanzhou ship recorded in an old photograph taken during the excavation. <i>Photo by author.</i>	128
Figure 5-7	Modern iron nail seen at the bottom of the hull. <i>Courtesy of Museum of Overseas Communication History</i>	129
Figure 5-8	Scarf of the keel showing circular holes to place coins and a mirror. <i>Courtesy of Museum of Overseas Communication History</i>	130
Figure 5-9	Bow from the front view of the Quanzhou ship. <i>Photo by author</i>	131
Figure 5-10	Stern from the aft side of the Quanzhou ship. <i>Photo by author</i>	131
Figure 5-11	Plan of the planking arrangement showing the positions of the iron brackets and butt. <i>After Burningham, N. and J. Green 1997</i>	133
Figure 5-12	Long scarf joint that only appears in the ninth strake between Bulkhead No. 10 and No.11 at the starboard side. <i>Photo by author</i>	133

Figure 5-13	Three layered hull planks showing rabbeted seams in the innermost planks. <i>Courtesy of Museum of Overseas Communication History</i>	134
Figure 5-14	Clinker steps of the plank-shell from the combination of the rabbeted carvel seams and rabbeted clinker. <i>After Burningham, N. and J. Green 1997</i>	135
Figure 5-15	Degraded metal object found from the hull, said to be a nail punch. <i>Courtesy of Museum of Overseas Communication History</i>	136
Figure 5-16	Cross-sections showing the remains of the bulkhead planks and brackets. Bulkhead No.8 (<i>Top image</i>) presents the use of the large frame in the forward side and the brackets in the aft side, and the same arrangement appears from the Bulkhead No.7 to No.12 (<i>Right side images</i>). Bulkhead No.1-6 (<i>Left side images</i>) have the brackets in forward side and large frames in aft side.	138
Figure 5-17	Stopped scarf joint of the bulkhead plank fastened by an iron clamp <i>Courtesy of Museum of Overseas Communication History</i>	139
Figure 5-18	Iron clamps fastening bulkheads planks together. <i>Courtesy of Museum of Overseas Communication History</i>	139
Figure 5-19	Bulkhead stiffener partially remains in the bottom of the hull. <i>Courtesy of Museum of Overseas Communication History</i>	139
Figure 5-20	Wooden strips standing in the Bulkhead No. 10 and No.11 representing the reconstruction of the bulkhead stiffeners. <i>Photo by author</i>	140
Figure 5-21	Fairing laths sitting on the inside at each clinker step. <i>Photo by author</i>	140
Figure 5-22	Photograph showing the degraded bottom bulkhead plank. <i>Courtesy of Museum of Overseas Communication History</i>	141
Figure 5-23	Bilge boards (or bottom ceiling planks). <i>Photo by author</i>	141
Figure 5-24	Bulkhead plank has the recess for a metal bracket to be attached where corrosion and a nail hole can be seen. The nail might have been driven diagonally upward. <i>Photo by author</i>	142
Figure 5-25	A part of the bulkhead plank, indicated by a circle, barely shows the evidence of recessing but not completed. <i>Photo by author</i>	143
Figure 5-26	Square nail hole identified in the inner hull plank. <i>Photo by author</i>	144
Figure 5-27	Top view of the Bulkhead No.1 that has original half-frames. <i>Photo by author</i>	145
Figure 5-28	Large half-frames attached into the bulkheads. <i>Courtesy of Museum of Overseas Communication History</i>	146
Figure 5-29	Old photograph of the forward mast step after excavated. <i>Courtesy of Museum of Overseas Communication History</i>	147

Figure 5-30	Old photograph of the main mast step after excavated. <i>Courtesy of Museum of Overseas Communication History</i>	147
Figure 5-31	Timber discovered around the stern. Its purpose of use has not been determined. <i>Courtesy of Museum of Overseas Communication History</i>	148
Figure 5-32	A cylinder shape timber, which might have been a part of the windlass. <i>Courtesy of Museum of Overseas Communication History</i>	148
Figure 5-33	Radiocarbon date's probability on the specimen, "Sample. 1".	150
Figure 5-34	Radiocarbon date's probability on the specimen, "Frame".	150
Figure 6-1	Discovered location of the Shinan shipwreck in the waters of the Shinan archipelago. <i>From National Maritime Museum of Korea 2006b</i>	153
Figure 6-2	Cross-section showing the buried state of the Shinan shipwreck. <i>Courtesy of National Maritime Museum of Korea</i>	154
Figure 6-3	Plan of the hull. <i>Courtesy of National Maritime Museum of Korea</i>	155
Figure 6-4	Diagram of the excavation using a grid system to record the cargo location. <i>After National Maritime Museum of Korea 2006b</i>	157
Figure 6-5	Woods, one of the major cargo of the ship, could be stored in the hull to function as dunnage. <i>Photo by author</i>	158
Figure 6-6	Keel members. <i>Courtesy of National Maritime Museum of Korea</i>	159
Figure 6-7	Joined keel members, showing a hog. <i>Courtesy of National Maritime Museum of Korea</i>	159
Figure 6-8	Hooked scarfs of the keel join, secured by a wooden pin and iron clamps. <i>Courtesy of National Maritime Museum of Korea</i>	160
Figure 6-9	Diagram showing driven nails into the keel, garboards, and Photograph of the bottom bulkhead plank showing the driven nails. <i>Courtesy of National Maritime Museum of Korea, photo by author</i>	161
Figure 6-10	Drawing and photograph of the bow transom. <i>From National Maritime Museum of Korea 2004, Photo by author</i>	162
Figure 6-11	Baulk on the inside at the starboard in the bow. <i>Photo by author</i>	163
Figure 6-12	Hull planking arrangement in fore part of the hull: rabbeted clincker changing to rabbeted carvel. <i>Courtesy of National Maritime Museum of Korea</i>	164
Figure 6-13	Butt joints (lap joint and tongue and groove joint) tighten by butt straps. <i>Courtesy of National Maritime Museum of Korea</i>	165
Figure 6-14	Butt strap attached into the bulkhead plank. <i>Photo by author</i>	165
Figure 6-15	Reconstructed image of the coaming structure. <i>Courtesy of National Maritime Museum of Korea</i>	166
Figure 6-16	Sheathing plank that has been covering the hull. <i>Photo by author</i>	167
Figure 6-17	Diagram of the scarf joint of the hull planks fastened by iron clamps. <i>Produced by author</i>	168

Figure 6-18	Profile showing the position of the bulkheads. <i>Courtesy of National Maritime Museum of Korea</i>	169
Figure 6-19	Cross-section showing floors into which the end of the large half-frame slot. <i>Courtesy of National Maritime Museum of Korea</i>	170
Figure 6-20	Drawing of bulkhead planks from the Bulkhead No.1 (<i>Top left image</i>) to the stern transom (<i>Bottom right image</i>). <i>Courtesy of National Maritime Museum of Korea</i>	171
Figure 6-21	Tenon used for the joint of the bulkhead planks. <i>Photo by author</i>	172
Figure 6-22	Vegetable fibre identified in the seam of the bulkhead planks. <i>Photo by author</i>	172
Figure 6-23	Half-frames of the aft side of the Bulkhead No.1-3. <i>Photo by author</i>	173
Figure 6-24	Limber cut in the bottom end of the frame. <i>Photo by author</i>	173
Figure 6-25	Drawing of the half-frame showing irregular distribution of the nails. <i>From National Maritime Museum of Korea 2004</i>	174
Figure 6-26	Bird's eye view from the aft side of the hull showing arrangement of the frames and brackets. <i>From National Maritime Museum of Korea 2004</i>	174
Figure 6-27	Wooden brackets fastened into the surface of the bulkhead planks. <i>Photo by author</i>	175
Figure 6-28	Wooden brackets. <i>Photo by author</i>	175
Figure 6-29	Drawing of the foremast step. <i>Courtesy of National Maritime Museum of Korea</i>	177
Figure 6-30	Drawing of the mainmast step and photograph of the mainmast step from top view. <i>Courtesy of National Maritime Museum of Korea, Photo by author</i>	177
Figure 6-31	Photograph showing a drainage hole in the tank. <i>Photo by author</i>	178
Figure 6-32	Drawing of the tank. <i>Courtesy of National Maritime Museum of Korea</i>	178
Figure 6-33	Wooden bracket to fix the tank <i>Photo by author</i>	179
Figure 7-1	Takashima located in the Bay of Imari, Nagasaki Prefecture	181
Figure 7-2	Two bulkhead planks recovered from the Takashima underwater site <i>Courtesy of Takashima-cho Board of Education</i>	185
Figure 7-3	Drawing of the bulkhead plank No.1439 (lower image) and No. 1440 (upper image). <i>Photo by author</i>	185
Figure 7-4	Nail holes on the end of the bulkhead plank No. 1439. <i>Photo by author</i>	186
Figure 7-5	Degraded nail remains on the end of the bulkhead plank No. 1439. <i>Photo by author</i>	186
Figure 7-6	Nail that has been diagonally driven from the surface to the lower seam. <i>Photo by author</i>	187

Figure 7-7	Edge of the lower seam of the No. 1439 plank has recesses and holes which probably relate to fastenings that have secured the seam of the bulkhead planks. <i>Photo by author</i>	188
Figure 7-8	Two large recesses in the upper part of the No. 1440 plank. <i>Photo by author</i>	189
Figure 7-9	Nail holes and degraded nail on the end of the No. 1440 plank. <i>Photo by author</i>	190
Figure 7-10	Small nail holes identified on the surface of the No. 1440 plank.	190
Figure 7-11	Drawing of Anchor No.3 <i>After Takashima-cho Board of Education 1996a</i> and photo of the wooden anchor after conservation treatment by PEG. <i>Photo by author</i>	193
Figure 7-12	A set of stone anchor stock for the compound anchor. <i>Photo by author</i>	194
Figure 7-13	Shank of the compound anchor stored in the Museum of Overseas Communication History. <i>Photo by author</i>	195
Figure 8-1	Ship lines of the Quanzhou ship. <i>From Burningham, N. and J. Green 1997, Courtesy of Western Australian Museum</i>	200
Figure 8-2	Ship lines of the Shinan shipwreck. <i>Produced by author</i>	201
Figure 8-3	Modified buttock lines (<i>left image</i>) and non-modified buttock lines (<i>right image</i>) which does not show smooth transition of the lines. <i>Produced by author</i>	202
Figure 8-4	Reconstruction of the arrangement of the sheathing planks. <i>Courtesy of National Maritime Museum of Korea</i>	203
Figure 8-5	Photograph of the degraded iron nails from the Quanzhou ship. <i>Courtesy of Museum of Overseas Communication History</i>	213
Figure 8-6	Photograph of the exposed seams of the uppermost planks of the Quanzhou ship, showing location of nail holes. <i>Photo by author</i>	213
Figure 8-7	Piece of the hull plank SW-82-182 from the Shinan shipwreck, showing its rabbeted seam. <i>Photo by author</i>	216
Figure 8-8	Cross-section of the nail remaining in the exposed seam. <i>Photo by author</i>	216
Figure 8-9	X-ray image showing remains of the nail. <i>Courtesy of National Maritime Museum of Korea</i>	217
Figure 8-10	CT-scan image showing remains of the nail. <i>Courtesy of National Maritime Museum of Korea</i>	217
Figure 8-11	Photograph of the sheathing plank used as a specimen for CT-scan. <i>Courtesy of National Maritime Museum of Korea</i>	218
Figure 8-12	CT-scan image of the sheathing plank showing the evidence of the use of five nails. <i>Courtesy of National Maritime Museum of Korea</i>	218

Figure 8-13	Photo image and CT-scan image of the batt plate. <i>Courtesy of National Maritime Museum of Korea</i>	219
Figure 8-14	Specimen cut from the hull plank SW-82-182. <i>Photo by author</i>	220
Figure 8-15	Exposed sections of the degraded nail remaining in the specimen and its microscopic images. <i>Courtesy of Kyushu Techno Research, Inc</i>	221
Figure 8-16	Degraded nail from the bulkhead plank No. 1440. <i>From Takashima-cho Board of Education 2005</i>	222
Figure 8-17	Specimen, “Sample.1” provided by Museum of Overseas Communication History. <i>Photo by author</i>	230
Figure 8-18	Specimen, “Sample.2” provided by Museum of Overseas Communication History. <i>Photo by author</i>	230
Figure 8-19	Specimen, “Frame” provided by Museum of Overseas Communication History. <i>Photo by author</i>	230
Figure 8-20	Microphotographs of the specimens for wood species identification. <i>Courtesy of Forestry and Forest Products Research Institute</i>	231
Figure 9-1	Plan of the Bangkachai II Shipwreck. <i>Courtesy of Thai Underwater Archaeology Division</i>	258
Figure I-1 (Appendix)	Drawing of the No. 9, 15, 18, and 19 planks. <i>From Takashima-cho Board of Education 2001</i>	273
Figure I-2 (Appendix)	Drawing and photo image of the KZK01 No.193 plank. <i>From Takashima-cho Board of Education 2008 and Sasaki 2008</i>	274
Figure I-3 (Appendix)	Drawing and photo image of the No.221 plank. <i>From Takashima-cho Board of Education 2008 and photo by author</i>	275
Figure I-4 (Appendix)	Drawings and photo images of the No.601, 909, and 949 planks. <i>From Takashima-cho Board of Education 2008 and courtesy of Takashima-cho Board of Education</i>	277
Figure I-5 (Appendix)	Drawing of the No.1035 plank. <i>From Takashima-cho Board of Education 2008</i>	278
Figure I-6 (Appendix)	Photo images and cross-section showing a driven nail of the No.1142 planks. <i>Photo by Sasaki and author</i>	278
Figure I-7 (Appendix)	Drawing and photo image of the No.1476 plank. <i>From Takashima-cho Board of Education 2008 and photo by author</i>	279
Figure I-8 (Appendix)	Drawing and photo image of the No.1607 plank. <i>From Takashima-cho Board of Education 2008 and photo by author</i>	280
Figure I-9 (Appendix)	Drawing and photo image of the No.1863 plank. <i>From Takashima-cho Board of Education 2008 and photo by author</i>	280
Figure I-10 (Appendix)	Photo image of the TKS13- No.8 plank. <i>Produced by author</i>	281

Figure I-11	Drawing of the No. 16 (Large piece) and No.17 (Small piece) planks.	
(Appendix)	<i>From Takashima-cho Board of Education 2004</i>	281
Figure I-12	Drawing of the TKS14- No.26 plank. <i>From Sasaki 2008</i>	
(Appendix)		282

List of Tables

Table 3-1	Dimensions of Chinese ships recorded on the <i>Tosen no Zu</i> .	50
Table 5-1	Radiocarbon dates of the ship timber samples from the Quanzhou ship.	150
Table 6-1	Planks tires and the space of the holds.	168
Table 7-1	Remains of the components of the composite anchors. <i>From Takashima-cho Board of Education 1996</i>	192
Table 8-1	Iron production methods developed in early China. <i>From Osawa 2004</i>	208
Table 8-2	Description of the iron nails of the bulkhead planks from the perspective of their metallurgical study perspective. <i>From Osawa 2005a</i>	222
Table 8-3	Chemical components of an iron ingot from the Avraga Site as a comparable resource for the nail of the Takashima underwater site. <i>From Osawa 2005b</i>	223
Table 8-4	Types of woods used for the timbers from the Quanzhou ship, Shinan shipwreck, Takashima underwater site. <i>Original data from previous site reports: Museum of Overseas Communication History 1987, National Maritime Museum of Korea 2004, Takashima-cho Board of Education 2008</i>	227 228
Table 8-5	Result of wood species identification on timber samples recovered from the Quanzhou ship in 2009.	229
Table 8-6	Assemblage of the wood species of the timbers from the Takashima underwater site. <i>after Takashima-cho Board of Education 2008</i>	234
Table 8-7	Woods used for the Penglai shipwreck No.1, 2, 3, and 4.	239
Table 8-8	Woods used for the Goryeo Dynasty's ships.	240
Table 8-9	Density and hardness of the woods.	243

Acknowledgements

This research would never have been completed without the support from organizations and individuals listed below.

This PhD research has been fully supported by the Endeavour Postgraduate Award provided by Australian Government during the period of 2007-2011 with its administrative assistance from the Austrailing International. The Mishima Kaiun Memorial Foundation provided the research with research grant to conduct fieldworks in overseas. Part of result of this research includes the result of the outcomes of a project financially assisted by the Toyota Foundation. Further funding has been obtained through a number of research grants available at Flinders University.

During the fieldwork in China, I obtained full-support from staff of the Quanzhou Maritime Museum (Museum of Overseas History Communication), and I would like to express my gratitude to Dr. Ding, Yuling and Wang, Feng. During the fieldwork in Korea, the staff of the National Research Centre of Marine Cultural Heritage (National Maritime Museum) provided in-kind support, and I want to thank Seong, Nack-Jun and Lee, Chul-han. I have greatly benefited from the staff of Matsuura city for their support during my research in Takashima. A part of the data presented in this research has been obtained through cooperation with Drs. Noshiro, Shuichi and Abe, Hisashi from the Forestry and Forest Products Research Institute and Osawa, Masami from the Kyushu Techno Research Inc. My appreciation extends to experts and members of the following organizations for their support: Asian Research Institute of Underwater Archaeology, Australasian Institute for Maritime Archaeology, École française d'Extrême-Orient, Department of Maritime Archaeology of Western Australian Museum, Institute of Nautical Archaeology at Texas A&M University, Ministry of Marine Affairs and Fisheries of Republic of Indonesia, National Museum of the Philippines, Shipbuilding History Research Centre at Wuhan University, Thai Underwater Archaeology Division of Fine Arts Department.

I especially thank the following individuals for their generous support during the fieldwork, including Randall Sasaki, Amer Khan, and Nicholas Burningham who provided insightful advice and feedback during this research. To colleagues during my candidature, James Hunter, Debra Shefi, Adam Paterson, Jason Raupp, and Robert Stone I owed thanks. I owe a very important debt to Kelvin Rodrigues for his editing work. Finally, Dr. Mark Staniforth, Dr. Jeniffer McKinnon, and Jeremy

Green are acknowledged for their supervision based on their expertise. My appreciation also extends many people who are not listed here and who helped me during the period of the four years of research and during the period extending to the last decade, as some of the data used in this research are from the excavations I participated in more than ten years ago.