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Technological continuity and change: A study of cultural adaptation in pram-class boatbuilding in the Netherlands

Neyland, Robert Stephen, Ph.D.

Texas A&M University, 1994
TECHNOLOGICAL CONTINUITY AND CHANGE:
A STUDY OF CULTURAL ADAPTATION
IN PRAH-CLASS BOATBUILDING IN THE NETHERLANDS

A Dissertation
by
ROBERT STEPHEN NEYLAND

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

August 1994

Major Subject: Anthropology
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August 1994

Major Subject: Anthropology
ABSTRACT

A Study of Cultural Adaptation
in Pram-Class Boatbuilding in the Netherlands.
(August 1994)
Robert Stephen Neyland,
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This study traces the development of an ancient class of Northern European watercraft, called pram. The term pram-class is used herein to refer to a broad range of flat-bottom, hard-chine work boats and freighters. The vessels categorized as pram-class are also known by a variety of local names, but share a characteristic construction justifying their collective analysis.

Pram-class watercraft can be found throughout much of Northern Europe, however it is the archaeological remains of pram-class vessels from the Netherlands that are principally analyzed here. Prams and pram-class vessels span the Late Middle Ages through the twentieth century, but vessels built with some of the pram's characteristics date to the late Roman occupation along the Rhine. As a long-lived type of watercraft, prams provide an opportunity to study technological continuity and change in boatbuilding over the formative centuries of Western history.

The theoretical approach applied to this study is that of cultural adaptation. Within this approach, special attention is focused upon the technological adaptation exhibited in pram-class construction. This
analysis views boat design and water transportation as determined by several interrelated and interdependent factors; factors that include economics, technology, culture, access to resources, and the physical environment.

Two hypotheses are applied to the history of prams. The first hypothesis considers the specific development and use of pram-class vessels to be the result of a number of influences, which are primarily cultural, economic, technological, and resource factors. These interrelated and interdependent factors exist as parts of a system of information feedback loops, which influenced the building and continued employment of pram-class vessels. The second hypothesis states the more general view that technological continuity and change result from the process of cultural adaptation. Economic and cultural factors, as well as access to resources and the physical environment, act to stimulate technological innovation or reinforce continuity.

The historic development of pram-class vessels is closely tied to the development of the local economy. Changes in the local economy during cycles of prosperity and crisis influenced the quantity of prams produced and the manner in which they were built. The history of Dutch pram-class boats thus demonstrates technological adaptation in response to several factors. Factors in water transportation in turn influenced cultural and economic adaptations.
ACKNOWLEDGEMENTS

I would like to express my special appreciation to the Center and Museum for Shiparchaeology in Ketelhaven. Without their support for research and encouragement this study would have been impossible. Jaap Morel, Director, and Rob Oosting, Head of Research, have been constant advocates in support of both archaeological field work and analysis. Karel Vlierman, Curator, and Lucas van Dijk, Conservator, have also been especially supportive. Many members of the staff and other individuals in the Netherlands have provided important information and discussions about ship construction and Dutch maritime culture that is used in this dissertation. Several of their personal communications are cited within this work. Expenses for research and training in the Netherlands were provided by the Center through the International Association for the Exchange of Students for Technical Experience (IAESTE). The Center also funded all expenses for the 1992 and 1993 excavations and conservation of artifacts.

The final months of writing the dissertation have been tough financially and I wish to thank Velma Neyland, my mother, and Jim and Margaret McLaughlin, my wife's parents, for helping us to keep our heads above water. Since moral support can be as important as financial assistance, I would like to thank the members of my committee for their comments and assistance. Special appreciation is extended to Drs. David Carlson, Kevin Crisman, and Vaughn M. Bryant, Jr. for giving important career advice and encouraging me to finish. Finally, I would like to thank my wife for assisting with the illustrations, proofreading, and simply putting up with all of it.
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CHAPTER I
INTRODUCTION

The history of an ancient Northern European inland watercraft, called pram in English or in Dutch praam, is the topic of this study. Prams are flat-bottomed, hard-chine work boats and freighters designed for shoal-water navigation. There is a broad range of related watercraft fitting this description but having many different names; therefore, vessels that conform to the pram type are referred to in this study as pram-class. Pram-class vessels are found throughout much of northern Europe, but this study deals chiefly with archaeological examples from the Netherlands. Most of the shipwrecks discussed within this study were excavated in the IJsselmeer polders, reclaimed tracts of land formerly covered by waters of the Almere during the Middle Ages and the Zuiderzee in the Postmedieval Period (Fig. 1).

Prams and pram-class vessels span the medieval era through the twentieth century. The use of the name pram dates to the Late Middle Ages, but prototypes of pram-class vessels were used on the network of rivers along the Roman western frontier and date to the second century.
Figure 1. Locations of ship and boat wrecks discussed within this study. (Drawing by author.)
A.D. These are the earliest archaeological evidence of plank-built vessels in this region.

Prams represent a long-lived class of boats, the significance of which is explored through an analysis of technological continuity and change in the pram design and the relationships between water transportation, economy, resources, environment, technology, and culture. This study employs two hypotheses specific to the history of prams. The first hypothesis is specific to the historic development and use of pram-class vessels and interprets their development as the interaction of cultural, economic, technological, and resource factors. These factors are interrelated and interdependent, occurring as a system of information feedback loops, which influenced the building and use of prams over their history.

The second hypothesis is closely related to the first, but more general in that it treats technological continuity and change as a process in the pram design. One of the primary means by which a society reacts to episodes of crisis and opportunity is through technology, resulting in technological change or continuity. Prams exhibit an impressive continuity of design over time, although there is evidence for innovation and
technological change. This second hypothesis states that technological continuity and change are the result of the process of cultural adaptation. Economic and cultural factors, as well as access to natural resources, act to stimulate technological innovation or reinforce continuity.

The theoretical approach applied to this study is that of cultural adaptation, and specifically the use of technological adaptation as exhibited in pram-class constructions. This analysis views boat design and water transportation as determined by several interrelated and interdependent factors.

Pram-class vessels were primarily used for transportation of the goods and materials produced by the local economy. Smaller vessels transported livestock, the produce of farmers, and the common materials of building rubble, manure, and human refuse. Larger vessels carried an assortment of bulk goods: peat, bricks, stone, shells for lime production, lime, lumber, hay, reeds, grain, and other farm produce. Their shallow draft also made them serviceable lighters for off-loading cargo of deep-drafted ships (Aubin 1702). Napoleon even experimented with the type as a troop transport and gunboat (Sopers 1974:90).
The development of pram-class vessels is closely tied to the development of the local economy. In this study, the relationship between the local economy and the long-term use of prams is emphasized. Prams made transportation of locally-produced goods economically feasible and offered alternative employment in transportation for farmers and laborers. Changes in the local economy and new opportunities influenced the quantity of prams built, their dimensions, continuity, and innovations in their design.

The continued use of prams during cycles of prosperity and crisis is of special interest. The Roman Era represents a long period of economic development, but the withdrawal of Roman legions and subsequent demise of state-supported commerce caused a lengthy period of economic and demographic crisis during the Dark Ages (Whitehouse 1989:3-21). From the tenth through the twelfth centuries, there was once again an increase in population and production, marked by the colonization of new areas of land (Hodges 1989:70). Subsistence strategies, like this region's changing delta, continually shifted as conditions dictated. This can be seen in changes in livelihoods—-from agriculture to pastoralism or to laborer and then back to agriculture as
resources and economic conditions fluctuated (Besteman 1990:91-117).

The Late Medieval to Early Modern Eras of the Netherlands witnessed the colonization of the peat moors and the rise of a complex state and a capital-intensive society. Processes associated with the development of a complex society were at work during this period: intensification in agriculture; proliferation of specialized economic strategies in both the rural and urban economies; and in some instances technological innovation while in others technological continuity. The effects of these broad-reaching processes are evident in the use of pram-class vessels and in the growth of water transportation networks.

Growth and prosperity in the Netherlands reached their zenith from A.D. 1550 to 1650. Growth, in both the rural and urban sectors, continued until about A.D. 1650 and resulted from several positively interrelated factors, which include: the development of an international exchange economy; a series of innovations in agriculture, industry, energy, and transportation; an increase in the rural population; and the demographic changes and economic development brought on by the Eighty Years War (Vries 1974; Tilly 1990). The immigration of
Flemish refugees and Sephardic Jews to the Netherlands also brought a diffusion of new skills and an influx of capital (Scoville 1951; Wallerstein 1976).

The unique internal economy that emerged in the late-sixteenth century coalesced around the shipment of bulk goods, chiefly grain, but also peat, salt, timber, bricks, fodder, manure, livestock and dairy products. Large areas of land were reclaimed from the sea, canals were dug, and waterways were improved. The use of specific classes of boats, such as prams, were shaped by these factors. As trade increased, so grew the demand for inland water transports such as prams; the proliferation of which facilitated access to markets for both rural and urban citizens. Increased marketing, again, escalated demands for the building of pram-class vessels (Vries 1974:161-81; Glamann 1978:206-64).

After A.D. 1650, a period of decline began that lasted through the eighteenth century. There are numerous indicators of decline: a leveling off and reduction in population; lack of capital investments in the local infrastructure; reduced international and domestic trade; and subsequent loss of markets (Vries 1974; van der Woude 1975). Local boatbuilders and shippers had to deal with the economic crisis through new
technological and market strategies, either by economizing boat construction, using more economical types, or by reorienting market strategies (Boxer 1965; Israel 1989).

Inland vessels exhibit several changes in hull design over time. In the Roman Era, vessels having pram-class characteristics were bulk carriers 20 to 34 m in length, but during the Dark Ages (5th and 6th centuries) these large freighters disappear from the archaeological record and inland vessels of this size do not reappear until the Late Middle Ages. Examples of inland watercraft types are scant in the Dutch archaeological record from the fifth through the tenth centuries.

By the twelfth century, however, there are more archaeological examples of inland craft, both plank-built and extended dugout watercraft. From the Late Medieval to Early Modern Eras, hull capacity increases parallel the growth in bulk trade, with directional changes from more lanceolate-shaped hulls to those having a box-like, rectangular shape. This trend is directed by the transport of bulk goods. Hold depth and freeboard also vary with vessel function. Continuity in hull construction is still evident in the continuous use of flush-laid bottom planking, the hard chine, and use of
well-established framing schemes. These trends are identified in the archaeological record and analyzed in regard to Dutch history. Innovations in woodworking tools, sailing rigs, the introduction of the stern rudder and later the leeboard encouraged specialization of small craft. Also important were innovations in closely associated technologies such as new types of nets, fishing techniques, and the development of canal and lock systems. During the sixteenth century small craft specialization expanded rapidly, which suggests that a number of economic, technological, and social factors may have created new opportunities. The history of the pram-class demonstrates technological adaptation in response to economic cycles of crisis and opportunity.
CHAPTER II
BACKGROUND AND RESEARCH DESIGN

Prams and the Pram-Class

From the Late Middle Ages to the present, the word pram has been defined as both a small flat-bottomed boat and a sturdy seagoing vessel (Konijnenburg 1913:79-81). Prams commonly have a relatively high length to breadth ratio, flat bottom, and hard chine. Their long, narrow, flat-bottomed construction is a perfect design for negotiating narrow canals and inland waterways.

As early as the thirteenth century, tax documents from the Baltic and Eastern Sea cities of Wismar, Rostock, Stralsund, and Stettin mention the prahm (Rudolph 1969:85-86). Pramen are also mentioned in Dutch records during the Late Middle Ages. Boats with different spellings of the name are mentioned in records of the city of Kampen in the fourteenth century: pramekazle in A.D. 1326 and pramekerlen in A.D. 1365 (Wijk 1949:519). Prams are mentioned in the city of Utrecht's toll records during the first half of the fifteenth century and such listings continued through the following centuries (Sigtenhorst 1990:186-88; Unger 1980:167-68).
Origins of the word pram are uncertain, although philologists have suggested a derivation from the old Slavonic pramu or pormu (Ellmers 1984a:156; Wijk 1949:519). Throughout Northern Europe there are boat types referred to by similar names, such as the old Nordic pramr, English pram, the French prame, the middle low German pram and the high German prahm. Although some of these boats are different from one another, most are relatively similar. Crumlin-Pedersen found written sources verifying the use of the prahm during the Middle Ages as lighters for cogs on the coast of southern Sweden (Crumlin-Pedersen 1969). In more recent historic periods the name has been used for boats throughout most of Northwestern Europe. The name has not been commonly used in North America, but the bateaux and flats used in the American colonies are similarly constructed watercraft (Chapelle 1951:34-35).

The type was first identified archaeologically by Ole Crumlin-Pedersen (1969) in reference to boats excavated at Falsterbo castle in southern Sweden (Fig. 2). These reached lengths of 18 m and were 3.6 m wide and had L-shaped transition strakes between the bottom and sides referred to as chine-girders or bilge strakes. These boats had been placed as a foundation for the seaward rampart built between A.D. 1311 and 1318.
Figure 2. Falsterbo pram. One of six barge-like vessels, or prams, excavated at Falsterbo, Sweden in 1934 and 1935 and dated to approximately A.D. 1300. (Drawing by author, after drawings by Nils Tidmark and Nils Lindahl in Bass 1972.)
Crumlin-Pedersen also noted examples of similar boats from Egersund in Flensburg Fjord, Denmark dated to about A.D. 1090, one from the town of Hedeby in Shleswig-Holstein, and an early example from Elbing in Poland. A number of Roman-era boats having flat carvel-planked bottoms, hard chines constructed of L-shaped bilge strakes, and framing patterns similar to those of the medieval and post-medieval prams have been found in Switzerland and the Netherlands (Taylor and Cleere 1978; Arnold 1992). Perhaps the oldest reported example having some pram-like features is the Ljubljana boat found in Yugoslavia and dated to the pre-Roman Iron Age (Salemke 1973).

Wide usage of the name pram for a type of flat-bottomed, hard-chined boat is the reason the term "pram-class" is used within this study to identify a general category of boats sharing many similarities in construction. Within the Netherlands there are many types of relatively similar flat-bottomed pram-like boats. Besides boats referred to as pram there is the vlot, bok, punter, schuit, schouw, zomp, pot, and snijboon to name a few. Frequently these pram-class boats were identified by their specific occupations such as the eighteenth-century modderschouwen (mud boat), vuilnissschuit (dust or refuse boat), and
veenderrijschuit (peat boat) described later in this work.

The use of the term pram-class is much like Reinder Reinders' use of the term cog-like to refer to vessels having some or all of the features attributed to cogs (Reinders 1985a). Thus, pram-class is an artificial categorization created only for the purpose of this study and includes both small and large vessels that have most of the following criteria:

1. A bottom consisting of flat, carvel-laid bottom planks, and lacking a keel plank (Although there may be a central plank having skegs fastened underneath the bottom in the bow and stern.);

2. Bottom and sides meet in an abrupt angle forming a hard chine;

3. Stealers may be used in the construction of the sides, both in the bow and stern;

4. Framing systems in most cases use flat floor timbers and straight top timbers alternating with L-shaped futtocks;

5. A long, narrow and sometimes lanceolate shaped hull, usually having a low freeboard;

6. A raking stem and sternpost that fit directly on top of rectangular toes shaped from the ends of the central-most bottom planks; and

7. An open cargo hold with small cabins, or cuddies, in the bow and stern.

While these characteristics define the perfect example of a pram-class vessel, it should be recognized
that there is a great deal of variability in small craft and although most examples mentioned herein meet these criteria there are differences in framing schemes and hull constructions.

Classification by Shipbuilding Tradition

Theories on the history of shipbuilding have focused primarily upon systems for classifying ancient watercraft and tracking the evolutions of various types. These efforts have resulted in a number of different classification schemes, which include groupings based on the type of building material, ship functions, sailing rigs, armaments, historic type-names, construction origins, construction sequences and methods, and overall shape and form (Hocker 1991:4-8). Most of these typologies are based upon archaeological or ethnographic examples.

Recent approaches have classified ships and boats by identifying cultural shipbuilding traditions. These approaches emphasize the native shipbuilding methods of a particular geographic region and culture. Shipbuilding traditions within European continent contrast between those of Northern Europe (Scandinavia) and the Mediterranean Region. These differ chiefly in whether
the hull strakes fit edge-to-edge (carvel) or overlap (lapstrake) and by what method they are fastened together (Hornell 1946:193-94; Hasslof 1972:27-72).

The Mediterranean tradition broadly defines a hull construction from softwoods in which the planks are laid edge-to-edge and fastened together with numerous pegged mortise-and-tenon joints. Hull strength is primarily in the interlocking hull strakes and framing is relatively insubstantial, functioning more to hold hull shape than as an added dimension of strength. Over time, frames play a more significant role in the design and strength of the ship until the mortise-and-tenon construction eventually disappears and is replaced by a skeletal construction, in which the posts, keel, and frames are laid first, thereby achieving the shape of the hull.

Northern European traditions have been divided into subcategories such as Scandinavian, Celtic or bottom-based, Anglo-Saxon, and more recently Basque or Iberian. The Scandinavian clinker tradition describes a hull constructed mainly from oak, consisting of thin lapstrake planking fastened together with iron rivets and roves; a flanged keel or keel plank to which the garboards are riveted; relatively insubstantial widely spaced frames; and a heavy sheer strake (Brogger and Shetelig 1953).
Vessels built in the Celtic tradition, or bottom-based tradition, employ a flat bottom which provides a foundation for the entire construction. The bottom is of thick carvel-laid oak planks fastened only to the frames. There may or may not be a keel plank, and the transition between bottom and sides is very distinct (often making a sharp angle described as hard-chined and in the earliest boats employing an L-shaped bilge strake). The manner in which the medieval boats are caulked, consisting of moss held in place by willow laths and thousands of little iron nails or sinterels, is also distinctive (Marsden 1966; Ellmers 1984a; Hocker 1991; Arnold 1992). Pram-class vessels fit into the Celtic or bottom-based tradition.

Goodburn (1986) attempted to define an Anglo-Saxon boatbuilding tradition. Descriptions of sixteenth-century Iberian and Basque hull remains have focused on similarities of construction that may be the basis for hypothesizing an Iberian tradition. These features include the use of a master frame coupled together with a pegged dovetail joint, a mast step that was an enlarged portion of the keelson, transverse timbers that fit perpendicular to the mast step, ceiling planking that extended just above the floor timber heads, and filler planks that closed the space between the frames (Oertling 1989:249). Although these features have been found on
other sixteenth-century shipwrecks of different nationalities, the emphasis in interpreting ship construction is to delineate and classify ethnic or regional traditions.

Nautical archaeologists have used shipbuilding traditions to classify ships according to cultural and geographic affinities or on the basis of building sequence. The skills and knowledge of the shipwright are viewed as deeply rooted in a cultural heritage. These skills presumably developed through a lineage, passed on as information in the community, or from father to son or master to apprentice. Closely tied to the identification of shipbuilding traditions are attempts to trace the evolutionary lineages of the various traditions. Linear theories usually rely upon a technological evolution of incremental steps.

Classification of shipbuilding traditions has provided a lasting foundation for understanding the history of watercraft design and technology. There are however limitations to the use of shipbuilding traditions as a theoretical model. As Hocker (1991) pointed out, there are inherent problems in attributing shipbuilding traditions to a specific group of people, such as with
the Celtic tradition which includes watercraft built by non-Celtic peoples.

In defining shipbuilding traditions, nautical archaeologists have used traditions as permanent building blocks, particularly in dealing with technological change and continuity. Shipbuilding traditions, once identified by scholars, are treated as inherently conservative. Vessel types not clearly fitting into an existing tradition are classified as localized traditions, the products of diffusion, or the mixing of traditions. While technological change does occur through diffusion or by slow incremental changes, it also occurs rapidly through innovation, giving a culture the ability to pursue new opportunities or respond to crises. Ecological, economic, and technological factors are as influential in technological change and continuity as cultural traditions.

Classification systems based on building traditions frequently fail to relate shipbuilding and watercraft to the more dynamic interactions between technology, economy, resources, and cultural factors. Classification by tradition, as an analytical model, may be reaching a point of diminishing returns with delineation of the most distinct traditions. Emphasis on the tradition in which
a vessel is built may neglect the analysis of key factors influencing ship design and systemic interactions.

Linear evolutionary views can be implicitly biased in interpreting the evolution of shipbuilding traditions. There is an assumption that ship construction, or technology, should develop from simple to more complex designs and that continuity of design implies a culture bound by traditional views or conservatism. Technological continuity or change due to crisis or opportunity is frequently not analyzed in regard to cultural adaptation.

This is not a denial of either the existence or significance of cultural traditions in shipbuilding, but rather a reduction in emphasis. This work differs from other studies by considering the process of cultural adaptation and analyzing pram-class watercraft as the product of a complex interactive system of economic, social, resource, environmental, and technological factors. Native shipbuilding and ship design are treated in this work as part of an interactive system of several factors. Shipbuilding traditions within this analysis are the result of cultural adaptation. Thus, continuity and change are viewed as being driven by cultural adaptation rather than the result of ethnicity.
Cultural and Technological Adaptation

The theoretical model applied in this analysis of pram-class watercraft is primarily one of cultural adaptation, with emphasis on the technological adaptation of watercraft. This theoretical perspective demonstrates positive correlations between ship construction and the broadly-defined ecosystem. Innovations in ship design mirror changing social, economic, environmental, and technological variables. Technological innovations commonly occur as the result of directional searches within a cultural system (Clarke 1968:93; Butzer 1982:282), which may by chance discover new inventions or adapt existing technologies to new arrangements.

This approach is appropriate to inquiries into the development and specialization of water transportation, particularly as it relates to change and continuity in pram-class vessels. Pram freighters and the transportation networks of canals are an integral part of the economic and technological sectors that evolved in the Netherlands during the Late Middle Ages. Water transport, thus, is seen as a mechanism of cultural adaptation to the environment, resources, and changing economic circumstances.
The primary focus, within this cultural adaptation model, is upon the interdependent relationship between technology (pram-class vessels), environment and available resources, and culture (Fig. 3). It is this interaction that drives continuity and change in the pram-class vessel design. Over the long history of this class of boat, periods of economic crisis or opportunity have either influenced directional change and new market strategies or reinforced continuity of design.

Cultural adaptation concentrates on the interrelationships between people and nature. Adaptive strategies chosen by communities in regard to livelihood, labor, resource management, and reproduction are of primary interest. In order to understand these complex interrelationships, the aspects of ecology, systems theory, and cybernetics are incorporated.

Ecology is a biological concept based in energy and organisms. The value of borrowing this concept from the biological sciences is that ecology permits a structured organization of unlike variables, emphasizes function and interchanges between component parts, and facilitates a systemic study of interrelationships within an organic whole (Butzer 1989a). The main drawback is that it does not allow a role for culture and human cognition.
Figure 3. Model illustrating the interactive variables of an adaptive system as they relate to pram-class construction.
Systems theory and cybernetics are more useful in interpreting culture and human cognition. Systems theory emphasizes the interdependence of the complex interrelationships within a culture. Feedback loops operate to discourage change or encourage innovation. Thus, information feedbacks can either reinforce equilibrium or direct change and ultimately lead to system expansion or simplification. Cybernetics illuminates the role of human cognition in the ecosystem. Culture is regarded as an information system in which technology and social organization are viewed as encoded information. Adaptive choices and cultural variety are significant variables in this information system.

Several historic events and processes leading to the development of a complex state society occur in the Dutch cultural ecosystem during the period under consideration: the rebellion and war with Spain and the emergence of a complex state society; increased productivity in the economy through intensification of resource use; multiple innovations in technology and finance; specialization in agriculture and industry; increase in available labor and capital accompanied by the rise of a capital-intensive society; and the development of an innovative local and interregional shipping and transportation network. Prams in both the urban and rural economies were influenced by
the intensification of agriculture, animal husbandry, and industry within the late-medieval Netherlands.
Intensification resulted in an increase in the number of local markets, more local and international trade, and an increase in the number and variety of pram-class vessels.

What systematic canal irrigation was to the Nile Delta, Mesopotamia and Latin America, land drainage and reclamation were to the Netherlands. As in these civilizations, the process of agricultural intensification was paralleled by state formation. Intensification represented an accumulation of positive feedbacks, which were rapidly internalized and thereby transformed the rural economy. Intensification increased productivity and reliability of resource yields, favoring demographic growth and nucleation of population centers in cities and villages. It also led to specialization of subsistence technologies and lessened the self-sufficiency of the peasantry, who increasingly turned to local markets and craftsmen for their needs. Changes also occurred in diet, demography, and social behavior.

Intensification does not necessarily stimulate administrative centralization or social stratification. Studies linked to development of the Nile Delta and prehistoric field drainage have shown that the emergence
of irrigation agrosystems and field drainage was an incremental process, which exhibited continuity in its local management (Butzer 1976; Doolittle 1988). In the Netherlands region, as in the Nile Delta, intensification proceeded in incremental steps, occurring at the local level, and represented countless personal decisions rather than changes imposed by a centralized authority.

At some level the group either overtly or implicitly condones the changes. Cognition, decision-making, perception, and a large amount of adaptive variability in dealing with the environment act to encourage intensification (Buckley 1967). Peoples living within the region bounded by the present day Netherlands seem to have demonstrated a great deal of adaptive variability, particularly in the Medieval and Modern Eras.

Innovations in technology are essential to episodes of growth, a necessary condition of which is broad social access to resources. These lead to niche growth and increased variability. A number of studies of complex societies show that demographic growth coincides with periods of strong and efficient government. Power and even the perception of power engenders trust in the system and a willingness to take risks in order to optimize potential opportunities.
Periods of decline, however, are marked by losses in productivity and population and frequently occur during times of weak and incompetent government (Butzer 1990:120). The formation of the Dutch Republic in the sixteenth century may have stimulated intensification through the necessities of war and increased taxation on the rural sector, however, a weak government and lack of capital investment in the local, rural sectors played a part in the economic decline of the late seventeenth and eighteenth centuries.

Demographic studies employ a more historical approach. Population growth can be related to improvements in technology and increased access to resources, while population decline points to fundamental problems in society or the environment. Studies, such as those by Butzer (1976, 1980, 1984), Whitmore et al. (1989), and Deneen (1976) show that when examined over long periods of time, populations exhibit both episodes of progressive intensification and systemic breakdowns or catastrophic collapse. These are seen by several scholars to be cycles, driven by both demographics and economics (Goldstone 1991; Kondrative 1922). Growth is not necessarily linear, but more episodic with spiraling cycles of intensification followed by stagnation and decline. The Dutch Golden Era, from 1550 to 1650, and
the following period of decline seem to illustrate this cycle.

From the late Middle Ages to the Modern Era, the relationship between capital and technological innovations is evident in long wave economic cycles, such as Kondratiev (1935) "long waves" or "innovation waves" (Schumpeter 1939). Economic downwaves may be the crisis stimulating experimentation and development of new technologies (Graham and Senge 1980). As a capitalist economy begins to slide towards depression, innovators begin to look for new inventions with which to secure more favorable returns on capital. Ehrensaft (1980) indicated that this was the case with the clustering of agricultural innovations in a recession as farmers adopted new technologies to increase production in the face of declining prices.

European economic success in the Late Medieval and Early Modern Eras can be attributed to advances in technology. Butzer (1988) concludes that in pre-industrial Europe, megacycles of food prices and demography were steered by technological and economic transformations. Cipolla (1965) described innovations in ship design, navigation, and artillery, as providing the technological means for the economic expansion of Europe.
According to Headrick (1981), technological changes in the nineteenth century determined the timing and location of the European conquests of Africa and Asia. Others have also emphasized the relationship between technology and the alteration of social forms, especially in medieval Northern Europe (Bloch 1956; White 1962a). Societies considered to be traditional are initially conservative in that they seek to minimize risks. Only when strong market opportunities provide an incentive for optimizing solutions do long-term risks increase in probability, such as an emphasis on cash crops or settlement of marginal environments.

Change through innovation then is a complicated process. Although significant innovations can be singled out, the process of development and implementation is obscured by many factors affecting the ultimate acceptance of an innovation and the rate of diffusion (Rosenberg 1972). Improvements may have to occur before newly introduced inventions become acceptable. Many technologies are dependent upon the level of human skills and, in industrial periods, the development of skills in machine-making. Technology diffuses in its purest form through migrations of those skilled in the technology, as evidenced by the sixteenth- and seventeenth-century Protestant migrations, which introduced many new
innovations and industries into the Netherlands (Scoville 1951, Wallerstein 1976:139).

The key factor of acceptance and development is often dependent upon complementary technologies or subsequent innovations. Improvements in older established technologies may also extend the use of the old technology. Social, legal, and institutional variables are also factors that can retard or direct the development of innovations.

Significant innovations that have major directional impacts on the economy, or subsistence system, have clustered during certain historic periods and were followed by periods in which the new advances were consolidated. Innovations also do not occur randomly within the economic system but frequently concentrate in specific entrepreneurial sectors (Berry 1991:55).

The rates and driving forces of innovation processes have received a great deal of attention in the literature, such as in studies by Walton (1970-71), Rosenberg (1972), and Spratt (1982). The development of technology is never direct, and when plotted in a flow chart may follow a circuitous route. Critical Path Schedules and Cash Flow Curves were borrowed from
economics and applied to the archaeological issues of technological change by Spratt (1982). These models make it clear that a wide variety of technical, economic, market, and social processes are part of the innovation process. Technical evolution may depend more upon innovations in related technologies and changing system factors that can be incorporated into a holistic technology system. The kinetic forces acting upon a technological system may be technical, social, economic, environmental, or all of these factors. It is the interplay of these factors in the history of prams that is documented in the ensuing treatise.
CHAPTER III

THE LATE ROMAN ERA AND THE PROTOTYPES OF PRAM-CLASS VESSELS

Geography

The land mass built up on the deltas of the rivers flowing out of Germany and France comprises the present-day Netherlands. To the west, this delta is sheltered from the North Sea by sand dunes stretching in an arc from South Holland to the northwest where they form islands sandwiched between the North Sea and the shallow Waddenzee. It was the large inland body of water, however, that geographically united the provinces of the Netherlands in their economic and settlement strategies (Vries 1974:24-26). The network of inland waterways with their connections to the rivers of Germany and France and to the North Sea and Baltic tied together industry, transportation, economy and culture.

The inland waterway that is the present day IJsselmeer has undergone many changes since the Romans explored the region (Fig. 4). It has changed from a freshwater lake (Flevomeer) to a brackish lake (Almere) then to a salty inland sea (Zuiderzee) and finally, by man's intervention, returned to a freshwater lake
Figure 4. Four maps of the principal changes in the inland body of water. (a) Flevomere about A.D. 200, (b) Almere about A.D. 1300, (c) Zuiderzee after A.D. 1700, and (d) the IJsselmeer today.
IJsselmeer) (Ente 1976:15-35). During the period of their conquest and colonization of the West, the Romans called the shallow lake Flevo Lacus. Germanic tribes, such as the Frisii, had settled around the shores of the lake and in the midst of a broad area of boggy wetlands. It was this difficult terrain that probably insured the tribes independence from Rome. Although the Romans constructed a canal connecting the lake to the Rhine, they never attempted a serious conquest of this region. The lake was filled by outlets of the Rhine, the Vecht and IJssel, and flowed into the North Sea tidal inlets, such as the Vlie (Lambert 1971:32).

The end of Roman occupation and the early Middle Ages saw an expansion of the Flevomere, brought about by a rising sea level. The Roman-era lake was followed by the larger brackish Almere, which dates approximately from the Carolingian period to the St. Elizabeth's Flood of A.D. 1421. During the twelfth and thirteenth centuries, the sea level continued to rise as storm flooding expanded the Almere and eventually caused the North Sea to break through the dunes. Storm floods extended the inlets, such as the Marsdiep and Vlie, into the Waddenzee and turned the Almere into a tidal arm of the North Sea (Besteman 1990:94-96; Lambert 1971:106-14). The deepening of these inlets thus permitted direct
navigation from Almere ports to those of the Baltic. As early as A.D. 1340, this expansion led to the Almere sometimes being referred to as the Zuiderzee (Besteman 1990:94–96; Lambert 1971:109).

The flooding and inundation that created the Almere and then the Zuiderzee created periods of crises as well as opportunities. Villages and fields were destroyed, necessitating large capital investments in land reclamation and drainage systems. The formation of the Zuiderzee also provided important economic connections for the provinces of the Netherlands. The Marsdiep and Vlie provided navigable outlets to the Baltic and North Sea. Germany was accessible by the Rhine via the IJssel and Vecht Rivers. The Vecht River also provided connections to the waterways of Holland. This inland waterway, the binnenweg, was a network of lakes and rivers that connected to the Scheldt, a navigable estuary. This route led south to the markets and manufacturers of Flanders and Brabant, and was further enhanced by the building of canals in the sixteenth and seventeenth centuries (Lambert 1971:154–55).

Before the colonization of the northern Netherlands, numerous small rivers, sea arms, and lakes gave it an estuarine character. The rivers and marshes isolated the
area, which allowed it to remain a wilderness until the twelfth century (Vries 1974:26). This is in contrast to the southern Netherlands in the area of the Rhine, which had been part of the Roman and Carolingian Empires (Lambert 1971:34-35).

Roman Trade in the West: A.D. 100-400

Roman-era barges found along the Rhine river and tributary system in the Netherlands and Belgium are the earliest examples of vessels that have pram-class characteristics. When the western regions of the Roman Empire, Gaul and Belgica, were colonized, the network of rivers provided an excellent means of transportation. When compared to land transport, water transport was significantly less expensive. This was particularly true for heavy and bulk goods for which land transportation costs equaled or exceeded initial purchase costs (Walbank 1987:79).

The deployment of Roman garrisons in fortresses along the Rhine and the low cost of water transport were the stimulus to trade and industry. Initially, it was the army that provided a catalyst for the local economy. Provisioning of the troops necessitated large amounts of agricultural produce and manufactured wares, while
Romanization of the colonies created a local appetite for goods from Italy and elsewhere in the Empire. The wages of the troops and administrators made it possible to import luxuries without the need for a balance of exports and the Roman west therefore grew prosperous. One result of this prosperity were the trade settlements that sprang up along lines of communication on rivers, tributaries, and lakes (Walbank 1987:79-96).

As Gaul and Belgica colonies matured, native industries developed and Italian products began to be replaced by local or regional wares, such as those manufactured in Gaul at la Graufesenque. Much of this local industry can be ascribed to cheaper transport for fuel, raw materials; and finished products to nearby markets. Other industries also moved closer to the frontiers as well. Gaul was primarily responsible for agricultural production to feed the western provinces and Roman troops, and also for grain shipments to Rome. In addition to grain, the region produced large quantities of raw materials, including timber, and manufactured considerable quantities of woollen cloth and linen.

There was also an increase in mining, especially for lead. The state was involved in much of the mining, organizing it under imperial procurators. The opening up
of quarries and mines was a further stimulus to the growth of towns and the civilization of frontier areas. Smith work was carried on locally and ingots of silver, iron, and lead were marketed within the region or exported to the Mediterranean. Finished products of tin and silver-plated bronze and brass were produced in the western empire and marketed interregionally. Glass workers migrated out of Italy and provincial glassware, produced in workshops in Gaul and Belgica, such as in the cities of Arles and Lyons, rivaled that of Italy. By the Late Empire, the western provinces had become essentially self-sufficient for all of their primary needs (Walbank 1987:79-96).

Archaeological evidence for waterborne trade can be seen at several sites in the Netherlands, generally around the Roman forts or trading outposts. These were placed along a riverfront or at the confluence of a river with one of its tributaries or where roads intersected (De Boe 1978:30).

**Zwammerdam Vessels**

The Roman-era vessels discussed in this work come from the lower and middle Rhine rivers and tributaries and date from the Middle to the Late Roman Empire. The
first Roman-era vessels to be excavated in the Netherlands were from a Roman castle near Zwammerdam (Weerd 1988a, 1988b). The Zwammerdam-type vessels are characterized by their flat carvel-laid bottoms, hard chines with vertical sides, and use of alternating L-shaped frames. Stem and sternpost are absent; instead ends are squared off like those of a scow and closed with short boards that run perpendicular to the centerline of the boats. The exception to this is a vessel excavated at Woerden in 1978, which had a wide, heavy timber at one end (Haalebos 1987). All of these vessels appear to have been designed for bulky cargoes, and were used to provision and transport building materials for construction of Roman forts on the Rhine River.

The Zwammerdam vessels were excavated from along the riverfront of the Roman fort identified as Nigrum Pullum. Here the remains of six vessels and some loose planking, which was distinctive for its mortise-and-tenon fastenings, were found. The vessels are believed to date to A.D. 175-260, a period in which the former wooden fort was replaced with one of stone and a bath, vicus, and riverfront quays were built (Weerd 1978).

Zwammerdam 1, 3, and 5 were dugouts, each cut from a single tree. Zwammerdam 1 was of oak, 6.99 m long and
1.05 m wide, and had a well for holding live fish. Zwammerdam 5, also considered a fishing boat, was 5.48 m long and 0.76 m wide. Zwammerdam 3 was 10.4 m long and 1.4 m wide and had alternating L-shaped frames, a small mast step, and fir washstrakes (Weerd 1978:16).

The other three vessels have some pram-class features. They were larger barge- or scow-like boats over 20 m long with carvel-planked bottoms composed of six to seven strakes fitted between L-shaped bilge strakes, and had L-shaped frames with knee ends alternating on port and starboard sides. All three vessels were thought to have been built to carry stone for the construction purposes (Weerd 1988a:41). Like similar vessels from Kapel Avezaath, Druten, and Woerden, the Zwammerdam barges date to after A.D. 150, a period of conflict with the Germanic tribes. It was this threat that forced the Roman military to replace the former wooden forts with those of stone. Pollen retrieved from the moss caulking and the fir planking (Abies alba) indicate these materials originated in southern Germany (Weerd 1978:15-16). The boats also may have been built there, although it is possible boatbuilding materials could have been collected there and sent to boatyards down river.
Zwammerdam 2 was 22.75 m long with a maximum width of 2.8 m and height of 0.95 m (Fig. 5). The bottom was constructed of seven parallel strakes sandwiched between the two bilge strakes. This vessel and Zwammerdam 4 both have upper side strakes that overlapped the bilge strakes and were fastened with clenched iron nails. This formed relatively low, vertical sides. Inner wales fit inboard to the upper part of the side strakes and were notched to fit over the heads of the frames (Weerd 1978:17).

The alternating L-shaped futtocks consisted of a long straight foot that extended across the bottom of the hull and a vertical knee end that extended to the top of the upper strake. The knee end had been crudely shaped and still retained the appearance of a tree branch (Weerd 1978:16-18). This upper part of the frame had appeared to be flimsy and weak compared to the sawn frames of later medieval and modern prams. Perhaps the bilge strakes provided sufficient strength and stiffness to the hull that sturdier shaped frames were unnecessary. On the side of each frame opposite the branch end, each frame had a mortise and the tenon-like end of a short futtock was inserted. The futtock was notched to fit over the joggle of the chine and top strake. Frames were fastened to the planks with treenails. The floor timbers had limber holes cut in the outboard face for the
circulation of the bilge water. The mast step is a long stringer or keelson-like timber fastened atop the frames. It contained a mast step mortise one-fourth the length of the boat from the bow (Weerd 1978:16-19).

A preliminary reconstruction of vessel 2 by de Weerd (1988a:40, fig. 3b) shows an angular craft having abrupt transitions where the hull strakes make a sharp angle toward the ends. The bottom is also shown to be almost completely flat longitudinally, rising up only at the ends of the boat. The reconstruction plan shows the bottom planks to have been scarfed together with diagonal scarfs, while flat scarfs were used in the hull strakes.

Zwammerdam 4 was large, even by medieval and modern standards, having a maximum length of 34 m, width across the bottom of 4.4 m, and depth of 1.2 m (Fig. 6). The ends of the vessel curve inward giving the hull an elongated oval shape. It is not clear how the ends were closed, but probably an arrangement of transverse planks was used. Long lengths of timber were used: one strake was 21.6 m in length. The bottom was composed of six strakes sandwiched between the port and starboard bilge strakes. The side was heightened above the bilge strakes by the addition of one lapstrake sidestrake (Weerd 1978:17; Weerd 1988b:fig. 76).
Figure 6. Zwammerdam 4. It is the largest vessel of its type discovered, having a surviving length of 34 m. (Drawing by author, after de Weerd 1988b.)
Frames were laid side by side in regularly spaced pairs with alternating knee ends. The knee end of the first frame was always on the port side and the knee end of the second frame on the starboard side. As with Zwammerdam 2, short upright futtocks fit into mortises in the horizontal ends of the L-shaped frames, opposite the knee ends. Upright futtocks were occasionally used elsewhere on the sides. These were not fitted to the other frames, but functioned like top timbers fastened to the sides above the chine. These top timbers may have supported transverse beams or a gangway. A relatively wide stringer was nailed on the inboard faces of the futtocks at the height of the upper part of the bilge strake and one photograph appears to show remnants of an inwale, or clamp (Weerd 1978:19, fig. 22).

The mast step is relatively large, with the mortise cut into a frame. Above the mast step was a mast partner constructed of two planks reinforced with iron straps for the support of the mast. Two of the iron straps are U-shaped with enough space between the straps and beam for a bolt to slide behind the mast and lock it in position (Weerd 1978:17; Weerd 1988b:figs. 81, 82).

Zwammerdam 6 was 20.25 m long with a maximum width of 3.4 m across the bottom and a maximum height of 0.9 m
(Fig. 7). The hull did not curve inward as in vessels 2 and 4, but had scow-like ends and a more rectangular shape. As in the other vessels there was some rise to hull towards the ends. Vessel 6 remains fuller throughout its length than vessels 2 and 4 which taper more from amidships to the stern. The ends of the vessel were reinforced with iron straps around the corners. The bottom consists of seven strakes between the two carved bilge strakes. The sides of the vessel were raised one strake higher with the addition of a carvel laid strake above each bilge strake. In two places the second strake was fastened to the bilge strake with mortise-and-tenon joints, but in all other instances it was fastened with iron nails. An inwale was fastened inboard to the upper part of the top strake and was notched on the lower inboard face to allow for the frame heads (Weerd 1978:17, fig 23).

Frames are not paired, but knee ends alternate port and starboard. Again, futtocks were placed opposite the frames' knee ends. In the bow and stern there were two crossed frames, which may have prevented the ends from twisting or hogging. All planking fasteners, except the mortise-and-tenon joints, were clenched iron nails (Weerd 1978:17, 19; Weerd 1988b:figs. 81, 82).
A mast step, somewhat similar to that of vessel 2, was nailed on top of the frames and the mortise was placed one-quarter of the vessel's length from the bow. Mortises in the after portion of the step and in one of the forward frames probably held stanchions for the deck (Weerd 1988b:fig. 82).

Steerage was accomplished with one or more large steering oars. In some vessels steering oars might have been placed at both ends (Ellmers 1984b:105, figs 81, 82). A large steering oar, 5.15 m long, was found in association with the Zwammerdam vessels. It had two or three holes in the central part of the blade for changing the depth of the oar and a rectangular slot was present at the top of the oar for attachment of the tiller. The blade was widened by two boards fastened together with mortise-and-tenon joints and at three corners with an iron nail (Weerd 1978:17, 20).

**Pommeroeul Vessels**

Of five vessels found at Pommeroeul, Belgium, the site of a former Roman village located on the river Haine, two were similar to those of Zwammerdam (De Boe 1978). The village had been located at the confluence of the river with one of its small tributaries and the
former Roman road leading to Baval. Four of the boats had been abandoned during the second half of the first century A.D. or the early second century A.D. The other boat may have been abandoned in the second half of the second to early third century A.D. This location was favorable for trade, since it was connected by land to the whole network of roads in northern Gaul and by water to the Scheldt and the mouths of the rivers Meuse and Rhine.

Two of the boats were extended dugouts and a third vessel was too damaged to be identified. One of the barges was similar to Zwammerdam 4, with a cabin at one end (Fig. 8). This barge was estimated to be 18 to 20 m long, but only part of the midship section and stern were preserved for 12.7 m. Width was about 3 m and depth of hold 0.67 m. The bottom was composed of three carvel planks between the bilge strakes. The planks were scarfed together diagonally. Strakes were caulked with cord held in place by numerous small iron nails. At the preserved end, the perpendicular bilge strake smoothed out into a curved spoon-shaped end (De Boe 1978:23-27).

In the stern, the starboard side was complete to the gangway, which consisted of four timbers fastened together with iron nails. According to De Boe's
Figure 8. Pommeroeul vessel. The ridged gangway served as a footing upon which the waterman walked and propelled the boat by poling. (Drawing by author, after photograph in De Boe 1978.)
description, a clamp-like timber rested on the upper edge of the bilge strake. A plank was secured to the inboard face of this timber with its bottom edge resting on the frame heads. This construction supported the gangway. A plank fastened to the outboard edge of the gangway appeared to be several centimeters higher than the gangway and probably functioned as a washstrake. Raised ridges and an inner rim were on the upper face of the gangway and provided a secure footing for the boatman. Frames were placed in L-shaped pairs with alternating knee-ends. The frames were fastened to the hull with clenched iron nails driven from both inside and outside (De Boe 1978:27).

The cabin in the stern was about 2.3 m long. The walls of the cabin were constructed of thin overlapping oak planks outside and lined with thicker pine planks inside. These were nailed to small posts, the footings of which were fitted into mortises in floor timbers and the gangway. A stanchion, which fit into a centrally-placed mortise cut into a frame, probably supported a roof beam. Pine ceiling planking was placed over the floor timbers and this appeared to have been covered with straw ((De Boe 1978:27).
The second barge was not as well preserved. Only the bottom and a portion of one lower side survived for about 15 m. Although part of one end survived, De Boe does not identify stem or stern. This vessel was similar to the other barge, with the exception that the bottom planks were nailed together (De Boe does not record the specifically how the planks were nailed together, but possibly it was by toe-nailing) and fewer frames were used in its construction. Frames were L-shaped and in one photograph of the ship, appear to occur singly (De Boe 1978:27, fig. 33). The sides of the hull were heightened with the addition of one strake above each bilge strake. The preserved side consisted of several carvel-joined planks (De Boe 1978:27-28).

The author mentions a large number of finds from the area around the boats. These included a number of iron ferrules for punting poles and boathooks. There were anchor stones or weights for fishing nets and a sounding weight of stone. Remnants of ancient cargoes may be represented by fragments of leather, peat, coal, building stone, and pottery. The artifacts indicate economic activities in agriculture, leather working and tanning, and woodworking (De Boe 1978:29).
Druten Vessel

Another vessel with similar construction to the Zwammerdam and Pommeroeul vessels, and dating to the middle Roman period, was excavated in 1973 in the city of Druten in the Netherlands (Hulst and Lehmann 1974:7-24) (Fig. 9). Sixteen meters of the hull survived, apparently from about amidships to just short of one end of the vessel. It is uncertain in which direction the bow and stern lay because of the lack of preservation of the ends. The flat bottom curved upward and tapered inward toward the end of the boat. The wider end, which was closest to amidships, had a breadth across the bottom of 2.8 m. From here the hull tapers to a 1.72 m breadth across the bottom. The narrowing of the hull was achieved through a reduction of the bottom planks from five to three strakes, between the two L-shaped bilge strakes. The bottom planks were 6 to 8 cm thick.

The bilge strakes became reduced in size in their run toward the ends and as they rose with the curve of the hull were modified to being only side strakes. This curved shape was carved from a single log with the curving tapered ends cut across the grain rather than with it. The midships portion was much thicker than the ends. This is what maintains the curve of the bottom and
Figure 9. Druven vessel. (Drawing by author, after Huls and Lehmann 1974.)
prevented the ship from hogging. The authors did not find a second side strake above the bilge strake or note any signs of fastening onto the bilge strake. They suggested that since the bilge strake was 80 cm high an upper strake may have been unnecessary. No evidence of caulking was recovered from the planks (Hulst and Lehmann 1974:11).

The frames consisted of pairs of floor timbers with alternating knee ends. The upright knee ends of the frames were formed from relatively insubstantial limbs as in the other vessels. It may be noteworthy that with the paired frames in Zwammerdam 4 and Woerden the forward knee end was usually placed on the port side and the after knee end on the starboard side. If the same held true for the Druten barge, then the partially preserved end could be the bow. One would expect a mortise for a mast step in the bow of the boat, but there was no evidence of one noted. The frames were fastened to the bottom with iron nails set in clenched pairs, one nailed from the inside and one nailed from the outside. The knee end was usually fastened to the bilge strake with sets of three iron nails placed in a triangular pattern. Each floor timber had three half round limber holes for the circulation of bilge water (Hulst and Lehmann 1974:12-14).
On floor timber 7, a ridge was present, which contained two small mortises. An iron hook was attached by an iron strap to this frame at about the centerline of the ship. Although the authors appear to have reconstructed a pair of frames with the iron hook as a mast step (Hulst and Lehmann 1974:13, Fig. 7), there is no parallel for this construction and its function is uncertain. Lying on top of floor timber 14 was part of the interior cabin. Plank fragments found in this area were poorly preserved portions of interior ceiling having a thickness of only 0.6 cm. A small batten-like timber, 3 cm by 2.2 cm, was fastened to these. A timber, 50 cm long by 10 cm wide by 11 cm thick, was nailed perpendicular to frames 4 and 5. It contained a small mortise, measuring 8 cm long by 6 cm wide by 4 cm deep, probably for a stanchion (Hulst and Lehmann 1974:13-14).

Several artifact finds came from the boat. Pottery sherds of terra sigillata ware, a terra nigra sherd, and amphora sherds of Schwerkeramik ware were identified. Also found were a bronze coin from the Middle Roman Period and several iron artifacts: the hook and strap attached to frame 7, the shaft for a boat hook, the iron prong for a boat hook, and an ax. Brick fragments, a piece of limestone, and numerous pieces of slate were also found. The slate seems to have been cargo, for it
was found scattered throughout the ship, and was perhaps transported for roofing tiles. In one instance the slate had been stacked in sheets and one piece of slate had an attachment hole drilled in it. The author notes that there was a great demand for building material in the second and third centuries, but demand for slate was chiefly in Belgium and Germany for roofing villas. It is unknown to what extent slate was used for roofing villas in the Rhine delta. When slate has been found in settlement sites it is in smaller quantities compared to the sherds of fired roofing tiles (Hulst and Lehmann 1974:18-21).

Woerden Vessel

A ten meter section of another large Roman-period vessel was excavated in 1978, during excavations near the Netherlands' city of Woerden at the site of the former Roman fort of Lauri (Fig. 10). Dendrochronological samples suggest that the wood was cut after A.D. 169. Therefore the sinking of the vessel was determined to be before the first quarter of the 2nd century (Haalebos 1987:25-28).

The mast step was 7.5 m from the bow. On the basis of the mast step being one-fourth the distance from the
Figure 10. Woerden vessel. Site plans and cross-sections. (Drawing by author, after Haalbos 1987.)
bow, the estimated total length was 29.6 m. The hull's breadth was 3 m at the mast step, narrowing to 2.4 m where the sides begin to curve in towards the bow.

The bottom was constructed of a patchwork of planks. Aft of the mast step there were three broad planks, but forward of the step the bottom planking was more irregular, consisting of both broad and narrow planks fitted together. The bilge strake had relatively high sides compared to those of the vessels mentioned above. The sides of the hull were raised even higher with the addition of two lapstrake strakes. All of the side strakes were fastened together with iron nails. Aft of the bow, the second strake became thicker, possibly functioning as a wale. A clamp was fastened inboard of the second strake and further strengthened the hull longitudinally. The stringer and the upper edge of the outer second strake supported the ends of the transverse beams. The uppermost strake, the sheerstrake, was slightly thinner and narrower than the second strake (Haalebos 1987:25-26).

Frames were paired with alternating knee ends. The knee ends of the first frame of the pairs was always to port and the knee end of the second frame to starboard. The floor timbers had five to six half-round limber
holes. The mast step was cut into a large floor timber, which had a high broad ridge along the forward face of the timber. A timber was placed on top the after portion of the mast frame and helped to form the relatively large mortise. This construction was reinforced with iron straps running fore and aft over the two timbers. Directly above this was a large composite beam, a mast partner, that supported the mast at deck level. It consisted of three transverse timbers held together by iron straps. On the after ends of the iron straps, space was left for a timber to slide behind the mast and secure it in place. The mast could thus be raised and lowered at ease. Many of the medieval and modern pram-class vessels also had masts that could be unstepped or lowered with ease, especially to facilitate passing underneath bridges. Although the Romans also built bridges over rivers and streams, this parallel function might or might not be accurate. There would be other advantages to dropping the mast: providing access to sailing or towing rig, or for easy passage while loading and unloading cargo. If it was a necessity to raise and lower the mast frequently, the reason for it is uncertain.

Another beam might have been located 1.25 m aft of the mast partner. At this location there were two blocks fastened to both the stringer and side strake. Where the
blocks were fastened to the hull, dovetail-shaped notches had been cut (Haalebos 1987:25-26). The function of this arrangement as a support for a beam is one possibility, but not certain.

A small stringer or ceiling plank was fastened to the inboard faces of the frame knee ends at a height about level with the top of the bilge strake. There appeared to be a ceiling aft of the mast beam. Also, on the forward face of the mast beam there appears to have been a bulkhead constructed of short planks (Haalebos 1987:25-26).

The Woerden vessel is the only example having the bow finished with a stem-like post. This stem is a massive, broad timber that fit over the ends of the bottom planks. The join between bottom and stem was protected and made water tight with thin pieces of planks nailed to the underside of the ship. The ends of the bilge strakes were fastened to the sides of this heavy stem. The underpart of this join was secured with a cross of iron straps fastened with iron spikes. On the forward and lower part of the stem, a horizontal groove was cut into the timber, but the purpose of this groove is uncertain (Haalebos 1987:27). This large, heavy stem may have some functional parallels in the block stem and
sternpost used in both ancient and modern small craft from the southern Baltic (Rudolph 1974).

A number of finds were found aft of the mast step. These consist of a pair of leather shoes, a scale, and four terra nigra pots from the inner Rhine region. The bottom in this area was covered with a layer of plant-like material, which was determined to be wheat or spelt. In the forward area of the ship were found numerous hazel nuts (Haalebos 1987:25).

The Zwanmerdam, Pommeroeul, Druten, and Woerden vessels represent large inland transport vessels from the Roman occupation in the West. As a type, they represent large rectangular craft well-suited to the cost-efficient shipment of bulky goods and building materials. These craft show many similarities to later pram-class vessels: carvel-laid bottoms; hard chines; lapstrake sides; alternating L-shaped frames; occasional use of inner wales; and, in the example from Woerden, use of a stem fastened to the bottom and sides. Most of the smaller craft used during this period appear to be dugouts or extended dugouts. This is probably a reflection of the availability of timber supplies. As long as there were plentiful supplies of trees with which to make dugouts, such craft may have been more economical. However,
contributing factors to an absence of smaller Zwammerdam style craft may be due to a lack of sophistication in the organization of labor and absence of specialized sawers and sawmills economically producing lumber.

Much of the discussion concerning these Roman-era vessels has concentrated on whether their construction represents an indigenous native tradition or is the result of Roman influence (Weerd 1988b; Arnold 1992). While this debate is not central to the theme of this study, in my opinion the Zwammerdam-type represents innovations in the native boatbuilding technology. The archaeological evidence indicates that flat-bottomed, hard-chined boats were indigenous to central and western Europe. The expansion of this native boatbuilding tradition was most certainly the result of Roman transport needs. Whether Roman workmen, native boatbuilders, or both built these vessels is uncertain. The mortise-and-tenon repairs in Zwammerdam 6 are an obvious Roman influence. Other Roman influences, possibly in scarfing and fastening, may be revealed when these vessels are recorded and analyzed in detail. Arnold suggests that one Roman influence may be the pegging of the hull to the frames (Arnold 1992:121). De Weerd (1988b) argued for a Roman derivation of the boats, primarily on the basis of frame spacings using the Roman
foot, the *pes monetalis*. Arnold (1992:100), however, has shown that frame spacings in these north European vessels do not compare with measurements from Roman-era Mediterranean shipwrecks. Distances between frames may not be suitable for comparing systems of measurement, since the builders might have placed frames by eye. Builder's scribe marks have been found on the bottom hull planking of medieval and modern Dutch wrecks. Perhaps further study of Zwammerdam 2, 4, and 6 will discover similar scribe marks and settle the question of whether or not the Roman system of measurement was used in these vessels.

The Zwammerdam-type vessels disappeared as the Empire declined. Withdrawal of the Roman legions resulted in the end of trade in bulk goods, and with the abandonment of the forts the need for heavy building materials disappeared. There is virtually no archaeological evidence for the continuation of river craft during the Dark Ages (5th and 6th centuries) that follow, either dugouts or plank-built craft. This is a reflection of the low level of trade and diminished population density. Construction of the larger Zwammerdam type craft was abandoned like the Roman forts and urban centers, but smaller dugouts and extended dugouts continued to be built. It was from these smaller
craft that pram-class vessels developed in the Middle Ages, when a trade in bulk goods once again was possible.
CHAPTER IV
CRISIS AND CONTINUITY A.D. 400-1000

The seeds of economic decline took root towards the end of the Empire. Large-scale trade was dependent upon provisioning large population centers of the army and civil service. The high rate of taxation during this period resulted in the collapse of large-scale independent enterprise. Imperial authority bought the goods and supervised their transport and distribution. Interregional trade at the beginning of the fourth century had prospered in both the common articles of consumption as well as luxury goods, but it was the latter which became the dominant goods of trade during the Dark Ages and Early Middle Ages. Local trade increasingly was reduced to the level of the craftsman who makes and sells his own goods. Those involved in wholesale trade had to limit their exchanges and endure increased risks (Walbank 1987:79-96).

Interregional and foreign markets were oriented towards the elite estate landowners. Estates were increasingly self-sufficient in most of the necessities, relying to some extent on itinerant labor and local markets. In part, it was a result of the increasing power of the large landowner that caused the West to
break away from the Empire. The West was poorer, less
united, and weakened by peasant uprisings. This resulted
in its dissolution into several successor states, or

When state control disappeared, that part of the
economy depending upon it disappeared. What was left for
the economic foundation of medieval Europe was a residue
of small artisans and merchants gathered around markets
in the towns and manors of the monasteries. Only a few
elites were wealthy enough to continue irregular trade in
luxuries from the Mediterranean. As Western Europe was
dominated by chiefdom societies, the money economy
disappeared, political relations became tenuous, and the
trade in luxury goods devolved into a gift exchange
between elites (Walbank 1987:79-96; Whitehouse 1989:3-
18).

Dark Ages: 5th-6th Centuries

The withdrawal of Roman troops and officials ended
the state supported provisioning of Roman legions and
officials. The period that followed shows subsequent
population reduction and settlement abandonment along the
Rhine. Historic and archaeological evidence for the
period following the Roman occupation is meager. In the
area north of the Rhine, the Romans had employed indigenous Frisian and Frankish tribes as clients, using them as buffer populations against the Germanic tribes. It was the Frisians in the coastal areas of the western and northern Netherlands and the Franks in the central and eastern river region that inherited what remained after withdrawal of the Empire (Bloemers and Thijssen 1990:145).

Environmental changes may have contributed to a sharp decrease in population. By the third century areas subject to flooding, along the Atlantic coast and shores of the Flevomere, evidence a decline in population. There is such a lack of archaeological evidence of habitation in the Frisian areas of Holland, Zeeland, and Texel during this time that there is some question as to whether the Frisians of the Roman period are the same as those found in the Merovingian period (Besteman 1990:98).

The population left behind in the former Roman cities resorted to self-sufficiency. Settlements became more dispersed and rural, oriented around agriculture and animal husbandry. Where there was continuity of habitation of these sites, cemetery evidence indicates a significant reduction in population. Former Roman
fortifications and stone structures underwent secondary reuse as did other material goods and utensils. Many of the sites that continued to be used show a dark humus layer dating to this period, evidencing an agrarian transformation in conjunction with more scattered dwellings built of less durable material (Bloemers and Thijsen 1990: 145-47).

Markets dried up and coinage became scarce. Transportation routes became increasingly insecure, thus discouraging travel and long-distance trade. The former trade in bulk goods, which had been dependent upon the Roman state for its existence, disappeared. The trade in luxury goods continued but declined in volume. What trade was left consisted of smaller shipments in smaller vessels (Hodges 1982).

Early Middle Ages: 7th-10th Centuries

Population began to increase in the seventh century. In the Frisian north, artificially raised mounds of earth, the terpen, were once again inhabited and new ones raised. During the Early Middle Ages, Frisians used their knowledge of seafaring to develop into eminent traders within Northwestern Europe (Besteman 1990:106-111).
In the second half of the seventh century the Frisian kings expanded southward along the coastal areas of Holland and Zeeland to the southern side of the Sheldt, conquering Utrecht and Dordrecht, and thus controlling the river delta and trading settlements. Territorial expansion brought them into conflict with the Franks who, in A.D. 695, retook these two trading towns and conquered Frisia as far north as the Vlie. By A.D. 734 all of central Frisia had fallen to the Franks. Shortly after the Frankish conquest, Anglo-Saxon missionaries converted the Frisians to Christianity. Utrecht and Dorestad then became the Frankish centers of Frisian trade (Besteman 1990:104-05).

The Frisian subsistence system was primarily one based on animal husbandry, since saltmarsh and peat areas were more suitable to this pursuit than agriculture. In areas more suitable to agriculture, however, such as around the trading settlement of Medemblik and the beach barriers, grain crops were grown. Probably here, like elsewhere in Europe from the late Merovingian period onwards, population increase was paralleled by a shift to cereal cultivation. Along the coastal areas and the shores of the Almere, however, fishing was an important occupation and provided a commodity for trade (Besteman 1990:106).
Stockbreeding remained the chief livelihood of the Frisians, since conditions in the salt marshes were well suited to sheep raising. Analysis of bones at the early medieval settlements of Den Burg, Medemblik, and Schagen show that although cattle bones predominate, there is a high percentage of sheep and goat bones. The latter were slaughtered when they were old, indicating they were kept primarily for wool and dairy products rather than meat. The emphasis on livestock is further indicated by the gifts of property which were mainly pasture and hay fields (Besteman 1990:106).

This then was the mainstay of Frisian trade. Frisians could offer meat, fish, skins, leather, parchment, and wool in exchange for luxury items. Frisian mantles and cloth are mentioned in written texts and they must have also participated in craft production (Lebecq 1983:131-34). Salt was another important commodity. Salt was produced in the coastal Southwest Netherlands, but also possibly extracted from the saline peat bogs in the northern Almere and Vlie region (Besteman 1974).

Animal husbandry probably gave Frisian mariners the freedom to become middlemen merchants. Agriculture is more labor intensive and the scheduling of planting and
harvesting limits the harvesting of other resources and long-distance trade. Access to water transport and the knowledge of coastal and inland water routes gave them a natural option as traders. As Slichter van Bath (1965) indicates, livestock provided the Frisians with a more mobile capital for trading than that of an agricultural society. This rise of a trader class reinforced the trade in luxury goods via small ports of trade which were no more than mooring places under the protection of local elites. Frisian merchants traded in the service of a king, aristocracy, or ecclesiastical authority and in return were provided some protection and legal status. Ports, such as Dorestad and Medemblik, prospered and facilitated both local and long-distance trade (Hodges 1989; Es 1990).

The passage between the Almere and the Vlie widened and deepened in the Early Middle Ages, opening up a new trade route from Dorestad, via the Kromme Rijn, Vecht, Almere, and Vlie, to Frisia and the North Sea (Fig. 11). This encouraged the growth of Dorestad and led to the beginning of a Frisian trading station at Medemblik (founded ca. AD 700). With the Frankish assumption of power, these trading settlements expanded during the Carolingian period, with Medemblik becoming the northern auxiliary of Dorestad (Besteman 1990:105-110).
Figure 11. Early Middle Ages trade route via the Kromme Rijn, Vecht, and Almere. Carolingian settlements included both toll stations (1) and trade settlements (2). (Drawing by author, after Besteman 1990.)
Excavations at these sites have produced a variety of finds, illustrating both interregional and regional trade. The finds indicate a special relationship with the middle Rhine and Meuse regions, but also contacts with Southeast England, Norway, Sweden, and perhaps with the Mediterranean or Southern Europe. As a regional center, Dorestad probably served a large catchment area extending west to the coastal area of Holland and north to the North Sea and Waddenzee, including the hinterland of present-day Friesland and Groningen (Es 1990:170, fig. 8). Since some of the trade goods from Dorestad were manufactured on the spot, local trade probably provided Dorestad with the raw materials for its craft production, as well as agricultural products. The local area provided timber and wickerwork for building purposes, wool and perhaps flax for weaving, skins for leather working, and bone and antler for processing. There is also evidence for iron smelting, amber working, and possibly glass manufacturing.

The trading centers seem to have peaked in the eighth century. Trade fell off thereafter due to depredations of Viking raiders from the north. Dorestad was attacked in 834 and continued to be plundered until 836. For a short period, 841 to 850, it was in the possession of Viking chiefs. By the time peace returned
In the ninth century, Deventer and Tiel had surpassed Dorestad as the chief trading centers for the region. Environmental changes, the widening of the Lek and silting of the Rhine, finished Dorestad as a favorable trade center.

There is little archaeological evidence of local watercraft in the Netherlands after the late Roman occupation until the twelfth century. Excavations at Dorestad produced some iron fasteners attributed to shipbuilding and a few clinker riveted planks from a vessel built in the Scandinavian tradition, but not an entire boat. It is probable that on the rivers and fen streams and in the shallows, dugouts and small flat-bottomed planked craft built somewhat in the Zwammerdam style continued in use. A site at Krefeld, Germany dated to the eighth century, produced fragments of the end of a small vessel having L-shaped bilge strakes with two bottom planks in between, and sides raised by one strake. The frames consist of long timbers extending across the bottom, and up the sides of the boat with alternating L-shaped ends similar in principle to those found on the Zwammerdam-type vessels (Fig. 12a). A Swiss Merovingian site (Bouveret) dated to A.D. 620–670), also produced a few plank fragments from the end of similar boat (Arnold et al 1988; Arnold 1992:102) (Fig. 12b).
Figure 12. Remnants of two small craft from the Early Middle Ages. Figure 12a (not to scale) shows the eighth-century Krefeld boat from Germany and 12b the Bouveret boat fragments from Lake Geneva, Switzerland (A.D. 620-670). (Drawing by author, after Damman 1974, and Arnold 1992.)
These plank fragments consist of two bilge strakes and the two bottom planks that fit between them. One interesting feature seen on these planks is the edge-to-edge fastening with the use of wooden pegs, a feature of the sixteenth century boat from Workum, Friesland, which is discussed later in this work. These two examples of boat remains provide some evidence of continuity in the building of flat-bottomed boats during the Early Middle Ages.
CHAPTER V

ECONOMIC AND DEMOGRAPHIC RECOVERY: A.D. 1000-1250

Population pressures were a substantial cause of colonization from the tenth through the twelfth century, although heavy flooding during the twelfth century increased the incentive to migrate further into the peat moors. This period of colonization was also paralleled by similar movements in France, England, and western Germany (Bos 1990:123-24).

The peat bogs, which covered most of central Holland, western Utrecht, and central Friesland had been virtually empty until the tenth century. Reclamation of the peat bogs was begun on a modest scale during the Carolingian period, but the peoples lacked either the knowledge of how to protect the land from flooding or, since there was still an abundance of wild peat moors, lacked the incentive to dig drainage ditches and build dikes and dams (Besteman 1990:111).

A shifting land use pattern might have been more economical for a simpler society as land was plentiful and populations relatively low. There is as yet no archaeological evidence for the use of drainage ditches during the Carolingian period. The stimulus for
colonization was probably increased population pressures and loss of agricultural land in the dune region (Besteman 1990:111-112).

Characteristic of these initial medieval settlements in the Dutch delta are the terp settlements. Terpen consist of both man-made mounds and elevated embankments along a stream or river. The man-made embankments have been divided into two types: towns along large rivers that developed on only one bank and those which developed, usually later, along both banks of a small stream. This double-banked development, often located where a fen stream widened and joined a large river, is associated with the reclamation settlement in the wild bog area. Those villages that grew into towns usually developed as one or more individual mounds that were eventually filled in to form elongated terpen, with wharves built along the watercourse and the stream or river transformed into a canal (Sarfatij 1990:185).

Some of these rural settlements would become the late medieval towns. Figure 13 shows the later provinces and principal cities that developed out of these early settlements. Ceramics recovered from excavations within several present day cities demonstrate that many of these began as rural settlements colonized along sand dune
Figure 13. Map of Netherlands' provinces and principal cities. The map shows the Zuiderzee prior to its diking and reclamation.
ridges either during the tenth to the twelfth centuries or from the twelfth through thirteenth centuries.

The peat lands were used primarily for growing cereals until the fourteenth century, at which time, emphasis began shifting to animal husbandry. Cultivation of grain was the main objective, however, some small herds of livestock probably always grazed the adjacent peat bogs. Since the oligotrophic peat requires enrichment of the soil as well as deep drainage for cultivation, this may have necessitated more intensive land. Enrichment may have been accomplished initially by incidental flooding followed by human activities such as burning, adding ditch dredging materials, excavated clay, and eventually animal manure and town soil (Besteman 1990:110).

Reclamation of peat land was not without inherent problems, for land drainage and cultivation encouraged shrinkage and subsidence of the peat. In the early periods, colonial expansion involved farmers from old waterlogged reclamations migrating to new areas. The shifting reclamations occurred first on a local scale. As land subsided farmers extended the ditches into virgin peat bog, reclaiming new fields and using old fields for pastureland. Archaeological surveys in Westfriesland
have shown this form of land use can be traced from the eighth to the thirteenth centuries (Besteman 1990:112). Although drainage ditches might not have been necessary in the oldest settlements, by the thirteenth century the naturally raised bog had been depleted (Besteman 1990:110). When it no longer became possible to extend fields, farmers were faced with a crisis. Apparently, many chose to migrate.

In North Holland migration took a southern route, first into southerly areas of North Holland, later into South Holland and Utrecht. The elites of this region were the counts of Holland, who exploited and encouraged this southern migration of Frisians into regions under their control (Bos 1990:125-27).

Villagers dealt with the crisis of land subsidence by constructing a network of dams and dikes to drain the peat bogs and created drainage boards, waterschappen, to oversee these projects. These boards had a high degree of autonomy, consisting of representatives of the local inhabitants, the heemraden or dijkschepennen and in the case of Holland this board included a representative of the counts, the schout. Local inhabitants participated on the drainage boards through an electoral process. In the thirteenth century many waterschappen united into
larger organizations capable of dealing with drainage problems larger in scope (Vries 1974:28-29).

The well-drained districts provided opportunities for intensive land use. The long-settled clay soils were improved with the use of dikes. Still, many peat soils were not marginally improved until much later. Agriculture was unspecialized during this period and peasants may have worked larger tracts of land because of the minimal returns on ill-drained and often flooded fields (Vries 1974: 33-34).

During this period of colonization, the counts of Holland endeavored to bring the peat bogs of what is now South Holland under cultivation. Military successes by the counts of Holland and innovations in land reclamation were an immediate stimulus to colonization. Land reclamation and colonization spread human habitation over the peat bogs and marshlands of South Holland, Utrecht, and Zeeland (Bos 1990:121-125).

There is some difference in the development of the frontiers of South Holland versus land development in North Holland, Westfriesland, Friesland, and Groningen. In South Holland the nobility were able to exert more control over the reclamation of lands, while elsewhere
within the northern Netherlands, a weak nobility failed to dominate the peasantry. The basic structural unit of the new lands in South Holland were peasant farms divided into long thin parcels of land, separated by drainage ditches. The secular or ecclesiastical lord provided a parcel of land, stipulating width and length, and imposed the land use tax to insure a tributary relationship between elite and peasant (Bos 1990:120; Vries 1974:26-28).

In North Holland and Friesland, archaeological and historical information indicates that reclamation took place quickly over the course of the second half of the tenth century. A lack of archives related to land administration and taxation, as well as farm fields of variable widths and lengths indicate the lack of a strong central authority (Bos 1990:124). A free peasantry, however, completely independent of secular or ecclesiastical authority, seems unlikely until the thirteenth century, since this does not fit the norm for early medieval life (Besteman 1990:117).

It does appear, that in the regions of North Holland, Friesland, and Groningen, land was colonized without leaving space for castles or estates. Noblemen were not in control here as in the areas of Europe once
under Roman and then Carolingian control. Elites, within
the northern Netherlands, must have been forced to
bargain with the peasantry (Vries 1974:35-41).

From the tenth to the late thirteenth century, most
trade was administered by elites. This was particularly
ture of the local market exchange, which consisted of two
classes, elites and subordinate peasants (Hodges 1982).
Before A.D. 1300, most peasant communities in western
Europe were self sufficient as far as subsistence
commodities. Local markets existed for the exchange of
supplementary goods. These were small and independent of
the larger market system. In bishoprics like that of
Utrecht, ecclesiastical prelates, noble families and
their households, and monks formed an elite class. This
class created an urban environment, which included
servants, warriors, artisans, and merchants. Elites
received subsistence goods as tribute, but craft objects
required either peasant specialization or interregional
or international trade. Peasant specialization in this
period usually involved a system of patronage. Peasants
had limited access to the means of production and
exchange, for they lacked the capital to invest in tools,
materials, and transportation. Surplus raw materials and
craft goods passed through the hands of the elites, who
acting as intermediaries employed travelling peddlers to
sell the goods at local and distant markets (Verhoeven 1990:276). Furthermore, the shortage of coinage and the lack of a real market economy was a deterrent to trade (Hodges 1989).

Areas in the Rhineland around Cologne and the Middle Meuse were probably better integrated commercially than the hinterlands in the Netherlands. Towns like Utrecht prospered because of increased trade with German towns on the Rhine River. The urban environment increased in the late twelfth and thirteenth centuries as new towns were created by local nobility in order to increase their grip on the peasantry and exact tribute (Verhoeven 1990:276-77).

The development of markets and craft production can be seen in the pottery trade. In the Middle Meuse and Rhineland areas, specific centers of production were organized at the community level to produce for distant urban markets in the Netherlands. Community production centers were located along transportation networks, as in the case of potteries in the villages of Elmpt and Bruggen on the Schwalm River, a tributary of the Meuse. Towards the end of the thirteenth century, however, local village potteries began to produce functional wares for their local markets. In response to a diminishing
market, the more distant producers began to specialize in
the production of stonewares (Verhoeven 1990:277).

Water Transportation and Watercraft

The improvement of the economy during this period
led to innovations in navigation and shipbuilding
technology in both seagoing and inland vessels. This
resulted in the building of a larger variety of ships and
boats. The introduction of the stern rudder is one of
the more significant technological innovations in ships,
but this period also saw the introduction of fore and
after castles, bowsprits, bonnets or reef points on the
sail, and the use of a windlass to raise the sail and
yard. New tools expedited the building of ships.
Shaping timber with a frame saw instead of ax and adze
was a faster and a more efficient use of wood. By A.D.
1250, shipbuilders were using the brace and bit, an
innovation based upon the development of the hand crank,
for drilling holes in planks and frames (Unger 1980:143-
44).

Increase in trade within the North Sea and Baltic
regions required improvements in cargo carriers. Cargo-
carrying capacity increased by ships becoming longer and
broader and deeper of hold, eventually resulting in a
vessel that could efficiently and economically carry bulk cargos. These larger ships relied more on sails than rowers, thus making the transport of bulk goods more efficient. Since increased size made beaching more difficult, deepwater harbor improvements were synchronized with those in ships. New ship types are mentioned in the records, such as the buza, a prototype of the buss, used throughout the North and Baltic Seas for fishing and cargo carrying. Other vessels were also mentioned, the hulk, keel, bark, and ewer. Cogs develop into deep-water merchantmen capable of long-distance trade to England and even Iceland. The cog also became more defensible as the height of its sides increased and castles were added fore and aft. The cog by the end of the twelfth century was a sturdy, defensible ship with more cargo carrying capacity than contemporary ships such as the keel, knarr, longship, and galley (Unger 1980:135-41).

There was a greater variety in design during this period than before. Specialization in ship design was encouraged by the increased mercantile activity throughout Northern Europe. The trade in bulk goods and different coastal requirements may have influenced shipbuilders to begin to experiment with specific designs for specific types of cargoes (Unger 1980:146).
Local water transportation during this period reflects the needs of a primarily subsistence economy and although trade was increasing, it is still relatively small when compared with later periods. Long-distance trade was in the hands of elites and consisted mostly of peasant surplus exchanged for luxury goods. Transportation was necessary for the migration of people and livestock to the peat moors and in moving small amounts of surplus goods to towns for exchange or tribute. Watercraft were also necessary for the construction of towns, dams and dikes, and the building of canals.

Two basic types of inland watercraft have been recovered from this period in the Netherlands; large expanded dugout vessels characterized by the Utrecht boat and flat-bottomed pram-class boats.

**Expanded Dugouts: The Utrecht Type**

The expanded-dugout (Utrecht) type is represented by the remains of three vessels: one found in Utrecht in 1930 and approximately dated with dendrochronology to the eleventh century and by iron fasteners, sintels, to the twelfth century (Vlek 1987:67; Reinders 1983:25) (Fig. 14). The Waterstraat ship, dated to the second half of
Figure 14. The Utrecht-type of extended dugout. Expanded planking plan of the Utrecht dugout found in 1930. (Drawing by author, after Vlek 1987.)
the twelfth century, excavated in Utrecht in 1974 (Fig. 15), and a smaller version discovered near Velsen in North Holland and dating from between the end of the eleventh century to the late twelfth century exhibit a similar construction (Fig. 16) (Vlek 1987:103, 142). All of these are fairly similar in construction, having rounded dugout bottoms reduced with ax and adze from the hollowed-out trunk of a tree, lapstrake sides, scow-ended fore and aft with the ends strengthened by knees, and curved long- and short-armed frames.

The shape and dimensions of these vessels depended upon the availability of large trees from which to build the bottom. The bottom of the larger Utrecht boat came from a tree trunk with a diameter of over 2 m and the smaller Waterstraat boat required a tree trunk of at least 1.5 m in diameter. Holes were drilled in the bottom and used as thickness gauges while shaping the dugout bottom and these later were plugged with small unwedged treenails (Vlek 1987:107-45).

Reconstructed lengths for these vessels are approximately 17.2 m for the Utrecht vessel, 13 m for the Waterstraat vessel and 6.5 m for the Velsen boat. All of the vessels had squared-off ends. The Utrecht vessel is classified as defining the type, although the
Figure 15. The Watersmat vessel. (Drawing by author, after Vlek 1987.)
Figure 16. The Velsen boat, a smaller version of the Utrecht-type of extended dugout. (Drawing by author, after Vlek 1987.)
construction of all three boats vary to some degree. The Utrecht ship had stem and stern planks at either end that extended the ends and closed the juncture of bottom and sides. The surviving end (probably the stern) of the Waterstraat boat was formed from the same bottom plank, strengthened with knees and a heavy wooden board in the very end (Vlek 1987:107-45).

Each side of the Utrecht boat consisted of three strakes: a garboard, a heavy half-round-shaped wale cut from the heartwood of oak, and sheerstrake having an outer rubbing strake. The heavy wale overlapped both side strakes and strengthened the hull longitudinally and probably increased the transverse stability of the hull in the water. A sheerstrake was fastened to the inside edge of the heavy wale. The garboards and sheerstrakes consisted of two planks scarfed together with flat scarfs. The rubbing strake was fastened to the outer upper edge of the sheerstrake and consisted of several planks. The side strakes were fastened together with treenails and caulked with moss, lath, and iron sintels. The Waterstraat boat had a similar construction, but the smaller Velsen boat had only two side strakes and the heavy wale was missing entirely (Vlek 1987:107-45).
All of the Utrecht boat's frames were of naturally grown timbers that served to hold the shape of the bottom and sides. These were arranged in a pattern of short frames extending across only the bottom plank alternating with long frames extending across the bottom and garboard to the wale. This pattern differs amidships, in an area that was probably the cargo hold, where five long frames were placed consecutively. In the Waterstraat boat, the framing pattern differed slightly with two short frames between long frames while the Velsen boat uses longer frames throughout (Vlek 1987:107-45).

Limber holes for the circulation of the bilge water were cut in the outboard faces of the frames. As mentioned above, four knees were used to close the ends of the boat. The Utrecht and Velsen vessels had small mast steps, presumably for towing masts, mortised into a frame and placed one-third of the distance from the bow. Propulsion of these boats was primarily by poling and towing, although it is possible that a small mast could have been rigged with a sail. In the stern of both the Utrecht and Waterstraat boats, a threnus, a transverse beam to support the steering oar was recovered (Vlek 1987:107-45).
All three boats of the Utrecht type, exhibit a construction that seems to define a specific extended-dugout tradition. The use of these boats in the twelfth century reflects the regions' colonizing and frontier aspect. Native timber of good quality was still available in the area and although there are some indications that these may have been built further up the Rhine, it is also possible that their construction was local. The disappearance of the type, or at least the larger versions, has to be attributed to depleted local timber reserves. As long as there was suitable timber available, dugouts remained an economical and relatively simple watercraft to build, requiring the felling of a minimal number of trees, and the use of only a few tools: an ax, adze, and augur to shape and assemble the hulls. Although they are considered as evidence of watercraft used in interregional trade between Utrecht and German cities on the Rhine, local trade and their use in the building trades during dike and city construction may be as likely. Local trade and transportation would a seem reasonable use for the smaller Velsen boat.

It is the use of the second type of inland boat from this period, the pram-class vessel, that continued in use through the Late Middle Ages. Having a construction only slightly more sophisticated than that of the Utrecht
type, pram-class construction provided a comparatively strong, light-weight, shoal-draft hull. The hull design was not dependent upon availability of large tree trunks and gave the builder more control over the final form.

**Pram-Class Vessels from the Thirteenth Century**

Three vessels found at Meinerswijk near Arnhem, the first in 1974 and the others in 1976, are representative of small pram-class craft from the thirteenth century (Reinders 1983). All were found in a sandpit, which formerly had been an old bed of the Rhine River before it filled with clay after the Rhine changed course.

The first wreck discovered was estimated by divers to be 25 m long and 4 to 5 m wide. Only a few frames and planks were recovered, but it appears to have been hard chined with the sides and bottom fitting together at a 135 to 140 degree angle. Some of the planks recovered were 5 to 6 cm thicker at the edge than in the middle. From a photo of one of these planks it appears to be from the bottom and the thicker portion where it joined the side of the ship (Reinders 1983:14, Fig. 8). Moss caulking on this edge indicates the join between the bottom and sides. The same photo shows a small wooden treenail which might have joined the side and bottom.
There is an absence of floor timbers in the framing sequence. Naturally grown, knee-ended floor timbers, were placed opposite or alongside of each other (Reinders 1983:14, Fig. 8).

Of the second vessel found in the sandpit, only the bottom and the lower side strakes were intact, most of the frames had been lost. The bottom was lanceolate-shaped and measured 8.5 m long and was 1.65 m at the widest part (Fig. 17). Four planks make up the bottom, with a maximum width of 40 cm and thickness of 2.6 to 2.8 cm. Each central strake was composed of a long and a short plank fitted end-to-end with a flat scarf. The edges of these scarfs were widened, filled with moss, and held in place by lath and sintels. The central planks come together to a point at the ends of the boat, but do not form the rectangular toes present in later pram-class vessels for fastening the stem and sternpost heels. Nothing survived of the posts, but it seems likely that posts would have been the easiest way to close the ends of this boat (Reinders 1983:15-20, 40-41).

The lower side strake was a maximum 27 cm wide and 2.4 cm thick. It fit against the beveled edge of the outer bottom plank, ending 75 cm and 60 cm from the ends. Bottom and side strakes were joined at the chine with
Figure 17. Meinerswijk boat, an early pram-class vessel. Cross-section is reconstructed. (Drawing by author, after Reinders 1983.)
treenails 1.3 cm in diameter, angled from outboard and spaced 25 to 30 cm apart. The seam between the planks was caulked with moss overlaid by a lath of willow, which was held in place by iron sintels. Marks on the upper edge of the lower side strake indicate that there was at least one more upper strake (Reinders 1983:15-20, 40-41).

Frames were spaced closely together; flat floor timbers were followed by L-shaped futtocks with alternating knee ends. Strakes were joined to the frames with two treenails each. Treenails were wedged on the outside and were 1.5 to 2 cm in diameter. The forward half of the boat was much more narrow than the after half. A mast step was set forward and fastened on top of the frames with iron nails and treenails. The mast step was fitted with a 12 cm diameter mortise for a small mast (Reinders 1983:15-20, 40-41).

The third vessel was a 6 m long fragment of a log boat (Fig. 18). It also is an extended dugout, but has a different method of construction from that of the Utrecht example. Port and starboard sides of the boat were made from two halves of a log, split along the longitudinal axis. Three bottom planks were inserted between these halves. An additional plank was added to each side to give the boat more depth of hold. The three bottom
Figure 18. Meinerswijk extended dugout. (Drawing by author, after Reinders 1983.)
planks were cut from the same tree and were 8 cm thick. These planks were relatively wide, 38 to 46.5 cm at the surviving end of the boat and increasing to 48.5 and 53.5 cm where the hull was damaged (Reinders 1983:23-30, 41-43).

The sides were built exceedingly heavy; after splitting the log, the inside was carved out and the outside shaped leaving a 8 to 12 cm thickness to the upper side. These strakes do not have perpendicular sides, unlike the bilge strakes in the Zwammerdam type and the early medieval boats, but curved inward such that they had a C-shaped cross-section. Another strake was placed edge-to-edge (35 cm wide and 8 cm thick) with the upper edge of the C-shaped dugout strake (Reinders 1983:23-30, 41-43).

The end of the dugout was closed with three 7 cm thick planks. These were notched to fit the bottom planks and fastened with clenched iron nails. Floor timbers were spaced widely apart, 1 to 1.2 m. These were attached to the bottom planks with two treenails each and to the bilge strake with one treenail. A futtock was placed between each pair of floor timbers. As with the Utrecht-type, the end of the boat was strengthened with a knee-like timber (Reinders 1983:26, 41).
Caulking consisted of moss, lath, and sintels. The seams between the bottom planks were completely filled with moss, held in place below with lath and sintels and above with only sintels. On the side strakes, caulking was just the opposite--moss with lath and sintels on the inside and on the outside only sintels. The three short planks in the bow were caulked where they joined the bottom strakes with lath and sintels on both upper and lower joins. Where lath was not used the sintels were placed closer together (Reinders 1983:26, 41).

This dugout bears similarity to boats found in Bremen and Krefeld, Germany as well as elsewhere in Northern Europe and shows an alternative strategy to the Utrecht type of expanded dugout (Reinders 1983:42; Ellmers 1984b). It also can be viewed as a transitory type bearing some similarities to other hard-chined vessels having heavy L-shaped strakes at the join between the bottom and side. This small boat has many similarities to other small boats excavated in the IJsselmeerpolders and to the present-day Dutch punters.

While the latter two boats are relatively small craft, the first pram-class vessel found in the sandpit was large, if the 25 m length is correct. It is the first river vessel of this size since the end of the
Roman period. Its size alone is a strong indication of growing trade along the Rhine River. This length and breadth may have been strengthened by using only L-shaped futtocks rather than alternating futtocks with floor timbers. This was done in the late fifteenth-century boat, K 73/74, discovered in the Ijsselmeerpolders (discussed later in this work). The size of this vessel also might be considered a trend towards specialized vessels for bulk-cargo transport. Although it may have been able to carry a variety of bulk cargoes, its size alone might restrict it to this trade.

These archaeological examples support the view that in the thirteenth century there was an increase in trade and an increased sophistication of inland watercraft. The larger river vessel might also indicate a growth in available capital investment in tools and materials, as well as labor specialization. The overall impression left by these vessels is evocative of the Late Roman Period and of small craft used in a frontier environment and economy.
CHAPTER VI

OPPORTUNITY AND CRISIS IN THE LATE MIDDLE AGES:
A.D. 1250-1500

The late thirteenth and fourteenth centuries were a period of increasing regional differentiation. A new economic and social structure was evolving in which trade, finance, and non-agrarian production all played a part. New towns and urban centers developed during the thirteenth century near the dams constructed across rivers and streams. Rural population decreased in some areas (based on deserted house sites) and people moved to the burgeoning urban centers. During the fourteenth century, there were both economic and demographic crises in Europe resulting from plague and crop failures. Some members of the peasantry supplemented their subsistence agriculture by hiring out as day laborers to dig peat, which supplied the increasing fuel demand of the urban centers (Bos 1990:125-27).

Differences in prosperity and status were noticeable among the peasantry during this period. Although the economic situation in the thirteenth century did not allow rural specialization, peasants benefitted from the alternative sources of income brought about by local and regional trade. During this period, local elites, such
as the counts of Holland, encouraged the formation of towns and urban trade. In the case of North Holland this was achieved through conquest and consolidation with South Holland (Bos 1990:127).

Agriculture remained important in many areas, but in the peat moors the emphasis shifted to trade, shipping, and industry. Many Holland villages benefitted by the shift of the herring shoals from the Baltic to the North Sea around A.D. 1400. Hollander merchants traded with Prussians for grain and timber despite attempts by the Hanse to prevent their developing this trade (Bos 1990:129).

The renewed importance of trade is evidenced by rural settlements. Settlements located at a distance from roads or navigable waterways were abandoned and the village and church moved to new locations along a road or river. Village mobility, either due to economic crisis or new opportunities, coincides with and causes abandonment of fields and the increasing marshiness of the land. It may be that the increasing inundation of farm and pasture lands forced the population into alternative subsistence strategies. Alternatively, the increased marshiness might be an indication of the
abandoning of land and neglect of drainage ditches and dikes (Bos 1990:127).

Watercraft During the Thirteenth and Fourteenth Centuries

During this period the trends of increased vessel size and specialization of types continues, despite some economic setbacks due to population decline. Cogs continue to be built larger than before and by A.D. 1400 the average size is about 100 tons. Hulls became more rounded in form with a broad flat bottom, and a heavier construction. Fore and after castles become an integral part of ship construction and heavier masts having shrouds and ratlines were introduced. The tiller of the stern rudder passed through an opening in the stern and was attached to the whipstaff so that the helmsman might navigate better. This and the use of compass and charts improved the ability of mariners to navigate (Unger 1980:163-6).

Other types of vessels competed with cogs, at least for the short haul. The keel, buss, and hulk were still used. Frams are first mentioned in the records as coaster, lighters, and river transports. Many other small craft were also built for fishing and coastal trade. Smaller vessels were frequently used for short
voyages, often the intermediary transport of goods. Smaller shallow-drafted vessels were needed in the shoal waters of the Almere, where larger cogs could not sail. The medium-sized vessels of Holland shippers transshipped goods across the Almere to Hanse towns such as Kampen, an important deepwater port (Unger 1980:167-8).

The Period Around A.D. 1500

Because of low or marginal returns on the poor agricultural lands of the peasantry, there was an upsurge in proletarian labor pursuing non-agricultural activities such as peat digging, seafaring, and transportation. At times, the landless could hire out as day laborers or sailors; in the riverbank villages nonagricultural activities such as brickmaking, river transport, and dike maintenance attracted migrant laborers. Many peasants supplemented their income by transporting brick, clay, peat, and farm products in their small boats. North of the river IJ, a dense network of waterways placed every village in communication with the sea. Sailing and fishing were a natural part of the rural economy and some laborers crewed on herring boats (Vrles 1974:64-68).

Two tax surveys, the Enqueste of 1494 and the Informacie of 1514 provide data on the economic situation
Two tax surveys, the Enqueste of 1494 and the Informacie of 1514 provide data on the economic situation for Holland (Fruin 1866; 1876). (In fact, these are the best available statistics on population and occupation for the period.) By looking at the sources of income listed in these surveys, Bos (1990) found that regional specialization was occurring.

For many villages, the most important activity was cutting peat. Those listing agriculture as the main occupation, supplemented farming with shipping and trade. Most North Holland villages listed only shipping and trade as the primary occupation, however, the seven villages located along the North Sea coast listed only fishing. The village of Ransdorp in North Holland, stated that "there are no possibilities of making a living from the land, except if the women keep a cow or two" (Fruin 1866). Additionally, women in these villages were probably involved in home industries of spinning and knitting. One village stated that its men earned their livelihood "at sea, sailing east and west (to the Baltic and the Bay of Biscay), some carry their own goods and others sail for wages" (Fruin 1866). Although agriculture and animal husbandry were still practiced in these villages, it was no longer the main occupation (Bos 1990:127).
Shipping, trade and especially fishing probably conflicted with the cultivation requirements of planting, tending and harvesting. Scheduling the harvesting of marine versus agricultural resources could have created conflicts, which encouraged specialization and trade among local communities, as was found to be the case in a study of eighteenth-century seafaring and agricultural communities in Cape Cod, Massachusetts (Yentsch 1988:138-60).

Reciprocal trade is a likely strategy for procuring different resources in a coastal environment. The rural sector could not have specialized without massive imports of grain. In the fifteenth and early sixteenth centuries grain deficit areas had to rely chiefly upon nearby regional rather than international surpluses. In Groningen, for example, farmers and merchants sailed to Lier, Wener, and Reen to buy grain to supplement their own production (Vries 1974:169). Local trade began to be supplemented by long distance trade to a greater extent in the first half of the sixteenth century. Surplus grain came from the Baltic, primarily Poland, which eventually became the major source of imported grain.
Innovations in Small Craft: A.D. 1350 to 1550

During this time there was a great increase in the specialization of small craft in the Low Countries, resulting in a variety of new types under 50 tons. This increase was a reflection of specialization in the local economy, which carries over readily to maritime activities. Fisheries expanded rapidly in the North Sea as a result of new catching and curing methods. This led to the herring buss, a type of fishing boat designed specifically for this catching and curing. Other North Sea fishing vessels included the doggers, hoekers, pinken, schuiten, and slabberts. Swift vessels like the ventjager relied on purchasing part of a fresh catch from a deep-sea vessel and sailing swiftly to market with it. Many of these, such as the buss, smack, karveel, heude, and hoeker also carried cargo in off seasons. Smaller versions of the cog, or kaage, continued in use for short-haul freightage and passenger ferriage (Unger 1980:206-08), while inland waters saw an increase in the use of schuiten, praamen, aaken, poonen, and others on the inland rivers (Petrejus 1971).

The number of men necessary to man these ships fell, making them exceedingly economical for short haul freightage. The sprit rig came into common usage in the
fourteenth century as a sail on two poles with a common mast step. Free-footed gaffsails were in use by the early sixteenth century. Both of these fore and aft rigs gave small craft the ability to go against the wind and make headway in a crosswind. Another sail could also be placed forward, hung from the forecastle. This rig was more efficient on inland and coastal waterways: making ships more maneuverable, requiring less manpower to operate, and with savings in both labor and sailing time.

Unger (1980) suggests that the adoption of fore and aft rigs about A.D. 1400 may have been in response to an economic crisis brought on by population decline resulting from the plague. He also attributes attempts to improve the productivity of small craft as the result of the expanded consumption of fish, meat, and cheese. Presumably, Unger means that increased demand led to an increase and specialization of fishing craft. Since meat and cheese require more frequent marketing than grain crops, this also was an incentive to growth in the local economy and in the numbers and types of small craft farmers and skippers used to transport this produce to market. This caused shipbuilders to experiment with new designs in an attempt to match design with occupation (Unger 1980:209). It is just as likely that the expanding and increasingly specialized rural and urban
economies, the growth of urban centers, and rebounding population opened up new opportunities for mariners and shipbuilders. Innovations in finance increased credit and new investors also were a contributing factor.

An Early Fifteenth-Century Vessel: M 40

During the fifteenth century there was an increased reliance on navigation and trade, while much of the local economy remained diversified. No examples of pram-class vessels have been excavated from this period. This is probably due to the randomness of shipwreck discoveries, but might reflect a relatively low quantity of boats during the period. One vessel, M 40, has some interesting pram characteristics that may shed light on strategies in water transportation and the local economy during this period (Fig. 19).

The excavation of this small freighter was begun in 1949 on lot M 40 in the Northeast polder (Center for Shiparchaeology archives, unpublished excavation report). The vessel had several pram-class features, such as its flat carvel bottom, hard chine, inwale above the frame heads, and stem and sternpost heels that fit atop the rectangular toe-like ends of the central bottom plank. The vessel is distinctly different from prams, however,
Figure 19. A vessel from about A.D. 1400: M 40. (Drawing by author, after site plan in Rijksmuseum for Shiparcheology archives.)
for in the bow and stern the carvel bottom strakes changes to lapstrake side strakes. The fine ends of the ship were V-shaped in cross-section and indicated a more seaworthy vessel than a typical flat-bottomed pram. G.D. van de Heide, the excavator, suggested this was a coastal vessel, sailing the Waddenzee or North Sea. This interpretation was based upon the presence of seaweed and bryozoans attached to the hull's bottom. He dated the site to the sixteenth or fifteenth century, but the ceramics indicate an earlier date, possibly about A.D. 1400 (Center for Shiparchaeology archives, unpublished report).

The ship remains were 16.5 m from stem to sternpost with a breadth of over 4 m. The bottom consisted of five strakes, including a central plank that ran from stem to stern. Towards the ends the two planks on either side of the central plank angled upward to attach to the posts. The scarf for the central plank and the two outermost bottom planks were placed at about the same location aft, while the scarfs for the two planks to either side of the central plank had scarfs at about the same location in the forward half of the ship. This pattern of placing scarfs can be seen in other late-medieval vessels in this study. The flat scarfs were fastened with two rows of iron nails. The bottom planks
were caulked inboard with moss and lath, which were held
in place by iron sintels.

Stem and sternpost were notched to fit over the
shaped ends, toes, of the central plank. Both posts
appear to have been upright timbers, but the stem had
more rake than the sternpost. Both also appear to have
had rabbets for the hood ends of the strakes. The stem
was of one or two pieces of wood and the sternpost
consisted of at least two timbers. A single gudgeon
survived on the lower part of the sternpost, while higher
up on the post was an eyebolt to take the uppermost
rudder pintle.

The sides consisted of three strakes amidships,
increasing to fives strakes at the ends as the bottom
strakes curved upwards. This gave the ship a low
freeboard amidships. The uppermost strake was relatively
narrow, along the upper inboard face of which fastened
the inwale. The inwale was square to trapezoidal in
cross-section, probably becoming more trapezoidal at the
ends. This provided longitudinal stiffening to the hull
and prevented hogging.

Frames consisted of both floor timbers and the
futtocks that fit on top of the floor timber heads. The
evidence is unclear from the drawings but the floor timbers appear to extend to the chine or sometimes just above the chine, perhaps alternating to port and starboard with long and short arms. Futtocks were placed directly on top of the floor timbers and fastened with iron nails. In the very bow and stern the floor timbers continued up the posts as V-shaped timbers, or wrangen. Fastened to the sternpost was a triangular-shaped block which may have supported the afterdeck.

Two mast steps were found in the vessel, both of them in the forward third of the vessel. These were notched mortises cut in doubled floor timbers. The more forward of the two steps showed the heaviest construction. It is uncertain why two mast steps were needed, but the vessel K 73/74 also had a similar construction, although the mast steps were spaced a little further apart on the K 73/74. Six strakes of ceiling extended to just forward of the larger mast step and aft to 2 m forward of the sternpost.

Hearth and galley appear to have been in the stern. Here were found remains of a ceiling and a possible deck beam. The report from this excavation did not indicate the locations for the artifacts recovered, and only mentions possible living quarters in the stern and
facilities for cooking. Listed among the finds were several glazed tiles, probably from a hearth, two red earthenware cooking pots, a ceramic frying pan, and a fragment of a red earthenware bowl. These were part of the hearth and galley. No remains of food were found, although a cow's skull was listed in the artifact inventory.

Ship's equipment consisted of two windlasses (one from the bow area and the other from the stern), a fiddle block, another small block, an iron hook, rigging thimbles, and a number of iron bolts and fittings. Tools included an iron boat hook, ax, adze, draw knife, pair of iron pincers, and a sail-maker's palm. Personal effects consisted of a short sword and small knives, leather shoes and a slipper, and two leather bags. Some fragments of woolen cloth were found mixed with rope, however, it is impossible at this time to determine if this was part of the ship's inventory, sailor's apparel, or remains of cargo. No clear evidence of cargo was found. Some limestone net weights were found inside the ship, but netweights are a common intrusive find on IJsselmeerpolder shipwrecks. On the other hand, if the vessel did have a windlass in the stern, one possible function for this windlass would have been to pull a net. Nineteenth and twentieth-century Zuiderzee fishing
vessels used such a windlass in the stern to pull a drag or tow net; a fishing arrangement that date to at least the fifteenth century (Dorleijn 1987:118-20).

G.D. van de Heide described the ship as one that was strongly built, but also one that was a fast sailor with straight raking ends that had sailed the salty waters of the Waddenzee or North Sea (Center for Shiparchaeology archives, unpublished report).

The chief differences between M 40 and prams is the bottom planking that changes to lapstrake side strakes at the ends, the framing scheme which sets the futtocks on top of the ends of the floor timbers, and the use of deadwood in the stern that gave the hull a finer run.

Although not a pram, vessel M 40, shares some similarities with prams and may be a related type like the ewer or bacove. Like pram-class vessels, M 40 was carvel bottomed and hard chined throughout most of the hold area, only changing to a finer lapstrake hull towards the ends. Also the straight raking posts fit directly on the bottom of the hull, probably over toes of the bottom planks instead of scarfing to stem and stern hooks as with cogs. The low-freeboard is also found in
most prams as is the inwale fastened to the inboard face of the sheerstrake.

Vessels like M 40, and K 73/74 discussed below, indicate how the pram type could have been adapted to the purposes of coastal trade. Giving the hull a finer entrance and run made for a faster and more seaworthy vessel, while retaining the hard chine amidships maintained the optimum hull capacity, allowed for a shoal draft, and provided a stable working hull. The hard-chine construction was also perhaps simpler to design and build in comparison with that of round-hulled vessels.

M 40 represents a vessel built possibly for fishing, trade, or both. Its construction may indicate a more diversified rather than specialized economic strategy. M 40 could have sailed coastal and inland waters alike as a generic short-haul transport or fishing craft. It seems representative of the increasing shift away from agriculture to fishing, shipping, and trade.

Two Inland Freighters from Around A.D. 1500:
B 55 and K 73/74

Two ships from this period, wrecked between A.D. 1475 and 1500, have been recovered from the
Isselmeerpolders. While the two were relatively close in size with similarities such as flat bottom, framing pattern, and hard chine (at least amidships in the K 73/74) they were constructed quite differently (Reinders et al 1986).

The principal difference is that while the B 55 is flat and hard chined throughout the K 73/74's bottom planks curved upwards, like those of M 40, and changed from carvel bottom planks to lapstrake side strakes, thus forming a V-shaped hull in the bow and stern. Like the previous shipwreck, this construction may represent the attempt to combine the economical pram-class construction with a more seaworthy design.

**A Pram-Class Vessel: B 55**

The wreck of a large flat-bottomed freighter was discovered in 1975 while laying a sewer line in the city of Lelystad. Most of the bottom of the hull survived except where it had been damaged during ditching, but the side strakes primarily survived in the stern (Fig. 20). The artifacts, recovered from the stern, date the wreck to the period around A.D. 1475-1500 (Reinders et al 1986:31-41, enclosures 8-10).
Figure 20. A pram-class vessel from the late fifteenth century: B 55. (Drawing by author, after Reinders et al 1986.)
The B 55 was without a keel and had a flat bottom and hard-chine throughout its length. The bottom was 18.5 m long and 3.5 m wide. The bottom consisted of seven strakes, 50 cm wide and 3.5 cm thick with their planking seams caulked from the outside with moss and lath, and held in place by iron sintels (Reinders et al 1986:33).

The sternpost was recovered, lying inside the boat. The post had rabbets cut for the strake hood ends and the shipbuilder positioned the rabbet in such a way that the uppermost strake covered the upper part of the post. The sternpost also had three iron T-shaped gudgeons for the rudder. A skeg fit underneath both the hull's bottom and the sternpost (Reinders et al 1986:35, enclosure 9).

Five overlapping side strakes, fastened with clenched iron nails, survived in the stern. These were fastened to the bottom with small treenails or pegs. The join at the chine was made watertight with a lath of wood, a kimlat, running along the chine and nailed to the port and starboard side strakes. Side strakes were caulked on the inside with moss and lath and secured with iron sintels. The second strake in the stern was a stealer, which began four meters from the sternpost. Forward of the stealer, the third strake becomes the
second strake. Stealers were caulked both on the inside and on the outside of the vessel (Reinders et al 1986:34-35).

Frames consisted of floor timbers, L-shaped futtocks and a V-shaped timber in the very stern. Floor timbers have a regular spacing across the bottom and were fastened with two treenails per plank to the bottom. Floor timbers alternated with L-shaped futtocks. It is possible that top timbers were used, especially if the boat were five or six strakes high. One frame in the stern would seem to be a top timber and the remains of some treenail holes in the third and fourth strakes could have been fasteners for top timbers (Reinders et al 1986:37, enclosure 8).

The surviving fragments of the mast step were 6 meters from the forward end of the bottom. It was made from a heavy floor timber, twice the width of the other frames, within which a mortise for the mast was cut (Reinders et al 1986:37).

The rudder was well preserved and lay underneath the port side of the wreck. It was constructed of three pieces of wood and was triangular in section with the thicker part aft. The rudder extended lower in the water
than the ship's bottom. This may have helped to prevent lateral drift (the sideways motion of the ship away from the wind), to keep the ship on a straight course, and to have provided the rudder with more force in steering the vessel. The rudder could slide upwards to keep it from dragging in the shallows (Reinders et al 1986:35).

The galley and living quarters were in the stern separated from the cargo hold by a bulkhead and set upon an interior floor of ceiling planking. A jumble of tiles and bricks interspersed with peat bricks, which were fuel for the fire, indicated the hearth remains. Galley wares consisted of a small red earthenware frying pan, a stoneware bottle, a red earthenware pitcher, a pewter pitcher, two red earthenware cooking pots and a fragmentary bronze cooking pot, a copper pall, and part of a basket (Fig. 21). Tools consisted of parts of a handsaw, an iron lock, and a red earthenware pot containing pitch for caulking. Two knives with wooden handles were recovered. A dagger with sheath and a mace, also represent personal possessions (Reinders et al 1986:38-39, enclosures 10, 11).

This long, narrow ship (6:1 ratio on the bottom) with low freeboard seems more appropriate for inland waterways, rivers and canals, than the Zuiderzee. The
Figure 21. B.55 artifact assemblage. (Reinders et al. 1986.)
shape of the vessel suggests that of a pram-class bulk cargo carrier. Although the cargo is uncertain, fragments of shells and bricks, both of which were common cargoes for bulk freighters, were observed in the bottom of the hold and under the frames. Reinders et al (1986) note the similarity between this vessel and the painting of a sprit-sail freighter dated to about A.D. 1470 in the Binnenlandsvaarderskapel in Oude Kerk, Amsterdam (Kloek 1975:5). The pewter pitcher had the city of Haarlem's coat of arms, which may indicate the vessel sailed the network of canal and rivers that connected that city to the Zuiderzee and Flanders (Reinders et al 1986:39-41).

K 73/74

K 73/74 was a vessel that like M 40 had some pram-like construction features, but differs primarily in the ends of the boat (Fig. 22). Most of its construction is pram-like, however. Flat floor timbers were missing and frames consist primarily of L-shaped futtocks, like those of most prams. It is uncertain whether K 73/74 should be strictly classified as a pram-class vessel because of the manner in which the ends were constructed. The significance of K 73/74 for this study is that it exhibits innovation and change in the basic pram design.
Figure 22. A late fifteenth-century freighter. K 7374, having variations on stern-class construction. (Drawn by author)
K 73/74 was found in Eastern Flevoland in 1963 during the deepening of a drainage ditch between agricultural lots K 73 and K 74. The wreck was excavated during May and July of 1971. The vessel was relatively intact, except for a 2.8 m long section destroyed by the ditching machine. The excavation began on 10 May 1971 and was completed by 14 July. Although well preserved, the boat had hogged, with the bow and stern drooping lower than midships. The K 73/74 was a long, narrow freighter, 15.8 m long and 2.4 m wide having a length to beam ratio of 6.6/1 (Reinders et al. 1986:17-19).

The bottom consisted of five strakes, 3 to 4 cm thick with a central strake running from stem to sternpost. The central plank and outermost planks are all 40 cm wide, while the planks on either side of the central plank were 36 cm wide and have scarfs symmetrically positioned in about the same locations. Bottom planks were scarfed together with flat scarfs fastened by clenched iron nails. The central plank narrows towards the ends to form a toe for the posts, while the other bottom planks continue on to the posts as side strakes. All bottom planking was caulked from below using the traditional moss, lath, and sintels (Reinders et al. 1986:19-20).
The stem and sternpost were each cut from a single piece of wood. Both have a single hole through their sides, which probably functioned for the tying of ropes. Two T-shaped iron gudgeons were on the sternpost for attachment of the rudder. The bottoms of both posts are notched to fit over the toe-like ends of the central plank and treenailed together. A 3 meter length of chain was fastened to the inside of the stem above the foredeck. The authors do not give a function for the chain, but it may have been used in mooring the boat. Both posts had rabbets for the hood ends of the planking, however, the authors do not make it clear whether this notching was a true rabbet as on the B 55 (Reinders et al 1986:19).

Each side consisted of two overlapping planks amidships, but at the vessel's ends this increases to a total of four side strakes. The overlaps of the sides were 8 to 10 cm and fastened with clenched iron nails. Scarfs were 30 cm long and the ends fastened with iron nails. The sides were fastened to the bottom with iron nails spaced about 15 to 20 cm apart. A 10 cm square inwale was atop the frame heads reinforcing the hull longitudinally. This inwale ran the length of the vessel and crossed over the posts at the ends. It was fastened to the uppermost strake with treenails and in several
places bolted to the heads of the frames with iron bolts. Towards the ends, on both port and starboard sides, the inwales curved inward toward the posts. In order to make this transition, the builder fit together shorter, curved inwale timbers, and fastened the scarfs with both iron nails and treenails, while the strakes were fastened to the frames chiefly with treenails (Reinders et al 1986:21-22).

In several places on both the port and starboard inwales, 5 cm diameter holes had been drilled vertically through the inwale. Reinders et al (1986:21-22) suggest that these might represent fasteners for a washstrake. Alternatively, they could represent evidence for gangways or holes for attaching rigging or securing cargo. The latter would produce distinctive wear patterns, however, there is no mention of any such marks. They could also represent thole pin holes for the use of oars. Although Dutch flat-bottomed vessels were most frequently poled through shoals, oars could also be used (see Figure 26). In the stern, a triangular-shaped clamp was spiked to the inwale. Its function is unclear, but the piece also had vertical holes positioned in about the same place as the two vertical holes in the bow inwale (Reinders et al 1986:22, enclosure 5). Possibly these held pins or fittings that helped grip the end of a punting pole. An
example of a weyschuit, possibly using such an arrangement for poling from shore is shown in a 1615 drawing by Hendrik Corneliszoon Vroom (Berk 1984:30).

Frames consisted of port and starboard futtock pairs that extended across the hull's breadth and were scarfed and fastened together with iron nails and treenails. Paired frames consisted of alternating long and short legged futtocks (Reinders et al 1986:20-21, enclosures 4,5). By alternating the positions of the scarfs, the hull was given more strength longitudinally as well as laterally. This longitudinal strengthening also may have resulted in the foregoing of floor timbers in order to place futtocks closer together.

There were two mast steps in the vessel, positioned 4.3 m and 6.6 m aft of the stem. Each mast step was cut into the upper faces of thick frames. The mast-step mortises were 12 cm long by 10 cm broad and 6 cm deep. The forward step was braced with two planks between it and the frame unit directly aft. It had been necessary to repair the aftermost mast step. On the frame containing this mast step, a small board was added to complete the after face of mast step. This repair was held in place and reinforced with two iron bands fastened
across the frame (Reinders et al 1986:21, enclosures 4, 5).

There were no signs of ceiling ever having been fastened to the frames. The vessel did have small fore and after decks; such a small deck is called a plecht by the Dutch. The foredeck was the most complete and consisted of five planks supported by five beams. Notches were sawn in the planks so that they would fit tightly over the futtocks. Only two pieces of the after deck survived, but it appears to have had two levels. The aftermost deck was raised to the height of the invale. It rested on the lower deck and a bulkhead closed off the space between the two, forming a small compartment accessed through a hinged door. The lower deck was 40 cm above the bottom and supported by four beams (Reinders et al 1986:22-24, enclosures 4,5).

Most of the artifacts from this ship came from the area around the after mast step. These consisted of two stoneware pitchers, personal effects such as money and a dagger and knife, and tools such as adzes, tongs, an ax, a wooden bailer, and a caulking iron and drill (Fig. 23). The eleven coins found were from diverse mints, but three were minted in Kampen and two in Utrecht. There was no evidence of a hearth or galley on board, or permanent
Figure 23. K 73/74 artifact assemblage. (Reinders et al 1986.)
living quarters (Reinders et al 1986:24-28, enclosure 7).

The small artifact assemblage is typical of the restricted material culture of the Late Middle Ages. The absence of a hearth and galley might also be an indication of a short-haul vessel. The coins, if they belonged to the skipper and not a passenger, indicate involvement in the money economy.

K 73/74's significance to the study of change and continuity in pram-class boatbuilding is in its constructional variance with that of pram-class vessels. It serves as a hypothetical example for the development and evolution of new types of boats from the old pram-class design. Its long and narrow hull seem indicative of a vessel that was could be easily rowed or poled. The two mast steps indicate that the vessel could have been sailed or towed. K 73/74 does not seem to a vessel built for the hauling of bulk cargoes for it contrasts sharply with the beamy vessels of later centuries. Nor does the design of K 73/74 resemble that of fishing vessels. Its function can only be hypothesized, but its hull shape suggests that of ferry or short-haul freight carrier.

Vessels of K 73/74's design seem to disappear from the archaeological and historic record at the end of the
Late Middle Ages. It seems plausible that the increasing economic importance of transporting bulk goods demanded beamier vessels than the K 73/74 and thus made its long narrow design uncompetitive.
CHAPTER VII

A PERIOD OF GROWTH AND CHANGE: A.D. 1550-1650

The Dutch Golden Age

The late sixteenth century witnessed a period of unprecedented growth within the Dutch provinces. Growth occurred in rural and urban areas, coming about through several positively interrelated factors. These factors include: the development of an international exchange economy; a series of innovations in agriculture, industry, energy, and transportation; growth and expansion of both urban and rural populations, and the state formation process induced by the Eighty Years War (Tilley 1990; Vries 1974).

The international exchange economy that emerged in the late-sixteenth century coalesced around the economical shipment of bulk goods, chiefly grain, to cities such as Amsterdam. Cities possessed the markets, capital, and credit to finance large-scale enterprises. Innovative commercial methods and the prototypes of modern financial institutions, public and private banks and produce and shipping exchanges, were successfully established. This also included the prototypes of commodities and futures markets (Barbour 1950;
Wallerstein 1976). The economy was marked by an increased productivity in labor and capital, which was in contrast with previous periods of basic expansion in population and agricultural land. The dominant middle class, the urban workers, and rural peasantry all achieved a relatively high standard of living for the time. Specialization and diversification in agriculture, industry, and transportation were essential to this phenomena. This period also witnessed many innovations in shipbuilding and the introduction of new watercraft types (Vries 1974; Unger 1980).

Differences between country and town became even more distinct during this time. Although some areas of Holland, such as Waterland, were economically decimated by the Spanish army during the Eighty Years War, other areas, such as Amsterdam, benefitted from the influx of Protestant immigrants from Flanders and the city of Antwerp (Walton 1970-71:123-40; Wallerstein 1976). In turn, rural areas benefitted from investments by an increasing number of urban capitalists searching for investment opportunities. Urban capital was used to reorganize much of the countryside, drain new and old flooded lands with the aid of windmills, renew and build new dikes and dams, and dig canals for the peat and

As towns grew they depended increasingly upon agricultural and dairy imports from rural areas. The rapid transformation in local economies is evident from the area of Waterland, which stated in the Informacie of 1514 that they made their living from the sea trade, but within a generation of that statement, had become Amsterdam's supplier of dairy products (Fruin 1866; Bos 1990:129).

Trade and Grain

Specialization of agriculture and international trade went hand in hand. Large-scale trade in bulky commodities was one of the great triumphs of the Dutch sixteenth-century economy. Grain production had declined in the Netherlands during the fifteenth century and by the sixteenth century the region was a net importer of grain, chiefly from Poland. The tendencies of earlier periods were accelerated in the late sixteenth and early seventeenth centuries. The rural economy became increasingly specialized and focused upon trade, with imports of grain and exports of home-produced goods. The rural economy responded to a self-created opportunity to
specialize and produce for international markets (Vries 1974:165).

Trade links with Poland solidified by the second half of the sixteenth century, tying together both the Polish and Dutch economies (Vries 1974:169). In response to capitalist market demand, Polish nobles increased control over their demesne, enserfing the peasantry into a system of what Wallerstein (1976) terms "coerced-cash crop labor". Maczak's (1968) study of the Polish grain trade illustrates that even with this domination of the peasantry by the nobility, Poland exported no more than twelve percent of its rye crop and five percent of its wheat in the late sixteenth century and less in the eighteenth century. The requisition of an exportable surplus for the Dutch thus required vast amounts of Polish land and labor. Urban growth and rural specialization within the northern Netherlands was built upon the labor of hundreds of thousands of serfs and the produce of millions of hectares of land. (Sclichter van Bath 1963). Polish imports grew rapidly and in the first half of the seventeenth century 77 percent were carried in Dutch ships. Grain imports to the Netherlands also came from Denmark and France. By mid-seventeenth century, foreign grain fed over half of the inhabitants

Amsterdam was the entrepot of seventeenth-century Europe and the city's merchants dominated the Baltic trade in grain. The ability of Amsterdam merchants to import large quantities of grain was the basis of the shipping and commercial economy of the city. Amsterdam's merchants termed the grain trade the Moederneegotie (the mother commerce). By the seventeenth century, Europe's sailing vessels delivered tons of grain to Amsterdam and took on cargoes of cheese, butter, madder, tobacco, oils, and garden and nursery fruits. Exports in manufactured goods, increased demand by industries for domestically produced hemp, flax, coleseed, dyestuffs, peat, and clay.

The growth of international trade was in part due to the Dutch rural sector's ability to respond to the opportunities offered by international trade. Relieved of the need to devote resources to grain production, the Dutch could shift to other forms of production that gave a greater return. Labor released from agriculture was available for use in industries and commerce. Capital could be reinvested in land improvements and in the production of specialized crops, which would yield a
higher cash value. The rural sector also exploited water and wind-based power (Vries 1974:166).

The grain trade allowed the provinces of the northern Netherlands to devote more resources to animal husbandry and become the major exporter of dairy products to the rest of Europe. In the fifteenth and early sixteenth centuries dairy products were exported only on a small scale. Rhineland Germany, and the North Sea and Baltic coasts provided the major markets for Dutch cloth, herring, soap, and some manufactured goods. Archival data shows that by the 1540s, dairy exports had not yet assumed the economic importance they would have in the seventeenth century. A specialization in dairy products yielded a much higher income than grain and the international export of dairy products stimulated large-scale trade. Tobacco and madder, although unknown in the sixteenth century, became important exports in the seventeenth century (Vries 1974:166-67).

An energetic trade in livestock emerged. Horses, dairy cattle, and oxen were fattened on the pastures of Holland and Friesland for export to England and Flanders. This trade in livestock represented a large network in which northern Netherlands' merchants acted as middlemen. As early as the sixteenth century, Danish farmers on
Jutland bred oxen and drove them to the Netherlands. Danish cattle drives became more frequent as meat consumption increased throughout the early seventeenth century. Oxen were also exported by sea to the Zuiderzee port of Enkhuizen. From here animals were reexported to Flanders and France, although most were fattened and slaughtered for urban consumption and provisioning of ships. (Glamann 1978:233-35; Vries 1974:168).

Transformation of the Peasantry

Tenurial customs, agricultural crops, and a balance of economic power among the classes resulted in specialized farm households with income and demand patterns that supported a rural, as well as urban, population of craftsmen and merchants. This new rural class transformed the old peasant society, who adjusted to the limitations of land and developed into an occupationally differentiated society (Vries 1974:234). With windmills for motive power, peat for fuel, numerous canals for transport, and an abundance of labor and resources from the rural sector, the Dutch Republic became a major industrial nation.

This transformation occurred primarily in the commercially active provinces of Holland, Zeeland,
Friesland, West Friesland, and Groningen. The rural sector's ability to expand was inherited from the physical, legal, and sociological characteristics of earlier times. The Dutch economy did not portray the typical cyclical pattern of population growth, reduced per capita income, crisis, and recovery that other European nations suffered during this period; although by the 1660s the urban and rural sources of this growth were spent (Vries 1974:242).

Economic gains could not have been achieved without a dramatic change in peasant agriculture. Peasant farmers in the Netherlands were able to specialize in growing a variety of commercial crops far earlier than anywhere else in Europe. The Netherlands was exceptional in that, during the late-sixteenth century, innovations in agriculture and transport combined to allow rural specialization in horticulture (Vries 1974:153). Additionally, during the fourteenth and fifteenth centuries innovations in animal husbandry and the insertion of fodder crops into crop rotation made it possible to keep larger flocks of sheep and herds of cattle. In turn, the addition of more manure to the fields increased the productivity of grain yields (Davis 1973:18).
Pasturage of cattle and sheep in the sixteenth century led to increasing regional specialization. As land was converted to livestock raising, less land was available for cereal production. The rental value of arable land increased as it became scarcer, thereby forcing intensification in order to increase production (Wallerstein 1976:78).

The rural transformation of the Netherlands was linked to more than a mere surplus. For the surplus to be an economic advantage there had to be an increase in local markets and improvements in transportation. Inland water transportation was one industry that required low-cost labor for boatbuilding, cargo handling, and navigation. This was filled in part by a migration of labor away from the farm, and was crucial to the development of both rural and urban centers.

Profits of farmers and landowners were spent in part on consumer goods, but also found their way into the economy through taxation and capital investments in shares of local fishing, shipping, and milling enterprises. These entrepreneurial, or yeomen, farmers have been described as the "prime mover" in the end of feudalism by Takahashi (1952). Although Wallerstein (1976) considers this an exaggeration, he agrees that a
capitalist system could not have arose without their economic input. It was from these yeomen farmers and some merchants that a class of industrialists arose (Wallerstein 1976:87-89). Investments in transportation are evident, for both wagons and boats were built in greater numbers from the sixteenth to the seventeenth centuries (Vries 1974:216). In 1638, tax documents show that 12 of 37 farmers owned shares in ships and fishing boats in Holland. Ownership of boats increased and credit from a boatwright was possible (Vries 1974:223).

Associated with this prosperity was a movement to create more local markets during the late sixteenth century. Between the fifteenth and sixteenth centuries, the area served by regional markets contracted with the growth of more local markets. This was perhaps due to the rising output of dairy products, which had to be marketed more frequently than grain. Distance to market became a greater burden as farmers had more business to transact; therefore, local markets became a necessity. The increased market requests from villages would seem to evidence this (Vries 1974:156). A proliferation of markets can be seen after 1562. There were also requests for waterways to be deepened. As mentioned above, urban capitalists invested in land reclamation projects, thereby increasing the number of farms. This facilitated
more trade between rural and urban areas, since newly-built roads and canals connected new farms to the towns that had financed the development (Vries 1974:159).

The nonfarm sector of these market centers was composed of craftsmen, merchants, transport workers, and day laborers. This broke up the undifferentiated peasantry of earlier centuries and gave rise to a new social structure with a relatively high rate of literacy. Inventories show that the rural craftsmen and traders were wholly divorced from agricultural pursuits, while day laborers were disproportionately engaged in peat digging, inland transport, shipbuilding, seafaring, and dike maintenance (Vries 1974:230-31). This reflected the needs of a commercialized economy. Thus, by the eighteenth century, the rural population was economically specialized, mobile, educated, and receptive to urban values (Vries 1974:235).

The revolution and process of state development created sudden economic opportunities, as well as placing the rural economy under pressure to increase production. Stimulus to specialization and agricultural intensification may have come about through increasing taxation, either direct or indirect, on the peasantry.
The Netherlands war with Spain (1568-1648), created an inflated wartime budget that was a catalyst to the expanding economy, increasing the rate of diffusion of technological and economic innovations, and furthering the development of interregional and international trade. The States General of the Hapsburg Netherlands (eventually to become the Dutch Republic) was able to borrow large sums of money at low interest and short notice from financiers in cities like Amsterdam. State-backed annuities, secured by new taxes and yielding attractive interest, permitted the Dutch Republic to raise a loan as large as one million florins at only three-percent interest within two days (Parker 1976:212-13). It was this access to credit and capital that permitted the creation of the Dutch national state. In formative capitalist societies military expenditures served to stimulate more production and surplus (Wallerstein 1976:98). Also, military enterprise fostered a credit-creating system. While purchases for the army and navy undoubtedly stimulated the local economy, Dutch merchants continued to carry on an international trade with Spain, making their greatest profits in that trade. Dutch seafarers also used their former contacts to penetrate the trading networks of both the Spanish and Portuguese empires (Tilly 1990:90,92).
Some positive incentives to the development of the rural economy were reorganization of confiscated Catholic church lands and Protestant investment in the rural sector. During the revolution, the provincial governments confiscated monastic lands and dedicated these to the new reformed clergy. Parishes were consolidated and the size of the religious staff radically reduced. Much church revenue was dedicated to education and charity. This new administration of lands exhibited both energy and efficiency. In the decades after the Reformation village schools arose, five universities were founded, and the care of orphans, the aged, and sick expanded (Vries 1974:210-11). By mid-seventeenth century, the Church had constructed an educational establishment in both rural and urban areas. There are few statistics on literacy, but an Italian observer remarked in 1566 that "the common people have mostly a beginning knowledge of grammar and just about all of them, yes, even the farmers and country folk, know at least reading and writing" (Vries 1974:212).

Urban capitalists and the State drained large sums of money from the rural sector to the cities through landownership and taxation. During the Revolution, however, urban capitalists reinvested in the rural sector on a large scale. Chief among these investments were the
millions of gulden that went into public systems of water transportation, the trekvaarts, and into land reclamation projects. Farmers, moreover, voluntarily taxed themselves to support local drainage authorities, maintained and improved their soil, and invested in sturdy, spacious homes and farm buildings (Vries 1974:213).

Peat Digging and Water Transport

The growth of peat production and water transportation were often linked together in single projects. The peat industry supported the construction of a network of canals with deep draft locks to move the fuel from the peat bogs to urban markets in a way that no other commodity would have done. Once this network was built, it provided transportation for other rural economic activities. At strategic points, fuel-intensive industries flourished and villages of skippers, barge workers, shipbuilders and sawyers were born (Vries 1974:204).

Initially, only industries such as brewing and pottery manufacturing hired laborers to dig peat on a permanent basis. In Holland peat digging had become specialized in the 1530s, when new techniques permitted
the diggers to dredge peat from below the water table. Until the sixteenth century primarily farmers dug the peat (Lambert 1971:210-11; Vries 1974:203).

In the 1570s, a rapid growth of Holland's cities increased the demand for peat, initiating mining on a large scale. The principal users of peat were the fuel intensive industries such as brick and tile works, salt refineries, lime kilns, breweries, distilleries, and paper mills. Investment brought about the exploitation of remote, virgin peat bogs. One of the earliest projects was funded by the noble family, Ewsum of Groningen, which began digging canals in 1565. This project required a considerable amount of capital, and eventually the company fell into the hands of urban capitalists. Investment by urban capitalists in Holland resulted in their eventual control of the peat-digging industry in Groningen and Friesland by the 1620s. The companies dug canals, established villages for the laborers, and shipped enormous quantities of peat (Vries 1974:203).

Peat cutting began on a large scale in 1580 in Herenveen in Schoterland and excavation of low moor peat peaked in Friesland about the same period. Early in the next century companies were set up in Groningen for the
speculative exploitation of the surrounding swamps, while partnerships of rich aristocrats bought up the moors around Friesland. The goal was to supply peat as a household and industrial fuel for the fast-growing towns of Holland (Faber et al 1965; Lambert 1971). The rising prices for peat were an incentive to producers. Prices rose from 0.06 guilders/ton in 1575 to 0.30 guilders in 1650 and by 1789 were 0.53 guilders/ton (Faber et al 1965:66,69).

In the moors around Groningen and Drenthe the land was normally turned over to the individual peat-cutters for agricultural development before the peat was completely dug away. In Friesland, however, much of the land was reforested by the aristocracy who owned the moors. Since the former peat lands were deficient in nutrients, supplements such as street sweepings were used. Sweepings and refuse were at first supplied free but later were sold to the peasants (Lambert 1971:232-35).

Growth and Specialization of Water Transport

In Holland most inland transportation workers belonged to either a large or small inland transporters guild, the Grootbinnenlandvaardersgilde or
Kleinbinnenlandvaardersgilde. Size of watercraft tended to increase over time. In fact, the construction of canals barely kept up with the demand created by an increasing volume of trade and desire for larger vessels. Efforts were already being made in the sixteenth century to update old canal systems with larger locks. The size of canals and inland vessels tended to increase during the seventeenth century. The transportation guilds frequently objected to changes, as evidenced by the resolutions of Groningen's municipal government referring repeatedly to conflicts over locks that were too small to accept Groningen's peat boats (Vries 1974:206).

The variety of small craft continued to increase as did the size of bulk carriers and seagoing ships. Leeboards increased sailing efficiency and handling of inland craft. These were oval planks fastened outside the hull on port and starboard sides, which could be lowered into the water and raised as needed, in order to prevent leeway. Leeboards were one of the most significant innovations for flat-bottomed sailing craft, making them more seaworthy and maneuverable vessels. Their introduction extended the use of flat-bottom craft and to further specialization of types (Unger 1980:253).
A great deal of specialization occurred in pram-class vessels. There were a multitude of small boats, including schuiten, punters, bokken, and vlotten. Many of these, like the four seventeenth-century workboats described below, were designed for specific functions. Larger pram freighters built with fore and aft rigs and leeboards were better at navigating the Zuiderzee, while their shoal draft allowed them to enter any port and to travel the networks of canals connecting the Zuiderzee to Flanders and Antwerp. Some small craft, like the
sixteenth-century vessel (WN 92) described below, retained the fine lines and lanceolate shape of medieval small craft. Others began to develop features more efficient for the bulk trade: longer and fuller throughout (including the bow and stern), with the bow eventually becoming round and bluff, and the overall shape more rectangular than lanceolate. One archaeological example of such a vessel was the shipwreck from Capelle, the sinking of which was dated to 1593. The remains of this pram-class vessel were discovered and relatively well recorded by Cornelis Jan Glavimans in 1822 (Reinders 1987:13-14). This vessel shows a sturdy construction with relatively high freeboard and a shape still lanceolate but fuller than that of the WN 92 vessel discussed below, thus, indicating the developmental trend
towards increased hull capacity in the larger pram freighters.

Passenger Transport: Trekvaarts

Jan de Vries (1981) sees the quintessence of the inland transportation system in the financing of extensive networks of public transport, the trekvaarts. Trekvaarts were used primarily for public transport, for the timely transport of passengers and their personal goods, in contrast with the canals and rivers upon which the bulk goods and most freight moved. Trekvaarts were financed by the cities they connected and provided efficient and rapid transport for passengers (Fig. 24). The construction of trekvaarts represented sizable investments of capital, but even so eventually every principal town in the Netherlands was connected by trekvaarts (Fig. 25). In Friesland, four trekschuiten per day left Leeuwarden on four routes for Franeker-Harlingen, Bolsward-Workum, Dokkum, and Sneek. Five daily sailings also connected several Friesian cities with Enkhuizen and Amsterdam. The frequency of canal boat service on the trekvaarts was unique in all of Europe and is perhaps the earliest case of a packet service. Amsterdam was connected with Haarlem, Hoorn, and Zaandam with hourly service from sunrise to sundown.
Figure 24. Trekschuit ferrying passengers on the trekvaart (By courtesy of the Collection Center for Shiparchaeology, Ketelhaven).
Figure 25. Transportation networks, ca. 1660. (Drawing by author, after Vries 1974.)
Leiden and Amsterdam were also connected by an overnight barge for passengers. The system of intercity and urban-rural canal services arose between the end of the sixteenth and mid-seventeenth centuries and was such an efficient system of internal transportation that rates changed very little over the years. Trekvaarts, canals, and small waterways for drainage also served to open new routes for shipping and thus benefitted agriculture, commerce, and industry (Vries 1981).

Miles of canals were dug in Friesland and Groningen to serve the peat industry. These were also used not only for moving peat, but also agricultural and dairy produce to market. Canals were also dug to improve interurban and rural-urban communications. By the early sixteenth century, the first major canal projects had been initiated. Dikes and land reclamation projects increased the need for artificial waterways and locks. Most traffic was private haulage. Before the 1580s regular services connected only a few cities. Afterwards, guilds operated regular services in between cities, while villages employed boatmen with franchises to provide services to markets. By mid-seventeenth century every city was connected by at least weekly sailings and major routes had daily and sometimes hourly sailings. Services were called beurtvaarten and
marktschepen for market boats, snipschuiten for covered canal boats, damschuiten, and veerschuiten for ferries (Fig. 26) (Vries 1974:206-208).

Figure 26. Seventeenth-century veerschuit. The mast has been laid down and the boat is propelled by three oarsmen. (From Schiltmeijer, no date.)
These services provided low cost transportation which encouraged farmers to specialize in commercial crops and more intensive exploitation of agricultural lands. Low transportation costs also affected industries, permitting them to move raw materials over longer distances. Low-cost bulk goods transport allowed greater distribution of production centers and populations of workers (Unger 1980:274).

A Late Sixteenth-Century Pram: WN 92

The remains of a late sixteenth-century pram were excavated near the town of Workum, in the province of Friesland, during the summer of 1992. This wreck (designated WN-92) may typify a pram from the sixteenth century that was used along the shoal Frisian shores of the Zuiderzee and on the increasing number of canals (Fig. 27).

The reconstructed hull is 14.3 m long, 2.8 m broad, and 0.8 m deep. The length to breadth ratio of 5.3/1 is between that of earlier medieval craft and later pram freighters. The fine hull shape and style of caulking indicate a construction design borrowed from smaller craft. For example, the lanceolate shape is similar to that of punters from this century. Vessels K 73/74 and M
Figure 27. Site plan of WN 92 pram. (Drawing by author and Kathleen McLaughlin-Neyland.)
40 also have fine lanceolate hulls, but WN 92 differs from these vessels in having a completely flat bottom suitable for the shallow coastal areas. Its shape, however, is more unspecialized than that of many later prams with their fuller, more box-like shapes.

The wreck rested squarely on its bottom, only the stern had a slight starboard list, where a trench cut into the peat allowed the stern to settle lower into the sediments (Fig. 28). Amidships, the hull survived up to the tops of the futtocks and inwale; however, in the bow and stern, the inner wale and third strake were not preserved. The upper portions of the wreck appeared to have been exposed for some time. This was evident by the degraded condition of the wood and the enlarged water-worn holes in the inwale. Where there were former treenail and nail holes, flowing water had followed the wood grain, wearing away the softer parts of the timber. Below the upperworks, however, the rest of the hull and ceiling planking were complete and well preserved.

Hull Construction

The bottom of the hull was constructed of five strakes, with a central strake running from stem to stern post and two strakes on either side. Each bottom strake
was composed of two planks butted together (a total of ten planks) (Fig. 29). These butted joins were placed in a symmetrical pattern, with matching joins on the two strakes closest to the central strake, and matching butt joins on the central strake and strakes at the port and starboard chines. This symmetrical placing of plank joins and the use of straight, regularly shaped strakes running from stem to stern differs distinctively from flat-bottomed prams in which the bottom is composed of a patch-work of planks such as the E 14, and A 71 discussed in Chapter VIII (McLaughlin-Neyland and Neyland, in press).

The butt joints of the WN 92 planks were not fastened together, but instead were all nailed to two floor timbers. None of the bottom strakes were scarfed together, although flat scarfs were present in the side strakes. The central plank and port and starboard bottom chine planks butted together amidships, and all were nailed to the same floor timber. Plank ends of the other two strakes' butts were nailed to a floor timber approximately 140 cm aft of the amidships set of plank joins. Plank joins were thus staggered in the bottom with only two floor timbers used for fastening the plank ends. The nail heads were recessed in the bottom planks. Elsewhere, the bottom strakes were fastened to frames
Figure 29.  WN 92 planking lines. Longitudinal sweeps represent the upper, inboard edges of strakes. Builder's scoring marks shown on bottom planking. (Drawing by author.)
with treenails 2.5 to 3.0 cm in diameter. Occasionally, smaller treenails 1.5 cm diameter were used in the bow and stern and on the after starboard side. Larger treenails were cross-wedged and a few of the smaller treenails were wedged with deutsels (square wooden wedges). The smaller treenails might indicate the use of temporary clamps to hold the bottom planks in place during the initial hull assembly.

The central plank and five other bottom planks were sawn from oak timber (Quercus spp.). Two or three planks on the stern starboard side, however, were identified as beech (Fagus spp.). The use of beech planks might indicate the economies in lumber during a refit to the hull. Both in the bow and in the stern the ends of the central plank were shaped into rectangular toes that supported the heels of the stem and sternpost.

Traces of the builder's scribe lines were found on the bottom (see Fig. 29). The scribe line on the central plank was not continuous from stem to sternpost, but ran most of the length of the central plank, beginning approximately underneath the mast step and running aft to the sternpost heel. A second scribe line was found on the strake on the port side of the keel plank. The mark was scribed very close to the edge of the plank and was
clearly visible before the bottom planking was disassembled. It ran from the 14th to the 22nd floor timbers (WN 92 frames were numbered from stern to stem). Amidships and just aft of amidships, two series of seven diagonal lines were set above this scribe line. These probably represent builder's measurements, however their spacing is irregular. Those found amidships were spaced further apart than those aft. Distances between the slashes were inconsistent, but can be lumped into three ranges of spacings between the slashes: 6 cm, 9 to 13 cm, and 18 to 20 cm. The most consistent were three spacings of 18 cm and two spacings of 6 cm. A scribe line was also present on the after half of the port chine strake. No scribe lines were visible on the starboard side of the bottom, but lines present on the original hull bottom would have been lost here during a refit.

In Dutch inland watercraft, scribe lines are frequently found on the inboard face of the bottom planks. These usually consist of a scribed centerline accompanied with diagonal slashes and/or V and X marks (Neyland 1991; McLaughlin-Neyland, 1994). The centerline aided the builder in shaping and fitting the hull planks and timbers during building. The other marks usually seem to be related to the initial location of the mast step (although the mast step could be relocated after a
vessel was given sea trials). On WN 92, however, the diagonal slash marks were not located with the centerline nor were they in the area of the mast step. The function of these slash marks on the WN 92 is uncertain, although they probably represent some measurements or notations made by the builder. Also the purpose of the port-side scribe line in the stern is unclear, however, its proximity to the plank edge may indicate that it was scribe mark used as a guide when sawing.

The outermost bottom planks were stepped, or notched, to the thickness of the stealers (see Figure 29), so that the ends of the bow and stern stealers fit tightly into these steps. The stealer ends butted against the bottom plank edges, thus allowing for a smooth transition between the stealers and the strake above, the second side strake. In the case of the forward starboard stealer, this join was tightened by the placement of a small thin wedge. Two, possibly three, drain holes with plugs were found in the vessel. The plug in the after starboard strake was found pulled from its hole (Perhaps, as mentioned above, an indication that the boat had been scuttled). Unlike a treenail, the plug had a thicker squared cross-section on its inboard end to facilitate gripping and removal.
The bottom was caulked from underneath with moss and willow (Salix spp.) lath. The moss and lath were held in place by prikken, made from an unidentified wood type. The sharpened ends of the prikken were driven into the lower plank edges and the thicker part of the prikken held the lath in place (Fig. 30). Prikken were 1.0 to 1.3 cm wide, 1.0 to 1.5 cm long, and had a maximum thickness of 0.2 to 0.4 cm tapering to a minimum of 0.05 cm. The thicker outer ends of the prikken exhibit tool marks from when they were driven in the holes. They penetrated the wood at least 0.6 cm and were spaced 0.4 to 0.5 cm apart. The plank butts were also caulked with moss held in place by prikken. A few other archaeological examples of vessels from the Netherlands have had caulking held in place by prikken: the twelfth-century Rotterdam punter, an unpublished pram-like vessel R 1, and a bomschuit also excavated from near Workum, (Oosting, pers. com.; Center for Shiparchaeology archives). This method of securing the caulking dates to at least the twelfth century as evidenced by a boat dredged from Rotterdam harbor (Oosting pers. com., Center for Shiparchaeology archives). The use of prikken survived into the nineteenth century in the construction of the bomschuit (Petrejus 1977:52).
Figure 30. Schematic detail of WN 92 caulking with prikken, lath, and moss. (Drawing by author.)
The willow laths were 0.9 to 1.0 cm wide and 0.2 to 0.3 cm thick. Maximum lengths for laths were not recorded because most were broken when the bottom of the hull was disassembled. The lower edges of the planks were beveled slightly, cut about 0.5 cm less than the upper edge. This provided a 1 cm gap between bottom strakes for wedging the moss. The bevels tapered inboard until the plank edges became flush. In one instance, a 3 cm wide by 0.6 cm thick piece of lath was used as a repair to a damaged edge. Like the smaller laths, it was held in place only by prikken. The bevel of the edges underneath the repair lath was more acute than elsewhere—the lower edge measuring about 0.7 cm less than the upper edge.

The outboard edges of the bottom chine planks were beveled to fit the angles of the side strakes. As with the caulking bevels, the lower edges of the planks were 0.5 cm less than the upper edges. In the bow and stern where the strakes curved sharply in towards the posts, the lower plank edges formed a more acute angle and were 0.7 to 1.0 cm less than the upper edges of the planks.

The sides were fastened to the bottom with pointed wooden pegs and iron nails. The pegs were spaced about 1.4 to 1.6 cm apart (center to center) and were about 5
to 8.5 cm in length and 1.2 cm in diameter. Their ends tapered to a rounded cross-section near the point, but for much of their length they had an octagonal cross-section. Pegs and holes appear to have been caulked with a white-colored substance. On the outboard faces of the bottom planks, many pegs and peg holes were visible due to the excessive wear on the hull's bottom. Repair planks with moss caulking had been nailed over the exposed areas. In several cases, pegs were observed to be shorter than the pre-drilled holes. Iron nails were spaced from 4 to 10 cm apart and placed between the wooden pegs. These could represent repairs to tighten up a leaking hull.

WN 92 had a sharply raked stem, 120 cm of which survived. The heels of the stem and sternpost were notched to fit over the toes of the central plank. The stem heel was fastened to the forward toe of the plank with three iron nails and the sternpost heel to the after plank toe with four nails. The stem had a trapezoidal shape in cross-section, measuring 16 to 17 cm molded, 10 cm sided inboard, and 8 cm sided outboard. Rabbets were not present on either the stem or sternpost. Hood ends simply fit flush against the posts where they were heavily tarred and fastened with iron nails. A hole 3.5 cm in diameter, probably for a rope, was placed through
the molded faces of the stem just forward and above where the stealer joined the stem. On the forward sided face, 3 to 4 cm above the hole, were the remains of a large spike or bolt (2 cm by 2 cm in section). A wooden plug, 2 cm in diameter, also on this face, was located 20 cm up from the bottom of the post.

The sternpost was a more substantial timber, 125 cm of which survived, and was not raked as sharply as the stem. The post's trapezoidal section was 8.5 cm sided inboard and 5 cm sided outboard by 28 cm molded. On the port side were draft marks for the one, two, and three foot levels. Only the two-foot draft mark survived on the starboard side. The marks were 1 to 1.2 cm diameter holes drilled to a depth of 1 to 1.5 cm. Above the three-foot draft mark there was a worn hole similar to that described for the stem. On both the port and starboard sides there was the impression of the lower gudgeon. A gudgeon with "T" shaped arms fit there and was fastened with numerous iron nails.

Three overlapping side strakes survived on both port and starboard sides. Each side consisted (from bottom to top) of forward and after stealers, two continuous side strakes, and a thick inwale running inboard along the uppermost strake. All of these planks were cut from oak
(Quercus spp.). The two upper strakes and probably the inwale consisted of three planks scarfed together. Preservation was relatively good, but considerable portions of the upper strake and inner wale did not survive. Stealer hood ends were still fastened to the posts, but only two of the second strakes' hood ends and none of the third strake's survived.

There were four stealers, two in the bow and two in the stern. Opposite port and starboard stealers were approximately symmetrical in length and shape. The bottom of the hull was cut away along its outer edge to accommodate the stealers. Where the forward starboard stealer terminated in a butt joint with the bottom strake, the aforementioned small shim was used to tighten this juncture. The placement of a shim here was either a repair or an alteration made by the boatbuilder, since none of the other stealers were fitted with shims.

In the bow, where the stealers had their greatest width, both port and starboard stealers had a groove crudely scored on the inboard face. These grooves had a 1 cm maximum depth and extended from the hood ends aft to futtock 31, about 98 cm on the starboard side and 84 cm on the port side. On both sides, grooves were 10 cm below the upper edge of the stealer. The function of
these crudely cut grooves is uncertain, but their placement does seem deliberate. The crudeness of the grooves suggests that they were made after the hull was built, possibly as another repair. Sometimes, in Dutch small craft damaged hood ends were cut away and a wider stem used to fill the gap (van Dijk, pers. com.).

Removal of a portion of the hood ends might have resulted in the need to pull the upper half of the stealers inward to fit against the stem. This might have been achieved by cutting a groove in the forward stealers and slightly cupping the planks. This is only speculation, however.

Somewhat aft of these grooves and the last futtocks, both stealers had distinctive, slightly raised brown impressions. The best preserved of these occurs on the starboard stealer and was 16 cm long by 4 cm wide. The area forward of the marks was blackened from charring.

Similar impressions were visible on other strakes and probably have to do with shaping and bending the strakes before they were placed in the boat. The raised impressions were probably marks left by the fulcrum upon which the strakes were bent over a fire. The stern stealers, however, had neither grooves, bending impressions, nor evidence of charring. The stealer hood ends were a maximum of 5 cm wide and beveled 35 to 38 degrees to fit flush against the stem. They were fastened to the stem with iron nails.
The second strakes were the first continuous strakes between stem and sternpost. Amidships, between the stealers, they were fastened to the outer edges of the bottom planks with both wooden pegs and iron nails. As mentioned above, the strakes consisted of three planks fitted together with flat scarfs and fastened with two rows of iron nails at both ends of the scarf. A scarf on the starboard side contained at least 4 small wooden pegs (1.3 cm diameter), as well as iron nails. Scarf tables were 41 to 42 cm long. Port and starboard planks were about the same length, and scarfs were placed in matching locations on both port and starboard sides.

The second strakes were relatively wide (46 to 52 cm) and showed signs of having been bent and shaped with fire. Each strake consisted of three planks. Scarfs were placed a little fore or aft of those on the second strake. Areas on the inboard face were charred and burned, and several impressions (resulting from bending) similar to those seen on the two forward stealers were visible. At least three such marks were recorded on the port side and one on the starboard side. In some cases, the surface of the wood either forward or aft of the marks (depending on the direction of the stem or stern and the desired bending) was reduced slightly (about 0.2 cm). Associated with one such impression and charred
wood on the stern port side were a series of scoring marks, possibly made with a chisel. These may have assisted in bending the plank where it needed to curve inward to the sternpost.

The third strake was also a wide strake (45 to 52 cm). Both the third and second strakes were at their minimum breadth amidships and may have become slightly wider towards the ends of the boat. Much of the third strake was not preserved, especially towards the bow and stern. This strake appeared to have suffered a lot of wear prior to the deposition of the vessel. This was evident from the worn condition of the wood. The long life and heavy use of the vessel was also indicated by heavy coatings of tar used inboard on the strakes, strake overlaps, and over the futtock heads, which gave the impression that the vessel's master had attempted to hold it together with tar and caulk.

Strake overlaps were fastened with clenched iron nails. Two sizes of iron nails were used to fasten the strake overlaps: nails with heads of about 1 cm alternated with larger nails having heads 2 to 3 cm in diameter. Strake overlaps were always caulked with moss and on the upper inboard edge of some strakes a thick moss-tar mixture had been applied. At least one instance
of charring was observed on the third strake, forward on the port side.

The inwale rested on the heads of the futtocks and top timbers, and was fastened to the upper inboard face of the third strake. The wale was trapezoidal in cross-section (8.5 cm upper molded face by 6.5 cm lower molded face by 12.5 cm sided). The trapezoidal shape probably helped the boatbuilder twist this thick timber as the hull curved inward near the ends. The inwale was fastened to the upper strake, the notched heads of some futtocks, and top timbers by both treenails and iron nails. There were only a few iron nails on the upper molded face. Numerous iron nails spaced in a recognizable pattern might have indicated a covering board. A covering board would have protected the upper plank edge, wale, and notched frame heads; however, there is very little evidence for a covering board.

One or two scarfs survived on the starboard side of the inwale. A short piece, about 70 cm long, fitted in the stern, about where the sheer begins to curve inward toward the sternpost. The scarfs were about 13 cm long and fastened with iron nails and treenails.
The lack of preservation of the vessel's upper edge made it difficult to determine whether or not another strake was fastened above the third strake. The one starboard fragment with a surviving upper edge had a few nail holes, and a few plank fragments recovered could be the remains of an upper strake. The nail holes, however, may have only fastened the inwale to the strake. If there was an upper strake, it would have had to be supported by knees or top timbers since futtock heads ended at the inwale and top of the third strake. The surviving top timbers also appeared to end here. There are examples, however, of pram-like vessels from later periods having washstrakes supported by knees (Berk 1984:151).

Frames consisted of floor timbers, futtocks, and top timbers (Fig. 31). There was a consistent arrangement of floor timbers alternating with futtocks. Several top timbers survived in the hull and others could be inferred from fastener remains in the side strakes. Most of the top timbers appear to have been paired with floor timbers; however, in some cases the top timbers were placed more closely to the futtocks. This may have served to support beams or bulkheads, although neither remained intact inside the wreck. Most port and starboard futtocks extended across the bottom so that
Figure 31. WN 92 construction plans. (Drawing by author.)
their heels overlapped. The heels of opposite futtocks usually fit against each other, but were not fastened together. In this vessel there were a total of 15 floor timbers, 16 sets of port and starboard futtocks, and 10 top timbers to port and 12 to starboard.

There were also the two curved timbers, which Dutch shipwrights call wrangen, one in the bow and the other in the stern. These frames rested on the stem and sternpost and were fastened not to the posts, but to the strakes. The above floor timber count does not include the two forward-most pieces that served as blocks to support the ceiling planking. A small piece of peat was also used in this area as a support for a ceiling plank. Also not included in the count are the three short pieces of wood, located between the 13th pair of futtocks and the 13th floor timber forward of the stern, which were used to support the mast step. Floor timbers were sided 8 to 14 cm and molded 8 to 9 cm. Futtocks were sided 10 to 14 cm and molded 7 to 9 cm on the legs and 8 to 17 cm sided and 8 to 13 cm molded on the arms. Top timbers were sided 8 to 10 cm and molded 3 to 11 cm.

Floor timbers were straight timbers spanning the bottom and ending a few centimeters short of the chine, allowing bilge water to circulate around their ends. The
floor timbers were fastened to the bottom planks with treenails, except for the two floor timbers covering the butt joints of the bottom planks, which were fastened only with iron nails. Futtock heads supported the inwale, in some examples terminating underneath the inwale and in others notched to hold the wale. Futtocks were fastened to the side strakes primarily with treenails, but also with iron nails. Treenails placed in floor timbers and futtock legs were cross-wedged on their outboard ends. Cross-wedges were also used on the inboard ends of treenails placed in the arms of futtocks. Occasionally iron nails and deutels were used to wedge treenails.

Many of the futtocks had chocks nailed to their forward and after faces (see Figure 32). These varied in size and shape and secured the removable ceiling planks over the chine. The boatbuilder attempted to make most chocks triangular in shape, but a few were more rectangular and could perhaps represent replacements. Chocks were used in a variety of sizes, lengths vary from 9 to 29 cm, widths from 5.5 to 10 cm, and were 0.5 to 2.5 cm thick. They were fastened to the futtocks with one or more iron nails.
Aft of amidships, several futtocks had holes drilled through their heads. Around the holes, on the inboard sided faces of the frames, were shallow, rectangular depressions roughly cut with a gouge. The holes, 2 cm in diameter, penetrated through the inboard sided face to either the forward or after molded face. On the inboard face the area around the hole was gouged out to roughly a square or rectangular shape. One such area measured 2.8 by 4 cm. The holes were usually placed about 45 cm above the bottom planks or roughly 35 cm above the ceiling planking. The holes probably served to secure ropes holding cargo. One source suggested that they may have been used to tether livestock, such as cattle and sheep (Roelfzema 1992, pers. com.). Since a significant part of the economy depended upon raising livestock and ethnographic information corroborates this purpose, the use of these holes for tethering livestock is plausible.

Shims were nailed to the upper surfaces of several of the floor timbers and futtocks to support ceiling planking. On the starboard side, just aft of the mast step, both the upper faces of the 11th floor timber and 11th pair of futtocks forward of the stern had a combination of shims and notches to hold the ceiling planks.
Only the lower portions of top timbers survived in the hull. Top timbers were short timbers that began at the second strake and extended to the inwale. Like some of the futtocks, they were notched to fit the wale and fastened to the strakes with both iron nails and treenails. Top timbers were not always evenly spaced between the futtocks. In some instances, they were set a few centimeters from a futtock. In these locations a top timber and a futtock closely spaced together might have supported a beam or bulkhead.

The vessel from the Workumer Nieuwland polder had tight-fitting ceiling across the bottom of the vessel, terminating a little over a meter forward of the stern (Fig. 32). Ceiling planking was constructed of a mixture of wood types. Both pine and oak were used, as well as some other unidentified hardwoods. The longer planks were of oak while many of the shorter ones were of pine. Some of the short planks at the very stern (between futtocks 3 and 5) were reused bottom planks. This is evident from the remnants of pegs in the edges of these planks. The planks also had small holes, 1.5 cm in diameter, in their inboard and outboard faces. Probably the holes were left by temporary clamping with cleats during hull construction and had been plugged with tar. It is possible these ceiling planks may have been planks
Figure 32. WN 92 ship reconstruction. (Drawing by author.)
replaced from the starboard side in the stern.

Amidships, in what was the main cargo area, the ceiling consisted primarily of four long oak planks. Some of these had been repaired or fitted with other smaller planks. Three planks were joined with scarfs; two of these were repairs, but the two most central ceiling planks were fitted together with a 12 cm long scarf fastened with iron nails. Forward, this same plank had a large rectangular hole, 58 by 23 cm, mortised for the mast step.

The space between the futtocks was covered by removable ceiling planks. The edges of these rested on top of the other ceiling planks and against the side strakes. Small 1 cm square strips of wood were wedged between the futtocks to support the outboard edge of each removable plank. The futtock chocks prevented the planks from flipping up and also served as guides for sliding the planks in and out. Removal of these planks permitted access to the bilge. A few iron nails were in some boards suggesting that as the boat neared the end of its life, some boards were nailed in place. Alternatively, the iron nails might indicate the reuse of boards like the former bottom planks reused as ceiling. On the starboard side between the 11th floor timber and 11th
pair of futtocks (the same location as the above-mentioned shims), there was a gap in the ceiling planking and no boards were found during the excavation that fit here.

The builder and operator of the vessel went to great lengths to construct and maintain tight ceiling, although the boat was old and worn. In the bow, the ceiling is thinner and consists of overlapping pine boards. This overlapping created a watertight fit. Tiny wedges (1 to 0.5 cm wide) were placed where these boards fit against the chine to insure the tight fit. This area was probably the floor of the forward cuddy and provided a dry place for a few goods, personal belongings, or for a person to curl up and sleep. A mismatched pair of children's shoes were found in this area on the port side.

The small mast step was fastened directly to the ceiling planking. It was centered on the central ceiling plank over a large rectangular slot in the ceiling. The mast step was stepped, 4.4 meters aft of the end of the stem, or roughly one-third of the vessel's length abaft the stem. The step was small, 50 cm by 10 cm by 3 cm thick. A worn oval area, 6 cm by 4 cm and 2 cm deep, was in the center of the piece for the heel of a small mast.
The step had four small bracing pieces; none of them were nailed together but all were fastened to the ceiling with iron nails. Directly underneath the step and in the notch was a pine plank 52 cm long and 2 cm thick. This plank spanned the 12th floor timber and the leg of the 13th starboard futtock. Its forward end rested on the three chocks placed forward of the 13th futtock. This plank had a worn area, 7 cm wide and 1 cm deep, immediately aft of the mast step. The notch in the ceiling plank allowed for draining the mast-step area. As mentioned below, the remains of what might have been the sail beam were found outside the boat. It is possible that this small mast step was a refit. The placement of notches on this beam parallel those in the ceiling and could indicate a tabernacle, which held a larger mast.

Just forward of the mast step, a board had been nailed across and on top of the ceiling planking. This fragmentary piece survived for 103 cm. It was 9 cm wide and 1.5 cm thick and fastened to the ceiling by both iron nails and treenails. The fragment might signify the position of a bulkhead. Also in the bow, on the port side, was a mortise in the ceiling plank immediately aft of the 16th starboard futtock. This mortise, 6.5 cm long by 4.4 cm wide by 1 cm deep, might have held the foot of
a stanchion or post. The bottom of the mortise had almost worn through to the plank below.

Some transverse beams were probably used in the hull. One beam, reused as a stake, was found outside of the hull on the starboard side of the stern. The end, driven in the ground, had been sharpened with an adze and the uppermost part had severely deteriorated, leaving 185 cm of the beam's length surviving. This timber has a maximum width of 13 cm on what was probably its molded face and 11 cm on its sided face. It seems to have been slightly cambered, with 3 to 4 cm of rise. Two notches were placed 21 cm apart on the same face, each 8 to 9 cm wide by 6 to 8 cm long and 4 cm deep. Iron nails and treenails were present in both notches, as well as a 2 cm diameter, cross-wedged peg in one notch. The notches might have held carlings that ran longitudinally.

Since the distance between these notches is the same as the width of the slot in the ceiling plank at the mast step, it is possible that a tabernacle for an earlier mast step fit between the notches and carlings. Such a mast step and sail beam construction can be seen on the ship from Capelle, excavated in 1822, and drawn by C.J. Glavimans (Reinders 1987:13-14, 105). This wreck, dated to the siege of Geertruidenberg in 1593, is perhaps only
a few decades older than the Workumer Nieuwland vessel. This beam fragment, therefore, might be the remains of the beam that supported the mast.

Numerous iron nails were present on what may have been the forward face of the beam. These nails could have fastened bulkhead planking to the beam. On the upper face, there were fewer iron nails, but here they were more regularly spaced, possibly for deck planks. The sharpened end of the beam had the remnant of a treenail hole, which might indicate where the beam was attached to a knee.

In the stern, two fragments were found just forward of the sternpost at about the height of the top of the second strake. These might be the remains of a single small beam for the after deck. The two fragments fit together, giving a total surviving length of 95 cm, and were possibly of pine. They were roughly shaped, 6 cm square and patches of bark remained on their surface. Three small iron fasteners were present in one fragment. Other evidence of a short beam or small support are two grooves worn in the forward most frame, the wrangen. These were opposite each other on the port and starboard inboard faces. As reconstructed, the position of the grooves would have indicated a beam just under the top
edge of the second strake. There was no indication of any fasteners in the grooves.

On the port side, 25 to 33 cm east of the sternpost, two pieces of pine planking had been used as stakes. These were later found to be fragments of the same plank. After refitting, the reconstructed fragment was 190 cm long by 34 cm wide (actual plank width) and 3 cm thick. This appears to have been a fragment of deck planking, either from the starboard stern or port bow areas. Its outboard edge had a curve that matched the reconstructed curve of the bow more than that of the stern. The deck planking had a few nails, with 1.5 cm diameter heads, for fastening to a beam. Where two nails penetrated on the underside, there was a 5 cm wide impression, probably from a small beam. The upper surface also had some staining around the outer edges of the plank.

Inventory

Only a few artifacts were recovered from WN-92 (Fig. 33). The small assemblage consists of architectural materials, ship's equipment, tools, galley-related finds, personal possessions, and cargo. The majority of artifacts were small brick fragments, most of which were recovered from the mud between the frames. The brick
fragments are believed to be the remains of cargo. Another possibility is that the vessel might have hauled refuse, such as building debris. Similar vessels such as bokken were used to transport debris from road construction in the early twentieth century (Crone 1946:90). If it had hauled town refuse as one of the seventeenth-century boats described later, there might have been a wider variety of sherds scattered about the bottom of the hold area.

Artifacts revealing more about daily life onboard the vessel include a pair of children's shoes, an adult's shoe, fragments of different leather garments (perhaps scrap leather for reuse), a copper eyelet from a garment, and sherds to a ceramic pan. The small size of the assemblage can be attributed to abandonment of the vessel. Also, WN-92 was a working boat that may have lacked a hearth and living accommodations, which would also account for the small assemblage.

Architectural materials include iron nails recovered from the sediments in the hull and a cleat and two wooden plugs. The plug, mentioned above, was actually situated a short distance from the hole it had stopped. Ship's equipment is represented by a few small, badly preserved fragments of right-twist rope measuring about 1 cm in
diameter, and a sheave and pin for a block. The remains of three heather brooms or scrub brushes comprise the total assemblage of tools found on board.

Ceramic finds were fragmentary and no intact vessels were recovered. Ceramics are predominantly composed of a green lead-glazed greyware. Six fragments of greyware fit together to form part of a small skillet. This skillet had a flat bottom with a reconstructed base diameter of 13 cm. Unfortunately the handle was missing, for the handle shape could be used for dating.

One tiny shard of glass was found while sieving mud from between the frames. It is the only glass found and is a non-diagnostic body shard. Glass seems to be relatively rare on shipwrecks during this period, as well as in rural Dutch inventories (Vries 1974:264). A fragment of a wooden barrel hoop was also found in the mud between the frames.

A few items of leather survived. The two largest objects appear to be fragments of a garment, partial sleeves or pants legs. Pieces had been cut away for other purposes. The leather fragments were found a meter or two apart, curiously each overlay a heather scrub brush. A correlation between the leather scraps and
brushes is difficult to understand, unless they were used to collect sweepings. A third brush was found in the stern, just outside of the shipwreck on the port side. A small fragment of a leather cutwork-decorated knife sheath was found. It was identified as a knife sheath by the central fold impression and the stitch holes along the two edges that closed together. The knife for this sheath must have been large, at least as wide as 4 cm. It is impossible to estimate maximum blade size because the fragment was cut both at the top and bottom, as if also intended for reuse. A fragment of a garment or pouch was also recovered. It was in very poor condition, and only a few cut edges and one folded and stitched edge were evident. Portions of this piece also appeared to have been cut away.

The remainder of the personal possessions consists of three leather shoes. Two of the shoes were situated next to each other in the extreme bow. They were found between layers of hay next to the chine on the starboard side of the boat, and were a mismatched pair of children's shoes both measuring 18 cm long. They were complete with the exception of their stitching. The right shoe had the back partially cut away, modifying it into a slipper. The method of fastening the sole, as seen in cross-section, can be used to approximately date
the shoes (Goubitz 1984:195). The adult shoe was fastened by a method dating from the seventeenth through the nineteenth centuries while the children's shoes were fastened together by a method popular from the sixteenth through the eighteenth centuries (Goubitz 1984:195, fig. 5:5-6).

A small circlet of copper wire twisted into a loop and closed on the end was found while sieving mud. Possibly it was an eyelet on a garment, since it bears a resemblance to twisted copper eyelets excavated from sixteenth- and seventeenth-century levels in Amsterdam (Baart et al 1977:157-58, figs. 170, 179).

The evidence indicates three possible cargos for the vessel. The strongest evidence found indicates that bricks were once hauled as a cargo. The sediments between the frames exhibited a stratigraphy in which a solid layer of brick dust overlay a layer of peat and clay between 3.5 and 4.25 meters from the surviving end of the sternpost. Forty-one percent of the 223 brick fragments recovered came from this area. Brick dust was ephemeral with concentrations mainly in the chine within the area 3.0 to 6.0 m from the sternpost, however, this area contains 75% of all the brick fragments recovered.
This roughly corresponds to the rear portion of the cargo hold, but forward of a possible cuddy.

There are indications that peat was once a cargo. Blocks of peat were found inside the ship and a distinct layer of peat underlay the brick dust in the sediments between frames. Also, peat mixed with clay extended as far forward as the mast step stopping at about where a bulkhead might have been located.

Hay or straw could have been a third cargo. There was a distinct layer of hay overlying the ceiling planking in the bow, 7.5 m forward of the sternpost. Hay was quite thick in places, and the straws seemed to be oriented parallel to the centerline of the shipwreck. The children's shoes lay within this layer of hay. Concentrations of hay were heaviest in the bow, up to 3 cm thick across the breadth of the boat between 10.6 and 11.3 m forward of the sternpost. Traces of hay were present aft, but were not as distinct as forward. Hay layers thinned towards the stern with heavier concentrations in the chine. In the stern, traces of hay were present as far back as 2.6 m from the sternpost, with concentrations 1 cm deep at the chine and 0.5 cm over the center of the ceiling planking. Hay in this area, however, was not oriented in any direction. A
similar depositional pattern was seen in the sediments between the frames, with heavier concentrations forward.

Fish and bird bones and a few hazelnut shells recovered from the wreck represent the remains of provisions. This material was scanty and was randomly distributed within the hull and thus, cannot be identified with certainty as ship's provisions. One piece of a bone, possibly from a bird, does appear to have cut marks from a thin-blade knife.

Significance of WN 92

Dendrochronology on the hull timbers dates the felling of the trees to the mid-sixteenth century, A.D. 1547 to 1553. One of the children's shoes has a parallel from a site in Zwolle dated to the second half of the sixteenth century. Judging by the amount of wear on the ship's hull, it was at the end of its career and was evidently many years old when it sank. It is uncertain how long the usual life-span for a work boat such as WN 92 would be, but it is highly likely the sinking of WN-92 dates to the last half of the sixteenth century. This late sixteenth century date marks a period of demographic and economic growth with significant canal building and land reclamation in Friesland.
The scarcity and types of artifacts recovered imply that the ship was abandoned. Possibly the ship was scuttled, as evidenced by the sharpened poles driven into the ground fore and aft of the vessel. This line of poles is roughly parallel to and between the medieval and 1620 dikes. As mentioned, some hull timbers had also been converted into sharpened stakes and placed outside the wreck, adjacent to the sternpost. These possible hull timbers provide further indications that the vessel might have been intentionally scuttled and sunk at this location. The ship overlay a worked peat bed and might have served as a dry working platform or dock. Alternatively, it may have been scuttled to serve as a barrier to increase sedimentation, ending its career as part of an empolderment structure.

The WN 92 vessel would have been suitable for a number of tasks such as transporting bulk cargos, livestock, people, lightering goods off ships, and perhaps some limited coastal fishing. It has the fine lines characteristic of medieval vessels like M 40 and K 73/74, but unlike some of later pram freighters that have fuller more rectangular hull shapes. While WN 40 may have carried a variety of cargoes, its hull still indicates general usage for a variety of tasks and does
not suggest the specialization seen in later pram-class freighters.
CHAPTER VIII
STAGNATION AND DECLINE: A.D. 1650-1790

Economic and Demographic Crises

The late seventeenth and eighteenth centuries were marked by economic stagnation and eventual decline in the Netherlands. This has been viewed both as stagnation and moderate decline (Wilson 1939; Boxer 1965; Blok 1970; van Dillen 1974; Israel 1989) or absolute decline between 1650-1750, with limited recovery after 1750 (van der Woude 1975; Jan de Vries 1984, 1985). Some areas were able to use local resources and adapt economic strategies to effect a recovery.

All the indicators of economic and demographic decline are present during the second half of the seventeenth century and most of the eighteenth century. There was an overall decline in population, internal migrations, a recession in agricultural prices, increased bankruptcies (Riley 1984 quoting Oldewelt), and a dwindling of industries (van Dillen 1974).

The causes of this crisis are complex, consisting of many interrelated factors: the small home market, foreign competition, political exclusion of lower classes, and
high taxation were some of the key factors leading to the diminished economy (Vries 1974; Bosscher 1985). Contributing factors to the decline were expensive and debilitating naval wars with severe losses, excessive taxation and a lack of reinvestment in infrastructure, heavy losses to Dutch shipping from privateering, and over-investment in plantation colonies (Lambert 1971; Vries 1974; van der Woude 1975). After 1730, the Dutch had lost their intermediary position in world trade, nor was there any further industrial development. Also, there was a gradual shift of interest from trade to types of finance such as insurance and credit banking, and foreign loans and speculation (Wilson 1939:113).

With the decline in naval power, the Dutch lost the ability to conduct business in a coercive fashion and grew increasingly vulnerable to trade barriers, especially those of the English, and higher taxes on their European exports. The result was a loss of jobs at home and a corresponding loss of gross national product. The central government was weak and divided, which exacerbated the crisis, and attempted to compensate for loss of state revenues by raising taxes. Faber et al (1965) credits the excessive tax burden as the chief cause of the economic decline. Taxes, particularly on agricultural products, accounted for an increasing
percentage of production costs at a time when agriculture was struck with natural disasters (Faber et al 1965). It is estimated that taxation took between 16-25% of the gross income of agriculture (van Houtte 1977:227-229). The agricultural recession also resulted in a drop in lease and property prices, an increase in arrears in taxes, and the abandonment of small owner-occupied farms, which resulted in an increase in farm size (van der Woude 1975). Thus, less capital was available for reinvestment in agriculture, land reclamation, developing and modernizing industries, and for purchasing shares in fishing and cargo vessels. Excessive taxation had far reaching effects in the overall economy.

The tax burden also shifted away from landowners to the proletariat, resulting in the poorest segments of the population paying the largest share of the tax burden. In 1680, during the period of low cereal prices, property owners bore 68% of the tax burden while 31% of taxes were levied from food products. Between 1760 and 1790, when cereal prices had risen and there were large numbers of unemployed industrial workers, only 43% of taxes came from property while the proletariat sector paid 53% of the country's taxes in excises on food (van Bath in Faber et al 1965). Governmental response to the economic
decline therefore increased the poverty of populations living marginally.

There was a population decrease in the provinces of North Holland, Southwest Friesland, and in the municipalities of Veluwe and Overijssel from 1650-1750. For example, in the Veluwe harbor of Harderwijk population declined by 20% from 1650-1750. Similar population decline can be seen in most of the cities situated on or near the Zuiderzee (van der Woude 1975:230). Climate and the environment were factors in the late-seventeenth century when increased storm flooding from the North Sea turned the Zuiderzee brackish, ending freshwater fishing on the inland sea and its associated waterways (van der Woude 1975:237). This environmental change contributed to a severe population decline in this region.

Continued economic crisis in the eighteenth century led to deteriorating living conditions among the poorer segments of society resulting in the postponement of marriages, use of contraception, and urban flight. Manufacturing cities were drained of talent as poverty increased. Orphan and widow asylums as well as other poor houses were filled as evidenced by Amsterdam's statistics of 1796 where one quarter of the population
were supported as paupers (Blok 1970). That more people were living marginally is evident among the declining working class population of Leiden and Delft, as well as in the rural provinces of Overijssel where the growth in population was accompanied by a corresponding increase in poverty and people forced to live in peat huts, old sheds, and pigsties. Some dwellings were less than 2 m high with a surface area of 3.5 by 4 m (Boxer 1965:293; van Bath in Faber et al 1965:85).

Industries dependent upon importing raw materials and reexporting finished products suffered severe economic hardships; for example, the decline of the textile industry was the result of foreign countries protective use of high import duties. The few Dutch industries surviving the 1730s and 1740s intact, either declined soon after 1750 or else were sustained in the late eighteenth century by increased demand in the home market. Growth in some economic sectors can be attributed to an increase in demand within local markets such as with sugar and gin (Israel 1989:384, 389).

Certain areas were able to withstand economic decline and perhaps make a recovery. Moderate growth in the regions of Friesland, Veluwe, Salland and Twente in Overijssel can be attributed to industries manufacturing
textiles and paper, digging peat, and the cultivation of tobacco (Faber et al 1965; Roessingh 1965, 1970). Fortunes fluctuated as industries tried to compensate for falling prices and increased competition. In the Baltic trade, a decline in herring and salt shipping was partially compensated for by an increase in timber imports and colonial exports from the West Indian colonies (van Dillen 1974).

Therefore, there was some interregional variation within the Dutch provinces in response to the failing economy; although when weighing industries lost against industries gained, employment is an important consideration. The prolonged crisis in agriculture was not compensated for by greater activity in the stock-market, nor was the decline of shipping countered by increased sales of colonial produce, and jobs created by the new spirit-industry did not equal unemployment resulting from the slump in the brewers' trade (Faber et al 1965:61).

The region of Overijssel was an exception to demographic decline. Here the population increased by 90% between 1675 and 1795. Boxer attributes this to urban flight while others believe it was a natural growth resulting from an excess of births over deaths (Faber et
al 1965:84; Vries 1985). Population growth can also be attributed to an increase in supplementary income, which allowed more cotters (Dutch share-croppers) to marry earlier, resulting in a rise in the rate of reproduction (Lis and Soly 1979:143).

The population in Overijssel rose 42% (from 71,000 to 122,400) between 1650-1748, and 25% in Veluwe (from 40,700 to 54,220) between 1650-1749 (van Houtte 1977). This increase corresponded with peat digging and industrial development in these areas, as with the linen industry in Twente and paper manufacture in Veluwe (van der Woude 1975).

City populations were employed in the following occupations: handicraft industry (51%), trade (25%), and other professions, mainly services, (15%). In the rural areas only 20% of the labor force was employed in the handicraft industry and in those rural areas with access to waterways 10 to 12% were employed in trade and transportation (van der Woude 1975).

Much of the rural population must have sought employment in a variety of seasonal job. Cotters in the Veluwe were able to supplement their incomes in a variety of ways besides day laboring for wealthy land owners.
There was seasonal work if one was willing to travel. In the winter there was bark stripping and excavating mud and excess vegetation from canals for paper mills, spinning and weaving, binding heath-brooms, and collecting berries. Bark stripping was also carried out in the spring in Drenthe while summers were spent in Holland and Friesland mowing grass and later wheat and oats (Faber et al 1965; Roessingh 1965, 1970).

Dutch grain production and agriculture revived in specific regions such as Zeeland and Groningen, which produced and shipped grain to Amsterdam for domestic consumption (Vries 1974:171). Other agricultural products also recovered by the second half of the eighteenth century, as prices rose for cash crops such as grain, potatoes, hay or fodder, dairy products, and livestock (Boxer 1965:285-86).

Opportunities Through Inland Shipping

Baltic grain imports steadily declined after 1650. In part this was due to increasing grain production and exports in other countries like England and France, which also reduced Amsterdam's merchandizing role in the international grain trade. Although there was decline in the tonnage shipped, trade in Baltic grain and
particularly timber continued. Much of the trade was conducted by skippers doubling as merchants of their own cargo and factors for merchants shipping cargo with them (Boxer 1965:283). The number of Dutch watercraft involved in the Baltic trade did not change appreciably over this time, but the size and carrying capacity of the craft decreased markedly.

Many of the vessels still involved in the trade after 1740 were smaller Frisian vessels (Israel 1989:380-1; Boxer 1965:287). Friesland actually increased its number of sailing vessels during the eighteenth century. In 1779, there were 2000 vessels registered in Friesland, but these were chiefly coasters under 80 tons (Boxer 1965:287). The size of canals and locks did not increase appreciably until the nineteenth century and thus limited the size of small craft using the network of canals (van Konijnenburg 1913, Schutten 1981).

The total fleet in the late-seventeenth century is estimated to be 8,000 sailing vessels. Possibly the largest part of inland shipping on the Zuiderzee can be attributed to the transport of peat (van Schalk 1969 quoted in Zeeuw 1978). In response to the economic crisis, the surplus urban population initially fled to work in the peat bogs of the northeastern provinces of
Drenthe and Overijssel (Boxer 1965). By mid-eighteenth century, however, many peat bogs north of Overijssel were depleted (van Bath in Faber et al 1965), but peat digging increased in the central districts of Friesland. In this region a population increase after 1750 can be attributed to an influx of laborers for employment in the peat industry (Faber et al 1965; Roessingh 1965, 1970). Peat digging continued to be an important, though perhaps marginal, source of employment during the eighteenth and nineteenth centuries. Great quantities of peat were also cut in the bogs west of the Vecht River, which because of their proximity served the Amsterdam market. Peat skippers, mainly from Groningen and Friesland, even went as far as Antwerp and other Flemish cities to sell their cargo (Zeeuw 1978).

Ethnographic information from the nineteenth and early twentieth centuries indicates that peat workers operated from April until mid-December. Large crews of women and children were used to load the peat, but a skipper only needed one or two mates as crew on the prams and other freighters (Schutten 1989, pers. com.). Many skippers had their wives as their only crew member. Only on some of the larger vessels were two men involved. To qualify as a skipper, the aspirant apprenticed for fifteen years, usually beginning at age 12 to 13. Mates
were paid at the end of the annual season, and skippers' made their profits directly from the sale of the peat (Schutten 1989, pers. com.).

Pram-class vessels were used extensively in the peat trade. Small vessels were used on the shallow waters of narrow drainage ditches and canals in the peat moors, while larger prams with more tonnage were used for sailing the Zuiderzee. Intermediate sized vessels also might be used to tranship peat from the moors to ports for transhipment across the Zuiderzee to the cities (Schutten 1981).

Pram-class vessels also were used in numerous occupations of transporting produce, freight, and passengers as they were in earlier centuries. They were also used as cheap transports for removing city refuse, building debris, mud, sand, and any number of cargoes relying upon the cheap transport of materials. Four such working boats from the late seventeenth century are described below.

Four Work Boats: A.D. 1650-1700

Four work boats, or schuiten, from the second half of the seventeenth century have been excavated in the
Ijsselmeer polders (Reinders et al 1984). These represent small craft built for the specialized purposes of transporting dredged mud, nightsoil, and peat. All of the work boats were sturdily built, with low freeboard, and in the case of two vessels, B 51 and B 13, had perpendicular, box-like sides. This shape, and the absence of a mast and rudder, gives them the aspect of floating boxes. Of the four vessels, only the mud boat B 19 had indications of having had a mast, although this evidence is inconclusive. They were evidently propelled by poling, since most lacked mast steps for sailing or towing and rudders. The extreme low freeboard indicates the requirements of hauling a heavy bulky material that had to be hand shoveled out of the vessels. As reconstructed, the two mud barges had slightly more curve in their hull sections and appear to have been better built than the other two work boats.

Although these craft may not at first glance suggest a specialized usage, the fact that they do not have the ability to be sailed, towed, or steered limited their employment solely to movement of heavy bulky material over short distances. These simply constructed boats reflect the tendencies in the modern era to build small craft for specific functions, even for such mundane activities as the removal of mud and city refuse.
Two Mud Barges: B 19 and MZ 6

The wrecks B 19 and MZ 6, identified as modderschouwen or mud barges, have a similar construction and dimensions (Figs. 34 and 35). In 1966 the mud barge B 19 was discovered during the draining of Eastern Flevoland polder, within the area where the city of Lelystad was later built. In fact, the quarter of Lelystad where the B 19 was found was later called Schouw. Between 1966 and 1972, when the shipwreck was excavated, the hull remains were covered with sand. Although slightly damaged on the after port side, it was relatively well preserved.

MZ 6 was discovered in 1971 during land development at lot MZ 6 in Southern Flevoland. When MZ 6 was first found it was well preserved, but it could not be excavated until 1977. At that time land drainage for agricultural purposes had lowered the water table resulting in the loss of the upper part of the vessel. It was apparent from very early during the excavation of MZ 6 that it was identical to the B 19 excavated earlier. One exceptional feature of the MZ 6 was the sole surviving transverse beam, upon which was inscribed the year 1664 and the Amsterdam city arms XXX. Archival research revealed that in this year the city's ship
Figure 35. Mud barge, NŽ 6. (After Reinders et al. 1984.)
builder Jan Lucasz Root was instructed to build 100 mud barges (Reinders et al 1984:25). Mud barges played an important part as transports in the organization of the Amsterdam's mud works, which maintained the depth of the city's harbor (Fig. 36). Mud mills annually dredged 200,000 cubic meters of silt from the inlet to the Zuiderzee.

B 19 had a length of 16.32 m, breadth of 3.92 m, and depth of hold 0.8 m. MZ 6 was 16.56 m long, 3.78 m broad, and 0.84 m deep. Pipe-bowls, pottery sherds, and soil profiles indicate both probably sank around 1700. Both were double-ended with flat carvel bottoms, and both were hard chined throughout with lapstrake sides and straight, raking posts. The bottom of B 19 was made up of seven planks while that of the MZ 6 consists of nine. Stem and sternposts were fastened directly to the toes of the central planks. The posts were set on top of the central plank. Each side consisted of three continuous strakes, but stealers were present in the fore and after ends of the boats. The two lower strakes angled outboard providing the hulls with some curve. The uppermost strake, the wale, was placed in a position more perpendicular to the bottom. Posts were rectangular in cross section and were rabbeted for the strakes' hood ends (Reinders et al 1984:9-11, 21).
Figure 36. Mud barges and mud mill in the harbor of Amsterdam during the late seventeenth century. (From Schilbeeijer, no date.)
Stealers began at the bulkheads in both vessels and bottom and sides planks were joined at the chine with iron nails. The overlaps of the sides were 8 cm wide, caulked with moss, and fastened with clenched iron nails. The wale was a thicker, heavier plank and was notched to fit over the lower strake (Reinders et al 1984:11, 22).

Frames consisted of floor timbers and futtocks. Some futtocks sat on top of the ends of floor timbers, extending only up the sides of the boat. In the B 19 and MZ 6 hulls, such futtocks were used only where bulkheads were placed and in the ends of the vessels. MZ 6 used more futtocks in its ends than did B 19, but this may have been a matter of timber availability or variations in local builders' construction methods. In the very ends of the boat V-shaped frame timbers were used. L-shaped timbers that extend across part or all of the bottom and up the sides were also used. Probably to increase the strength of the hulls' floor timbers, L-shaped frames were paired, although not fastened together. The general pattern suggests straight floor timbers forward of the L-shaped frames. Frames were fastened to planks with trenails wedged with cross-wedges and deutals (Reinders et al 1984:11-13, 22).
Three transverse beams were placed across the upperworks of both boats. These provided lateral stiffening and support for port and starboard gangways. The beams were fastened to the wale strake with bolts, which ran through the strake and were stapled to the forward face of the beam. The beams were also secured in place by T-shaped iron straps which fastened on top of the wales and beams. On B 19, iron rings were placed on top of the transverse beams. The authors suggested that these served to secure the barge to the mud mill (Reinders et al 1984:13, 23).

Strong bulkheads were placed fore and aft. These consisted of two thick strakes fitted lengthwise across the hull, spiked to the knee-ends of the L-shaped frames, and fastened to the wales with bolts. The forward bulkhead on B 16 may have had a mast step construction. On the forward side of this bulkhead were two boards and two beams placed to possibly form a tabernacle for a mast. A space 31 cm apart was between the beams. The bottom of the beams and boards were let into notches in the floor timber. The arrangement was spiked securely to the bulkhead. A mast placed here may have been used for towing the vessel. Presumably, the bulkhead provided a forward compartment, which would have been covered by a foredeck. The after bulkhead was like the other one
except for the mast tabernacle arrangement. An after deck began at the after bulkhead and was supported by six deck beams spiked fast against the wale and the frames. Twelve planks were laid across the beams. Between the after bulkhead and the first deck beam was a hatch opening of 164 by 48 cm, the rim of which was trimmed with lath (Reinders et al. 1984:13, 23).

Between the B 19's two bulkheads was the hold, approximately 8.5 by 3.6 by 0.7 m, having about 20 cubic meters of space. The hold on MZ 6 was 8.5 by 3 by 0.75 m having 19 cubic meters. The decks over the end compartments also served as platforms from which watermen propelled the craft with poles. One of the compartments on B 19 was fitted with a hatch for access. A large lock was found near the hatch (Reinders et al. 1984:15, 24-25).

Within the B 19's hold were found two wooden shovels, a pair of large mud boots, a small bottle, a tobacco box, a small wooden bottle, and a belt and knife in a leather sheath (Fig. 37). Most of those were either personal items belonging to the mud man or ship's equipment. The sparse assemblage and lack of artifacts necessary for sleeping and dining on board indicates that the crew lived elsewhere and that the cuddy was used as a dry area during the workday. Scattered throughout the
Figure 37. B 19 and B 51 artifact assemblages. B 19 (a) and B 51 (b) artifact assemblages consisted of a few personal items, working equipment, and some ceramics. (From Reinders et al 1984.)
B 19's hold were a number of ceramic and glass sherds and kaolin pipe fragments. These probably represent objects picked up with the mud. No artifacts were found in the bow. In the stern cuddy was 300 kg of ballast stone. Fore and after decks were probably in the same position on MZ 6, but neither decks nor beams survived. The bulkheads and gangways were in the same location, but there was no evidence of a mast tabernacle or step (Reinders et al 1984:15-17).

There were not many artifacts from MZ 6 that can be attributed to the ship's equipment or to the crew. Most of the artifacts recovered consisted of sherds and kaolin pipe fragments from the hold, although an iron boathook may have been ship's equipment and a fragment of a shoe could have belonged to a worker (Reinders et al 1984:25).

A Peat Boat: B 51

B 51 was another work boat found during the draining of Eastern Flevoland in 1966 and was excavated from April 18 to June 10, 1972. The location of the vessel was 18 km to the northwest of the former Zuiderzee city of Harderwijk. The former water depth in this area was 3.1 m at low tide. It was determined from the ground profile that the vessel must have settled there at the end of the
eighteenth century. The excavators believed the boat to have been a type for the short-haul transport of peat, either soft or firm peat, called veen or turf. The strongest evidence for this was the peat found between the frames of the hold, which was up to 6 cm deep in the hold (Reinders et al 1984:37, 43).

Wreck B 51 was a double-ended, flat-bottomed work boat, with an extremely hard chine throughout its length (Fig. 38). It had a shape slightly leaner than that of the other three boats, but the nearly perpendicular chine gave the hull its box-like sectional shape. The freighter had a length of 14.5 m, breadth of 2.98 m, and hold depth of 0.66 m. Since there were no signs of a mast nor oarlocks, the boat must have been propelled chiefly by punting. The broad inwale would have provided a walkway upon which a crewman could walk and pole the boat through the shallows (Reinders et al 1984:37-45).

The bottom consisted of four planks, which were irregular in form and varied in breadth. Bottom planks were 4.5 to 5 cm thick and fastened together with flat scarfs. Stem and sternpost were heavy, block-like timber, diamond-shaped in cross section, and placed more vertical than in the other work boats mentioned here. Exceptionally heavy posts like those on B 51 are referred
Figure 38. The B 51: a possible peat boat. (After Reinders et al. 1984.)
to by the Dutch as blokstevens, which translates literally as block stems. Both posts were rabbeted for the strake hood ends and the top of the posts extended 20 cm above the upper strake (Reinders et al 1984:37-39, enclosure 6).

The lapstrake sides consisted of two strakes to each side, while stealers were absent. The lower strake was the broader at 40 cm wide, while the upper strake was 17 cm broad. The upper strake overlaps the lower by 8 to 10 cm and was fastened by clenched nails. The overlap between strakes was caulked with moss. The juncture of bottom and sides was strengthened with both floor timbers and futtocks. Framing units usually consisted of a floor timber with port and starboard futtocks. In some instances, futtocks were scarfed together and the builder alternated the positioning of these scarfs on port and starboard sides of the boat, but did not place them over the centerline. This arrangement was strengthened the hull's structure transversely. Frames were slightly thicker, 7 to 10 cm, in the fore and after parts of the boat and were in some instances notched for the strake overlaps and in some cases notched to contain the inwale (Reinders et al 1984:39-41).
A keelson was laid on top of the frames and ran most of the length of the vessel. It began 80 cm aft of the stem and ended 70 cm before the sternpost. The keelson was of three lengths fitted together with a flat scarf and flat scarf. The keelson was 7 to 8 cm molded and 30 to 32 cm sided (Reinders et al 1984:41).

The upperworks were strengthened with inner and outer wales. The inwale ran the entire length of the vessel and was triangular in cross-section. It had a maximum thickness of 17.3 cm and breadth of 32 cm. The inwale chiefly provided longitudinal strengthening and with the frame heads supported the gangway. Amidships the inwale was a heavy timber that covered and protected the frame heads. In the bow the inwale consisted of two slighter, curving timbers, which did not cover frame heads, since here the frame heads would have been protected by fore and after decks. Fastened to the outboard face of the sheerstrake was a small wale, 7.5 to 8 cm thick by 17 cm broad. The wale ran from stem to sternpost and extended slightly past both posts. Inwale, sheerstrake, outer wale, and futtocks were all fastened together by treenails (Reinders et al 1984:41).

Fore and after decks were supported by a transverse deck beam and a longitudinally running beam. The
decking, three planks in the bow and four in the stern, was laid laterally across the boat and spiked to the deck beams and inwale. The transverse beams lay in notches cut in the futtock. This beam was in turn notched for the other beam end. The cargo hold measured 11 by 2.4 by 0.5 m and had a capacity of 13 cubic meters. The fore and after compartments occupied very small spaces and probably served primarily as platforms. Fore and after decks were present but no bulkheads separated the bow and stern compartments from the hold. Since the space underneath the decks was very small and open to the hold presumably no one lived aboard the boat (Reinders et al 1984:41-43).

Most of the artifacts were found in the forward half of the vessel, but not under the deck. The only exception was a shoe fragment was found under the foredeck. A red earthenware cooking pot and a chafing dish were found close together, but the red earthenware lid lay some distance away. Several ceramic and glass sherds were found, as well as fragments of another chafing dish. In the stern, almost under the deck, was a short-handled shovel, probably used for cleaning between the frames. A fragment of iron chain was found in the bow. Ceramics finds indicate a date of about A.D. 1700
for the wrecking of the vessel (Reinders et al 1984:43-45).

As mentioned above, the vessel was determined by the authors to be one that hauled soft or hard peat. This identification was based upon the presence of layers of peat in the cargo hold and a hull form similar to that of vessels known to haul peat. It was probably a vessel that only moved peat short distances, as indicated by its low freeboard, and lack of a mast and rudder.

A Dust Boat: B 13

This boat was found on September 21, 1977 while drains were being dug in the city of Lelystad. The excavation took place a few days later, from September 26 to 29. B 13 had a flat carvel-built bottom, which forms a hard chine with the single side strake (Fig. 39). The bottom was built of six parallel strakes having a thickness of about 6 cm and breadth of about 38 cm. The two middle strakes ran fore and aft, and finished with a toe for the foot of each post. Both posts had a slight curve and were roughly triangular in cross section. The stem had slightly more rake and was 6 cm longer and 4 cm broader than the sternpost. The stem had one rabbet and the sternpost had double rabbets, the first of which ran
Figure 39. The B 13: a dust boat. (After Reinders et al. 1984.)
to the full height of the stem and the second ended 10 cm below the top of the post (Reinders et al 1984:29-36, enclosure 5).

The sides of the boat consisted of only one strake, 50 cm wide and 4 cm thick. On the inside of this strake, between the bulkheads, a second 4 cm thick strake was placed. The authors determined this was a wearing board to protect the side of the boat in the hold area. An additional outer strake, consisting of one oak and two pine planks, was placed outboard after the boat was built. For most of its length (the area of the hold) the strake was of oak, but in the ends the pine planks were used. A layer of moss caulking was placed between the inboard and outboard strakes (Reinders et al 1984:29-31).

Frames consisted of floor timbers, futtocks, and top timbers. The sides were attached to the frames by two or three treenails. The bulkheads were sandwiched between a floor timber and top timber. Floor timbers and futtocks were paired together. In the center of the boat was a pair of two futtocks. Between the frame pairs in the hold were six thin planks, 1.5 cm thick, used probably as ceiling to protect the hull. The floor timbers stopped 6 cm short of the chine. This and the limber holes under the futtocks allowed bilge water to circulate around the
chine. Fastened to the frames were 4 cm thick bulkheads made of pine (Reinders et al 1984:32-33).

Found in the bottom of the hold was a scatter of artifacts: pipe-bowls, a toy gun, marbles, a coin dated 1620, and several ceramic sherds. The nature of these objects and the foul smell of the inside of the ship gave the excavators the impression that the cargo had consisted of town refuse. The pipe bowls were dated 1630-1650, so it was estimated that the boat sank around 1650. Some majolica sherds were found in the boat. Since such decorative ceramics are seldom found on shipwrecks from the IJsselmeerpolders but are frequently found in town sites, their presence on B 13 was another indication of a vessel hauling household refuse. A few bricks, flagstones, and floor tiles were found in both ends of the boat (Reinders et al 1984:33-35).

The boat had a reconstructed length of 9.32 m, breadth of 2.52 m, and depth of hold of 0.52 m. This boat is an example of a small, strongly-built work boat. It was propelled primarily by punting, for there was no indications of a mast step. Reinders noted seventeenth-century pictorial representations of Amsterdam refuse boats that resemble B 13. Figure 40 shows two such seventeenth-century small craft transporting night soil
Figure 40. Small pram-class boats collecting night soil and street sweepings. (From Schiltmeijer, no date.)
and street refuse from Amsterdam. Besides the sanitary significance of the removal of city waste, nightsoil was a valuable addition to farm land both as fertilizer and to raise the level of the land (Reinders et al 1984:35).

These four working boats from the second half of the seventeenth century indicate some of the specialized purposes pram-class vessels were used for during this period. Although these are exceedingly humble small craft, they represent a significant part of the transport systems that kept the harbor of Amsterdam cleared, removed nightsoil from the city, and transported peat for fuel. It is interesting to note the similarity of the two mud boats with one another and the general impression of their having been better built than B 51 and B 13. This may be the result of their having been built in a shipyard. The construction of the latter two vessels gives the impression of a lower level of craftsmanship, suggesting they were produced very economically or by someone who was not a skilled boatbuilder.

These boats were built in the late-seventeenth century, which was a period of decline for the Dutch economy. It is likely that profits in the transport of materials such as mud, town refuse, and peat would have been marginal. Therefore construction expenses would
have been kept at a minimum. Despite recessions in the economy, pram-class boats and other small craft continued to have specialized functions. Economic crisis during this period is perhaps dealt with by increased economic specialization. Thus, in watercraft a large number of pram-class types continued to be used for the transport of people and goods.

Prams were also constructed as larger vessels for the hauling of cargo, especially bulk materials (Fig. 41). Many of these were designed to travel short distances across the Zuiderzee or through the network of canals and locks to industrial centers such as Haarlem and by way of the Scheldt to the southern Netherlands and the area of present-day Belgium. The construction of these larger vessels was an enlarged version of the construction of the smaller working boats. Most of the construction features seen in the smaller boats is retained in the larger varieties. The larger prams usually had leeboards, a larger mast fitted into a tabernacle, mast step mortise cut into the keelson, fore and aft sail rig, and hearth and galley.

Two such vessels, discussed below, both dating from the second half of the eighteenth century represent larger pram-class vessels over 19 meters in length.
larger pram-class vessels over 19 meters in length.

**Two Prams Freighters: E 14 and A 71**

Two larger pram freighters were excavated in the IJsselmeer polders. The vessel designated E 14 was discovered in 1968 on an agricultural lot in Eastern Flevoland and excavated in 1974. The other was called A 71 and was discovered in Southern Flevoland in 1975 and excavated in 1980 (Neyland 1991; McLaughlin 1992; McLaughlin-Neyland and Neyland, in press).

Both hulls were those of medium-sized vessels having box-like shapes with fairly constant breadths throughout, dead-flat bottoms, and sharp angular chines. The vessels appeared to have been relatively full in the bow and stern, but with a short, fine entrance and run. Posts were vertical, almost straight timbers. Decks were probably present in the bow and stern over small cuddles. Both wrecks contained artifacts from the late-eighteenth century. A lighthouse token gives a terminus post quem of 1783 for E 14, while a badly-worn farthing with the date 175(?) gives a terminus post quem of the 1750's for A 71.
E 14 was the better preserved of the two shipwrecks having most of the port side intact (Fig. 42), while only the bottom of A 71 was complete and a few portions of the port and starboard sides survived in the bow (Fig. 43). For that reason, E 14 will be used primarily to describe the manner of construction of these prams and some comparisons with A 71 will be made. Although E 14 had been relatively well preserved, it was recorded very hurriedly with stereophotography, from which computer drawings were made. Only a few hull cross-sections and timbers were measured and drawn. Many of the details of the hull had to be obtained later from photographs.

The wreck of E 14 has a reconstructed length of 19.5 m and maximum breadth of 3.51 m. The maximum depth, measured from the lower surface of the bottom to the top of the coaming, is 2.09 m. Over the center of the mast-step mortise the depth is 189 cm. The hold has a volume of 71.4 cubic meters measured from the upper surface of the bottom to the lower surface of the covering board. A reconstruction of A 71 was not attempted because of its poorly preserved state.
Figure 42. E 14 site plan. (Drawing by Kathleen McLaughlin-Neyland.)
Figure 43. A 71 site plan. (Drawing by Kathleen McLaughlin-Neyland.)
Hull Construction

The bottom of E 14 was completely flat from stem to sternpost, having a reconstructed length of 17.6 m (Fig. 44). Toes of the bottom planks continue underneath and were fastened to the heels of the stem and sternpost. There were seven strakes running from stern to bow. These were composed of sixteen planks, in most instances fitted together with flat scarfs. Bottom planks were from 5 to 6 cm thick.

The planks were not symmetrically arranged and have a mosaic appearance. Plank widths and lengths varied, and planks narrowed considerably along their lengths. The fitting together of irregularly-shaped boards may be an indication of timber shortages and economies in lumber. This might have been at a cost of more labor, however.

It is uncertain how the builder of the E 14 produced irregular planks with complementary curves and tight fitting edges. One construction method, still used in the Netherlands today, can accomplish this. A boatbuilder can produce planks with complementary curves by overlapping the plank edges and sawing both planks with the same cut. This method of shaping carvel bottom
planks provides a good edge-to-edge fit, with no additional loss in plank width than might normally occur in removing sapwood from planks. Fitting plank edges by this method of sawing is still used today in the Netherlands in the construction of the punter (Fruithof 1976:31).

A skeg was fastened to the central-most plank in the stern and ran forward from the sternpost. The after end of the skeg abutted the sternpost, but the length of the skeg forward was not recovered. The impression left by the skeg in the A 71 was 260 cm long and 12 cm wide.

The bottom of the A 71 was constructed almost identically, having a length of 17.5 m and consisting of seven strakes formed from sixteen irregularly-shaped planks. The excavation report that plank joins were caulked with moss. Two plugged drain holes were also recorded. The bottom of A 71 had a centerline scribe mark and series of scribes under the foreship frames and mast step.

The principal dimensions of E 14's stem and rabbet were not recorded and can only be inferred from the photographs, which show 150 to 170 cm of the stem, up to the 4th strake. Rough estimates, derived from the
computer drawing and photographs, suggest inboard dimensions for a stem heel of 14 cm sided and 56 cm molded.

More details are available on the stem of A 71, which survived to a height of 134 cm. The heel was 50 cm molded and 20 cm sided inboard, but narrowed outboard to a minimum of 16 cm. It was fastened to the bottom by three treenails. The rabbet for the strake hood ends was 3 to 4 cm wide. Outboard, a gripe protected the end of the stem and the join between the toe of the bottom plank and heel of the stem. It may have slightly increased the lateral resistance of the hull. A wooden stopwater was located at the junction of the stem, lower stealer edge, and central plank.

The A 71 stem also had a series of draft marks designating the two, three and four feet marks. Spacings between the marks were not perfect, varying from 28 to 30 cm between marks, and probably were based on the Amsterdam foot, equivalent to 28.35 cm.

The sternpost was completely missing on both wrecks. An iron gudgeon was found near the stern of E 14 and had a maximum inner width of 21 cm and minimum width of 8.4 cm. These dimensions indicate a sternpost with a
trapezoidal cross-section. Seven fastener holes were on each gudgeon arm and a W-shaped mark was incised on the outer face.

Six overlapping strakes, of which only four were continuous from stem to sternpost, formed the sides of E 14. Discontinuous strakes, stealers, were placed in the ends of the hull to fill the space between the bottom and the third strakes. A total of eight stealers, four in the bow and four in the stern, were used in E 14. A 71, however, technically had only two stealers in the bow and the second strake was a continuous strake, but narrowed drastically amidships. The sides aft of midships in A 71 did not survive. In the bow, port and starboard stealers had asymmetrical widths, as well as lengths. As seen from inboard, the port and starboard hood ends exhibited a lack of symmetry as far forward as the first frame. These differences in width probably continued to the stem rabbet and resulted in an asymmetrical appearance to the hood ends.

Along its outer edge, the bottom was cut away to accommodate butt joints with the stealers. This method of fitting the stealers to the bottom insured a smooth transition where the first and second stealers terminated. Both the stealers and the third side strake
amidships were probably fastened to the bottom with iron nails.

The width of plank overlap between each finishing stealer and the strake directly above it increased so that the upper strake, either the second stealer or third strake, became the lower strake and fitted the bottom to form the chine. Insertion of the stealers after fastening the upper strakes is done in some carvel-built boats; however, this might not have been as easy to accomplish with the overlapping strakes of clinker-built boats.

The third strake was the first continuous strake between the stem and sternpost. It was composed of two planks scarfed together near amidships. The fourth strake was composed of three patched planks, which like the piece work of the bottom might represent the use of less-than-optimum timber.

The fifth strake was the wale. Here the hull changed direction and angled upwards. Amidships, the wale was perpendicular to the bottom, but in the bow and stern angled outboard. Evidence indicated a composite wale at the ends of the boat, and this was probably the case throughout its length. Although a composite wale
consisting of two strakes was not recorded amidships it seems likely that an additional board overlapped the fourth strake.

The upperworks of the hull had a carvel appearance when seen from outside the vessel. Although the sheerstrake fit edge-to-edge with the strake below it (the outer strake of the composite wale), its edge also overlapped the heavier inboard wale strake (see cross-sections Figure 45). The composite wale was constructed in such a way that inner and outer parts formed a step-like rebate for the lower edge of the sheerstrake. This also resulted in a carvel appearance to the upperworks of the boat. A similar wale construction is often of one piece as shown in Figure 34 of B 19, the seventeenth-century mud barge found in Eastern Flevoland (Reinders et al 1984: enclosures 2 and 3), but in the case of E 14 was a composite of two boards.

The inner wale was a thicker, triangular-shaped plank in the bow and stern where the hull begins to curve toward the posts. It had a maximum thickness of 10 cm on the upper molded face and 4 cm on the lower molded face. The wider dimension was intentional for it increased the breadth of the upperworks, strengthened the hull, and set
the angle of the sheerstrake so it ran smoothly into the posts.

The sheerstrake was the sixth strake and ran perpendicular to the bottom. It was wider and thinner than the other strakes, with a 4 cm thickness. Throughout most of the boat it was topped by a covering board. The covering board had a width of 20 cm, a thickness of 4 cm, and a total length of 13.68 m. It angled upward (as reconstructed at an angle of approximately fourteen degrees) so that water drained outboard. An 8 cm high by 4 cm wide coaming was present on the covering board. The covering board ended in the bow at the eighth frame and, as reconstructed, 230 cm from the stem. A short toerail, which was notched to receive 92 cm of the covering board, continued to the stern.

The stern probably had a toerail like that found in the bow. A short section of toerail was present forward of the bitt. It was notched to receive only 20 cm of the covering board. This thick, wale-like timber was rabbeted to fit over the upper edge of the sheerstrake. There was no trace of a toerail aft of the bitt, but it may have continued to the sternpost.
The width of strake overlap depended upon position in the boat. Amidships, most plank overlaps were about 6 cm, except that of the sheerstrake, which reached 8 cm in places. Plank overlaps increased at the ends of the boat to 8 to 10 cm, and increased where the stealers ended. The sheerstrake overlap was exceptional because it was 6 to 8 cm amidships, diminished to 3 to 5 cm fore and aft where the strakes began to rise upward for the posts, and then increased to 8 cm in the extreme bow. When reconstructed, the varying widths of the strake overlaps resulted in fairer exterior planking lines than interior planking lines.

Planking was fastened to the frames by treenails and probably with iron nails, although the latter were not visible in the photographs or mentioned in the excavators' notes. Stealers were fastened to the outboard edge of the bottom with iron nails. In selected areas of the hull the builder fastened the wale to the futtocks with iron spikes: amidships, where the mast was stepped, aft where the planks begin to curve toward the sternpost, and probably where the hull begins to curve inward towards the stem.

A 71 appeared to have sides that were of at least six strakes. Most of the construction was similar to
that of E 14. On A 71 pine sheathing was fastened to the outer hull planking. Moss caulking was placed between the pine sheathing and the hull and suggests that the sheathing and moss were used to patch a leaky hull. The sheathing might also have been used to protect hull planking because by this time the wood-boring worm Teredo navalis was a problem in the more saline waters of the Zuiderzee.

Frames consisted of floor timbers, futtocks, and top timbers (Fig. 45). Throughout the vessel there was a consistent arrangement: floor timbers paired with top timbers alternated with floor timbers set between port and starboard futtocks. This pattern changed only in the extreme bow and stern where port and starboard futtocks fit heel to heel. There were a total of 58 floor timbers, of which 32 were paired with top timbers and 26 fill the space between opposing port and starboard futtocks. The latter floor timbers were not fastened to the heels of futtocks. Floor timbers were 14 to 18 cm sided and 8 to 10 cm molded. Space between floor timbers (center-to-center) was normally 25 to 30 cm.

The first frame was a V-shaped timber resting upon the heel of the stem. The port frame head terminated at the upper edge of the wale and the starboard head ended
Figure 45. E 14 construction plans. (Drawing by author.)
at the fourth strake. Directly aft of this frame were two pairs of futtocks, followed by the consistent arrangement of floor timbers and top timbers alternating with floor timbers and futtocks. The stern has an arrangement similar to that of the bow. Futtock heads terminated at the upper edge of the fifth strake. Futtock dimensions were 13 to 16 cm sided and 8 to 16 cm molded.

Top timber heels normally began at the third strake, and their heads terminated at the upper edge of the sheerstrake and covering board. Estimated dimensions for the top timbers were 8 to 12 cm sided and 8 to 10 cm molded. Some top timbers, such as the one at frame 26 containing the leeboard bolt were noticeably larger timbers than others.

Two breasthooks strengthened the bow construction of E 14. They have reconstructed dimensions of 10 to 12 cm sided and 8 to 10 cm molded. The first and shorter of the two breasthooks fastened to the third strake and the larger example fastened to the fourth strake. How the breasthooks were fastened to the stem was not recorded, but in A 71 the breasthook was fastened to the stem with a single iron spike.
The combination mast step and keelson of E 14 spanned the thirteenth to thirty-sixth frames. It had a maximum length of 564 cm and was sided 58 cm. Because of its length, this timber provided some longitudinal strengthening to the hull, like a keelson. It appears to have been fastened to every floor timber with treenails. The mast was stepped 484 cm abaft the heel of the stem. The mortise for the heel of the mast was 28 cm wide by 32 cm long; on each side were deeper slots for the tabernacle boards, each about 4 cm wide by 32 cm long. On the port side of the tabernacle were two iron bolts, forward and aft of the slot, and protruding 4 to 5 cm above the mast step. These two bolts were perhaps part of a mechanism for securing the heel of the mast, perhaps by accommodating chocks. On E 14 a large forelock bolt that might have secured the mast in the tabernacle was recovered. It is 55 cm long, and has a constant 2 cm diameter. The slotted end held a forelock key, which would have prevented accidental withdrawal from the tabernacle and mast.

The mast step and keelson of A 71 was shorter, having a length of 338 cm, although since the mast step ended in a scarf it is possible that an additional timber fit on the end. The mast was stepped 466 cm from the heel of the stem. Like E 14 the mast fit in a tabernacle
and an iron forelock key found amidships perhaps secured the mast bolt and the mast in position.

Masts were placed in tabernacle constructions because it was necessary to raise and lower the mast to pass under canal bridges. Whether or not the E 14 and A 71 masts were lowered aft or forward cannot be absolutely determined from the data; however, prams frequently lowered the mast forward (G. Schutten, personal communication). The sail beam on E 14 was forward of the mast, and would have facilitated lowering the mast forward.

There were at least eight knees surviving on E 14, of which two were hanging knees and the other six standing knees. Two hanging knees supported the bow and stern bulkhead beams at frames 8 and 61. Although these beams were not preserved, the height of the knees suggests that the knees fit directly below the beams rather than beside them. At the approximate location of the stern bulkhead, the partially preserved arm of the knee appears to have had a fastener hole through its upper and lower sided faces.

The only knee individually measured was found loose in the hull, and is believed to fit at frame 16. This
knee had a 105 cm long body, with maximum molded and sided dimensions of 18 cm by 16 cm. It was fastened to the hull by four treenails, and the outboard face was notched to fit over two repair planks. The arm was 70 cm long with maximum molded and sided dimensions of 11 cm by 18 cm. The molded depth at the breech was not recorded, but was estimated to have been 16 to 18 cm. Probably the arm supported a beam; however, no beam fasteners were recorded. Evidently, it was a standing knee, because, as reconstructed, the arm supports the covering board. Another standing knee was 40 cm forward of this knee. These two knees might have held a large beam between them that strengthened the hull laterally and provided support for hatches forward of the mast step. A construction similar to this can be seen in the nineteenth-century model of a pram-class vessel, called a Drentse boeiermarktpraam (a farmer’s market pram from the province of Drenthe) (Maritiem Museum Prince Hendrik, model # 120).

A second pair of standing knees is just forward of the mast step at frames 18 and 22. This pair probably supported the large sail beam. Other standing knees were present at frame sections 36 and 58. The knee at frame 56 could be a small knee fastened to a top timber. Similar knees are shown on another pram wreck, designated
R 43, excavated in the Northeast polder, which dated to the nineteenth century (Center for Shiparchaeology archives; Schutten 1981:245).

Transverse beams reinforced the hull and in the bow and stern supported the mast and deck structure. In the bow and stern compartments at least three beams were necessary to support the deck. Both locations had a hanging knee and a bitt with a shoulder that might have supported a beam. Neither in the bow nor in the stern was there evidence of a knee aft of the bitt, but in both locations another beam seems necessary.

Two beams recovered from E 14 were found loose in the bow. One, probably a deck beam, spanned the breadth of the hull and had a curvature that would have given the deck enough camber for water to run off. This beam had a length of 228 cm, and was molded 10 cm and sided 10 cm. The ends were angled, probably to fit the curve of the hull. Each end had a short metal strip of unknown function on the after face. The length of this beam suggests its placement between the first and second frames in the bow. There is no evidence of a knee at this location, but the beam might have rested on a frame head or on the upper edge of the wale.
The function of the other beam is less certain. It was 165 cm in length and had a cross-section 10 cm wide with a maximum 9 cm height. One face has two rabbets, 2.5 cm deep by 2.75 cm wide, running the length of the beam. Possibly, it ran longitudinally between the other beams. There is exactly 165 cm between the mast-step mortise and the knee at frame 14. This beam could have fit here to serve as a ridgepole. The rabbets on the beam probably were cut to receive the upper edges of hatches. A drawing of a ridgepole for a pram-class vessel, called a zomp, is similar to this E 14 beam (Schutten 1981:231).

Other beams must have been present at the mast and elsewhere in the vessel to reinforce the hull. A pair of standing knees, located just forward of the mast-step mortise, supported a large sail beam. On R 43 a sail beam was located just forward of the mast-step mortise (Center for Shiparchaeology archives; Schutten 1981:245). In E 14 a sail beam was not found, but a single beam between the two knees would have had a sided dimension of 48 cm.

Forward of this construction was another pair of standing knees with a space of 40 cm between them. A beam located here, in conjunction with the beam at the
mast-step mortise, might have supported a small deck forward of the mast or hatches to protect this portion of the hold. Such a construction is shown on the nineteenth-century model of the *Drentse Boeiemarktpraam* (Maritiem Museum Prince Hendrik, model # 120). Other beams were probably fastened to the standing knees at frames 36 and 58.

Two thick blocks were found loose in the bow. One was fastened to a fragment of the starboard toerail. This hawse piece contained two holes, each 8 cm in diameter, for the hawser and was notched to fit over the deck. It was fastened to the stem by an iron bolt, and another iron bolt attached it to the port toerail. The second block fit above the first hawse bolster, capping it and the toerails. The fore-end of this block was rabbeted to fit against the stem. No evidence of fasteners was recorded on the upper block.

There was evidence for two bulkheads, one forward and one aft. A portion of the forward bulkhead survived on the port side and is visible in a photograph. Fastened to the forward face of the knee at frame 8 were three boards fitted together with lap joints. The photograph shows the bottom plank edges fastened to a beam at the height of the second strake. The lower
bulkhead beam appears to have been a relatively slight timber; probably it served primarily as a lower fastening point for the boards. The bulkhead boards extended above the knee to what was probably the upper limit of the deck beam.

There was probably a similar bulkhead in the stern. The most likely location was the after face of the knee at frame 61. There was enough space for the bulkhead planks to fit between the after face of the knee and the ceiling planking. Nothing remained of the stern bulkhead and no evidence of fasteners for a bulkhead were recorded on the knee.

No evidence survived of A 71's bulkheads, but traces of red paint, observed on a port futtock, and a large iron hinge could be indications of a forward compartment. The artifact scatter suggests a storage area for equipment in the bow and living quarters in the stern.

No ceiling was used in E 14 to protect the hold from damage. The only ceiling planking found in the hull was in the after compartment area. Here five reverse-lapped boards were fastened to the port side bulwark and futtocks. These seem to be thinner boards, probably no more than 2 cm in thickness. Below and perpendicular to
these was a narrow board with a rabbet or a lap joint on its inboard edge. This ceiling planking functioned as the inner wall of the stern Cuddy or was the remainder of a locker. No evidence was recorded of ceiling in the bow compartment, nor can any fastener remains be seen in photographs. A four-pane window with traces of red paint and latches was found in the stern compartment. It was possibly a door for an interior cabinet.

A 71 was furnished with ceiling planking, remnants of which survived in the bow and was indicated amidships and in the stern by iron nails in the upper surface of floor timbers. This may be an indication that A 71 carried cargoes from which it was necessary to protect the bottom of the hold, while the E 14 did not.

Rigging

No direct evidence of rigging was found in E 14. Mast steps on both wrecks indicate a single mast. In the bow compartment of A 71, a headstick for a fore staysail was found in association with five iron thimbles and two blocks. Representations of prams--engravings, drawings, and models--normally show a standard rig consisting of a gaff sail and fore staysail (Groenewegen, 1789).
Leeboard and Rudder

A leeboard was found lying inboard on E 14's port side. It had a maximum length of 316 cm and width of 199 cm. On the outboard face of the leeboard were five iron straps. Four of the straps fit over three pine repair planks. A curved iron strap ran along the after end of the leeboard. Also, on the after end were three holes of 3 to 4 cm diameters, attachment points for a line with which to raise and lower the leeboard. Two cheek blocks were attached to the port sheerstrake for raising and lowering the leeboard, possibly in conjunction with a fiddle-block found beyond the port side of the hull and between the forward most cheek block and leeboard bolt. One cheek block was approximately 282 cm and the other approximately 827 cm aft of the leeboard bolt. Thus, the fall of the leeboard tackle led aft. This arrangement of tackle probably allowed the helmsman to raise and lower the leeboard from the vicinity of the helm.

The port leeboard was attached to the vessel 92 cm aft of the mast-step mortise, by an iron eyebolt that probably hung on an iron hook. The presumed hook was not recorded, nor was it visible in any photographs. Inboard at this location there was an iron bolt-end, transfixed by an iron pin over the remnants of an iron washer.
Outboard, a short plank with an estimated length of 27 cm, was penetrated by the leeboard bolt. This plank was the leeboard pad and functioned to protect the hull from wear and possibly to increase the distance of the leeboard from the hull. No evidence of a leeboard guard, to brace the leeboard forward, was recorded.

The lower section of the rudder survived, and was found in a nearly upright position with the after end twisted to port so that it rested perpendicular to the hull. The surviving fragment consisted of the rudder shoe, to which were fastened three heavy planks held together by two iron straps. These iron straps were perhaps remains of the pintle straps. The upper and forward portions of the rudder did not survive.

**Inventories**

Both E 14 and A 71, had a larger number of artifacts representative of life on board ship than did the four seventeenth-century workboats and the sixteenth-century pram, WN 92. Although these two artifact inventories are much more complete, they seem sparse when compared to the inventories of other eighteenth and nineteenth century freighters. In this respect, the inventories may
represent the frugal life and marginal profits made by freighters like E 14 and A 71.

The artifacts are organized according to the functions of ship's and working equipment, tools, navigation and administration, personal possessions, weaponry, and domestic effects. The cooking of meals and provisioning are divided into hearth and galley, eating and drinking, and victuals and provisions.

On both E 14 and A 71 the majority of the ship's and working equipment was recovered from the forward compartment or, cuddy in the bow. The E 14 equipment represents spares (Fig. 46) including an array of fasteners, 18 sheaves, and 7 blocks. The sheaves are made from lignum vitae (Gualiacum spp.) and cluster into three basic diameter ranges: two are about 8 cm, fourteen are between 10 and 12 cm, while another two are about 15 cm in diameter. All of the sheaves show signs of wear and some are quite damaged around the edges. Two sheaves were specialized, one has two fragments of a leather strap lining the interior hole while the second has two small holes, one on either side of the central hole, probably for a pin to lock it in place. The number of used sheaves stored with the spare equipment is one indication that the ship was run very frugally. The
Figure 46. E 14 ship's and working equipment. (Drawing by Kathleen McLaughlin-Nesyland.)
seven blocks found on the site may also have been spares since any blocks in use on the rigging might not have been preserved. One block has the number XII carved into its cheek (McLaughlin-Neyland 1993).

A variety of previously-used iron fasteners concreted inside a small wooden container were recovered. This salvaging of scrap lends further support to the frugality of the skipper in operating the boat. The surviving pump components, two leather washers and a wooden cog are also categorized as spares because it is unlikely that these items, if part of the functioning pump, would have survived when the pump itself did not (McLaughlin-Neyland 1993).

Two ladder rungs indicate that a rope ladder was kept on board. This could be used over the side of the boat or through a hatchway into the hold of the ship. The use of punting poles is suggested by the presence of two knobs. Punting was an important means of propulsion in shallows even on larger prams, and punting poles could be used to push away from banks, and used for sounding the water depth. Two hooks found in the bow may have been used to load cargo into the ship or may have functioned as part of the rigging (McLaughlin-Neyland 1993).
A 71 also carried a number of spare fasteners (Fig. 47). A leather washer and a U-shaped iron fragment were perhaps part of the pump valve. Also, a headstick, four iron thimbles, two blocks, and possibly one or more of the three short hooks recovered were for a fore staysail stored in the bow (McLaughlin-Neyland 1993).

On E 14, tools were also stored in the bow. Most of the tools are those necessary for carpentry. A saw handle, a copper folding rule divided into increments of half a duim (a division equivalent to an English inch), three whetstones, a complete brace, and a knob for a second and perhaps larger brace (Fig. 48).

Two redware cups were receptacles for caulking material or brushes. One cup is filled with hardened pitch and remnants of fiber and iron encrustation are within the pitch. Some fibers could be remnants of a caulking brush. Other materials consist of knitted and knotted wool fragments, possibly indicating the use of an old garment such as a hat or sock, for caulking. The iron encrustation protruding from the surface of the pitch probably is the remains of a caulking iron (McLaughlin-Neyland 1993).
Figure 47. A 71 ship's and working equipment. (Drawing by Kathleen McLaughlin-Neyland.)
Figure 48. E 14 and A 71 tools. (Drawing by Kathleen McLaughlin-Neyland.)
The only tools from A 71 were an iron marlin spike and a heather brush found in the stern. The assemblage of tools on both vessels is incomplete for what would be expected on a boat of this type. The basic tool chest would be expected to have a hammer, chisel or caulking iron, adz, axe, caulking mallet, pincers, knives, and marlin spikes for working with the rigging. There was not a complete tool chest on either vessel (McLaughlin-Neyland 1993).

A few administrative items were found on the ship (Fig. 49). A writing slate and a large lump of chalk were found among the wreckage. Chalk was often used in carpentry and in marking on cargo or on the ends of barrels (K. Vlrieman, pers. com.). The slate measures 39.3 cm by 26.8 cm. The edges are beveled somewhat and the impression left by a wooden frame can be seen along the rim. The surface of the slate is marred by many permanent scratches. This may have been caused by crystalline inclusions in the chalk or by a slate pencil, which was the more common writing instrument used in that time (McLaughlin-Neyland 1993).

The most important artifact used in dating the ship is a lead token for the lighthouse in the region of North Holland and West Friesland. These tokens were purchased
Figure 49. E 14 administrative artifacts. (Drawing by Kathleen McLaughlin-Neyland.)
annually by ship's captains to support and maintain the operation of the lighthouses (Rijksdienst voor IJsselmeerpolders, 1987). The date on the token is 1783, and gives us a terminus post quem for the wreck. Also found was a small lead object resembling a baling seal. Impressed upon one surface of this seal is a cipher mark of 82. It is suggested by K. Vlierman (1990, pers. com.) that this seal is also an example of a lighthouse token, albeit from a different lighthouse, and the cipher 82 indicates the year 1782 (McLaughlin-Neyland 1993).

The domestic effects in the E 14 assemblage are sparse (Fig. 50): a window, a *gnotneus* oil lamp, and a chamberpot. The window was constructed with mortise-and-tenon joints with four thin glass panes held into their framework with a white plaster-like chinking. The panes are of different thicknesses and shades of light green, possibly indicating installation at different times or the use of left-over or recycled glass. Prams from the nineteenth century often had windows set into the hull in the stern of the craft; however, this window does not appear to have been sturdy enough to have functioned as an exterior port (McLaughlin-Neyland 1993).

It seems likely that it may have served as the door to a locker or perhaps as an interior window between
compartments. There are indentations in the top and bottom right side of the frame where hinges attached and a lock partially survived on the right edge. The position of the hinges suggest that this was the exterior molding and that the door opened outward. There are two indentations on the outside of the frame, one on either side of the lower panes, possibly for the attachment of a metal bar spanning the breadth of these panes. The exterior molding was painted red while the interior was left unpainted and rough. The window was found in the stern, close to the stern bulkhead, which is thought to have separated the living quarters from the hold. It was surrounded by small personal objects and bits of thin glass from several vessels; thus, supporting the supposition of its having functioned as a cabinet door (McLaughlin-Neyland 1993).

The *snotnus* was an oil burning lamp designed for interior lighting and can be placed on a level surface or hung on a wall. It is the only means of lighting that was found and probably gave only faint illumination depending upon the type of oil that was burned. Whale oil gave brighter illumination than either sheep or vegetable tallow (McLaughlin-Neyland 1993).
The last artifact in this category is the chamber pot. The chamber pot was broken into several pieces, some of which were not recovered. The fire-blackened bottom might indicate that it was placed close to a fire and therefore could possibly have another function such as removing hearth ashes (McLaughlin-Neyland 1993).

The hearth and galley categories included artifacts for the preparation of meals on board ship (Fig. 51). A hearth as such was not found, but evidence suggests there must have been a hearth of some kind on board E 14. Three unglazed redware tiles were found and show some burn marks. Three yellow fire bricks were also recovered, however other tools and accoutrement necessary for a hearth are missing. A fire box, a grill or trivet, an iron or tile hearth plate, fire tongs and cauldron would be expected to be part of a working fireplace; yet these were not found. It is possible that a firebox constructed of wood and sand was used, and a hearth of this kind would have left little evidence of its existence (McLaughlin-Neyland 1993).

A large red-earthenware ashpot with two stirrup handles might be another indication of a hearth. The ashpot functioned primarily as a container for coals and ashes from the hearth so that they could be disposed of
safely, thereby reducing the chance of fire (McLaughlin-Neyland 1993).

Three of the ceramic vessels, a small tripod skillet and two red-earthenware bowls, were fire-blackened suggesting their use in cooking. Three other vessels—a red-earthenware tripod sieve, a red-earthenware batter bowl, and a red-earthenware milk pot—seem to have been used for food preparation. The E 14 assemblage also contained two pewter spoons (McLaughlin-Neyland 1993).

On A 71 the remains of the hearth and galley were more definite. Hearth fragments consist of a broken iron hearth plate, six pieces of unglazed tiles, and a strip of copper molding, possibly sheathing for the wooden framework of the hearth. The galley assemblage consists of a cast iron cook-pot, an iron skillet of the type used for preparing pancakes, two fire-blackened ceramic bowls, and the copper lid to a tea kettle (Fig. 52). Both the cook-pot and the pancake pan were substantially repaired during their life. The leg of the cook-pot was replaced with a bolt and a patch had been riveted to the bottom of the pan. The owners decision to repair these objects rather than replace them could also suggest a frugal lifestyle (McLaughlin-Neyland 1993).
No dishes were found on E 14 for eating and drinking. Neither glasses nor drinking vessels of any kind were found and the few pots are presumed to have served for heating and serving single portions. Sherds belonging to a delicate polychrome faience bowl were found which may have been used as a drinking cup or a tea bowl. A 71 had a larger quantity of eating and drinking ceramics. These consist of a red-earthenware serving dish (possibly British Staffordshire ware), a blue and white majolica plate, a Rhenish platter, a cream pot, a Tigerware pitcher, a Rhenish red-earthenware plate, and two red-earthenware bowls. A 71 galley artifacts were found in two clusters in the stern on the port side. This clustering might indicate their storage in a locker or cabinet at the time of the boat's sinking. Three pewter spoons were also found among the ceramics (McLaughlin-Neyland 1993).

The remainder of the identifiable ceramic forms from A 71 were storage and serving vessels for victuals and provisions. There is a Tigerware pitcher that may have been used for both storing and serving a beverage. There is also a large red-earthenware storage pot, red-earthenware jar, and a small stoneware pot, which may have originally been purchased for its contents of marmalade or mustard. Three intact onion bottles were
recovered and range in size from 16 to 20 cm high. Shards from at least one more wine bottle and perhaps a case bottle, comprise the remainder of this galley assemblage (McLaughlin-Neyland 1993).

A 71 also had a water measure. The water measure is a small copper can with fastenings for a bale handle. It held approximately 21 fluid ounces and was used to dip a ration of water out of the bung of a water barrel. The water measure may have also been used to drink from, since there were no glasses or mugs recovered. The presence of this water measure may also be an indication that a water barrel was onboard at one time (McLaughlin-Neyland 1993).

The galley ware is sparse and each piece probably served multiple functions possibly indicating a lower economic bracket for the ship's inhabitants. The entire E 14 ceramic assemblage is composed of only twelve pieces, 83% of which is comprised of an inexpensive lead glazed red-earthware common in the Netherlands. This sparseness is unusual, evidenced by the assemblages of comparable ships wrecked during the same period.

The sparseness of the artifacts recovered and the nature of those found do not suggest a full-time kitchen,
rather they imply a small working galley in which food, prepared elsewhere in advance and transported in storage pots, was reheated and served. Alternate explanations for the scarcity of this functional category are that post-wreck disturbances such as those caused by salvage, ice-drift, nets or anchors catching on the wreck, or plowing, have removed items from the site or destroyed them entirely. Preservation was such that an accurate reconstruction of the living quarters is not possible, thus the exact nature of the hearth and galley will never be confirmed. However, the small size of all the cooking vessels, the few large storage pots, and the scarcity of galley-ware in general suggest a small make-shift galley for a skipper and his mate and the likelihood of permanent dwellings ashore at the home port (McLaughlin-Neyland 1993).

Personal possessions usually include such items as clothing, sewing and knitting objects, personal tools, smoking and toiletries, pocket money, and items of leisure. The largest number of possessions on E 14 were sewing accessories: seventeen buttons, one blue glass bead that may have served as a button, nine brass pins with round heads of coiled wire, a pin or needle case of turned wood, and hook and eye clothing fasteners (two
eyes) (Fig. 53). These probably comprised a sewing kit (McLaughlin-Neyland 1993).

The only remains of clothing recovered were some leather shoe fragments: a partial insole, heel, and welting from the seam. These were too fragmentary to adequately determine if all the fragments belonged to one or more shoes. They might even represent the recycling of scrap leather for use on the ship, such as washers for the pump valve or around the pins of blocks. Other possessions of leather include fragments, possibly from a bag or purse, and a knife sheath having an incised floral decoration. The sheath was relatively intact and remarkably similar to another knife sheath from the mud scow B 19 (McLaughlin-Neyland 1993).

Several bottles or bottle fragments were found, all of which were missing their closures; hence, there is no way to discern their contents. A small green-glass molded case bottle might have contained a medicine or tonic, a scent, or a smelling salt. A second glass bottle was small enough to be considered a vial. The last intact bottle was made of wood and had been turned on a lathe. The lid is missing but the absence of threads on the neck would seem to indicate a stopper-type closure. There is also a comparable example from B 19,
Figure 53. E 14 personal possessions. (Drawing by Kathleen McLaughlin-Neyland.)
the closure of which is unavailable for examination; however, a Museum illustration reveals it to have been a wooden stopper with a round knob on top (McLaughlin-Neyland 1993).

Two combs were recovered, one a black large-toothed comb made from baleen and the other a very fine-toothed comb made from bone. Fine toothed combs are commonly found on wreck sites and may indicate the habitual presence of lice and the need to remove nits from the scalp. Two kaolin tobacco pipes were also recovered. Both pipes are identified, by bowl shape and design features, as coming from Gouda in the eighteenth century. The bowls of both are an ovoid shape that was popular from 1750 to 1850, and one pipe has a relief molded design of a crown, fish, and waves that was produced from the second half of the eighteenth century until around 1830 (Duco 1987). The second pipe has a relief molded S above a small Gouda crest, the S indicates a pipe of common quality (Duco 1987). A coal-pot of red clay with a clear lead glaze inside and out was recovered and is thought to have served as an ashtray for the clay pipes. Three small copper or copper alloy fish hooks were found in the same area as the sewing accessories. A small kaolin-clay lion was found among the personal possessions
and seems to have served no other function other than as a toy or decoration (McLaughlin-Neyland 1993).

A broken spindle of turned bone, resembling a hair pin, and a brass scallop shell that looks like a decoration from a woman's clothing may indicate that a woman was on board. These were recovered in close proximity to the window. Women often worked as laborers loading peat onto the prams of the nineteenth century (G. Schutten, personal communication). Therefore it is not improbable that a similar relationship existed during the period this ship was in use and some personal possessions may have broken and been lost in the hold of the ship. Alternatively, the skipper's wife could have served as a member of the crew (McLaughlin-Neyland 1993).

Three small lead bullets found in the E 14 wreckage are the only sign of weaponry carried on board. Three coins were found in this wreck, two brass farthings and a large silver coin of greater value. One of the farthings is in fairly good condition and bears the arms of Utrecht and the date 1766. Details on the second farthing are now totally indistinguishable, however, the excavators discerned in the corrosion that it was minted in Holland sometime in the eighteenth century. The third coin is French, minted in Monaco in 1653, and is stamped Mono II,
indicating Honore II, a prince of Monaco. The denomination was a full ecu but the silver content of the coin meant that it had international value that was retained over the years (McLaughlin-Neyland 1993).

Only a few scattered personal possessions were recovered from A 71 (Fig. 54). A small cast-pewter pendant or medal, a small metal box that may have contained snuff or a spice, and an undecorated wooden knife handle were found in the stern. Two Gouda pipes were recovered; one with the Gouda crest, the letter S on the side of the heel and the cipher mark 77 on the bottom of the heel; while the second has only the S on the side of the heel. Two brass farthings were found in the bow, one of which still retained letters possibly designating the province of Zeeland and a portion of the date 175(?) (McLaughlin-Neyland 1993).

Cargoes

The only evidence for a possible cargo for E 14 were some birch branches found in the forward section of the hold, at the turn of the bilge. These branches comprised an area of 30 to 50 cm high and measured 3 to 5 m in length. They may have been part of a cargo intended for a broom maker, as they were uniform in size and formed
Figure 54. A 71 personal possessions. (Drawing by Kathleen McLaughlin-Neyland.)
into sheaths or bundles (K. Vlierman, pers. com.). If the ship was loaded when she sank, the cargo may have been salvaged, it may have caught in fishing nets and been carried off the site, or depending upon its inherent characteristics, it may have decomposed or been removed from the site due to natural processes such as currents and waves. Also, because of the lack of ceiling planking, peat may have been a likely cargo for E 14.

Comparison of the Ships

Ship Type

The identification of E 14 and A 71 is based on prominent construction features attributed to Overijssel prams (Crone 1946; Groenewegen 1789; Konijnenburg 1913; van Loon 1838). A study of this material suggests that prams of the Overijssel variety commonly had these construction characteristics:

1) Requiring a small draft of water, they were built with a completely flat bottom rising neither in the bow nor in the stern;

2) The bottom and sides met in a sharp, hard chine;

3) A relatively upright, straight to slightly curved stem and sternpost were fastened directly to the bottom of the hull;

4) A low-lying wale presented little sheer throughout most of its length, but in the bow and stern rose abruptly;
5) The upper hull was particularly full in the bow and stern, and thus the upperworks were much broader in comparison to the hull below the waterline;

7) Stealers in the bow and stern filled the space between the bottom and upper strakes;

8) Frames (floor timbers, futtocks, and top timbers) were arranged in systematic patterns with relatively regular lengths, widths, and spacings;

9) The stern deck was flat with the tiller passing over it.

E 14 and A 71 have all of the above-mentioned construction features. In addition to these, the two wrecks have other construction attributes in common with each other:

1) The carvel bottom was pieced together from planks of irregular lengths and widths;

2) The shipbuilder used planks of irregular lengths and widths to construct the sides of the hull;

3) The bottom was cut away to receive the stealers;

4) Beginning at the chine the sides were overlapping, but the sheerstrake was both overlapping and edge-to-edge with the wale, which results in the appearance of a carvel join between the wale and sheerstrake;

5) Five or six frame units set side-by-side functioned to support the heel of the mast in the mast-step mortise (in E 14 there was a second set aft where the leeboard was hung.);

6) The bow and stern had a short, fine entrance and run.

The two vessels were not identical. From what remained of A 71 it is apparent that aft of midships the
hull had a finer run than E 14. Also, in A 71 the second strake, although resembling a stealer in appearance and function, technically was not a stealer but a continuous strake. No evidence of ceiling planking was found in E 14, but in A 71 there appeared to have been ceiling throughout the bottom of the hold.

Many of these construction attributes suggest a frugal use of materials and economically built vessels. The planks having irregular widths and lengths used in the bottom and sides resulted in less wastage. Also, the builder reduced costs by purchasing less-expensive materials. The economies of timber supply and material use are complex, but it is likely that either insufficient funds were available to purchase long, straight lengths of wood or the vessel did not require particularly good timber. A savings in initial construction costs, however, might have resulted in a shorter life span for the vessel and more frequent repairs, which consequently would increase maintenance costs.

The lack of a ceiling in E 14 is an economy specific to that vessel. Unless there was removable ceiling, this must have limited the ship to cargo such as peat that would not damage the hull. This could also explain the
absence of gangways, since on vessels hauling peat the crew could walk over the peat, as on a deck (G. Schutten, pers. com.).

Savings in materials raise questions about how the boat was constructed. The irregular carvel scarfs of the bottom planks would seem to be labor intensive and difficult to achieve if each plank was individually sawn and fitted. A time and labor-saving method, such as sawing two edges together to remove the outer sapwood, must have been used in preparing the edges.

The shipwright's employment of irregular planks for the lower sides indicates that strakes below the wale did not need to be fitted to each other very well, since they overlap rather than fit edge-to-edge. This probably explains the varying overlap widths, which resulted in fairer planking lines for E 14's exterior but not its interior.

Some builders of carvel boats fit the stealers after the upper strakes. Although it is not impossible that the stealers were added after the upper strakes in these prams, there is evidence that this was not the case with either E 14 or A 71. Once the builder became experienced in constructing these vessels, he probably knew how the
planking ran (especially with the flat bottom and straight sides of constant flare) and could have estimated the stealers by eye and sawn them before the upper strakes.

The sides of carvel prams, of the nineteenth and twentieth centuries, were constructed by first raising and fastening the wales (G. Schutten, pers. com.). Although this seems problematical for lapstrake construction, benefits might outweigh the difficulties. This possible assembly might be evidenced by the few examples of iron spikes fastening the wale to the futtock heads. These seem to be placed in four important structural locations: amidships, at the location of the mast-step mortise, and in the bow and stern where the hull curved inward. Although the futtocks are crudely shaped, their heads always terminate at the wale—never above it. The overall shape of the futtocks is quite regular and small changes in angle could be achieved with an ax or adze after they were set in the hull.

Hypothetically, the E 14 vessel could have been built in the following sequence:

1) The bottom planks were sawn, fitted, and fastened to at least some floor timbers or held in place with temporary cleats;
2) Then the futtocks, all or only essential ones in the bow, amidships, and stern, were fastened to the bottom;

3) The wale, perhaps only the inner plank, was fastened to specific futtocks amidships and where the wale began its curve inward toward the stem and sternpost, and this would have allowed the builder to mold the beam and depth of the vessel;

4) The lower planks, either beginning or ending with the stealers, could have been fitted and fastened, but perhaps only loosely fastened to allow the shipwright some final adjustment in the hull's shape;

5) The fourth strake fit carvel with the inner wale plank and overlapped the third strake, and thus could have been fitted easily after the others were in place;

6) The outer wale strake could have been fitted any time after the fourth strake;

7) Some top timbers had to be set before the sheerstrake was set and fastened, followed by setting any remaining frames and fastening all the strakes to them with treenails.

This hypothetical assembly would have allowed the aforementioned savings in materials -- the use of planks with irregular widths and lengths and the use of lower quality or scrap wood.

Inventories

The assemblages for these two wrecks, while not identical, are complementary. The similarities lie in the artifact scatter representing the accommodation plan of the ship, and the types of artifacts represented. The
artifact scatter for both vessels consisted of ship's equipment and tools in the bow and personal possessions and galley items in the stern. This pattern indicates that equipment was stored in the forward compartment, while the galley and living quarters were located in the stern compartment (McLaughlin-Neyland 1993).

Prams and other small cargo vessels of the nineteenth century often served as primary domiciles as well as work boats (G. Schutten, pers. com.). The inventories of the E 14 and A 71 differ from those of nineteenth-century vessels by having incomplete hearths, small galley assemblages, scarcity of personal possessions, and seemingly incomplete tool assemblages. At best, these vessels were sufficiently equipped for overnight or perhaps seasonal occupation, during the periods when cargo was available for shipment (McLaughlin-Neyland 1993).

The types of artifacts representing the functional categories for these ships were, in many instances, quite similar. Ship's equipment was predominantly composed of spares such as blocks, iron fasteners, and pump and block components. The galley was represented by hearth tiles and other accoutrements, cooking pots, and skillets. The ceramics were predominantly a local slip-decorated
redware and generally inexpensive, while the pewter spoons recovered from each wreck seemed to be quite common for the time period. The category of personal possessions for both ships consisted of a knife, common pipes from Gouda dating to the eighteenth century, and a few farthings in coins. The wreckage of E 14 added combs, the remains of a sewing kit, and some small bottles to this category (McLaughlin-Neyland 1993).

The assemblages, when viewed together, represent more complete functional categories. The categories of tools, personal possessions, administrative, and domestic effects are more complete for the wreck of E 14, while that of hearth and galley is more comprehensive for A 71. Together these inventories give a fairly accurate concept of what work and life aboard one of these vessels would have been like. Above all they speak of frugality and multiple functions. This may result from many factors: the skipper's membership in a lower socio-economic profession, the ship's serving only as a temporary, short-term domicile during the working season, or the general decline in the Dutch economy during the eighteenth century (McLaughlin-Neyland 1993).

Neither E 14 nor A 71 were constructed as sturdy seagoing vessels. In fact, their construction seems more
appropriate for canal or river craft. Both vessels sank in the Zuiderzee, E 14 15 km north-northwest off the coast of Harderwijk, and A 71 6.5 km to the northeast of the mouth of the Vecht River and 12 km east of the harbor of Amsterdam. What is known of nineteenth and early twentieth centuries of prams constructed like E 14 and A 71 shows that these vessels were used primarily in canals and rivers. It was uncommon for a vessel of this type to be involved in Zuiderzee trade. Both of these craft, however, did venture into the Zuiderzee and the lighthouse token used along the coast of North Holland and West Friesland, found with E 14's wreckage, indicates that the vessel must have crossed the sea with some frequency in order to justify the expense.
CHAPTER IX
CONCLUSIONS

This work applies two hypotheses to the study of pram-class vessels. The first considers pram construction to be the result of interrelated and interdependent elements—essentially the interplay of economic strategies, resources and environment, social behavior, and technology. Pram development and employment during specific historic periods was a consequence of the interaction of these factors; thus, pram-class vessels are a manifestation of cultural adaptation. Prams embody both technology, as influenced by, and in turn influencing, growth and change in the transportation system and economy. Shipbuilding traditions represent an amalgam of technology and social behavior. The total system of technology, resources, economy, and social behavior are all interconnected with information feedback loops. Intensified agriculture and increased trade, for example, stimulated the construction of new and perhaps more specialized pram-class vessels. These economically produced boats provided watercraft for a variety of tasks, cheap transport, and increased profits that insured a continued demand for pram-class watercraft.
The second hypothesis is a corollary to the first in that technological continuity and innovation both result from the same process of cultural adaptation. This can also be viewed as technological adaptation, through which society adapts and innovates its technology in response to economic, environmental, and cultural stimuli. The system mentioned above, during periods of crises or opportunities, can either stimulate technological innovation or reinforce continuity. The construction of these vessels indicates perhaps more continuity than change. Although this continuity could be described in terms of a pram shipbuilding tradition, it is interpreted here as a reinforcement of the pram design through cultural adaptation.

More than simply a type of boat or shipbuilding tradition, prams and pram-class vessels represent a people's relationship over time with a changing environment and availability of resources, economy, and culture. Major historical processes and system changes have had far-reaching effects on local economies and transportation systems. System changes occurred from the Roman Empire to Dark Age chiefdom societies, followed by feudalism (in the northern Netherlands region certainly a weak feudal society) until a world capitalist system evolved in the sixteenth century.
Roman conquest and colonization extended that empire into the region of the Rhine Delta and to the freshwater shores of the Flevomere. Riverine watercraft, during this period, seem to be of three types: dugouts, extended dugouts, and large barge or pram-like transports, ranging in size from 20 to 34 m. The large transport vessels, exemplified by the boats from Zwammerdam, Pommereuul, Druten, and Woerden were built as a result of state supported trade in bulk goods, particularly in building materials. Demand for vessels of increased hull capacity and larger dimensions, than was possible for native dugouts and extended dugouts, stimulated technological innovations in the building traditions of river craft. This led to the development of the Zwammerdam type (Fig. 55). The Zwammerdam vessels probably represent an expansion of the native flat-bottomed boatbuilding tradition used in northwestern Europe. The size and capacity of the vessels, as well as some methods of fastening and building the hull can be attributed to Roman influence. A final interpretation of the Roman-era vessels, however, depends upon their final analysis and publication. It is interesting to note that even the postmedieval prams do not reach the dimensions of the largest Roman-era vessels. Perhaps there is significance in this for comparisons between state transports versus privately financed and owner merchant vessels.
Figure 55. Comparative chart of ships and boats from the Roman Era through the early fourteenth century.
through the early fourteenth century.
Utrecht
A.D. 1000-1200

Waterstraat
A.D. 1150-1200

Falsterbo
A.D. 1311-1318

Velsen
A.D. 1050-1200

Meinerswijk
13th century
The large Zwammerdam type vessels vanish from the archaeological record with the end of Roman occupation, as does the evidence for trade in bulk goods. The absence of Zwammerdam type boats smaller than 18 to 20 m reflects the economy and ease of dugout construction within this culture, but also is an indication of a marketing system not fully integrated with all members of the society. Had a viable local or interregional economy been present, as appears in the Late Middle Ages, then demand for smaller versions of the Zwammerdam type might have continued and resulted in more archaeological evidence. The inability of Western Europe to continue trade and transportation networks verifies the "structural advantage of the world-economy as a system over a world-empire" (Wallerstein 1976:122).

The Roman river ships bear many similarities with later pram-class vessels and to the later Rhine river vessel, the aak. Most of the construction features present in medieval and modern prams were present in the Zwammerdam craft: the flat carvel bottom, hard chine, lapstrake sides, propulsion by towing or poling, use of a gangway, L-shaped futtocks that alternate with flat floor timbers, inwale to provide longitudinal strengthening, and ends divided off into compartments. The chief differences in these vessels and later prams are the use
of the L-shaped bilge strakes and the lack of a stem and sternpost. However, the Woerden vessel has an extremely wide timber, like a *bloksteven*, functioning as the stem. Frames, especially the futtocks, were stronger and better made in the later craft; however, because bilge strakes strengthen the juncture of the sides and bottom, heavier futtocks were unnecessary. Steerage with a steering oar differs from the use of the stern rudder in later small craft, but the latter innovation was unknown in this region until the Late Middle Ages. Some later river craft continue to steer with an oar (Arnold 1992:96).

There is no archaeological evidence for the continuation of the Zwammerdam type after the end of the Roman Era. It is tempting to fit the Zwammerdam type into a classification scheme as an early evolutionary stage of prams. When considering changes in trade and economic strategies, as well as the level of labor and industrial organization, however, the building of large Zwammerdam type vessels must have ceased. This is not to say that all of the building techniques were lost. Some techniques may have remained within local cultures and used in the construction of extended dugouts. Also, around population centers it is possible that enclaves of boatbuilders plied their trade and continued to use some
of the construction techniques witnessed in the Zwammerdam craft.

Extended dugouts continued to be built, which is supported by some archaeological evidence (Early Middle Age Krefeld and Bouveret boats). Although these had the characteristic hard chine and flat bottom, archaeological evidence does not indicate that these were pram-class vessels. It is likely, however, that medieval prams developed from extended dugouts and simple planked craft similar to these vessels, through a series of innovations occurring in the Early or Late Middle Ages.

Factors that maintained the use of dugouts and limited production of extended dugouts and plank-built craft may have been the easy access to trees suitable for constructing dugouts. More significant may have been the energy and cost required to produce planks. The typical builder of small inland craft during the Dark Ages or Early Middle Ages did not have the ability to produce cheaply sawn lumber. The adze and ax, rather than the frame and pit saw, were the principal tools used by builders to shape timber. As long as timber resources permitted and trade was modest, producing dugouts or extended dugouts may have been more economical than plank built boats for inland navigation.
Factors causing economic and demographic decline after the Roman withdrawal were the default of state supported trade, which led to economic crisis, followed by deterioration of social and political institutions. Proliferation of the Zwammerdam type boats was the result of the interaction of both economic and political factors. During the Roman Era, the level of boatbuilding technology in this region was able to produce large river vessels. Not until the twelfth century, when trade expands and building projects initiated were there again vessels approaching this size. In fact, it may not have been until much later, in the thirteenth and fourteenth centuries, that trade again equalled that of the late Roman occupation and larger inland freighters were common (Fulford 1978:62-63).

When state trade ended with the withdrawal of Roman legions the large Zwammerdam-type ships would have ceased being built. Smaller versions of the Zwammerdam type, perhaps like the Roman vessels from Bevaix (Arnold 1992) could have continued to be built. If the Zwammerdam design was scaled down for the local economy, the resulting boats might not have had any real advantage over dugouts or extended dugouts. Within the boundaries of the present day Netherlands, there is as yet no
archaeological evidence of pram-class boats until the twelfth century.

In this region there is little archaeological evidence for the use of any inland watercraft during the Dark Ages and Early Middle Ages. Two examples have been found outside the Netherlands, one in Krefeld, Germany and the other from Lake Geneva in Switzerland, that have some pram-class features. The number and size of small craft during this time were limited by factors inhibiting trade in goods other than the luxury items used for gift exchange between elites. Political instability, low and dispersed populations, relatively small urban centers, self-sufficient agricultural systems, lack of coinage and a barter economy all acted to discourage any volume of trade and in particular the trade in agricultural and animal produce that would be essential to the later rise of the world economy. These factors prohibited the development of either larger or more sophisticated pram-class vessels. Given the economic system and level of technology, dugouts and extended dugouts must have been more than satisfactory for water transport in this frontier of peat moors, streams, and rivers.

From the tenth to thirteenth centuries there was a growth in population and the consequent colonization of
frontiers, development of urban centers, and increasing local, interregional, and long-distance trade. New methods of land reclamation—drainage ditches, dikes, and dams—were applied to settlement of the peat moors.

Closely associated to the increase in trade were advances in ship design: the stern rudder, bowsprit, bonnet or reef points on sails, and the use of the windlass to raise the yard and sail. New tools, chiefly the frame saw and breast augur, allowed a more cost-effective use of labor and materials.

It is during the twelfth and thirteenth centuries that we have the first archaeological examples of true pram-class vessels with the Rotterdam and Meinerswijk punters, and perhaps the larger Meinerswijk vessel. Unlike earlier riverine vessels, these watercraft had a lanceolate shape and appear to have had stem and sternposts. In construction and shape these boats are similar to later punters, pramen, and bokken of the late-medieval and modern periods.

The development of wholly plank-built vessels could be an adaptation or reinvention of many of the features found in the Zwammerdam-type and extended dugouts. Some of the construction features may indeed be a
redevelopment of ones used in the Zwammerdam type, such as the use of the inwale, small decks and compartments in the ends, and presence of a hearth and galley on board. These construction techniques may have continued in use in some watercraft, perhaps even in seagoing vessels or in simple extended dugouts or plank-built boats, and implemented in the construction of prams. Alternatively, many of these construction features may be an inevitable progression from dugout to plank-built small craft. These building methods spread with medieval colonizers into the frontier regions of the Netherlands.

The pram-class vessels represent a new type, but one having many similarities to the earlier scow- or punt-ended ships and boats. Still the early prams differ from these with their stem and sternpost, finer lines, and most examples absence of bilge strakes. The development of this new pram-class vessel resulted from external stimuli in the local economy, and changes in timber availability and society.

Many of the inland watercraft used during this period continued to be extended dugouts and some like the Utrecht vessel reached relatively large dimensions. Two types of extended dugouts from this time were represented in the archaeological record, exemplified by the Utrecht
type with its broad rounded bottom plank and the Meinerswijk vessel with its dugout bilge strakes and expanded bottom. The latter is a dugout expanded upon the same principles as the Krefeld and Swiss Bouveret boats from the Early Middle Ages, as well as extended dugouts of the Roman Era. The manner in which the Utrecht-type of boats were constructed is a reflection of the then plentiful timber resources and the less sophisticated organization of labor and capital. The simplicity of design, minimal level of technical knowledge and skills required, and economical construction (at least while timber was plentiful and trade limited), reinforced this style of construction. It was a type sufficient for the minimal level of trade and transportation needs of the time.

Despite the increased opportunities for the use of watercraft and technological innovations in shipbuilding during this period, extended dugouts seem to be as plentiful as plank-built pram-class vessels. The key factors here may be easy access to large timber suitable for extended dugouts and limited demand for shoal-water craft.

Demand for watercraft would have increased as trade and colonization expanded; however, demand was limited
because of trade and demographic factors and did not exceed the culture's technological and organizational ability to produce these boats. Had demand outstripped the means of production, thereby increasing costs, new methods of production with more savings in labor, materials, and time could have originated. In other words, both the extended dugouts and plank built pram-class boats were a reflection of the level of technology, resources, feudal economy, and social organization of the time.

Timber resources were undoubtedly a key factor. When local resources were depleted during the Late Middle Ages, timber was imported from outside the Netherlands and, although the change from rural to urban life was a factor, the use of wood declined as the primary building material in structures (Sarfati 1990:189). In the fourteenth and fifteenth centuries brick and stone were substituted more as building materials. Similar changes in shipbuilding, however, did not occur until the nineteenth and twentieth centuries when innovations in the production of iron and steel and the rising costs of timber combined to alter the basic materials of shipbuilding. The depletion of local timber resources in the Late Middle Ages thus led to increasing imports and
material costs, which resulted in economies in construction and conservation of materials.

The fourteenth century was a period of crisis marked by disease, famine, flooding, and land inundation with subsequent population and economic decline. Both crop failures and decreased demand for grain led to an agrarian crisis. This crisis stimulated some of the peasantry, perhaps those on marginally-productive lands, to seek employment as laborers. These people moved to urban centers, towns and villages, hiring out as day laborers digging peat or in the transport of goods. Local elites encouraged the growth of towns, crafts, and urban trade. As a whole, the late thirteenth through the fifteenth centuries witnessed an abandonment of settlements and farms. Evidence suggests that this was a reorientation of villages to locations on land or water transportation routes.

This movement emphasizes the increasing significance of trade in the late-medieval economy. Regional specialization was beginning to occur with increased activities in digging peat, fishing, shipping, and trade. Much of this specialization was the result of an inability to make a living from agriculture and the necessity of importing grains. Peat lands were more
suitable for raising livestock and increasingly there was specialization in pasturage. Animal husbandry provided marketing goods such as dairy products, hides, wool, and meat. An increased consumption of dairy products and meat encouraged this trend. Moreover, raising livestock unlike intensive agriculture, permitted communities and individuals to employ themselves in the alternative and seasonal occupations of fishing and shipping.

Specialization of production, a money economy, and employment of a large segment of the population as laborers encouraged trade, shipping, and shipbuilding. The number and variety of small craft increased, as did the specialization of vessels in fishing and shipping occupations. The introduction of such innovations as the sprit rig, fore staysail, and later the gaffsail made inland and coastal sailing vessels more efficient; thus, increasing productivity and fostering experimentation with new types. Archival sources record multiple types of small craft used for fishing and coastal trade. Some types of fishing vessels also had qualities that made them suitable for hauling freight in the off season.

The B 55 wreck is clearly a pram-class vessel having most of the characteristics of the later pram freighters and exhibiting sophistication in its construction (Fig.
Figure 56. Comparative chart of ships and boats from the fifteenth through the eighteenth centuries.
The sixteenth through the eighteenth centuries.
56). The finer lines and lanceolate shape seem characteristic of many small craft from the Late Middle Ages. Its fine lines are not unlike those of twentieth-century punters and bokken and other small pram-class craft. Placement of the mast far forward in the bow of the boat probably signifies the use of a sprit or gaff-rigged sail. The stepping of the mast in a heavy frame timber was a method commonly used among inland and coastal craft during this period. Steerage with a stern rudder also indicates an increased sophistication over earlier vessels, which were directed chiefly with punting poles. The presence of a galley and quarters in the stern indicates a new spatial organization in these boats for taking meals, sleeping, and storage of equipment. This arrangement may also imply trade over greater distances, although this trade probably remained interregional and only a few days from the home port. The presence of some personal weapons in the stern cabin may also be an indication of sailing away from home port and an increased need for personal protection. The shape of B 55 is that of a bulk cargo carrier and fragments of bricks and shells under its frames may be an indication of former cargoes.

Two other vessels from this period, M 40 and K 73/74, show some pram-class features, but these also have
some distinctively different characteristics. The pram-class features of the M 40 and K 73/74 vessels are the hard-chine, flat carvel bottom (at least amidships), posts that fit atop the central plank toes, and an inwale directly above the futtock heads.

Chiefly, they differ in the change of the carvel bottom planking to lapstrake sides in the bow and stern. M 40 also had futtocks that sit on top of floor timbers rather than alternating with them. The change in the ends to a finer V-shaped form makes a more seaworthy hull, possibly alleviating some hard chine problems with wear from grounding and the necessity of frequent repairs (WN 92 was heavily patched along the chine at both ends). This may indicate experimentation and innovation with the basic pram design in order to produce economically-built vessels suitable as coastal freighters and fishing craft. Their construction suggests small craft built to navigate in both shoal inland waters and function for deep water sailing. This may represent an attempt to exploit new opportunities in the local economy.

The boats' constructions may reflect an increase in local trade, increase in the transhipment of goods, or possibly an increased marketing of locally-produced goods in regions where there was an absence of local markets.
Since not all villages were permitted markets during this period, the wider distribution of markets forced the shipping of locally-produced goods over greater distances. This could have led to adaptations of the pram-class design to the necessities of sailing in open waters.

Growth in trade, transport, and fishing formed a diversified economy. This, coupled with technological innovations like the sprit sail, made coastal and inland navigation more efficient, and may have encouraged experimentation in small craft design. Since few later archaeological examples of vessels like K 73/74 and M 40 have been found in the IJsselmeerpolders, this absence could signify a movement away from the use of such vessels in the inland Zuiderzee trade, possibly due to the introduction of more efficient types.

The period immediately after 1550 was the Dutch Golden Age, which witnesses the development of a capitalist economy and world system. The regional economic specialization continued as did an intensification of agriculture and a population expansion. The intensification and specialization of agriculture, as well as the expanding population created a surplus of cheap labor. Wages dropped sharply from a
high point reached in the fifteenth century (Sclichter van Bath 1963 and 1968; Wallerstein 1976). A supply of laborers furthered the growth of urban centers and industries. Many of these workers also sought employment digging peat and in the transportation services, either handling cargo or as watermen, further encouraging the growth of cost-effective transport networks.

Marketing of locally-produced goods increased in the towns with the result that rural villages increasingly petitioned to be allowed their own local markets. This increased the amount of local trade and the frequency of goods being marketed. Innovations in banking and finance permitted more credit and investments. Also, the Spanish conquest of Flanders led to an influx of Flemish refugees with money and technical knowledge that stimulated rural and industrial growth. Dutch religious tolerance encouraged the immigration of Sephardic Jews, whose capital and business connections were an asset.

Increased wealth and credit led to investments that affected water transportation and the use of pram-class vessels. The excavation of canals into the peat moors, in order to cut and ship peat, and canals for the transport of freight and passengers were expensive projects and would not have been possible without urban
investors. Increased wealth among merchants, landlords, and yeomen farmers led to investment in shares of freighters and fishing vessels.

Moreover, the confiscation and sale of church lands as well as investments in literacy, although difficult to measure, were perhaps also a stimulus to innovation, economic growth, and a more skilled work force. Technological innovations and use of wind and water power furthered industrial development and allowed land reclamation in areas where it was not previously feasible. This was an unparalleled period of opportunities, innovations, and expansions.

The early tendencies for specialization in small craft was reinforced during the period from A.D. 1550 to 1650. An innovative public transportation service, the trekvaart, was initiated in the late sixteenth and early seventeenth centuries. These used many shoal drafted pram-class vessels, the trekschuiten. One of the most significant factors in the use of pram-class vessels was the peat industry, which required a large quantity of shallow draft boats to navigate small canals in the peat moors, and larger freighters to ply the network of canals between cities and the Zuiderzee. In fact, the growth of canals, the canalization of rivers, and the building of
pram-class vessels were closely tied together in a mutually reinforcing technological expansion.

Development of networks of canals was a key factor in the expansion and continuity of the pram-class vessels. Eventually this led to the use of vessels of different sizes, transporting peat to shipment centers, such as Zwolle in Overijssel, where it was off-loaded onto larger prams that transported peat across the Zuiderzee to urban centers (Schutten 1981). Since peat fueled the furnaces of industries, such as brick kilns and limeworks, shipment of peat to industrial centers often insured a return cargo of bricks, salt, lime, or manufactured goods.

WN 92, excavated in Workum, Friesland, is an example of a late sixteenth-century pram built and operated at the beginning of a new era. It was a pram capable of navigating rivers, canals, and coastal waterways. It appears to have been built for hauling moderate amounts of bulk goods and building materials, lightering cargo, and transporting livestock. The remains of past cargoes discovered in the vessel include bricks, peat, and hay. The boat's construction indicates that it was also suited for carrying livestock.
Its hull construction shows careful work in several areas: obtaining a tight fit of the ceiling, precise placement of removable ceiling planks between futtocks, sawing of regularly-shaped frames, and bending and shaping of side strakes with the use of fire. The use of prikken to secure the moss and lath caulking saved the expense of sintels. Although using prikken instead of sintels may not have been any more labor intensive, there is the question to whether prikken were not as durable or long-lasting. In sum, WN 92 appears to be a vessel used for the increasing transport of bulk goods, including raw materials and the products of industries. It also may reflect the regional specialization in fodder and livestock production. In hull shape, however, it is still finer than many later pramen, schuiten, and bokken. This finer lanceolate shape made the vessel more maneuverable by punting, and this may have been more important to the boatbuilder than increased cargo capacity.

The Dutch Golden Age ends after 1650 and was followed by a period of economic stagnation and decline. Decline occurred in population, agricultural prices, and industries. There was a great deal of migration between the Dutch provinces, urban flight, increase in paupers, and Amsterdam bankruptcies. Wars with England depleted
both the Dutch merchant fleet and navy; thus, as naval power was reduced, so was the ability to protect the merchant fleet, conduct coercive international trade, and negotiate international treaties favorable to Dutch trade. Dutch merchants were forced to rely more on the home market, which was small and bore an increasingly excessive proportion of the tax burden. Also debilitating to the home market was the lack of investment in local industries and transportation projects. Instead, the huge amounts of capital acquired during the Golden Age were reinvested in international markets, often to finance wars and support developing states within Europe.

Despite this crisis, however, some sectors of the local economy redirected their economic strategies and at least survived, if not prospered. The transportation sector, especially in the shipping of peat, was chief among these. Friesland was one province that pulled out of the decline through exploitation of the peat industry and shipping. Frisian shippers carried a larger amount of Baltic timber and grain, as well as peat. Skippers from Groningen and Friesland transported peat to Amsterdam and as far south as Antwerp. With a diminished market, however, the size and tonnage of vessels fell and most were under 80 tons.
Many working boats were essential to the operation of the trekvaarten, the Zuiderzee's sailing ferry service, and myriad tasks in cities and rural areas. Four such working boats were used in the latter areas and represent smaller and simpler versions of pram-class craft. These were built for special functions, basically as floating containers, two for the transport of mud, another for hauling town refuse, and the fourth perhaps for the short-haul transport of peat by poling through the smaller canals and transhipment of peat to larger freighters. None of these vessels were sailed and only one may have had a towing mast. They also lack stern rudders for steerage. While there were small compartments in the bow and stern areas, none appear to have been used for living and eating purposes. Since there was no strong evidence for masts or oarlocks, they were primarily propelled by punting, although such flat-bottomed boats were sometimes rowed (see Figure 26). They were thus limited to the movement of materials over short distances. Simplification in their design may indicate specialization, which limited their use to a few specific transport tasks. Although their design was simplified, they were strongly constructed of relatively heavy timbers and the B 13 had a double-walled hold (compare the four workboats with other pram-class vessels in Figure 56). This construction resulted from the
necessity of hauling heavy bulky material. The artifact assemblages also indicate this specialization for they are limited mostly to working equipment, a few personal items, and perhaps a few pieces of ceramics. A large number of such pram-class boats plied the canals and harbors of the towns to remove night soil, refuse, and building debris.

Two of the medium-sized prams used in the shipment of peat and other bulk goods are embodied in E 14 and A 71. Both of these vessels date to the second half of the eighteenth century. In general this was a period of decline in the Netherlands, although some areas were economically better off than others. While providing a livelihood, profits in the peat trade probably were not excessive. Some economies in hull construction would be expected during this time. The hulls of the two vessels show some savings in materials by the use of inferior timber. Since the lack of a ceiling in E 14 has parallels with the pram peat haulers of later centuries, this could be one economy specific to the peat trade. It was not necessary to protect the hull if the cargo was peat. The ceiling in A 71 may indicate the hauling of cargoes other than peat. This vessel was found near the mouth of the Vecht River, close to Amsterdam, and one possible occupation for it could have been the lightering
ships moored in the city's harbor. Aubin (1702) lists
cargo lightering as one occupation of Dutch prams.

The artifact assemblages of the vessels suggest a
frugality of life. Most of the assemblages are limited
in quantity and variety of items and are thus apparently
incomplete when compared to assemblages from eighteenth
and nineteenth century freighters. Although there are
other explanations for sparse assemblages, this could be
an indication of a marginal economic existence. Another
factor is that from the Late Middle Ages to the
Industrial Revolution there was an increase in the
quantity and specialization of material goods that is
reflected in the artifact assemblages.

Artifact assemblages from all the shipwrecks
discussed in this work are difficult to compare, since
they represent disparate collections over a long span of
time. Moreover, since many of the vessels discussed here
have few or no associated artifacts, they do not
illuminate long-term trends in the material culture used
on boats. There are also apparent differences between
the assemblages of working boats and freighters in the
quantity of artifacts and number of activity categories
represented (i.e. hearth/galley, personal,
administration, working equipment, navigation, etc.).
Some of the Roman-era vessels, such as the Woerden and Druten vessels, had a spatial organization on board, which included a galley and living quarters. From the archaeological evidence that we have of later inland river craft, we do not see this spatial organization again until the fourteenth century. This may be in accordance with Fulford (1978:63) who does not find a comparable level of trade in Europe again until the thirteenth and fourteenth centuries. It is evident that by this period, vessels used in inland trade had space separate from the cargo hold and organized for cooking, sleeping, and the storage of ship's equipment. Galley, hearth, and living quarters usually were in the stern of these vessels, while the stowage of ship's equipment and tools, if any, were in the bow. Although most of these vessels have the hearth and living quarters in the stern, this is not always the case. For example, the ship H 107 dated to about 1700 had living quarters in the bow. What determined the placement of living quarters is uncertain, but the stern on some vessels had a smaller area than in the bow. Living quarters located in the stern, however, would place the skipper closer to the helm.

There is also a striking growth in the complexity of material culture from the Late Middle Ages into the Modern Era. The quantity of objects increased as does
specialization. Later assemblages included objects used specifically for the hearth, galley, eating and drinking, provisioning, personal effects, weaponry, administration, and ship's and working equipment.

It has been noted by other scholars that within these categories material goods become more specialized (Molen and Vreeken 1990). No where is this more clear than with ceramics, which are affected by the changes in cooking and types of food prepared. These also reflect the increased use of meat, fish, and dairy products. Ceramics also become less general in function and more specialized, divided into specific utensils for preparing and cooking foods, separate utensils for serving, and for eating and drinking. Among the peasantry and proletariat this is an innovation, for prior use dictated ceramics with multiple functions of cooking and eating.

It is apparent that many factors influence boatbuilding technology and it is through technology that cultures adapt to their environment. Technological adaptation can occur rapidly when confronted with cycles of crises and opportunities, provided that there is enough latitude in the culture and environment for experimentation and innovation. While shipbuilding traditions seem to express historical continuity in the
personal decisions of shipbuilders, the deciding factors of technological continuity and innovation are dependent upon one or more of the factors previously discussed here. The construction and employment of pram-class watercraft has been shaped by periodic crises and opportunities. The ultimate growth in numbers and use of these vessels is the result of exploitation of opportunities created by the shoal waters of the Netherlands, which provided relatively low transport costs.

The construction of prams can be described as one of the most continuous designs of watercraft in Western Europe. Although changes and innovations can be recognized in these craft, there is a strong argument for continuity. This continuity is not so much an expression of the conservative traditions of boatbuilders or a rural population, but is the result of positive reinforcement of pram-class construction with the local economy, resources and environment, and social behavior. The construction of pram-class boats was reinforced in the region of the Netherlands by the exploitation and manipulation of the shoal water environment in order to cost-effectively move freight, bulk goods, and passengers. The network of canals and canalized rivers for the movement of bulk goods and trekvaarts for the
timely transport of passengers connected urban and rural markets and industries. This system thus provided cost-efficient and reliable transportation that was conducive to the development and continuation of the pram design. A cheap system of transport was a further stimulus to the growth of markets and industries. By the eighteenth century the pram design was so adapted to the economy and local waters that there were few major innovations until the introduction of new materials, iron and steel (Schutten 1981; Sopers 1974).

The approach used in this work uses cultural adaptation as a model to interpret change and continuity over time in the design of pram-class watercraft. Unlike previous analyses in nautical archaeology, which have focused primarily upon identifying shipbuilding traditions and defining ship types, this work has attempted to treat ship construction as a technology influenced by the interactions of several factors. These factors have been categorized as consisting of economic strategies, environment and resources, cultural and social behavior, and technological knowledge and infrastructure. From a historical perspective, these represent a complex system of mutually reinforcing interactions and interdependencies.
When traditions are used as interpretative models they inevitably describe a linear evolutionary scheme and fail to deal systematically with technological innovation or continuity, instead sometimes relying upon diffusion for explanations of change. While technological change can occur in a linear and incremental fashion, that is not always the case for as is shown here, change frequently occurs in episodes interspersed with long periods of consolidation of innovations (a comparison from research into biological evolution is the theory of punctuated equilibrium). Also, technological advances frequently occur in clusters of innovations. These may be mutually reinforcing, leading to new innovations and/or advances in established technologies. Within Western Europe growth and technological change have not occurred in an incremental linear fashion, but instead have occurred in spiraling cycles of economic, demographic, and technological expansions.

Rather than classifying this construction as a pram-tradition, this work has chosen the course described above. The definition and delineation of shipbuilding traditions, whether based on concept of construction, ethnicity, geography, or a well defined style of construction are systems of classification. Almost by definition, approaches relying upon describing traditions
imply a certain inherent conservative behavior on the part of the shipbuilders, similar to a view of traditional societies. The historic and archaeological evidence described here, however, has shown that shipbuilders and skippers were quite responsive to episodes of crises and opportunities.

Cultural adaptation used as theoretical model promotes an empirical evaluation of technological continuity and change in ship construction. Ship construction is the result of technological adaptation by shipbuilders to a number of environmental, economic, technological, and cultural factors. In order for the field of ship archaeology to mature, nautical archaeologists must expand their theoretical approaches to include or develop theoretical models that will lead to a deeper understanding of the significance and development of watercraft. While cultural adaptation is effective for studying complicated developments over long periods of time, equally germane are models emphasizing economics, human ecology, and world systems.
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