

## Comparing and conceptualising reconstructions; The Barcode 6 revisited

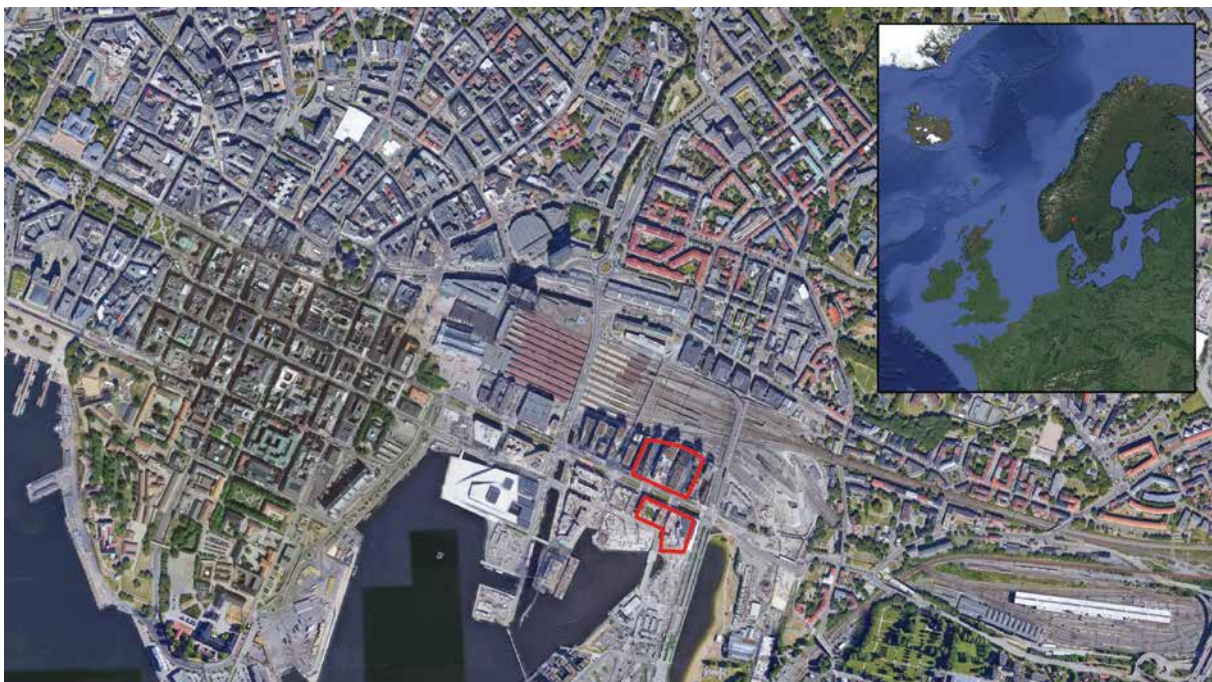
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**Abstract:** When opening a small boat-building workshop at the Norwegian Maritime Museum in Oslo, Norway in 2009, the intention was to foster collaboration between academics and craft experts. Over the years, the workshop has facilitated the building of several reconstructions of archaeological boats. This paper presents a reflective analysis of the methodologies and outcomes involved in reconstructing the 1595 CE Barcode 6 boat, known as the *Vaaghals*, which was successfully launched in 2011. Both digital and practical methods are evaluated and discussed.

**Keywords:** reconstruction, model building, boat building, experimental archaeology, digital methods, exhibition

### 1. Introduction

Since 2004, the Norwegian Maritime Museum has conducted excavations in the old harbour of Oslo, Norway. From the 1960s onwards, more than 60 shipwrecks have been uncovered in the old harbour, together with extensive wharf constructions that are the remains of Oslo's historical harbour, dating back to Medieval times (e.g., Christensen 1973; Christensen, Molaug 1966; Gundersen 2012; Molaug 2012; Paasche *et al.* 1995; Vangstad *et al.* 2020). The vessels date back to the 14<sup>th</sup> century, with an undisputable majority from the 16<sup>th</sup> and 17<sup>th</sup> centuries. During this era, Oslo was expanding as a town for shipping, especially for timber trade destined for the European market (Figs 1 and 2).



**Fig. 1** The modern harbour of Oslo, Norway, with two excavations, the Barcode B11-12 (2008-2009), and the B3/B7 (2015-2016) (map: S. van Riel/NMM)



**Fig. 2** Map showing results from the excavations, with harbour constructions and shipfinds. The Barcode 6 (after 1595 CE) vessel is marked with a red circle. Background map is from approximately 1700 (map: S. van Riel/NMM).

One of the vessels, the Barcode 6 (after 1595 CE) (Daly 2010), has received much attention, functioning as a ‘guinea pig’ in the museum’s required pursuit to build competence and knowledge in the areas of post-excavation documentation, conservation, reconstruction and exhibition (Falck, Egenberg, Vangstad 2014; Planke, Stålegård 2014; Hovdan, Sandvoll, Thome 2015; Sandvoll 2015; Vangstad *et al.* 2020). This paper intends to reflect upon our practices concerning documentation and reconstruction by examining the processes that culminated in building a so-called floating hypothesis, the *Vaaghals* (Eng: Dare Devil), in 2011 and the following exhibition of the original material in 2017.

These processes involved various experts, spanning from archaeologists, conservators, and ethnologists to boat builders and other crafts experts, as well as volunteers. Over the years, several representations of the boat have been produced, demonstrating some discrepancies. Since reconstructions have the ability to convince and present themselves as accurate, we wanted to investigate how the different methods of reconstruction can shed light on variation and diverse interpretations. Instead of blurring the fact that they differ, we tried to put the differences on the table, hoping to learn something that we could carry onward to new projects. The investigations made us conscious of how we create reconstructions and interpretations on different conceptual levels. On the one hand, through digital methods, we reconstruct to produce knowledge of technical features and abilities of a vessel, comparable to modern naval architecture. On the other hand, we reconstruct to understand crafts and practices, which can be conceptualised as the ‘patterns’ of building (Planke 2011; Planke, Øya, Heide 2022). These latter concepts touch upon the social aspects of building that create both continuity and change within communities of practice (Ravn 2020).

## 2. Reconstructions, experimental archaeology and interdisciplinarity

Reconstructions, in the shape of physical scale models, technical line drawings, and full-scale sailing hypotheses, have been considered vital tools within nautical archaeology for decades. The need for a minimum reconstruction of the often distorted and fragmented excavated material is obvious for creating an understanding of the outline and qualities of the vessel found. We are standing on the shoulders of years of practice, but as Crumlin-Pedersen and McGrail recommended in 2006, the advantages of working in interdisciplinary groups are key (Crumlin-Pedersen, McGrail 2006). The Barcode 6 is reconstructed through a dialogue between different sources and types of knowledge (Planke, Stålegård 2014), and the process can be described as hermeneutical, even phenomenological, as also discussed by Bischoff in her thesis on the reconstruction of the Oseberg ship (Bischoff 2020). So, instead of viewing the boat builder as a blank

slate that objectively can learn and apply the methods of the past, the boat builder's practical knowledge of the use of tools, material quality, dexterity, and work processes is viewed as a resource. While this is important, it is also vital that boat builders can interpret and are willing to accept that the tools and techniques of the past differ from their training. Ideally, this is the strength of academic training, and in this manner, boat builders and archaeologists can learn from each other's perspectives.

Interdisciplinarity in these projects also includes technical conservators who stabilise the timbers and, in the case of Barcode 6, shape the timbers in moulds before freeze-drying. To do this, the conservators must also be involved in the digital documentation and interpretation of the scale model. Specifying these three main groups of experts only touches the surface of what is needed to reconstruct, conserve, and exhibit an archaeological ship find. Still, for the purpose of this paper, they are the most crucial.<sup>1</sup>

### 3. Excavation and post-excavation documentation

We will not focus on the methods for digital excavation and post-excavation documentation here. Since the excavation in 2008–2009 (Gundersen 2012; Vangstad 2012), the methods in use have been developed and refined. This also relates to the post-excavation documentation, where we, in 2020, converted from 13 years of using a FaroArm for contact digitising (Hocker 2003; Jones 2007, Nayling, Jones 2012; Falck, Egenberg, Vangstad 2013; Falck 2014; Falck, Fawsitt, Kerr 2016) to Artec Eva/Leo structured light scanners, adding annotations directly onto the scans (van Damme *et al.* 2020). In this paper it is the supplementary use of this primary documentation that is of main interest. We want to stress that using these digital methods has facilitated cooperation between the experts involved in the work. Where one could surmise that the use of digital tools limits cooperation, as it demands basic qualifications in the use of digital software, this has not been our experience.

### 4. The building of a scale model

When opening a small boat-building workshop at the Norwegian Maritime Museum in Oslo in 2009, the intention was to create a place where academics and craft experts could work together (Planke, Stålegård 2014: 359). Calling it a laboratory, the BoatLab, emphasised this as a space for testing, trial and error, and experimenting, with an openness to the crafts and practices of the past – the ways of doing things. A basic method for reconstructing archaeological clinker-built ship finds is to use the scaled 1:1-drawings to create the shell, making nail holes in the strakes fit in dialogue with the framing system (Planke, Stålegård 2014: 375; Bischoff 2020: 64). Generally, we have practised this using a combination of paper-printed 3D drawings glued to cardboard (strakes) and printed 3D models in plastic (frames and other structural timbers). We built the Barcode 6 model in scale 1:5, creating a large model. The scale offered some material resistance and the possibility for higher precision (Planke, Stålegård 2014: 367). We searched for fixed points in the boat, which we could reference for other more doubtful parts of the construction. We soon experienced that they were few. Even in a situation with approximately 80% of the material present, interpretation and negotiation were necessary before making decisions. Especially difficult was the lack of beams, not providing us with any certainty of beam widths.

We have listed five important experiences from the building of the scale model.

- In a cardboard model, there is much room for adjustments and 'kneading' within a hull shape, where individual parts fit together.
- Lack of beams significantly increases the uncertainties of the reconstructions. This point is essential, as a majority of the finds from Oslo lack beams and should also be viewed in relation to point 1.
- One plank can alter the rest of the hull shape. This single plank can potentially be out of its original shape or not even be present.
- The shape of the floor timbers changed from their first on-site documentation to the time of documentation in the lab.
- Lastly, a (minor) discrepancy will occur since post-documentation is done on wet, swollen timbers, while actual boatbuilding is done on dryer wood.

<sup>1</sup> Other important crafts include the production of tar, reconstruction and sewing of sails, rope making etc.



**Fig. 3** The reconstructed boat on display at the head quarter of the DNB Bank in Bjørvika, Oslo, seen from the aft (photo: B. Kjølsevik/NMM)

## 5. The building of Vaaghals<sup>2</sup>

The model's main function was as a template for building the full-scale reconstruction. Using the same master builder, Lars Stålegård, for the model and the boat, created a valuable (and recommended) continuity in the work.

The reconstruction results from discussions and negotiations between the crafts persons, the documentation, the archaeological material, the archaeological context, and the building materials and tools in use. For the archaeologists involved in these negotiations, a whole new context for their interpretations is created. This is a practical context, a knowing how, not just a knowing what.

## 6. The exhibition

The vessel was intended for an exhibition in the new headquarters of the DNB Bank (Fig. 3). The importance of this version of the boat lies not in the naval qualities and capacities of the vessel but in the preserved materiality and outreach. The material is fragmented and distorted but stable through treatment in PEG and a vacuum freeze drier. We used the scale model's digital version to recreate each plank fragment's shapes, creating moulds that locked the timbers before entering the freeze-dryer. This made assembling the pieces in the exhibition workable, but without claiming that every fragment fitted perfectly. We found it interesting to evaluate how the exhibited vessel eventually differed from the other versions (Tab. 1). Compared to the cardboard model, the length of the vessel is less than 1% shorter, while its breadth shows roughly a 9% narrower version. Accurate overall measurements were difficult to achieve, considering the strakes were incomplete up to the gunwale. Test measures on strakes, before and after freeze drying, suggest that the shrinkage plays a lesser role in the differences than the adoptions done when assembling the material.

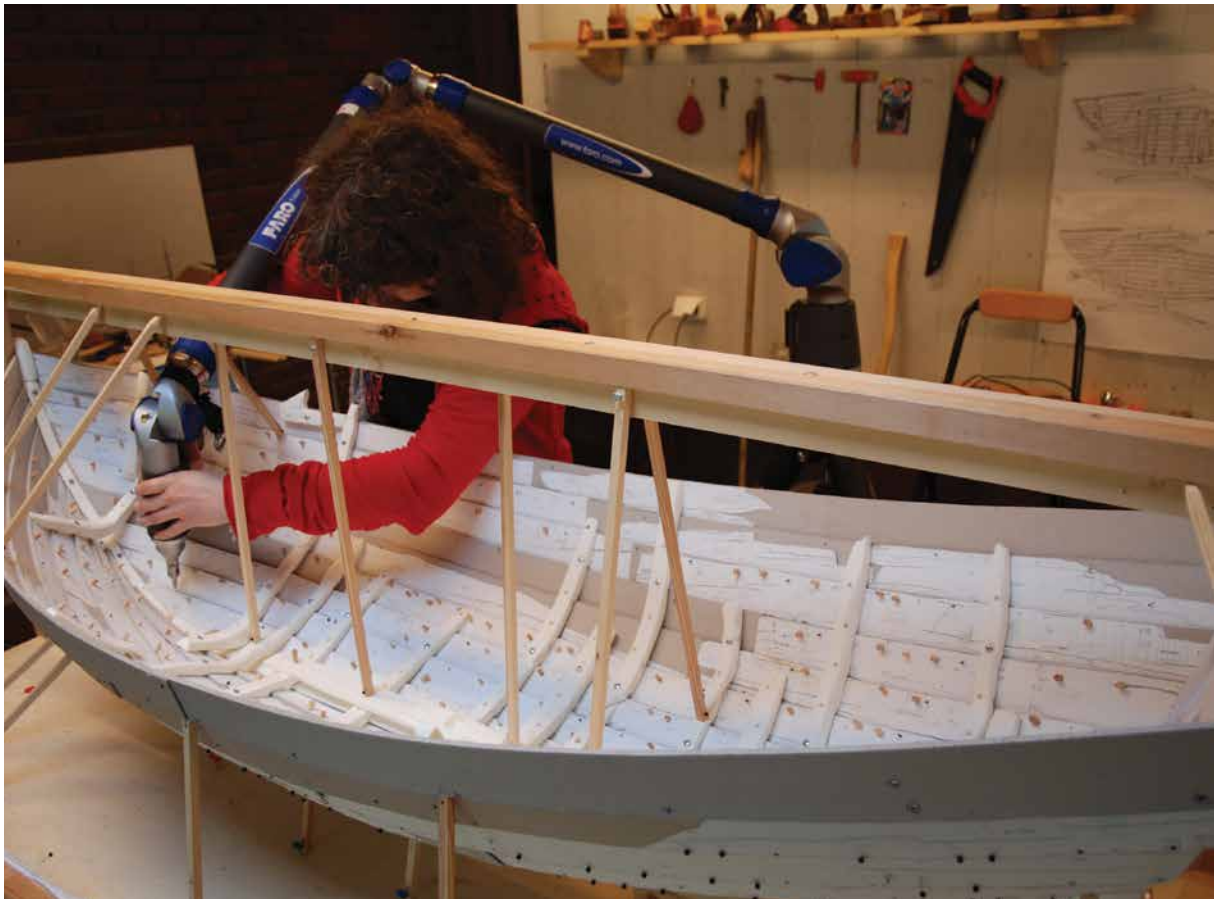


Fig. 4 Sarah Fawsitt is measuring the cardboard model using a FaroArm, back in 2010. Accuracy was complicated both by the method of contact digitising, and reaching certain parts of the hull with the measuring probe, especially in the bottom (photo: T. Falck/NMM).

<sup>2</sup> The work process is available at [baatlaben.blogspot.com](http://baatlaben.blogspot.com). The results are presented and discussed in Planke, Stålegård 2014. Both publications are in Norwegian.

## 7. Comparing the representations – identifying the discrepancies

### 7.1. The digital models

Two digital models were built in Rhino 3D to be run through Orca 3D.<sup>3</sup> The first model was a hull based on a FaroArm recording of the physical 1:5 model (Fig. 4). This digital model will be referred to as the Barcode 6 model. The second model was based on a combination of photogrammetry and an Artec Leo 3D scan carried out on the physical full-scale reconstruction. Since the reconstruction has been named *Vaaghals*, the digital model of it will be referred to as the *Vaaghals* model. This method of digital model building and analysis in Orca 3D is based on the method developed by Pat Tanner (Tanner 2020).

The two models were remarkably similar, but there were some visible differences (Fig. 5). One reason for some of the differences lies within the recording and building of the Barcode 6 model. After the 1:5 scale model was recorded, there was an asymmetry to the digital model hull that was attributed to the method of documentation with a FaroArm probe. The probe could sometimes push the cardboard boat model out of shape when taking points. It was also challenging to record points in the lower areas of the hull. For this reason, it was decided to make a half model of the port side and allow Orca3D to mirror it in its analysis. Thus, the asymmetry was eliminated from the shape of the Barcode 6 model. The photogrammetry and scan have shown that the asymmetry was not necessarily just a product of the FaroArm documentation. With the more dependable scans, it was decided to adhere to the characteristics of the reconstruction and make a complete, asymmetric hull for the *Vaaghals* model. There are also other differences between the two models that cannot wholly be accounted for by mirroring the port side of the Barcode 6 model. While the differences in the hulls were slight, they were picked up by Orca 3D when the hydrostatic analyses of the two hulls were compared.

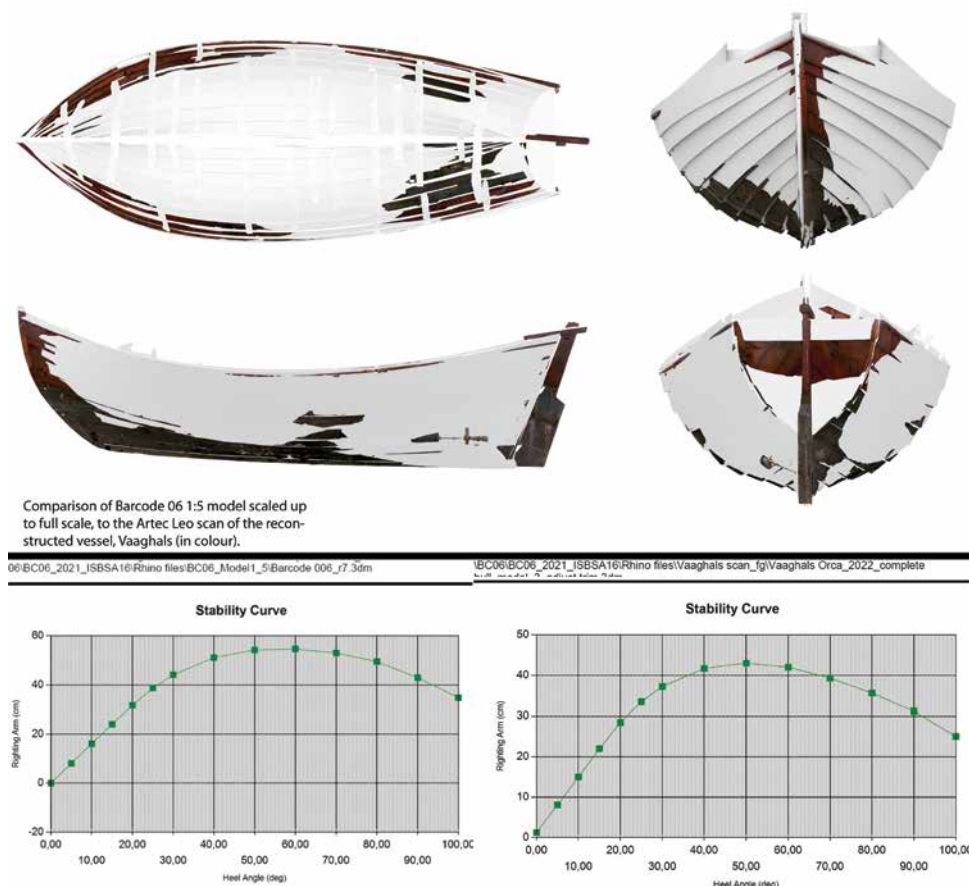


Fig. 5 Top: Comparison of Barcode 6 1:5 model (gray) scaled up to full scale, to the Artec Leo scan of the reconstructed vessel, *Vaaghals* (in colour). Bottom: Graphic display of stability curves for the two models (models: S. Fawsitt, K. Steen/NMM)

<sup>3</sup> Orca 3D is a plug in for Rhino 3D for naval architects to perform hydrostatic analysis.

## 7.2. Orca 3D hydrostatic analysis.

For the hydrostatic analysis, two Orca runs of each model were done. Each model had identical loadings of 1- and 4-ton ballast (Tab. 2).<sup>4</sup> The ballast was in point form and had an identical placement in each model. The Barcode 6 model had no heel due to being mirrored. The two models had slight differences in the overall dimensions and the subsequent waterline dimensions and waterplane value. There were slight differences in the hull coefficients, describing differences in the volume and area of the models. There were also differences in the volumetric centre of gravity, although slight. The stability curves produced by the hydrostatic analysis varied very little. The most significant difference was to be seen in the 4-ton loading between the Barcode 6 model and the *Vaaghals* model, where the symmetrical Barcode 6 model has a maximum righting arm of 55 cm at a heel angle of 60°. The asymmetrical *Vaaghals* model has a maximum righting arm of 43 cm at a heel angle of 50°, and a steeper drop off with an increase in the heel angle, although in both cases the models would have a freeboard of 0 at an angle of 20° heel. So, practically speaking, the difference in the righting arm and angle of vanishing stability are negligible. In conclusion, these slight variations in the interpretation of the Barcode 6 vessel have resulted in little variation in the resultant models, in as much as they can be interpreted by Orca 3D.

Overall dimensions (m)	Barcode 6 model	Vaaghals model	Exhibition
LOA	7.62	7.67	7.55
BOA	2.88	2.78	2.62
D	2.32	2.08	NA

**Table 1** Overall dimensions of the representations of the boat. Length overall, breadth overall and depth (authors: S. Fawsitt, K. Steen, Ch. Rodum)

Barcode 6 model_1 t ballast				Displacement 2350 kgf			
Waterplane values [cm]	Vol. [m <sup>3</sup> ]	Wetted surface [m <sup>2</sup> ]	Overall dimensions [cm]	Waterline dimensions [cm]	Hullform coefficients	Centre of buoyancy [cm]	Centre of gravity [cm]
LCF: 247 cm	2.29	17.92	Loa: 762	Lwl: 644	Cb:0.263	L: 259.6	L: 0
TCF: 0			Boa: 288	Bwl: 215	Cp:0.543	T: 0	T: 0
VCF: 30.51			D: 232	T: 63	Cx: 0.484	V: 14.1	V: 53.22
Awp: m <sup>2</sup>					Cvp: 0.405		
8.96					Cwp: 0.649		

Barcode 6 model_4 t ballast				Displacement 5350 kgf			
Waterplane values [cm]	Vol. [m <sup>3</sup> ]	Wetted surface [m <sup>2</sup> ]	Overall dimensions [cm]	Waterline dimensions [cm]	Hullform coefficients	Centre of buoyancy [cm]	Centre of gravity [cm]
LCF:249	5.21	26.86	Loa: 762	Lwl: 682	Cb: 0.332	L: 253.2	L: 0
TCF: 0			Boa: 288	Bwl: 255	Cp: 0.590	T: 0	T: 0
VCF: 57.7			D: 232	T:90	Cx: 0.563	V: 31,3	V: 30.19
Awp: m <sup>2</sup>					Cvp: 0.466		
12.39					Cwp: 0.712		

<sup>4</sup> *Vaaghals* is sailing with between 1500–2000 kg ballast.

Vaaghals Model_1 t ballast				Displacement: 2343 kgf			
Waterplane values [cm]	Vol. [m <sup>3</sup> ]	Wetted surface [m <sup>2</sup> ]	Overall dimensions [cm]	Waterline dimensions [cm]	Hullform coefficients	Centre of buoyancy [cm]	Centre of gravity [cm]
<b>LCF: 245</b>	2.28	11.59	Loa: 768	Lwl: 660	Cb: 0.277	L: 255	L: 254.6
<b>TCF: 0.684</b>			Boa: 278	Bwl: 204	Cp: 0.530	T: 0.827	T: -.275
<b>VCF: 24.19</b>			D: 195	T: 61	Cx: 0.523	V: 6.6	V: 48.46
<b>Awp: m<sup>2</sup></b>					Cvp: 0.444		
<b>8.394</b>					Cwp: 0.623		

Vaaghals Model_4 t ballast				Displacement: 2343 kgf			
Waterplane values [cm]	Vol. [m <sup>3</sup> ]	Wetted surface [m <sup>2</sup> ]	Overall dimensions [cm]	Waterline dimensions [cm]	Hullform coefficients	Centre of buoyancy [cm]	Centre of gravity [cm]
<b>LCF:253</b>	5.21	27.23	Loa: 768	Lwl: 696	Cb: 0.331	L: 256.8	L: 256.8
<b>TCF: -.781</b>			Boa: 278	Bwl: 244	Cp: 0.575	T: -0.3	T: -.401
<b>VCF: 53.1</b>			D:195	T: 93	Cx: 0.575	V: 25.1	V: 25.7
<b>Awp: m<sup>2</sup></b>					Cvp: 0.477		
<b>11.746</b>					Cwp: 0.693		

**Table 2** Results from the hydrostatic analysis of the Barcode 6 and Vaaghals models with loadings of 1 and 4 t. The analysis is done in Orca 3D (author: S. Fawsitt)

## 8. Conclusion

The representations of the boat differ from each other, and we intended to reveal and investigate these variances. This way, we can understand which discrepancies are essential in that they alter the properties of the vessel. The hydrostatic analysis performed on the Barcode 6 cardboard and *Vaaghals* models identified differences, but these were interpreted as slight. This makes us believe that the pursuit to transform the results from the cardboard model into a sailing vessel has succeeded in bringing on similar qualities.

Just as important, the investigation is useful to evaluate and better understand our practices on a conceptual level. Following the building of *Vaaghals*, Planke and Stålegård (2014) discussed the methods from a craft perspective, raising questions about what they experienced as a processual and fragmented practice within experimental archaeology. While our digital methods and hydrostatic analysis help create measures that are comparable to other vessels' naval capabilities in a numeric manner, the craft perspective potentially establishes an understanding of the ideologies behind the structure and 'the ways of doing things'. We believe that both these perspectives are helpful, and in the future, we hope to more actively combine the methods so that they may strengthen each other. Through the practical use of *Vaaghals*, questions concerning the rather sharp bottom are one area where the digital methods and the practical perspectives, with great advantage, can work together to reconstruct and discuss variances. The same applies to the general problem of the lack of beams in the Oslo finds, which creates uncertainties concerning the beam widths.

The practical aspects of building, rebuilding, and use of sailing vessels need to be a core aspect and task for the reconstruction work within maritime and nautical archaeology (Fig. 6). Speaking from the experiences at the Norwegian Maritime Museum, the cooperation between experts in crafts and archaeology is required, and more research that allows this collaboration is therefore called for. The archaeological ship material from Oslo contains many vessels from quite a limited period. More full-scale reconstructions will make it possible to create a unique understanding of the principles behind the building of these vessels, stemming from a very dynamic time in history.



**Fig. 6** The small cargo vessel, Vaaghals, has been rigged with one main square sail and one smaller sail in the fore. In the photo, the stability is tested by human force for the first time (photo: K. Steen/NMM).

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