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## **A Dry-Slip Facility for Fish Terminals on Open Coasts**

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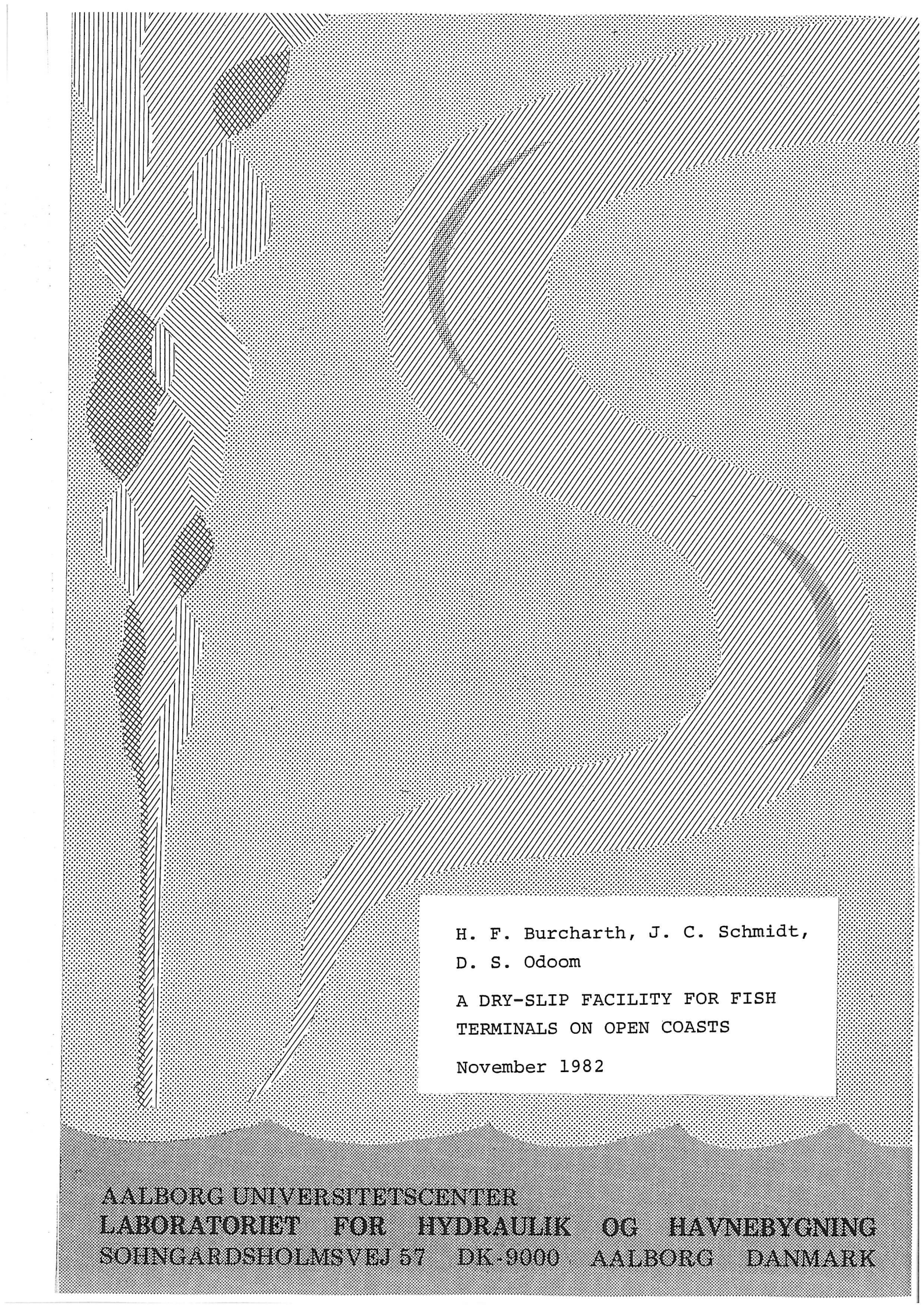
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A DRY-SLIP FACILITY FOR FISH  
TERMINALS ON OPEN COASTS

November 1982

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# A DRY-SLIP FACILITY FOR FISH TERMINALS ON OPEN COASTS

by

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## ABSTRACT

The paper describes a low cost facility for landing and shipping of fish and for bringing fishing boats ashore in periods of bad weather. The facility is meant for open coasts and represents an improvement from beach landing. Being a wooden pile structure it is much cheaper to construct than conventional harbours, and it represents an alternative to such harbours on coasts where littoral drift causes serious sedimentation and erosion. A proposal for a special device called "the dry-slip" for lifting fishing boats out of the water in bad weather situations is made. The dry-slip system was tested in a model. Cost estimates for a system capable of handling boats of sizes of up to a total weight of 10 tonnes are presented.

## 1. INTRODUCTION

The need for the development of fisheries in many developing countries is universally recognized. This implies improvement of fishing boats, and landing, storage and distribution systems, and can take place along dual lines. One is the introduction of high capacity facilities based on the newest technology. This, however, can be very costly and dependent on the presence of an extensive service system, which in turn necessitates an increased urbanization. The other is a gradual improvement of the efficiency of conventional techniques, thus enabling the countries themselves to comply with the demand for skill, money and technology. The dry-slip discussed in this paper has been developed on these lines, being a simple low cost facility for landing and shipping of fish, and for bringing fishing boats ashore in periods of bad weather or in case of lack of anchorage. It represents an improvement from the stage of landing boats directly on the shore, and is much cheaper to construct than conventional harbours on unprotected coasts. It can be constructed by non-specialized contractors and operated and maintained by the local people, and is suitable for open sea coastlines, either for serving stationary fishing villages or for serving the fleet of fishing boats which operate in some countries as nomads following the seasonal movement of the fish. It is an obvious possibility to place shipyards for building and repair of fishing boats in connection with some of the dry-slips, and the dry-slip could also be an alternative to harbours on coastlines where littoral drift causes serious sedimentation and erosion.

## 2. LAY-OUT OF AN OPEN SEA FISH TERMINAL

It is typical of many coasts that the weather is calm and stable in long periods, but very rough and unstable in relatively short seasonal periods. In periods with calm weather it is not necessary to bring the fishing boats on shore as the boats can anchor at sea outside the swell breaker zones. To allow for open sea anchorage it might, however, be necessary to alter the design of some of the traditional fishing boats. Since it is a very big advantage not to be forced to take the boats on land in order to land the fish, the fish terminals should consist of a pier where unloading of fishing boats and loading of reefer ships can take place in calm weather periods. When rough weather sets in and open sea anchorage and unloading along an unprotected pier is prohibited, it should be made possible to bring the fishing boats, loaded and unloaded, on land. The figures 1, 2 and 3 show examples of lay-out which meet with these demands.

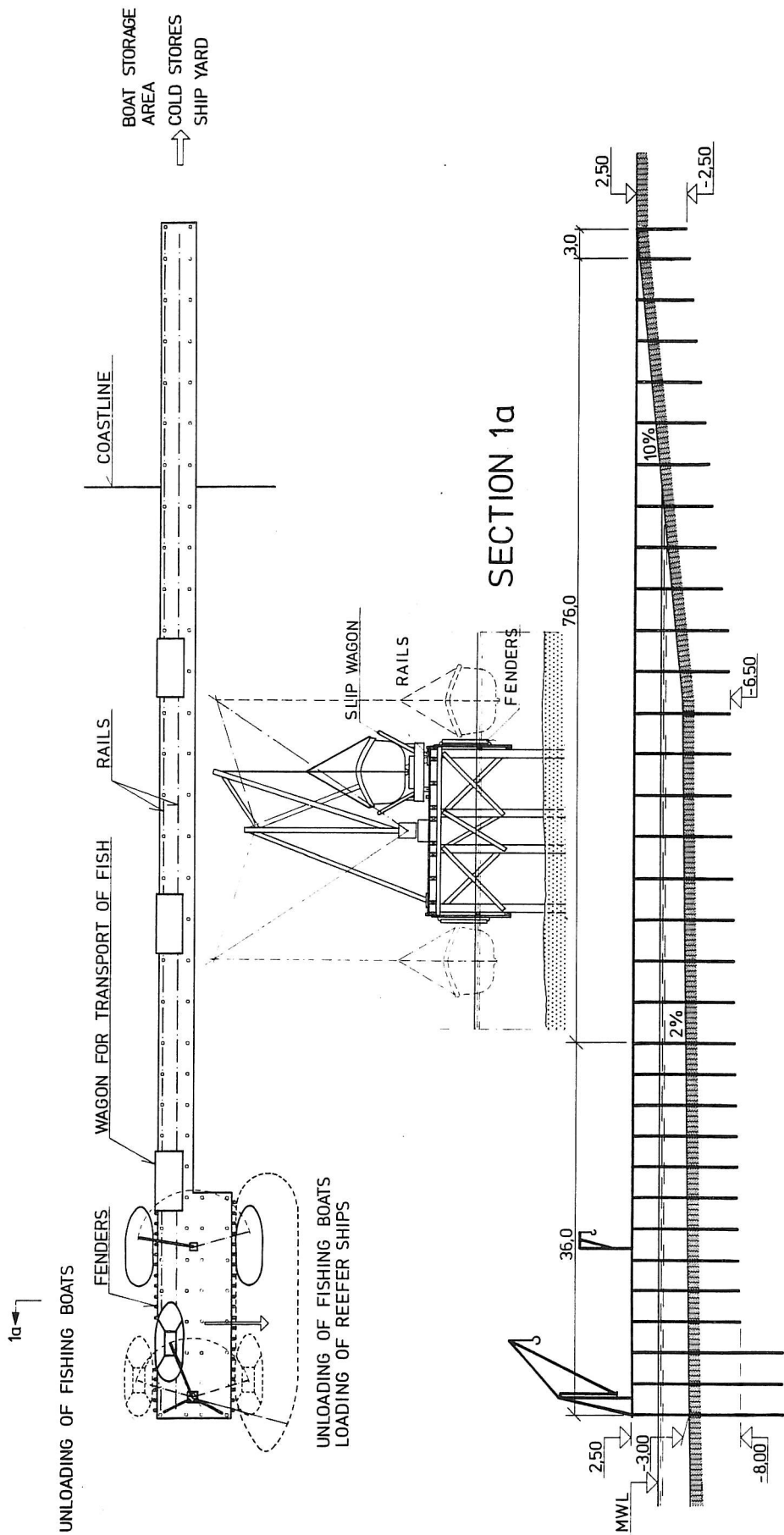
The pier should be orientated parallel to the wave orthogonals to obtain the best conditions for the boats when moored and handled by the lift system. On gently sloping shallow water coastlines, like the one shown in the figures, the wave crests will be approximately parallel to the coastline because of refraction. The pier should extend to water depths where breaking of waves does not take place during the good weather periods. The minimum water depth at the pier head is determined by the draft of the boats, the low water levels and the wave conditions.

The examples in the figures 1, 2 and 3 are based on handling of fishing boats with a draft up to 1.4 m, which for North European fishing boats compares to length and beam of approximately 10 m and 3 m respectively, and light displacement and load capacity of 4 t and 5 t respectively. With an assumed HWL and LWL of +1.0 m and -0.5 m respectively, the water depth of MWL at the pier should be minimum 3.0 m, boat movements in the waves taken into consideration.

The terminal could of course be designed for larger boats, but the mentioned size has been chosen because of its economical and technical feasibility. Fig. 4 shows a typical Nordic type of fishing boat designed for rough seas and open sea anchorage.

Although the boat used in the dry-slip model test was of the above type, most of the traditional fishing boats in various countries can be handled in a dry-slip.

Breakwaters are not introduced in the lay-out because they are expensive and because they very often create serious sedimentation/erosion problems on littoral drift coasts. The proposed pile structure is important in this respect since it creates minimum changes in waves and currents, and thereby in the natural littoral drift balance.



**ALTERNATIVE A**  
 OPEN COAST FISH TERMINAL WITH  
 DERRICK CRANE BOAT LIFTING SYSTEM

SCALE 0 5 10M  
 EXAMPLE WHERE LEVELS OF BRIDGE AND DRY-SLIP ARE BASED ON:  
 HWL +1.0M, LWL -0.5M, SEABED -3.0--4.0M,  
 DRAUGHT OF BOATS 0.5--1.5M

Fig. 1. Open coast fish terminal with Derrick crane boat lifting system

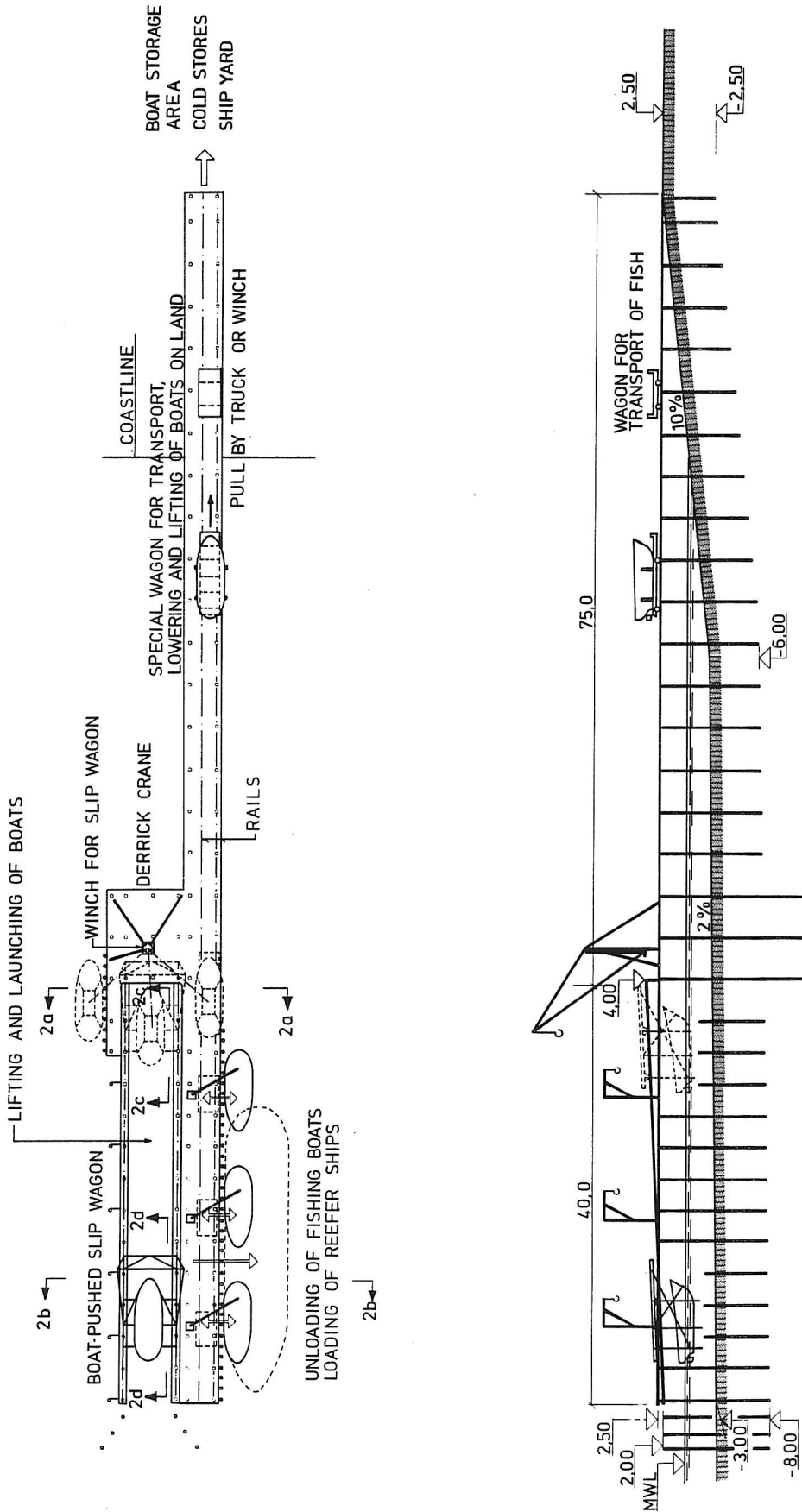
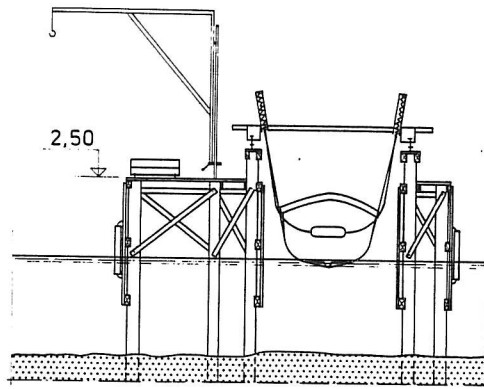


Fig. 2. Lay-out of open coast fish terminal with a dry-slip system.

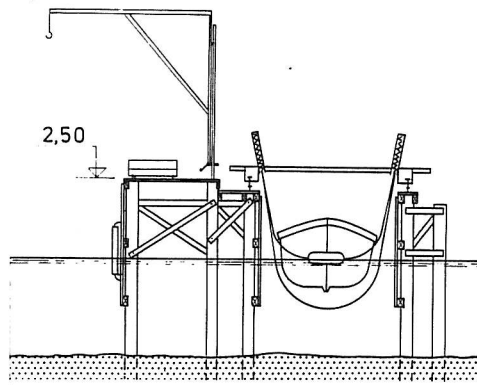
SCALE  
 0 5 10M

EXAMPLE WHERE LEVELS OF BRIDGE AND DRY-SLIP ARE BASED ON:  
 HWL +1.0M, LWL -0.5M, SEABED -3.0 - -4.0M,  
 DRAUGHT OF BOATS 0.5-1.5M

**ALTERNATIVE B**  
 OPEN COAST FISH TERMINAL WITH  
 BOAT-PUSHED DRY-SLIP WAGON

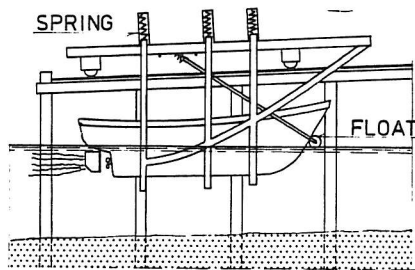


SECTION 2a



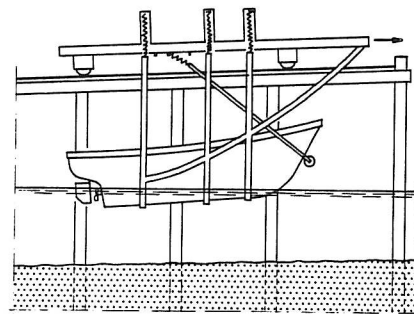
SECTION 2b

WAGON PUSHED BY PROPELLER THRUST



SECTION 2d

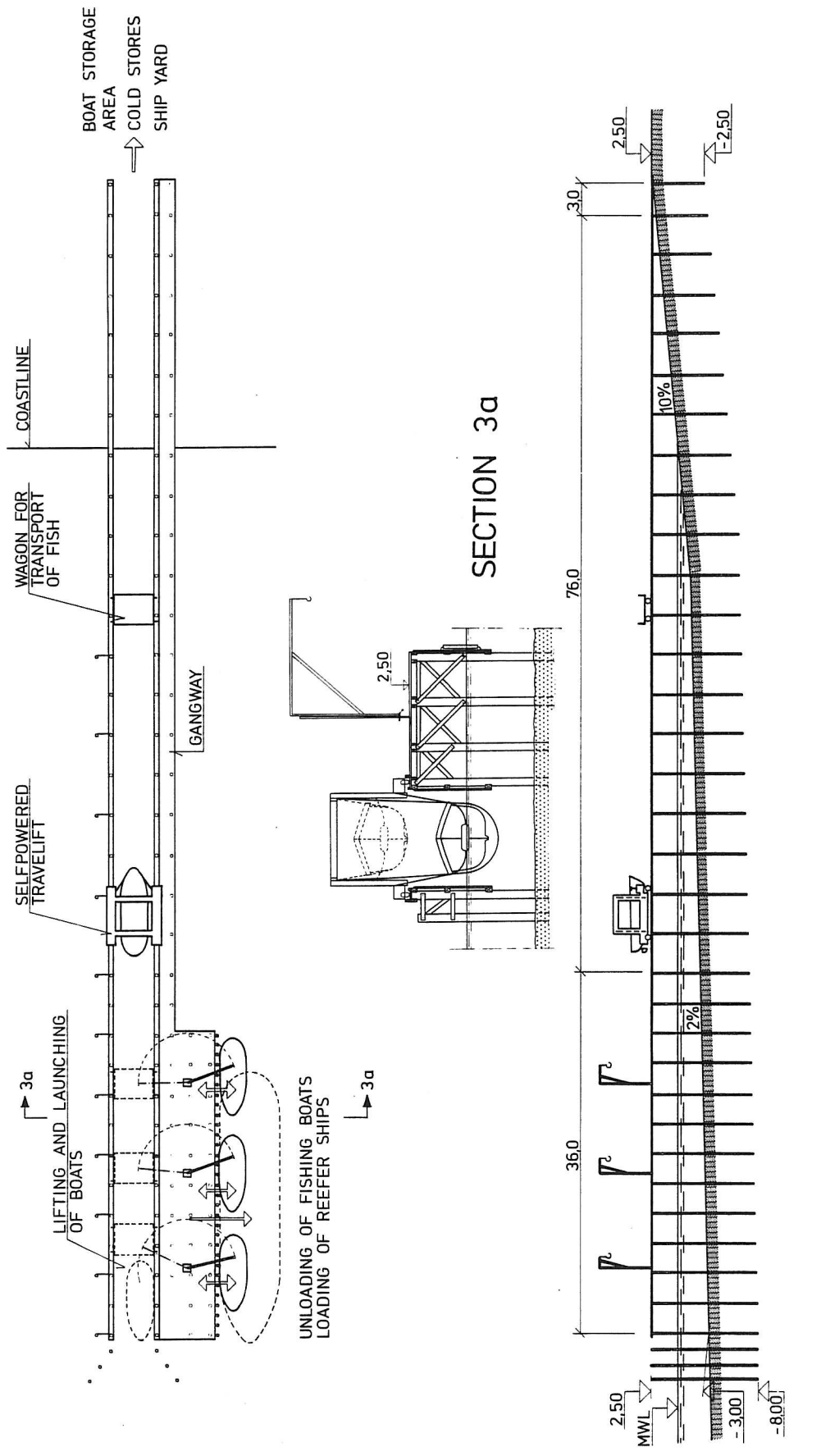
PULL BY WINCH



SECTION 2c

Fig. 2a. Details of the dry-slip



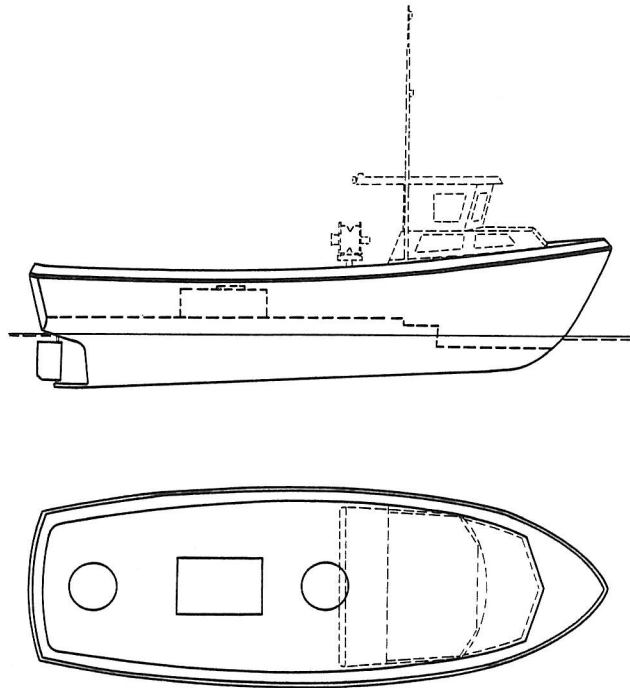


**ALTERNATIVE C**  
 OPEN COAST FISH TERMINAL WITH  
 SELF-POWERED TRAVELIFT

SCALE  
 0 5 10M

EXAMPLE WHERE LEVELS OF BRIDGE AND DRY-SLIP ARE BASED ON:  
 HWL +1.0M, LWL -0.5M, SEABED -3.0 - -4.0M,  
 DRAUGHT OF BOATS 0.5 - 1.5M

Fig. 3. Open coast fish terminal with self powered travelift.



LENGTH x BEAM x DRAFT LOADED = 8.2 x 2.8 x 1.3 m. ENGINE 36HP DIESEL.  
 LIGHT DISPLACEMENT 3.5 t. LOAD CAPACITY 4.0 t.

TYPE 27' FAKTA FIBER.  
 AALBAEK. DENMARK.

Fig. 4. Nordic type of fishing boat.

### 3. PRINCIPLES OF STRUCTURES AND OPERATIONS

The principles of construction and operation of the landing facility can be adjusted to the natural conditions (i.e. coast profile, type of seabed, wave climate), the skill in handling, the possibilities of maintaining mechanical equipment, and the amount of available money.

In the examples presented in this paper, the pier structure consists of wooden cantilever beams on 0.35 m diameter hard wood piles driven to a depth of about 5 m below the mud line. The pile spacing is 3 to 4 m (depending of water depth) and all piles are provided with transverse bracings to reduce lateral deflections, see Fig. 1 and 3. For the construction the pile driver starts on shore and travels seawards on already placed piles and cantilever beams. Only a relatively light pile driver is necessary for this size of structure. All joints are simple, as can be seen from the figures. Local timber can be used in most cases, e.g. for the West African coasts Opepe (resistant to marine borers)

for the piles, and Iroko for the superstructure. The bridge deck at 2.5 m above M.S.L. is made of wooden planks. The deck at the pier end is designed for the forces from overtopping storm waves by H.W.L. The relatively low deck level is chosen because it makes the handling of fish easier. During storms some overtopping is allowable since no handling of fish can take place at the pier because of the breaking of the depth limited waves in the shallow water zone.

Alternative A, figure 1, represents the outmost simple lay-out where a Derrick crane, placed at the pier head, lifts the boat from the water into a cradle. If a cradle is running on horizontal rails, a relatively small size fishing boat can be pushed by two to four persons, but of course a winch system or a small truck makes the transfer easier. To be able to place the boat on land without extra lifting equipment, the cradle should be of the type which can itself pull or push the boat in and out of the cradle. Although the wire in the Derrick crane could be provided with an elastic part, the lifting of the boats out of the water will be possible only in relatively calm weather. For this reason the system is only suitable for coastlines with very stable weather and low wave activity.

Alternative B, figures 2 and 2a, shows a dry-slip system where the boats can be taken on shore and launched even in relatively rough seas. The principle is that the boat is sailed into elastic straps hanging from a slip wagon, which is running on sloping rails above sea level. A strap with a float catches the boat, whereby the dry-slip wagon is pushed forward by the propeller thrust. The strap under the boat will then be lifted automatically, and eventually carry the boat. When the boat is approximately half way out of the water, the slip wagon will be pulled by a winch all the way to the top of the dry-slip, where a Derrick lifts the boat to a cradle, as described in alternative A.

As shown in Fig. 2a, the catching strap with the float can be moved to fit boats of different sizes. Diagonal straps prevent the carrying straps from jamming in the propeller. The necessary elasticity of the straps is obtained by springs. Relatively big boats should be carried by three straps, whereas small ones only need two straps. The stiffness of the strap system is hereby roughly adjusted to the different weights of the boats of different sizes. Moreover, non linear springs can be used to allow for very big differences in weights.

Model tests revealed that very small and tolerable movements (heave and pitch) of the boat are obtained if the stiffness is so that the elongation of the springs, when carrying the full weight of the boat, is approximately  $1/3$  of the maximum significant wave height,  $H_{Smax}$  at the entrance to the dry-slip. It means an elongation of approximately  $1/3 \times 1.8 \text{ m} = 0.6 \text{ m}$  for the geometry shown in Fig. 2. The applicability of the dry-slip is restricted to situations where the waves are non breaking at the entrance. This is so because in breaking waves or in waves very close to breaking, it is not possible to maintain full steering control of a small boat in relatively long waves since the crests of such waves represent a netto transport of water. The critical wave conditions can be calculated from the breaking wave criteria when water depth, slope of seabed, and wave periods are known. For example, at a water depth of 3 m at the slip entrance, with a

seabed slope of 1:40, and a peaky (JONSWAP-type) spectrum with a peak period of 6 sec. it was found that the critical significant wave height at the entrance was approximately  $H_{s,cr} = 1.3$  m. This represents a very rough sea for a small fishing boat. The reason why the dry-slip system is operational under such conditions is the forward movement of the boat when entering into the wagon straps and being gradually lifted out of the water. Wave overtopping of the stern, when the boat is hanging half way out of the water, was found to be moderate and acceptable for the type of boat tested in the model. Moreover, it was found that for non breaking waves the system is not sensitive to variations in wave period, nor to variations in the speed of the boat when approaching.

Guiding piles at the entrance lead the boat safely into the lifting/launching area, where vertical wooden planks are provided on both sides to prevent the railing of the boat from being trapped by the beams. The vertical planks also reduce long shore currents, if any.

The length of the straps is determined by the size (draft) of the boats to be handled, the water depth, the water level range, and the rail level range. Since differences in draft for a wide range of the small size fishing boats (loaded and empty) are less than say 1 m, it will not be necessary on coasts with moderate variations in water levels to adjust the length of the straps. The sloping rails will provide sufficient variations in the vertical strap levels. The distance from the still water to the lowest part of the straps should be the draft of the boat plus approximately 0.6 times the critical significant wave height at the dry-slip entrance. To reduce the length of the dry-slip, a fairly steep slope of the rails is desirable. However, since the boat should be able to push the slip wagon by the propeller, the slope is restricted. For a dry-slip with 10 t lifting capacity (weight of slip wagon < 2 t), a slope of approximately 1:20 is suitable. Winching of the wagon will then be necessary only for small boats.

To resist transverse horizontal strap forces and to keep the wagon weight low, a horizontal lattice on the slip wagon is proposed. At each wagon wheel special clamps are provided to prevent derailing of the wagon. The winch can be used both for the slip wagon and the Derrick crane. In the lay-out shown in Fig. 2 the crane can also lift and launch boats on both sides of the pier in calm weather and it can be used for loading and unloading of fish. When the dry-slip is not in use, fishing boats can moore in the slip area for unloading of fish directly to the trolleys for transport to land.

Alternative C is a more advanced system than alternative A and B, because the lifting and launching as well as the transport of the boats to and from the storage area are done by a selfpowered travelift with steering rubber wheels. To be able to operate in rough seas, some of the principles of the dry-slip might be applied, e.g. elastic spring straps and a catching strap that ensure forward movement of the travelift and a relative position of the boat and the lift. The travelift can be used for pulling and pushing of the trolleys for transport of fish.

Compared to the Derrick crane and the dry-slip wagon system, the travelift is mechanically a much more complicated device, which needs careful and regular service to ensure operationality.

#### 4. COST ESTIMATES

Construction costs might vary considerably from one country to another. Rough estimates of the costs of the three alternatives are given below. The figures are prices per ultimo 1982 for construction in North Europe. They do not include survey and design expenses and costs of roads and area surfaces on land. It is believed that the figures are fairly realistic also for developing countries, because, for instance, lower prices on hard wood would tend to be balanced by higher prices on steel.

Alternative A	1000 US \$
Piles:	
79 m <sup>3</sup> hard wood	26
Driving of 84 piles	10
Timber, superstructure:	
45 m <sup>3</sup> hard wood	20
Work up incl. joints	25
Fenders:	
42 pieces	11
Rails:	
225 m	13
Derrick crane:	10
Cradles:	
2 pieces	4
Stands for boats on land:	
15 pieces	9
Fish trolleys:	
3 pieces	3
Cranes for loading of fish:	
1 piece	3
	<hr/>
	134
Unforeseen 30%	41
	<hr/>
Total	<u>175,000 US \$</u>

#### Alternative B

Piles:	
104 m <sup>3</sup> hard wood	35
Driving of 118 piles	14
Timber, superstructure:	
43 m <sup>3</sup> hard wood	20
Work up incl. joints	25
Fenders:	
46 pieces	12
Rails:	
310 m	18
Derrick crane:	10
Dry-slip wagon:	17
Cradles:	
2 pieces	4
Stands for boats on land:	
15 pieces	9

Fish trolleys:	
3 pieces	3
Cranes for loading of fish:	
3 pieces	8
	<hr/>
	175
Unforeseen 30%	50
	<hr/>
Total	<u>225,000 US \$</u>

#### Alternative C

Piles:	
126 m <sup>3</sup> hard wood	42
Driving of 138 piles	16
Timber, superstructure:	
42 m <sup>3</sup> hard wood	20
Work up incl. joints	25
Fenders:	
31 pieces	8
Travelift:	85
Stands for boats on land:	
15 pieces	9
Fish trolleys:	
3 pieces	3
Cranes for loading of fish:	
3 pieces	8
	<hr/>
	213
Unforeseen 30%	62
	<hr/>
Total	<u>275,000 US \$</u>

For comparison with traditional harbours the following typical prices are given: Rubble mound breakwater in 3 m water depth, approximately US \$ 1700 per m. Sheet pile quay walls in 3 m water depth, approximately US \$ 1000 per m. Although a traditional harbour and the proposed fish terminals cannot be compared directly it is obvious from these figures that the proposed terminals are attractive from a construction economical point of view.

#### 5. MODEL TESTS

The dry-slip system was tested in a 1:25 scale model as shown in Fig. 5. A remote steered boat model with data as stated in Table 1 was used to find out the critical wave conditions for the operation of the dry-slip.

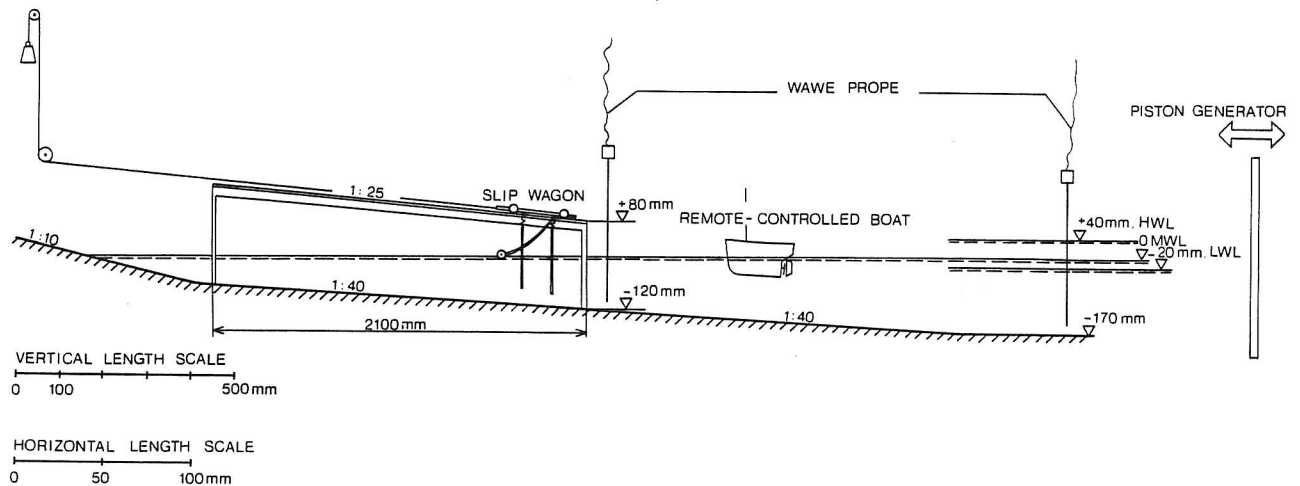


Fig. 5. Model test set-up

	prototype	model
Length over all	9.2 m	0.37 m
Beam	2.7 m	0.11 m
Draft	1.2 m	0.05 m
Light displacement	3.6 t	0.23 kg
Load capacity	app. 5.0 t	0.32 kg
Rolling period, loaded	3.0 sec	0.6 sec
Pitching period, loaded	2.0 sec	0.4 sec
Max. propeller thrust	3600 N	0.23 N

Table 1. Data for boat, tested in the model

The slip wagon was balanced to give a correctly scaled rolling resistance when pushed by the boat. The remote controlled boat was steered into the slip wagon straps under various wave conditions. The approach speed of the boat was varied according to a prototype range of 0.3 - 5 knot. When the boat was caught by the slip wagon strap, the propeller thrust was then adjusted to correctly scaled force. Landing and launching was tested in the following waves (prototype): Regular waves with periods of 2.5 - 7 sec. and heights up to breaking due to restricted water depth. Irregular waves with a peaky varians spectrum (JONSWAP-type) and peak periods of 5 - 6 sec. and heights up to  $H_s = 1.7$  m recorded at the slip entrance in 3 meter water depth. The elasticity of the springs in the slip wagon straps was varied to find a suitable modulus of elasticity. The tests were filmed and afterwards the films were played at a slow speed to represent prototype movements, whereby the movement of the boat under the various test conditions could be studied. The model test results are described in section 3.