Annex 1

Electrical report

National Inspection Council
Approved Contractor

H.L. FIELDING & SONS LTD

ELECTRICAL & MECHANICAL ENGINEERING CONTRACTORS

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19th July, 2006.

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First Floor, Carlton House,
Carlton Place,
Southampton.

ELECTRICAL REPORT
FISHING VESSEL "PAMELA S"

Report carried out by Mr. T. Fielding of H.L. Fielding & Sons Ltd.
The findings are only an opinion and are without prejudice.

Automatic and Manual operation of bilge pumps

Engine compartment. "Rule 500gph." Switched in wheelhouse. Wired for manual pump only. No float switch connected. Pump not fixed, lying loose in bilge. Electrical connections not watertight, and wired in open connector blocks.

Discharge ¾" hose discharging through approx. ½" welded tube to hull Fwd Starboard side approx. 6" above the water line. I was Unable to ascertain if a non-return valve was fitted. (Could not find one.) Suggest back flush pipe work to determine if non-return valve fitted.

Carried out electrical test on pump. Pump ran satisfactorily.
Water test needs to be carried out in situ because of the small hole on skin fitting with restricted flow. Suggest cleaning the bilge and then pumping clean water through. Man-Auto switch in wheelhouse shorted out before sinking.

Mid Ship Pump. "Rule 500gph." Automatic operation. Automatic pump removes water from bilge compartment. A float switch is not required on auto setting. It starts and works off the resistance encountered from the impeller. If water is present, resistance is incurred; the pump will operate until the bilge is empty. When no resistance is felt it is switched off. Pump screwed down and fitted satisfactorily. Connections lying in bottom of bilge badly corroded in open connectors.

? sh'd

Discharge ¾" hose to Fwd Port side outlet. Approximate size of discharge hole was 6mm restricting flow. Could not find a non-return valve.

Carried out electrical test on pump. Pump ran satisfactorily.
No volume test carried out. Needs bilge to be cleaned and water added as above.

Switch in wheelhouse. Fuse holder disconnected. Wired straight to manual. Auto side picked up on separate feed. Theoretically it should work on auto. ...cont'd

.../Cont'd.

Bilge Pump Aft " Rule 500gph" Automatic operation.

Pump not fixed down. Loose in aft locker. Unit was lying on its side on chain.
¾ " discharge to fwd port side. Small discharge pipe in hull of boat approx. 6mm, restricting flow.

Carried out electrical test on pump. Pump ran satisfactorily.
Electrical connection was poor. Not watertight and joint was taped.
Switch in wheelhouse not connected correctly. Probably had to leave switch in manual all the time for pump to operate.

Summing up on Pumps

1) Discharge Fwd ~~Port~~ (Std.) 3 in N° holes in hull range from 8mm to 6mm restricting flow and 150mm above water line.
2) All three switches in wheelhouse incorrectly connected i.e. shorted out and fuse holders disconnected. Poor connections.
3) Engine room pump no float and wired for manual only. Pump not fixed down. Poor electrical connection.
4) Mid compartment-Poor electrical connections and lying in bilge.
5) Aft compartment-Poor electrical connections and lying in bilge. Pump not fixed down.
6) All pumps tested directly to battery worked.
7) Unable to detect non-return valves.

Bilge Alarms No bilge alarms fitted.

Bilge Pump Test Unable to carry out test. Needs to be done in vessel but bilge should be cleaned first.

Batteries Bottom of batteries approximately 75mm below water line.
4 in N° heavy duty batteries fitted. 2 in N° to starboard and 2 in N° to port.
Starboard batteries not connected.
Port batteries one connected. Size of battery connected 120ah approx. Sufficient for running bilge pump.

Fuse Box – Wheelhouse. 2 in N° switch fuse 6-way fuse boxes.
Port unit disconnected, not working.
Starboard unit connected. All switches in "Off "position. Assuming vessel has not been touched all communications not working.
Wiring badly corroded. 6-way unit feeding GPS Radar VHF etc. Very poorly wired.

I.e. if switch in "On" position all navigation aids should work. Due to water ingress

on fuses and switches unable to ascertain if all switches work. ...cont'd

.../Cont'd.

Fused switch board Forward cabin controlling light. Made up unit with relays. All relays destroyed with water ingress, unable to test.

Annex 2

Recovery of wreck of '*Pamela S*' diver's observations

KAYMAC
MARINE & CIVIL
engineering

RECOVERY OF WRECK OF 'PAMELA S'
DIVER'S OBSERVATIONS

The following is a list of observations from the initial dive by Kaymac Marine on the wreckage of the fishing vessel 'Pamela S' in Camarthen Bay on 26th June 2006.

General Orientation

The wreck was portside down on a sandy bed in a depression approximately 1.0m deep caused by tidal scour below the hull, and facing with the bows pointing towards the north east. The sand had encroached onto the deck to within 0.3m of the engine room hatch upstand, and the port gunwale was largely buried from the 'A' frame at the stern to the sweep of the bow, with only the top 0.2m and handrail exposed.

Wheelhouse

- The port aft wheelhouse window was crazed, doubled vertically on the laminate and peeled back into the wheelhouse.
- The wheelhouse door circular window was missing, and the door was in the closed position but unlatched.
- The starboard wheelhouse windows were in situ and crazed.
- All the remaining windows were in situ and appeared undamaged.

Deck

- The engine hatch cover was off and found on the sea bed under the portside of the vessel (see drawing CHPS/290606/1).
- A bait box made from the lower part of a plastic drum was found on the deck against the port gunwale between the engine and fish room hatches. The box was approximately 50% full of dead spider crabs, and a large number of crabs were also found scattered on the port side between the wheelhouse and engine room hatch, and in the engine room itself.
- The fish room hatch was in the closed position but not secured.
- The steatite cover was in site and secured.
- The 'A' frame was found to have a number of bolts missing at the base plates where secured to the stern decking.
- The port side aft pot hauler attached to the 'A' frame was intact, with a mass of lines steaming to aft of the vessel.
- A small number of pots were found on the deck just forward of the 'A' frame.

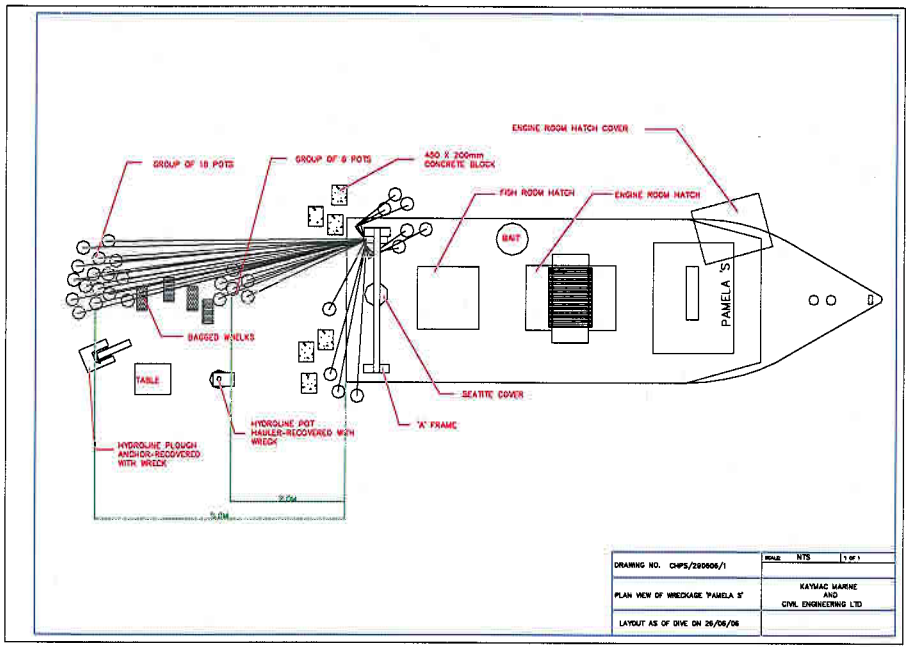
Seabed

- Directly aft of the stern, a single pot with line.
- Of the starboard stern, group of 3 pots with lines.
- 3 concrete blocks approx. 450mm x 200mm off the port stern.
- 3 concrete blocks approx. 450mm x 200mm off the starboard stern.
- 2.0m aft of the stern in line with the keel, a group of 6 pots with lines.
- 5.0m aft of the stern and slightly to the port side of the keel line, a group of 18 pots with lines.
- Between the two groups of pots, 4 full closed mesh bags of whelks.
- Approx. 2.5m off the stern in line with the starboard side, a Hydroline pot hauler was found with no lines or hoses attached. (This was recovered as a separate item and returned to the vessel once re-floated).
- Approx. 1.0m aft of this, an upturned metal table was found.
- 5.0m off the stern on the starboard side, a plough anchor was found. (This was recovered to the wreck by the diver).

Dive team

Supervisor: C. Hanson

Divers: A. Byrne
K. Passmore
R.Temple


ENGINE ROOM HATCH COVER
GROUP OF 18 POTS
GROUP OF 6 POTS
450 X 200mm CONCRETE BLOCK
FISH ROOM HATCH
ENGINE ROOM HATCH
BAIT
PAMELA 'S'
BAGGED WINKLES
TABLE
SEATTE COVER
'A' FRAME
HYDROLINE POT HAULER-RECOVERED WITH WRECK
HYDROLINE PLOUGH ANCHOR-RECOVERED WITH WRECK
2.0M
5.0M
DRAWING NO. CHPS/290606/1
SCALE NTS
1 OF 1
PLAN VIEW OF WRECKAGE 'PAMELA S'
LAYOUT AS OF DIVE ON 29/06/06
KAYMAC MARINE AND CIVIL ENGINEERING LTD

Annex 3

Report on Stability Investigation - FV *Pamela S*

Report on Stability Investigation - FV 'Pamela S'

1. *Introduction*

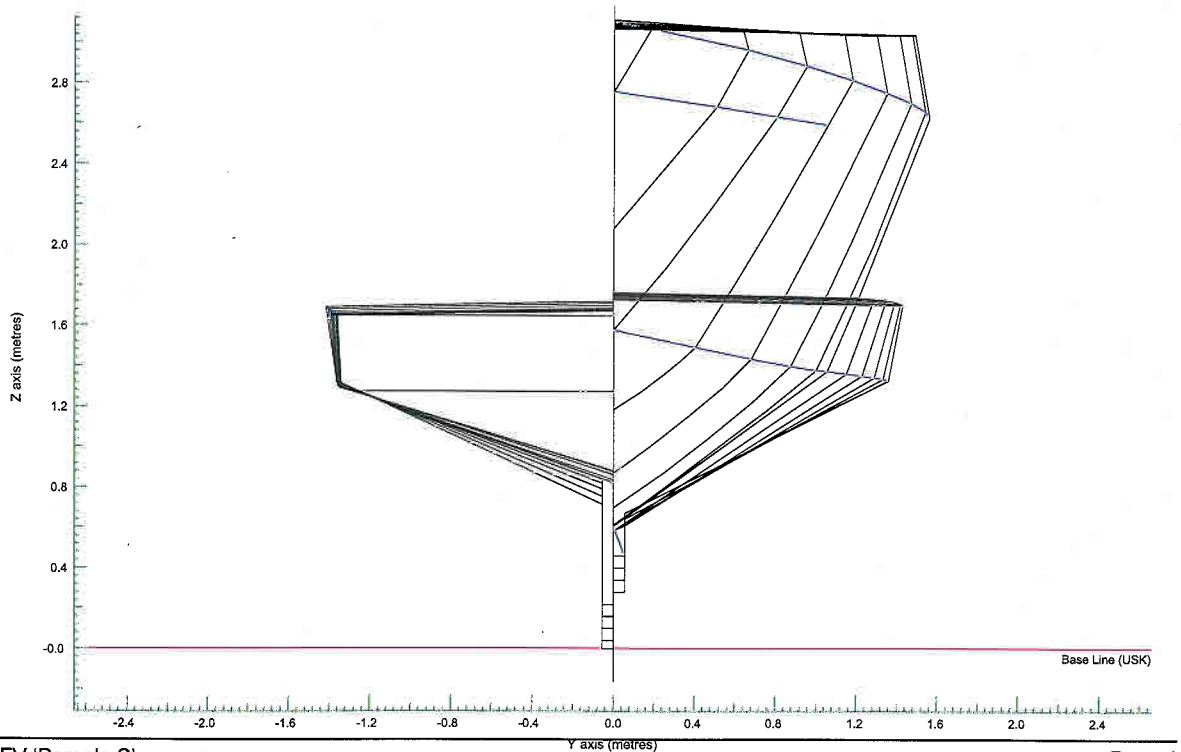
The objective of this report is to assess the stability of the fishing vessel 'Pamela S' in the loading conditions which would have been required for a Maritime and Coastguard Agency approved stability booklet if the vessel had a registered length greater than 12 metres and in the accident condition, with and without floodwater and aft peak ballast aboard.

Section 2 describes the measurement of the hull form and its internal compartments and tanks, and the generation of the computer model from the dimensions obtained. Section 3 describes the manner in which this information and the results of the inclining trial are drawn together to compute the vessel's lightship displacement and the location of the centre of gravity in this condition. Sections 4 and 5 specify, respectively, the vessel's principal dimensions and the background data required for the stability analysis. Section 6 details the stability and freeboard requirements included in the 1975 Fishing Vessel (Safety Provisions) Rules; all fishing vessels over 12 metres in registered length must comply with these regulations. Section 7 describes the seven loading conditions which would have been included in a stability booklet had the vessel been over 12 metres registered length and summarises the data computed for these conditions. Section 8 describes the accident loading condition given the available information and assesses the resultant trim, stability and freeboard information in light of the additional factors which may have contributed to the loss of the vessel. Section 9 comprises the report's conclusions. The appendices at the end of the report consist of the data forming the basis for the analysis.

2. *Hull and compartment definition*

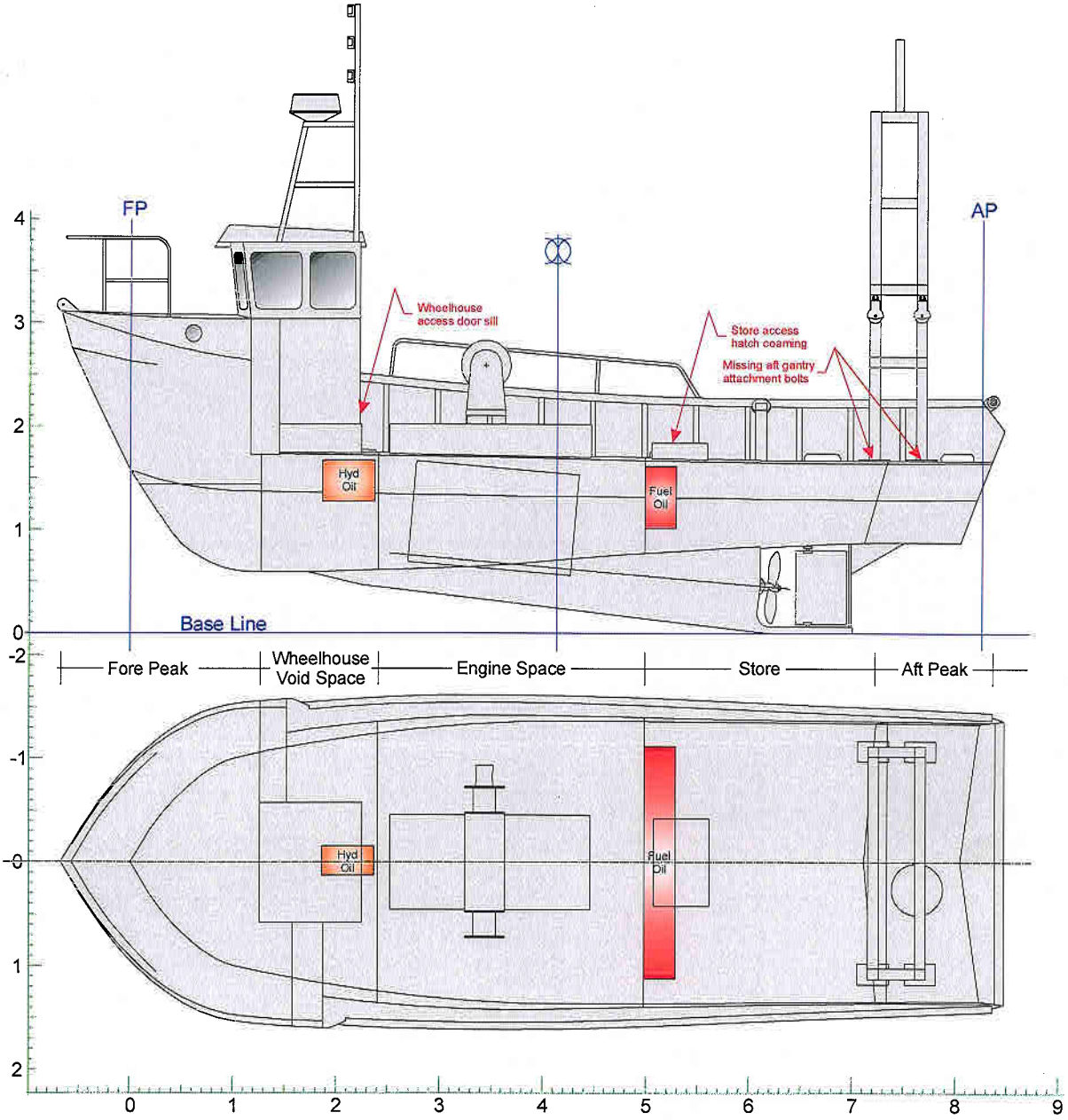
The shape of the vessel's hull and its compartments and tanks were defined using measurements taken manually and using a Leica TPS700 Series electronic measuring station. Half breadth and height dimensions for seven transverse sections through the hull were recorded by these means and entered into the computer to create a coordinate model of the hull shape. An additional twenty-two sections were interpolated automatically from the input section data to refine the model – see diagram 1 below. Appendix 5 is comprised of section, plan, profile and isometric views of this model.

Diagram 1 – Hull sections of fishing vessel 'Pamela S'



All longitudinal dimensions were taken about a Forward Perpendicular (FP) located adjacent to the forward end of the waterline at the time of the accident as shown in the general arrangement diagram below. The Aft Perpendicular (AP) was located 8.245 metres aft of the FP, close to the aft end of the same waterline. Vertical dimensions were taken about a Base Line passing through the the lowest point of the keel.

Diagram 2 – General Arrangement of fishing vessel 'Pamela S'



Dimensions of the internal compartments are listed below:

a. Accommodation..... : 2.27 metres overall length
b. Wheelhouse ..... : 1.26 metres overall length x 1.16 metres breadth
c. Void space under wheelhouse.. : 0.98 metres overall length
d. Engine space ..... : 2.58 metres overall length
e. Store ..... : 2.36 metres overall length
f. Aft peak ..... : 1.23 metres overall length
g. Fuel oil tank..... : 0.31m length x 2.38m max. breadth x 0.60m max. depth
h. Hydraulic oil tank..... : 0.51m length x 0.31m breadth x 0.40m depth

The geometry of compartments a. to f. in the list above was derived by the computer system from the hull model. The fuel and hydraulic oil tanks were defined from

measurements taken directly off the tanks. The geometry of all the compartments were entered into the computer system to complete the vessel model.

3. *Inclining trial*

The vessel was lifted back into the water at Burry Dock to conduct the inclining trial, the report of which comprises Appendix 1. Before the trial commenced, a small heel to Port of just over one degree was corrected by placing five 25kg weights on deck adjacent to the engine access hatch coaming, with their combined centre of gravity 1.163 metres to Starboard.

Draughts about the base line were recorded at the forward and aft perpendiculars to establish the position of the flotation waterline for the trial and two pendulums were used to record the deflections obtained from twenty weight movements, each of 25kg. The vessel's characteristics (i.e. displacement, KMt, VCB and LCB) were computed for the flotation waterline and this combined with the deflection data was used to establish the GM transverse (GMt). From this information the location of the centre of gravity in the inclining trial condition was derived. The range of GMt values computed from the twenty weight movements was from 0.660 metres to 0.788 metres, with a mean of 0.717 metres.

Tables of items to come off and to go on to obtain the lightship condition are also included in Appendix 1 along with a light ship summary.

4. *Principal dimensions*

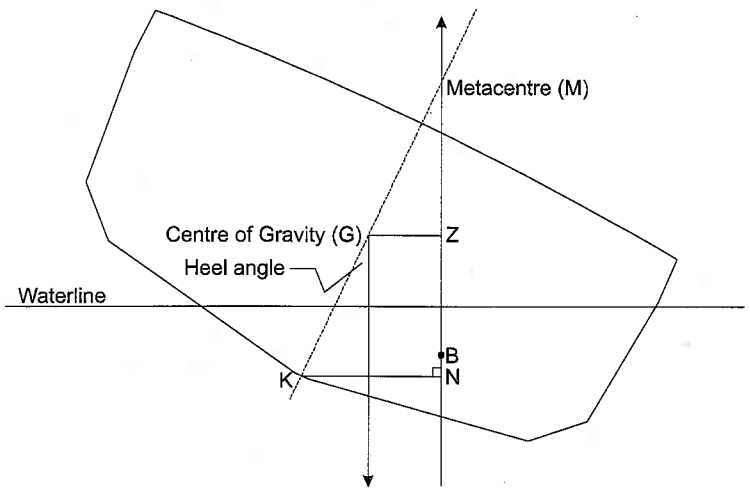
The vessel's principal dimensions are as follows:

Length Overall (LOA)	:	9.160 metres
Length Between Perpendiculars (LBP)	:	8.245 metres
Maximum moulded beam (at deck level)	:	2.858 metres
Depth (base line to deck edge at midships)	:	1.689 metres
Lightship displacement	:	8.736 tonnes
Draught midships at lightship displacement	:	1.445 metres about Base Line
Keel rake	:	0.984 metres in LBP

5. *Hydrostatic, KN and tank data*

Appendices 6 and 7 are comprised of hydrostatic and free-trim KN data computed from the hull model. The diagram below illustrates the relationship between KN values and righting levers (GZ):

Diagram 3 – Relationship of KN to righting lever (GZ)



It should be noted that the KN data used for the calculation of the stability data in section 7 of this report includes the volume of the hull below the fore deck and the main deck but

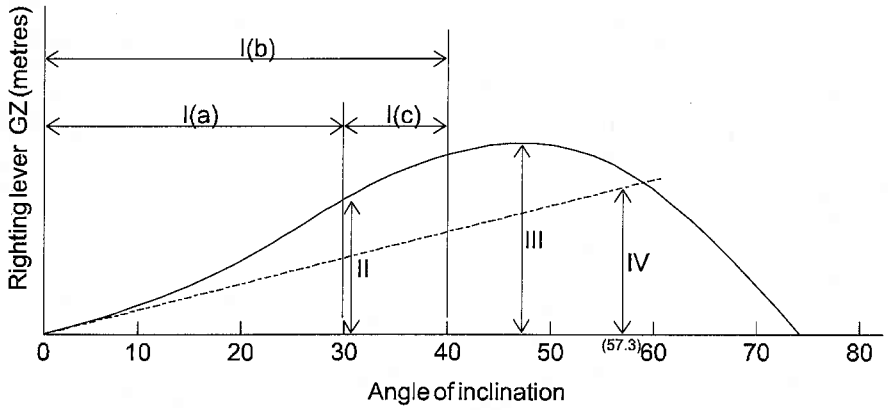
excludes the volume of the wheelhouse. This is normal practice in compiling a stability booklet for submission to the MCA as the wheelhouse can not be considered as watertight. The data is presented for three trims in tabulated and plotted form.

Appendix 8 is comprised of tables of the calibration, centres of gravity and free surface effects data for the vessel's fuel and hydraulic oil tanks.

6. *Criteria used for assessment of stability and freeboards*

Paragraph 3.1.2 of Merchant Shipping Notice 1770(F) requires that any fishing vessel of 15 metres in length or greater must comply with the following stability requirements:

Diagram 4 – Example of righting lever curve with requirement key points



I) The area under the righting lever curve (GZ curve) shall not be less than:
   (a) 0.055 metre.radians up to an angle of 30 degrees;
   (b) 0.09 metre.radians up to an angle of 40 degrees or such lesser angle of heel at which the lower edges of any opening in the hull, superstructure, deckhouses, or companionways being openings which cannot be closed weather-tight are immersed;
   (c) 0.030 metre.radians between the angles of heel of 30 degrees and 40 degrees or such lesser angle as defined in (b) above;

II) The righting lever (GZ) shall be at least 0.20 metres at an angle of heel equal to or greater than 30 degrees;

III) The maximum righting lever (GZ) shall occur at an angle of heel not less than 25 degrees;

IV) In the upright position the transverse metacentric height (GM) shall not be less than 350 millimetres;

The 'Pamela S' has a registered length of less than 15 metres and thus did not have to comply with these requirements. Nonetheless, it is instructive to compare the vessel's stability in the required conditions with the provisions of these rules.

In addition to the stability requirements, paragraph 3.2.1 of MSN 1770(F) specifies that fishing vessels of over 15 metres registered length shall be designed, constructed and operated so as to maintain adequate freeboards in all foreseeable operating conditions.

The following minimum freeboard values apply:

Minimum freeboard (H_{min})	=	LBP/40	=	0.206 metres
Forward freeboard (Hf_{min})	=	0.75 + 6.6LBP/240	=	0.977 metres
Aft freeboard (Ha_{min})	=	0.24 + LBP/37.5	=	0.460 metres

Note that where a watertight forecastle extends more than 0.07 x LBP aft of the FP, as in this instance, Hf_{min} may be taken about the top of the foredeck at the side.

With a length of less than 15 metres, the 'Pamela S' did not have to comply but again, it is instructive to compare the freeboards with these requirements.

7. *Assessment of loading conditions for stability booklet*

A fishing vessel is judged to comply with the requirements if it exceeds the stability and freeboard criteria stated in Paragraph 6 in 'all foreseeable operating conditions'. It is usual practice, therefore, for any stability submission to the MCA relating to a fishing vessel to include an assessment of the stability and freeboard in a set of loading conditions representative of a voyage profile.

The following conditions forming such a voyage profile for the 'Pamela S' were created on the computer:

1. Lightship
2. Depart Port, 100% Consumables, 2 Crew
3. Arrival Grounds
4. Depart Grounds, 1.0 tonnes (maximum) catch
5. Arrival Port, 10% Consumables, 1.0 tonnes (maximum) catch
6. Depart Grounds, 20% maximum (0.2 tonnes) catch
7. Arrival Port, 10% Consumables, 20% maximum (0.2 tonnes) catch

The deadweight makeup of these conditions and the trim and stability data computed for them is to be found in Appendix 2. As noted in section 5, the KN data used for these conditions does not include the volume of the wheelhouse. Transverse centres of gravity have not been included in the deadweight tables for these conditions as it would be normal practice not to include these in a stability booklet for submission to the MCA. Note also that maximum values have been used for the tank content's VCG and free surface moment data regardless of the fluid level. Again, this is normal practice in a stability booklet as it simplifies manual calculation and produces results which err on the safe side.

It is understood that a fishing operation such as that undertaken on the 'Pamela S' would not be commercially viable unless it was possible for the vessel to take somewhere between 2 and 2.5 tonnes catch aboard in a voyage. However, analysis has shown that such a catch weight would result in the aft part of the working deck (in the vicinity of the gantry) being over 0.4 metres below the waterline and with the vessel having no reserves of stability. The maximum catch in the conditions above has therefore been set at 1.0 tonnes, at which limit there are still reserves of freeboard and stability, albeit very small.

Table 1 below summarises the results of the trim and stability analyses for the seven loading conditions and compares them with the requirements detailed in Section 6 above.

Table 1 – Summary of stability and freeboard data for voyage profile loading conditions

		Loading Condition						
Requirement	***Min.***	***1***	***2***	***3***	***4***	***5***	***6***	***7***
Area to 30° heel (m.r.)	**0.055**	0.056	0.029	0.029	0.017	0.019	0.028	0.029
Area to 40° heel (m.r.)	**0.090**	0.066	0.029	0.029	0.017	0.019	0.028	0.029
Area 30°-40° heel (m.r.)	**0.030**	0.010	0.000	0.000	0.000	0.000	0.000	0.000
Max. GZ 30°-90° heel (m.)	**0.200**	0.086	0.000	0.000	0.000	0.000	0.000	0.000
Angle of GZ max. (degrees)	**25**	16.22	12.38	12.40	10.74	11.04	12.22	12.42
Min. GMt fluid (m.)	**0.350**	0.828	0.672	0.674	0.592	0.605	0.665	0.676
Freeboard at FP (Hf_{min}) (m)	**0.977**	1.509	1.506	1.506	1.526	1.527	1.510	1.513
Freeboard at any point (H_{min}) (m)	**0.206**	0.249	0.184	0.185	0.145	0.152	0.180	0.186
Freeboard at AP (Ha_{min}) (m)	**0.562**	0.311	0.184	0.185	0.087	0.099	0.171	0.182

Red underlined values fail the requirements

The data in table 1 indicates that, with the exception of the GMt fluid and the forward freeboard in all conditions and the freeboard at any point and area under the righting lever curve up to 30 degrees of heel in the lightship condition only, the vessel fails to comply with the stability and freeboard requirements and has very low residual stability in any condition.

The stability of a vessel will be dramatically reduced when it heels to the point where significant quantities of seawater can flood through apertures such as open hatches into the spaces that are assumed to be initially watertight. If a vessel is held over at such an angle or a greater angle for a period of time, there is the risk that such flooding will reduce the vessel's buoyancy and/or stability to the point where it will sink with or without capsizing first. Reflecting this, the regulations require that the righting lever, and thus the stability, is assumed to reduce to zero at the heel angle when the first flooding point is immersed.

Table 2 below lists the angles at which apertures in the vessel's watertight structure would become immersed in the loading conditions listed above. The angle at which the deck edge at midships on the LBP would immerse is also noted.

Table 2 – Summary of immersion heel angles for voyage profile loading conditions

Flooding points	***Loading Condition***						
	1	***2***	***3***	***4***	***5***	***6***	***7***
Access hatch to store	46.0°	29.1°	29.2°	21.4°	22.4°	28.0°	29.2°
Wheelhouse door	56.2°	48.3°	48.4°	44.7°	45.5°	48.0°	48.8°
Deck edge at midships on LBP	*10.3°*	*7.3°*	*7.4°*	*5.7°*	*6.0°*	*7.1°*	*7.4°*

The access hatch to the store has been included as a potential flooding point as it has no means of locking in the closed position.

The data in Tables 1 and 2 above indicate that, regardless of the loading condition, the vessel operated in a very dangerous state. The principal reason for this was a lack of adequate freeboard.

8. *The accident conditions*

The vessel's loading condition immediately prior to the accident was established as far as possible from the refloated boat and from information provided by suppliers.

Three accident conditions were examined:

a. Accident condition – No seawater taken on board
b. Accident condition – 1.2 tonnes seawater in Aft Peak and Store
c. Accident condition – No seawater taken on board – Aft Peak empty

Appendix 3 is comprised of the trim and stability data computed for the listed conditions – this data is summarised in Table 3 below. In all three conditions, transverse centres of gravity have been included in the deadweight tables so as to provide a more accurate model of the vessel at the time. Similarly, actual vertical centres of gravity and free surface moments have been computed for the tank contents (as opposed to maximum values used for the conditions noted in section 7), again, so as to model the condition more accurately.

Table 3 – Summary of stability and freeboard data for accident conditions

		Accident Condition		
Requirement	***Min.***	***a.***	***b.***	***c.***
Area to 30° heel (m.r.)	**0.055**	0.027	0.000	0.029
Area to 40° heel (m.r.)	**0.090**	0.027	0.000	0.029
Area 30°-40° heel (m.r.)	**0.030**	0.000	0.000	0.000
Max. GZ 30°-90° heel (m.)	**0.200**	0.000	0.000	0.000
Angle of GZ max. (degrees)	**25**	12.33	5.87	12.71
Min. GMt fluid (m.)	**0.350**	0.668	0.297	0.679
Freeboard at FP (Hf_{min}) (m)	**0.977**	1.503	1.589	1.485
Freeboard at any point (H_{min}) (m)	**0.206**	0.176	0.119	0.183
Freeboard at AP (Ha_{min}) (m)	**0.562**	0.173	-0.026	0.205

Red underlined values fail the requirements

Table 4 below lists the angles at which apertures in the vessel's watertight structure would become immersed in the accident conditions considered – the angle of deck edge immersion is also noted.

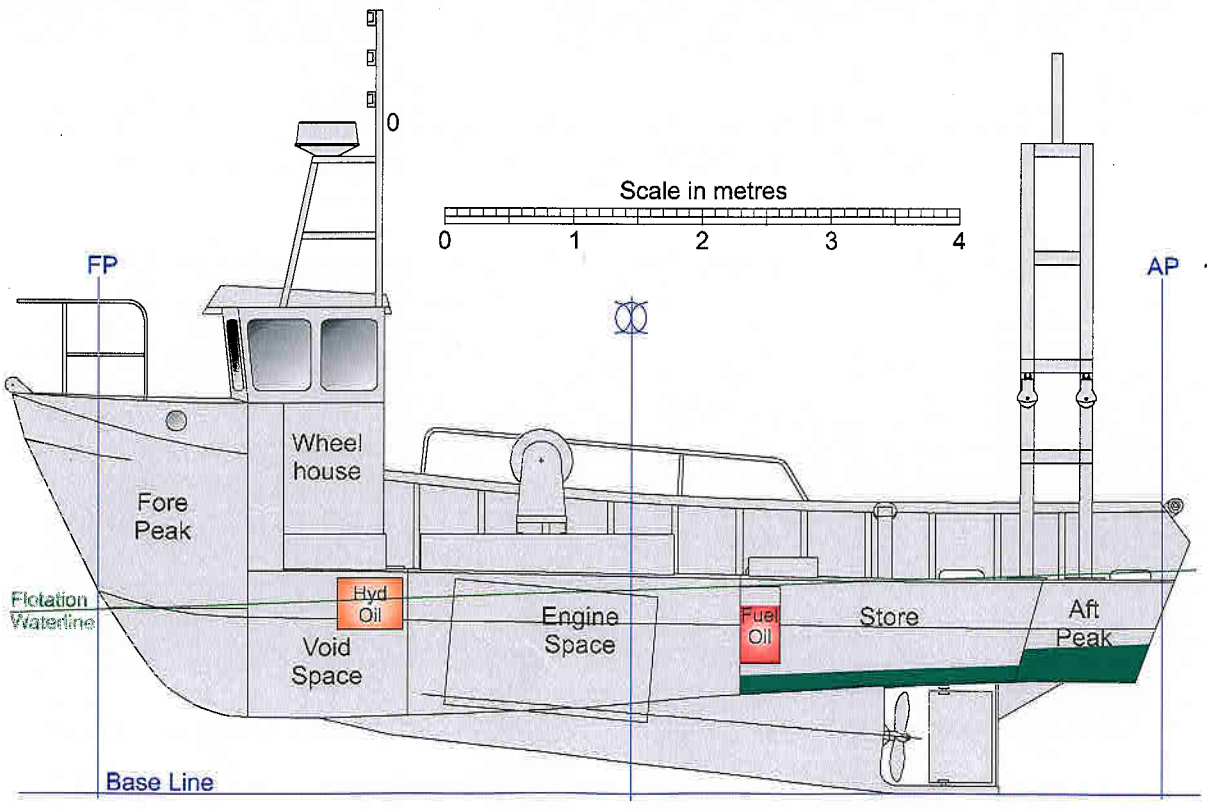
Table 4 – Summary of immersion heel angles for accident conditions

Flooding points	***Accident Condition***		
	a.	***b.***	***c.***
Access hatch to store	28.5°	17.2°	30.9°
Wheelhouse door	48.0°	45.5°	48.1°
Aft gantry bolt holes	9.6°	1.8°	10.9°
Deck edge at midships on LBP	*7.2°*	*4.9°*	*7.5°*

In accident condition a. the assumption is made that seawater has not, or has yet to find its way below the weather decks. For reasons explained below, it is unlikely that the vessel was in this condition which could be considered the 'best case' at the time of the accident in terms of the resultant stability and freeboards which are nevertheless very low.

It was noted that several of the attachment bolts for the aft gantry had not been fitted. The holes for these bolts were approximately 18mm in diameter and went through the gantry base plates and the deck, thereby giving water taken on deck through the scuppers access to both the store and the aft peak. Given this access and the very low freeboard, it is likely that seawater had been collecting in both these compartments for some time prior to the accident. Initially, the ingress of water would have been intermittent and at low pressure as the bolt holes were above the waterline. However, as more water was taken into the hull the stern was further depressed, further increasing the amount of water taken aboard as the boat rolled. Accident condition b. models the effect of 1.2 tonnes of seawater in the store and the aft peak (i.e. 0.6 tonnes in each compartment). It can be seen from the summary of results in Table 3 that this quantity of water aboard would have reduced the freeboard to minus 0.026 metres; in other words, a depth of water over the aft deck of 26 millimetres at the Aft Perpendicular. The flotation waterline with the vessel in this condition is shown in diagram 5 below.

Diagram 5 – Flotation waterline with 1.2 tonnes of seawater in store and aft peak

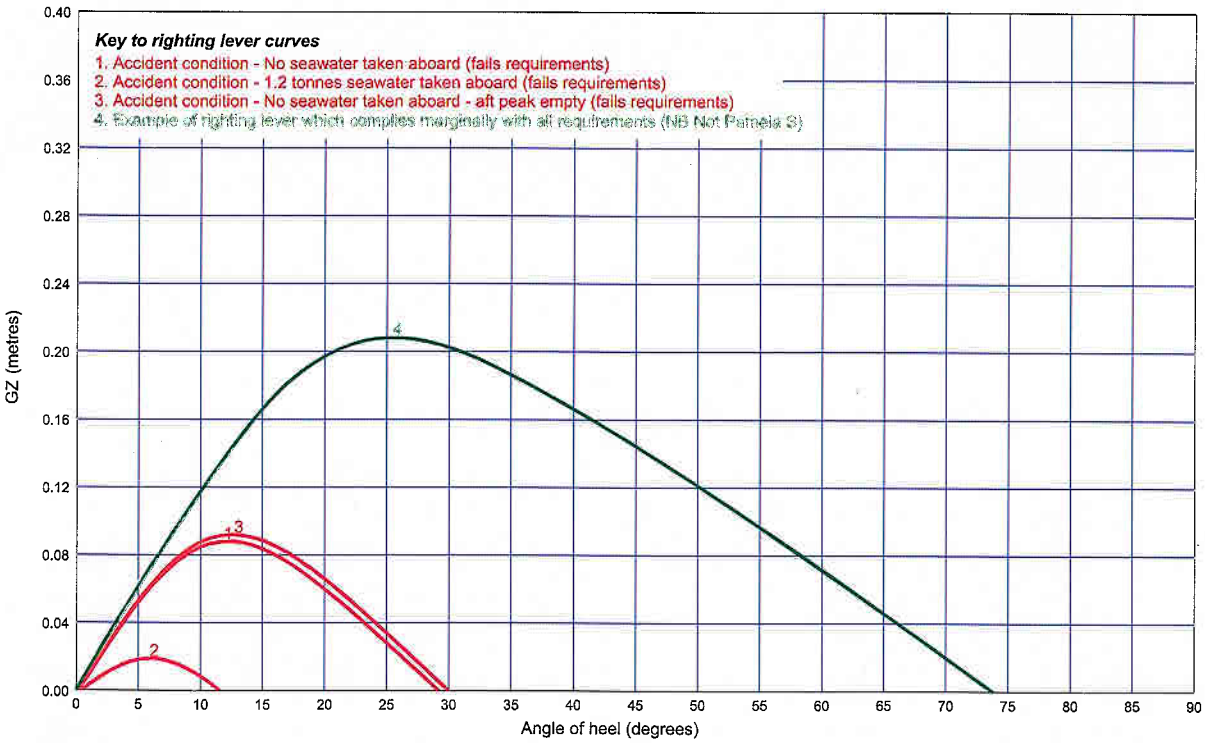


It can be seen from the flotation waterline in diagram 5 that at around this level of flooding, the flow of seawater through the bolt holes into the two aft spaces and possibly the spaces forward (the bulkheads are not watertight) would have become continuous. Further, the water pressure would be increasing as the stern sank lower in the water. By now, the accident was probably unavoidable. Reserves of stability were extremely low at this point but sufficient to hold the boat upright at least until water started to flood continuously through the store access hatch. The data for accident condition b. indicates that subsequent severe flooding into the store would initiate sinking by the stern, which would immediately take the vessel from a marginally stable to an unstable condition. The vessel therefore capsized as it sank by the stern.

Accident condition c. considers the stability of the 'Pamela S' in the same condition as a., but with the ballast in the aft peak removed. At the time of the accident, the boat was carrying about 185 kilograms of ballast, principally in the form of chain, in the aft peak. The addition of this ballast may possibly have improved the trim of the vessel in terms of its seakeeping, but it had a negligible effect on the stability (compare data for conditions a. and c. in table 3) and more important, it reduced the already critically low aft freeboard by over 30mm (19%). It is unlikely, given that the vessel already had very low freeboard aft, that the absence of the ballast would have prevented the accident from occurring, but it would certainly have delayed the point at which the accident became inevitable, thereby giving the crew more opportunity to spot the danger that they were in.

The accident was caused principally by a lack of freeboard, but emphasis is also placed on the extremely deleterious effect that that this had on the stability. Diagram 6 below superimposes all three accident condition righting levers in red on the same plot. An example of a righting lever which complies, but only marginally, with all the requirements of MSN 1770(F) (see section 6 above) is also included, coloured green, to illustrate the very significant shortfall in the vessel's stability.

Diagram 6 – Righting lever curves in accident conditions



9. *Stability in full load condition*

Comment is made in Section 7 on the maximum catch weight which a vessel such as the 'Pamela S' might be expected to carry, particularly with regard to the commercial viability of the operation. Appendix 4 is comprised of the stability and freeboard data for a loading

condition including the 2.5 tonnes catch which are considered essential for such viability. As the data indicates, the vessel has no stability in such a condition and would capsize.

10. Conclusion

Regardless of the loading condition, the 'Pamela S' has a very low level of inherent stability and insufficient freeboard relative to the provisions of Merchant Shipping Notice 1770(F). However, it is interesting to note that in all conditions bar the flooded accident condition the boat had a $GM_{transverse}$ value well in excess of the required figure (0.35 metres). As GMt is a measure of initial stability, it must be concluded that this aspect of the vessel's stability was adequate.

The boat's very low freeboard throughout the length of the working deck inevitably increased the tendency for seawater to be taken aboard through the four scuppers in the Port and Starboard bulwarks as the boat rolled and for this water to collect on deck. The open holes in the deck around the aft gantry base plates and a deck hatch which could not be locked shut made it possible for this deck water to get into the hull. This increasing quantity of water in the hull compartments was sufficient to gradually reduce the freeboard still further until catastrophic flooding was initiated through the store hatch followed by loss of the vessel.

Although the accident was principally caused by low freeboard, it should be noted that this characteristic had a less obvious, but no less significant, impact on the vessel's inclined stability, which fell a long way short of the requirements of MSN 1770(F). The advice from experts in the particular mode of fishing employed on the 'Pamela S' is that it would be necessary for the boat to be able to load between 2 to 2.5 tonnes of catch to make such an operation commercially viable. However, the stability data indicates that with such a load aboard, the vessel would have capsized whether or not seawater had found its way into the hull compartments.

Appendix 1

Inclining Trial Report

Inclining Trial Report

Vessel name/number ..... : 9 metre MFV 'Pamela S'
Trial location ..... : Quayside at Burry Dock, South Wales
Trial time and date ..... : Commencing at 10:00hrs on 28th July, 2006
Weather conditions ..... : Negligible wind
Water conditions ..... : Negligible water movement
Mooring lines ..... : Slack lines fore and aft
Specific gravity of water ..... : 1.025
Vessel condition ..... : See table of items to come off and go on
Draught at Forward Perpendicular (FP) : 1.586 metres about Base Line
Draught at Aft Perpendicular (AP)..... : 1.399 metres about Base Line
Mean draught at midships LBP ..... : 1.493 metres about Base Line
Trim over LBP ..... : 0.187 metres by bow
Pendulum 1 (fore) ..... : 2.388 metres length located in wheelhouse
Pendulum 2 (aft)..... : 2.402 metres length located at wheelhouse door
Inclining weights ..... : 10x25kg weights, CGs located 2.275 metres apart
Personnel ..... : Mr. M. Evans - MAIB
Mr. N. MacWhirter - Marine Data International Ltd.

Pendulum deflection table

Move No.	*Weight moved tonnes*	*Distance weight moved - metres*	*Deflections Fore pendulum - mm*	*GM fore metres*	*Deflections Aft pendulum - mm*	*GM aft metres*
1	0.025	2.275	18.0	0.783	19.5	0.727
2	0.025	2.275	18.5	0.762	20.0	0.709
3	0.025	2.275	20.0	0.705	21.5	0.660
4	0.025	2.275	18.0	0.783	19.0	0.746
5	0.025	2.275	21.0	0.671	21.0	0.675
6	0.025	2.275	18.0	0.783	19.0	0.746
7	0.025	2.275	21.0	0.671	21.0	0.675
8	0.025	2.275	20.0	0.705	19.0	0.746
9	0.025	2.275	18.5	0.762	21.0	0.675
10	0.025	2.275	18.0	0.783	21.0	0.675
11	0.025	2.275	20.5	0.688	19.5	0.727
12	0.025	2.275	19.5	0.723	20.0	0.709
13	0.025	2.275	21.0	0.671	19.0	0.746
14	0.025	2.275	20.5	0.688	20.5	0.692
15	0.025	2.275	19.0	0.742	20.0	0.709
16	0.025	2.275	19.0	0.742	20.0	0.709
17	0.025	2.275	20.5	0.688	20.5	0.692
18	0.025	2.275	21.0	0.671	21.0	0.675
19	0.025	2.275	19.5	0.723	18.0	0.788
20	0.025	2.275	19.5	0.723	19.5	0.727
			Mean GM fore	*0.723*	*Mean GM aft*	*0.711*

Inclined condition

Displacement .. : 9.633 tonnes
KMt ..... : 2.475 metres
GMt mean ..... : 0.717 metres
KG fluid ..... : 1.758 metres above Base Line
LCG ..... : 4.072 metres aft of FP (corrected for trim)

Items to come off to achieve lightship condition

Item	Weight tonnes	LCG - m about FP	Long'l moment t.m	VCG - m about Base	Vertical moment t.m	TCG - m about C/L	Transverse moment t.m	FSM t.m
Inclining weights	0.250	4.310	1.078	1.770	0.443	0.000	0.000	-
Heel correction weights	0.125	2.850	0.356	1.795	0.224	-1.163	-0.145	-
1 person at forward pendulum	0.087	1.130	0.098	1.550	0.135	0.000	0.000	-
1 person at aft pendulum	0.085	2.400	0.204	2.250	0.191	0.000	0.000	-
Oil fuel tank contents (SG 0.92)	0.297	5.135	1.525	1.351	0.401	0.000	0.000	0.000
Hydraulic oil tank contents (SG 0.84)	0.053	2.111	0.112	1.474	0.078	0.000	0.000	0.000
Miscellaneous items - aft peak	0.185	7.700	1.425	1.080	0.200	0.000	0.000	-
Total items to come off	*1.082*	*4.434*	*4.798*	*1.545*	*1.672*	*-0.134*	*-0.145*	*0.000*

Items to go on to achieve lightship condition

Item	Weight tonnes	LCG - m about FP	Long'l Moment t.m	VCG - m about Base	Vertical Moment t.m	TCG - m about C/L	Transverse moment t.m	FSM t.m
Engine space hatch	0.029	3.233	0.094	2.025	0.059	0.000	0.000	-
Total items to go on	*0.029*	*3.233*	*0.094*	*2.025*	*0.059*	*0.000*	*0.000*	*0.000*

Lightship Summary

Item	Weight tonnes	LCG - m about FP	Long'l Moment t.m	VCG - m about Base	Vertical Moment t.m	TCG - m about C/L	Transverse moment t.m	FSM t.m
Inclined condition	9.633	4.072	39.226	1.758	16.935	0.000	0.000	0.000
Total items to come off	-1.082	4.434	-4.798	1.545	-1.672	-0.134	-0.145	0.000
Total items to go on	0.029	3.233	0.094	2.025	0.059	0.000	0.000	0.000
Lightship	*8.580*	*4.024*	*34.522*	*1.786*	*15.321*	*0.017 to Port*	*-0.145*	*0.000*

Annex 4

Volume of water flowing through an 18mm hole (Bernoulli)

Assume:

- Atmospheric pressure
- head of water = 25mm
- Hole size 18mm

Bernoulli's theory.

$P/W + h = V^2/2g$
(Where P/W =pressure energy per unit weight,
g = gravitational force,
h = head of water)

(As atmospheric pressure P=0)
=» $V^2 = 2gh$

Rate of flow, Q = Cd a V
Where:
Q = rate of flow in m^3/s
a = area of hole
Cd = coefficient of discharge = 0.97 for a round orifice)

Q= Cd a □2gh
= 0.97 x ∏ x $(0.009)^2$ x √2 x 9.81 x (0.025)
=0.000173 m^3/s
=0.0103 m^3/min
= 0.622m^3/hour

The above assumes perfectly rounded edges .
For the purpose of this investigation assume Cd = 0.8

Q = 0.000143m^3/s
= 0.0086m^3/min
= 0.513m^3/hour per hole

Thus, for the purposes of this report a flow rate of 0.5 m^3/hour has been assumed.