Submersion of the fishing vessel O-Yang No.70

1.The Facts

Name of Vessel	O-Yang No.70
Port of Registry	Busan, South Korea
Shipowner	AAAA
Gross Tonnage	1,598.67tons
Engine power and type	One 2,794kW diesel engine
The one involved in the accident	AAAA(CEO)
Title	Shipowner
The type of marine officer's license	N/A
Time and Date of Accident	0457 hrs(UTC+12hrs) on 18th August 2010
Location of Accidnet	Lat. 48°00'00"N, Long. 179°44'00"E At the sea of about 470miles southeast from DUNEDIN port, New Zealand

A. The facts

At 1000 hrs(UTC+12hrs, New Zealand local time) on 14th August in 2010, the O-Yang No.70 left the port of DUNEDIN, New Zealand for pollack trawl fishing with a crew of 51 including the master BBB and a vacancy of a second officer. At 2140 hrs on 15th of the same month, the vessel arrived at the sea of 470 miles southeast from the DUNEDIN port, New Zealand and started its fishing job.

As the fish catches were high at the sea arrived, the vessel stayed at the point for three days casting and hauling nets three times. At 0300 hrs on 18th of the same month, it began forthly hauling nets when the chief officer CCC was handed over the watchkeeping duty from the master BBB.

When winding up the rope of nets that were still in the water, the chief officer recognized that the fish catches in the net were remarkably heavy. Considering the difficulty of hauling job, the first officer requested the master who was sleeping to command the hauling operation by telephone at 0305 hrs on the same day and the master BBB came up to the wheelhouse and commanded the hauling job, While the master BBB came up to the wheelhouse and command the hauling job, the nets were being raised to the upper deck. The boatswain DDD on the upper deck reported the master BBB that the amount of fish catches were too much and part of them had to be abandoned by opening the net in the sea water, therefore the master allowed to do so. Under the master's direction, the boatswain DDD abandoned about 20 tons out of 85 tons of fish catches at the sea around the stern and continued hauling operation, but he did not tie the rope of the net which was equipped to prevent the nets from being listed to one side.

At 0340 hrs on the same day, the nets hauled slanted to the left during the hauling operation and the hull of the vessel listed 4~5° to port, which caused the flowing backward of sea water to the fish handling space as the check valve of the drains did not work. The fish handling manager JJJ who was working in the space found that the drains at the stern emitted foam letting the sea water flow backward to the space, so that he asked the first engineer EEE, who was on duty in the engine room, to adjust the heeling of the hull. Therefore, the first engineer EEE began moving the fuel oil from portside to starboard through the fuel transfer pump installed at the bottom of the engine room.

At 0355 hrs of the same day, the hauling job was completed under the condition that the nets were gathered to the left and the hull heeled about 15° to portside when all nets were almost raised on the upper deck. When the nets were open to put the fish catches inside of the nets into the fishpond hatch, it was found that the fishes were attached each other due to the heavy weight of the total fish catches in the net, so they failed to be poured into the fishpond hatch smoothly. Moreover, as the hull heeled to port continually with the influence of the sea water flowing backward, the hauled nets on the upper deck also slanted to port more and more.

As the hull heeled to port letting the hauled nets slanted to port, the master BBB tried to turn the hull through hard-a-port considering that the heeling of the hull could be recovered by using the external heeling while turing the hull. However, the internal heeling occurred at the early time of the hull turning and made it increased, which caused that a large amount of sea water flooded into the fish handling space through the drains and the hole for filth. After all the water went into the engine room through the door open at that time.

As the sea water invaded into the engine room, the heeling of the hull was worsened and the master BBB directed all crew members to be ready for leaving the vessel at 0400 hrs on the same day. While the hull heeled continually and the sea water came into through the fishpond hatch of the upper deck, at 0420 hrs on the same day the master BBB judged that it was not possible to recover the situation and directed all crew members to leave the ship, hence, all crew members excluding the master who was sending distress signals left the vessel by life rafts, etc. At 0457 hrs on the same day, the vessel completely capsized and sank on position Lat. 48°00'00"N, Long. 179°44'00"E.

At 0610 hrs on the same day, 45 crew members of the O-Yang No.70 who were drifting on 7 life rafts were rescued by the New Zealand fishing vessel AMALTAL ATLANTIS, which listened the distress signals of the O-Yang No.70 and came for rescue. Three members drawn were found and another three including the master BBB were missing.

At the time of the accident, the weather was clear and the sea was also calm without wind and wave, but it was very cold.

B. Structure, equipment and the condition of the O-Yang No.70

The Korea(Busan)-registered steel deep-sea trawl vessel O-Yang No.70 is 1,598.67 G/T(L74.45 x B12.6 x D8.00m) with a 2,794㎾ diesel engine and was built and launched by Yamanishi Co., Ltd in Japan. She underwent the special survey by the Korean Register of Shipping and achieved a ship inspection certificate valid from 23 December 2009 until 22 December 2014.

The wheel-house of this vessel is located at the bow and there are trawl winch, derrick and a hole for throwing fish on the upper deck while the freezing room, temporary fish hold, fish handling space, etc are located under the upper deck. The two fish holds no.1 and no.2 are at the lowest space with the engine room.

A sea water pump(10ton/hr) for washing fish is connected to sixteen washing valves(2.5㎝ of diameter) through sea water pipe(15㎝ of diameter) at the fish handling space. Four drains(diameter 200㎜ x 2units, 150㎜ x 1 unit, 125㎜ x 1unit) with check valves for discharging treated wastewater are on the starboard and portside respectively. However, the drainage facilities are not inspected and maintained properly, so that the check valve of the drain does not function. Therefore, the vessel was in a dangerous situation that sea water could flow backward to the fish handling space under the heel angle of more than 4.5°.

There is a sewage outlet(800 x 500㎜) at about 300㎜ high from the bottom in the fish handling space for discharge smashed filth remained after handling fish out of the vessel. Although the outlet is usually closed with its watertight door, it was open at the time of the accident. In short, the vessel was in a situation that sea water might have flooded into the fish handling space if had heeled more than 9.1°.

The passage from the engine room to the fish handling space was equipped with a watertight door on the portside and the door should be closed all the time of sailing. Nevertheless, the door was being open at the time as the crew members had to often pass the passage as checking the condition of fishing equipments, freezing condition, etc.

At 2140((UTC+12hrs, New Zealand local time, the same as above) on 15th August 2010, the O-Yang No.70 arrived at the sea about 470miles southeast from DUNEDIN port of New Zealand and conducted fishing job three times as casting and hauling nets for three days.

While the vessel was hauling nets fourthly at 0300 hrs on 18th of the same month, 3000 boxes(approx. 78tons) of fish that had been caught were handled and stored at the fish holds and 200 pans(approx. 2.6tons) of fish was being handled at the fish handling space, She was also carrying about 520 tons of fuel oil(Bunker B oil) and 10 tons of other oil such as lubricant.

C. Consideration of the stability

1) Fish

Among the fish caught, ① 3000 boxes(approx. 78tons) of dressed fish were stacked in fish holds and ② 200 pans(approx. 2.6tons) of fish that were caught at the third hauling operation were being dressed. Detailed information of the fish stacking condition is as shown in the Table 1 below.

ITEM	WEIGHT	L.C.G.	MOMENT(T-M)		K.G.	MOMENT
	TON	M	FWD.	AFT.	M	T-M
Fish(Hold no.1)	39.000	+15.017	585.663		3.610	140.790
Fish(Hole no.2)	39.000	+2.009	78.351		3.415	133.185
Temp. storage(LOBBY)	2.6000	-3.237		8.416	6.852	14.815
TOTAL	80.600	+8.134	655.598		1.780	143.500

2) Fuel oil

520 tons of Bunker B oil was loaded as shown in the Table 2 below.

ITEM	WEIGHT	L.C.G.	MOMENT(T-M)		K.G.	MOMENT
	TON	M	FWD.	AFT.	M	T-M
No.1 F.O.T.(P&S)	220.000	+26.052	5731.440		3.783	832.260
No.2 F.O.T.(P&S)	70.000	+14.057	983.990		0.656	45.920
No.3 F.O.T.(P&S)	65.000	-1.652		107.380	0.448	29.120
No.3 F.O.T(C)	70.000	-2.069		144.830	0.551	38.570
No.4 F.O.T(P)	5.000	-15.222		76.110	0.730	3.650
No.4 F.O.T(S)	5.000	-16.176		113.232	0.936	4.680
No.5 F.O.T.(P&S)	40.000	-36.625		1465.000	5.907	236.280
No.5 F.O.T(C)	35.000	-36.915		1292.025	5.380	188.300
No.6 F.O.T.(P&S)	10.000	-38.299		306.392	7.311	73.110
TOTAL	520.000	6.174	3210.461		2.792	1451.89

3) Lubricating oil

10 tons of other types of oil including lubricant was loaded as shown in the Table 3 below.

ITEM	WEIGHT	L.C.G.	MOMENT(T-M)		K.G.	MOMENT
	TON	M	FWD.	AFT.	M	T-M
L.O.S.T.(C)	7.000	-22.076		154.532	0.397	2.779
L.O.T.(C)	3.000	-14.637		43.911	0.306	0.918
TOTAL	10.000	-19.844		198.443	0.369	3.697

4) Fresh water

Considering that the maximum amount of fresh water that can be stored in the O-Yang No.70 is 66 tons, it is estimated that there was 50 tons of fresh water remained at that time after using the water for four days, as shown in the Table 4 below.

ITEM	WEIGHT	L.C.G.	MOMENT(T-M)		K.G.	MOMENT
	TON	M	FWD.	AFT.	M	T-M
F.W.T.(P&S)	30.000	-31.200		936.000	5.274	158.220
F.W.T(C)	20.000	-31.564		631.280	4.141	82.820

TOTAL	50.000	-31.346		1567.280	4.821	241.040

5) Foods

According to the data for departure on the stability checking sheet of the O-Yang No.70, the food loading condition of the vessel was as shown in the Table 5 below.

ITEM	WEIGHT	L.C.G.	MOMENT(T-M)		K.G.	MOMENT
	TON	M	FWD.	AFT.	M	T-M
Foods	9.450	+20.050	189.473		9.533	90.090

6) Displacement and MOMENT

The displacement and moment of O-Yang No.70 are as shown in the Table 6, referring to the stability checking sheet of the vessel.

ITEM	WEIGHT	L.C.G.	MOMENT(T-M)		K.G.	MOMENT
	TON	M	FWD.	AFT.	M	T-M
Light displacement	1462.160	-4.258		-6225.977	6.009	8786.571
CREWS & EFFECTS	7.560	+18.851	142.516		8.171	61.776
STORES & SPARES	8.800	+6.365	56.011		8.086	71.160
PORTABLE TANK	18.807	-23.222		-436.735	6.134	115.362
Fishing gear	71.000	-14.179		-1006.730	8.648	614.000
Fuel oil	520.000	6.174	3210.461		2.792	1451.890
Fresh water (fore peak tank)	50.000	-31.346		-1567.280	4.821	241.040
Foods	9.450	+20.050	189.473		9.533	90.090
Fish(Fish hold no.1)	80.600	+8.134	655.598		1.780	143.500
Total displacement	2,228.377	-2.236		-4982.663	5.195	11,575.389

7) Free surface effect

Based on the stability checking sheet, the free surface effect of the O-Yang No.70 is as shown in the Table 7 below.

ITEM	I(M4)	S.G	I x S.G

Fuel oil tank	188.334	0.860	161.967
Lubricating oil tank	0.444	0.870	0.386
Fresh water tank	7.320	1.000	7.320
TOTAL	169.673		
GGo	0.056		

8) Hydro Particulars of the stability calculation

Reflecting all factors considered above in the stability calculation process of the O-Yang No.70, the hydro particulars are as shown in the Table 8 below.

ITEM	UNIT	VALUE	Draft interpolation
Displacement	W(T)	2,228.377	
Draft	deq(M)	4.297	
Transverse metacenter height	KM(M)	5.811	
	KG(M)	5.195	
Metacenter height	GM(M)	0.616	
Longitudinal center of buoyancy	LCB(M)	-0.191	
Longitudinal Center of Gravity	LCG(M)	-2.236	
LCB-LCG	BG(M)	-2.045	
Trim by the draft	MTC(T-M)	28.175	
Apparent trim	(M)	-1.617	
Fore draft(LBP)	dF(M)	3.477	-0.820
Aft. draft(LBP)	dA(M)	5.090	+0.793
Mean draft	dM(M)	4.284	
Free surface effect	GGo	0.056	
Height of center (KG+GGo)	(M)	5.251	
Metacenter height **(GM-GGo)**	**GoM(M)**	**0.560**	

9) The required metacenter value of the O-Yang No.70 according to the stability regulation

According to the stability provisions, the required metacenter of the vessel at the time of the accident was

GoM=0.04B+a×B/D-ß

(GoM: metacenter value, B: width of the vessel(12.600), D: depth of the vessel(5.600)

a: 0.54 in case of steel vessel, ß depends on the F/D value)

0.04B= 0.04×12.600=0.504m

a×B/D=0.54×12.6/5.600=1.215

Freeboard=Df(Freeboard Depth)-Mean draft

Df(Freeboard Depth)

= Moulded depth(Dm) of amidships +Bar Keel+Keel F.B+Deck Stringer+Keel Plate

= 5.600+0.174+0.012+0.007+0.014=5.807M

F=Df(Freeboard Depth)-mean draft=5.807-4.284=1.523

Therefore, F/D=1.523/5.600=0.272

ß is 1.081 according to the F/D value,

Therefore, GoM=0.504+1.215-1.081=0.638m

10) Conclusion

As being considered above, it is estimated that the O-Yang No.70 conducted its fishing job with 0.560m of metacenter height at the time of the accident, which was not satisfied the standard metacenter height of 0.638m required by the stability provision.

2. Causes

The Article 2.1.A, B and D of the「the Marine Accident investigation and Tribunal Act」shall be applied to this submersion accident.

A. Consideration of causes

1) Stability of the O-Yang No.70

At the time of the accident, the metacenter height of the O-Yang No.70 was 0.560m, which did not satisfied the standard metacenter value 0.638m of the vessel required by the stability regulation. While conducting the fishing job without securing enough stability, the vessel hauled the nets excessively full of fishes by force, which caused heeling. In result, sea water flooded into the drains of the fish handling space and was not recovered.

2) Heeling caused by the hauling nets

If the fish catches(about 76 tons) hauled list to port on the upper deck,

$GoM=[(w \times d)/\triangle] \times (1/\tan\theta)$, therefore,

w=moving weight(ton)

d=moving distance(Estimate a movement of 3m from amidships to port)

$\triangle$ =Displacement

$0.560=[(65 \times 3)/2228.4] \times (1/\tan\emptyset)$

$\emptyset \fallingdotseq 8.9°$

According to the calculation, approximately 8.9° of heeling occurs, however, it needs to consider that the stability would be much worse if 65 tons of fish catches are hauled on the upper deck and the heeling becomes bigger than the value of the calculation.

3) Conditions for flowing backward to the drains of the fish handling space

When the O-Yang No.70 heeled 8.9° to port, the drains of the fish handling space which was located about 0.5m height from the sea water surface becomes approx. 0.5m lower than the sea water surface. In this condition, the drains cannot prevent the sea water from flowing backward, so the water floods into the fish handling space, which causes the decrease of stability of the vessel and the hull heels to port.

4) Consideration of the improper sailing

The master BBB put the helm hard a port to adjust the heeling hull as the hauling nets listed to port increasing the RPM of the main engine. However, it is estimated that those actions taken at that time facilitated the submersion by letting the hull list toward the turning side(internal heeling).

According to the hull movement principles, the hull heels to the inward of the turning circle(internal heeling) and then to the outward of the turning(external heeling) when a steady turning becomes possible with a certain degree of turning angular speed, not heeling to the constant side during the turning.

That is, the hull heels to the inward of the turning circle at the beginning of the turning and then heels to the outward of the circle due to the centrifugal force afterwards. These are referred to internal heeling and external heeling respectively.

According to the basic knowledge of the hull movement principles, if the helm puts at large angle when the hull proceeds forward straight, there will be a force(MOMENT) to heel towards the side where the helm turned to(the listed side in this case). This is because the hull receives the water pressure(Fluid force) in proportion to the size of the turning angle of the helm while proceeding forward, so the advanced speed of the hull decreases due to the rudder force.

The rudder force increases in proportion to the angle of the helm and the speed while the longitudinal factors of the rudder force decreases the speed of the vessel and the transverse factors causes heeling of the hull toward the side where the helm turned to.

Afterwards, the centrifugal force occurs as the turning speed of the hull increases, which makes the hull hell to the opposite side of the turning direction. As the heeling occurs outward, that is, the opposite of the turning direction(the center of the turning), it is referred to external heeling.

B. The causes of the accident

This submersion accident occurred as the inspection and maintenance for the drain facilities of the fish handling space in the O-Yang No.70 were not conducted, so that the function for preventing sea water from flowing backward did not work while the hull heeled as the fishing nets listed to port during the hauling job under the insufficient stability, which caused the flooding of sea water into the vessel through the drains of the fish handling space increasing the hull heeling, and, therefore, led to capsizing and submersion of the vessel.

3. Lessons learned

A. In case of a trawl fishing vessel, the drains on the side of the fish handling space is equipped with the facility for preventing sea water from flowing backward, so discharging from inside to outside is possible but the reverse is prevented. However, the function does not work when the inspection and maintenance are negligent, which lets the sea water flow into the fish handling space and lose the stability, hence the vessel might capsize and sink.

B. When the nets are hauled on the upper deck with insufficient stability in a trawl fishing vessel, the nets can be listed to a side, which may cause a severe heeling.