On the Accidents of Small Fishing Vessels

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ABSTRACT

Fishing takes place in a natural environment that often becomes hostile to people and their vessels. Many studies point out these dangerous situations, specially on small vessels ones. In this paper, maritime accidents on three small Spanish fishing vessels during 2004 are studied.

As it is mentioned by IMO, the safety of seafarers and passengers and the protection of the marine environment can be enhanced by timely and accurate reports identifying the circumstances and causes of marine casualties and incidents. Although, this paper does not constitute an official report, it pretends to shed some light in this type of accidents.

Considerations about the causes of these accidents, hydrostatic calculations and some related experimental work are also included.

Keywords: *maritime accidents, fishing vessels, ship stability*

1. INTRODUCTION

Despite the best endeavours of all the people involved in the maritime sector, casualties and incidents resulting in loss of life and ships and pollution of the marine environment continue to occur.

As it is mentioned by IMO (1997), the safety of seafarers and passengers and the protection of the marine environment can be enhanced by timely and accurate reports identifying the circumstances and causes of marine casualties and incidents.

The investigation and proper analysis of marine casualties and incidents may lead to greater awareness of casualty causation and result in remedial measures for the purpose of enhancing safety of life at sea and protection of the marine environment.

As it is indicated in many previous works (Roberts, 2002, Hall, 1997), the commercial fishing industry is one of the most dangerous and deadly occupations in many countries. These works show that fishermen have been 50 times more likely to have a fatal accident over the last twenty years than the average worker.

In this paper, three maritime accidents related to three small Spanish fishing vessels are presented in order to shed some light in this type of accident in which the stability get a very important role.

2. BRIEF DESCRIPTION OF THE ACCIDENTS

A brief description of the accidents are presented, according to the official investigation,

“O Bahía”

The 2nd. of June of 2004, the ship “O Bahía” sank at the waters near Sisargas Islands (43º 22.5 N, 8º 52.6 W) on her way from Burela port (Lugo) to Vigo estuary. It drew to death 6 crewmen and other 4 disappeared.

“Enrique el Morico”

This ship sank on the 3rd, August 2004 at the Alboran Sea (36º 14.1 N, 2º 42.3 W), in front of the Almeria coast (South of Spain) due to two successive sea strokes. The skipper disappeared and the rest of the crew was rescued.

“Nuevo Pilín”

The ship “Nuevo Pilín” was lost at the Cantabric Sea, near Bilbao port (43º 34.0 N, 3º 13.6 W) on 19th, November 2004 . Three crewmen were dead and two more disappeared.

In figure 1, the locations of the three accidents are presented.

2.1 Sea States

In the three cases an study of the sea states was performed by “Centro de Estudios y Experimentación de Obras Públicas (CEDEX)” based in the data obtained from the Spanish Network of buoys and the Spanish Meteorological Centre and studies of wave generation from the “Puertos del Estado” Institution.

The data for the significant heigh ($H_{1/3}$), the modal period (T_z) and wave length (λ) are indicated in the table 1.

Figure 1 Locations of the accidents

Table 1. Sea States Characteristics

Ship	**$H_{1/3}$(m)**	**T_z(s)**	**λ(m)**
O Bahía	2.7	5.2	42
E.el Morico	0.9	3.1	15
Nuevo Pilín	2.5	5.5	47

A significant change on the predominant wave direction was detected in the three cases. At the ship O Bahía was a change from 300º to 60º. At the Nuevo Pilin the change was between 210º and 45º and for the Enrique el Morico between 90º and 270º.

2.2 Loading Conditions

The loading conditions estimated during the accidents are presented in the table 2, obtained from information collected from rescued ship hulls or supplied by survivals.

Table 2. Loading conditions at the accidents

Ship	O Bahia	E. Morico	N. Pilin
Disp (t)	74.28	38.9	69.39
Xg (m)	6.23	6.01	6.921
Zg (m)	2.22	2.034	2.191

On the O Bahia ship, two wet nets on deck were included. For the Enrique el Morico case, some water drums on deck at the port side to equilibrate some fishing tackels at the starboard side were considered. In this case, 650 trapnets were also considered. These conditions defer from those considered in the official Stability Booklet.

3. SHIP DATA

3.1 Ship particulars

The characteristics and different data from the ships are presented in the table 3,

Table 3. Ships Characteristics

Ship	O Bahia	E. Morico	N. Pilin
Loa (m)	18.00	16.02	17.75
Lpp (m)	13.50	13.80	13.50
B (m)	5.20	4.57	5.00
D (m)	2.35	2.15	2.35
T (m)	1.65	1.79	2.00
GT	44	30	37
Power (HP)	250		
Speed (kn)	10.5		8
Material	steel	FRP	Steel
Built	1999	2000	2001
Type	seiner	long liner	Seiner
Displac. (t)	75.98	39.047	85.46

These values point out the similarity between these ships. The figures 2-4 presents the body plan" and the figures 5-7 the general arrangement of the three ships. The figure 8 includes the comparison between the sectional area curves.

This shows that also the ship lines are very similar, only the aft section of the Enrique el Morico is slightly different.

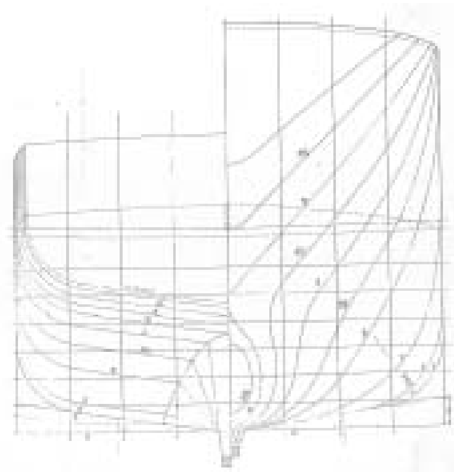

Figure 2 O Bahia Body Plan

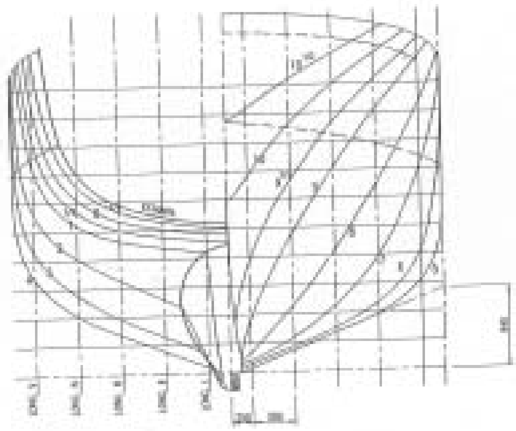

Figure 3 Enrique el Morico Body Plan

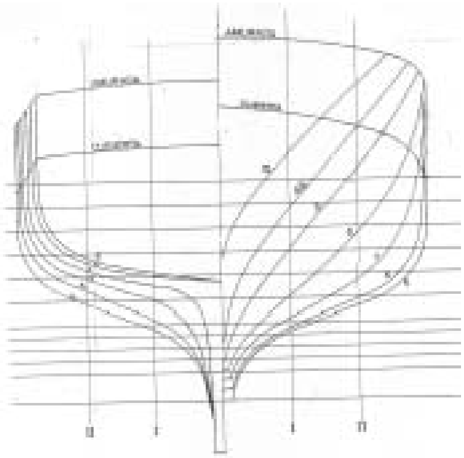

Figure 4 Nuevo Pilin Body Plan

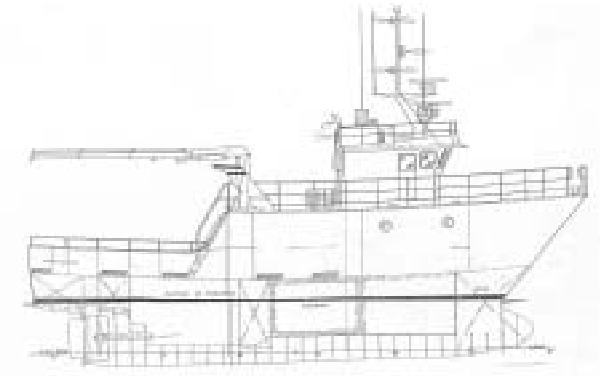

Figure 5 O Bahia General Arrangement

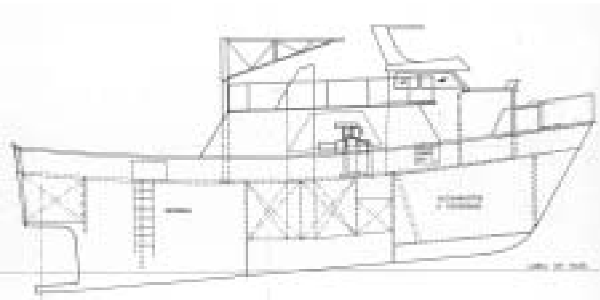

Figure6 Enrique el Morico General Arrangement

Figure 7 Nuevo Pilin General Arrangement

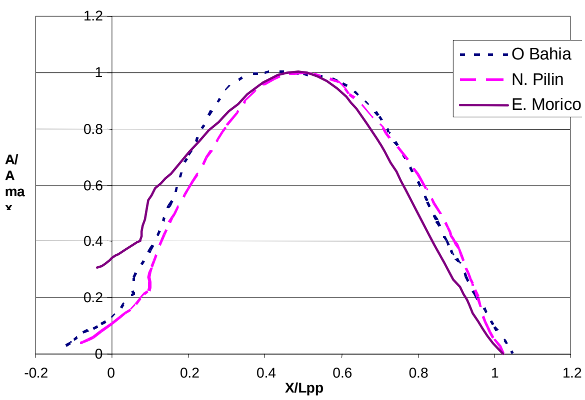

Figure 8 Sectional Area Curves

3.2 Stability Values

Table 4 collects the stability values from the "Stability Booklet" from each ship referred to the most compromising loading condition

Table 4. Stability Values

Ship	OBahia	Morico	N.Pilin	Criteria
Loading	Ar.100%	fish.dep..	Ar.20%	
Disp(t)	73.83	38.95	71.97	
T(m)	1.66	1.77	1.977	
trim (m)	0.01	0.181	-0.792	
GM(m)	0.639	1.13	0.612	> 0.35
GZ_M(m)	0.243	0.341	0.316	>0.200
$GZ_M(\theta)$	25º	27.5º	> 25º	> 25º
A_{30^o}	0.080	0.100	0.069	>0.055
A_{40^o}	0.115	0.154	0.113	>0.090
$A_{40^o-30^o}$	0.035	0.054	0.043	>0.030

As it can be seen, all the requirements are met, but in some cases very slightly. Based on the ship lines and loading conditions presented in the "Stability Booklets", the stability values have been calculated again using a program developed by the ETSIN and also with another two widely used commercial programs, stated as COM1 and COM2.

Significant differences have been found and some percentages related to these discrepancies are included as examples in the following table 5.

Table 5. Stability Values Discrepancies

	ETSIN	Com 1	Com 2
O Bahia			
Loading	Arr.100%	Arr.100%	Arr.100%
A_{40^o} -A_{30^o}	13.3%	16.3%	17.1%
E. Morico			
Loading	Arr.100%	Arr.100%	Arr.100%
A_{30^o}	30.2%	30.6%	29.6%
N. Pilin			
Loading	Depart.	Depart.	Depart.
A_{40^o} -A_{30^o}	36%	32%	36%

These discrepancies in the case of the O Bahia ship, mean that some stability criteria are not fulfilled. In the table 6 some values are presented.

Table 6. Recalculated Stability Values

	ETSIN	Com 1	Com 2	Criteria
Loading	Depart.	Depart.	Depart.	
$A_{40^o\text{-}30^o}$	0.028	0.029	0.027	>0.030
$GZ_M(\theta)$	23°	24°	23°	> 25°

The stability values at loading conditions at the accident using the ETSIN program are included in the following table 7.

For the O Bahia and Nuevo Pilin ships, the stability criteria are not fulfilled.

Table 7. Stability Values at Accidents Loading Conditions

Ship	O Bahia	Morico	N.Pilin	Criteria
Disp(t)	74.28	38.9	69.39	
T(m)	1.63	1.78	2.13	
trim (m)	0.45	0.18	-0.74	
GM(m)	0.564	1.104	0.451	> 0.35
GZ_{30^o}(m)	0.135	0.349	0.100	>0.200
$GZ_M(\theta)$	22°	27°	39°	> 25°
A_{30^o}	0.061	0.122	0.038	>0.055
A_{40^o}	0.076	0.179	0.056	>0.090
$A_{40^o\text{-}30^o}$	0.014	0.057	0.018	>0.030

4. LOSS OF TRANSVERSE STABILITY ON A WAVE CREST

According to Umeda & Hamamoto (2000), the loss transverse stability on a wave crest is one of the four capsizing modes of a ship. This is produced by the reduction of the metacentrical height when the ship is sailing in such condition, because the hydrostatic restoring moment is quite lower than the one obtained in still water.

It is widely accepted that the restoring arm decreases when the ship centre is situated on a crest of longitudinal waves, and this can be proved both mathematically and experimentally (Hashimoto et al. 2002), and this effect is most critical when wave length value is near ship length. It is also believed that this phenomenon can be mathematically explained by integrating the wave pressure up to the wave surface with the Froude-Krylov assumption.

This assumption can be used to obtain the effect of regular waves on ship stability. Nevertheless, this theory has some limitations, e.g. slender ships and high frequency of oscillation can not be analysed with this theory (Salvensen et al. 1970). Fishing vessels have low Lbp/B ratios and are not an example of slender ships. In the case of pure loss of stability in following seas, encounter frequency is low. So, the mentioned assumption shows limitations to model the problem.

According to Pauling (1961), in the case of following seas where the ship is sailing at wave speed, the viscous effects can be neglected in respect to hydrostatic forces that appears due to the variation of the waterplane form due to the effect of the wave. If the wave profile (Figure 9) is used to obtain the GZ curve, with the wave crest in a fixed position with respect to amidships, the pure loss of stability can be seen. For every angle, the equilibrium condition and GZ value is obtained.

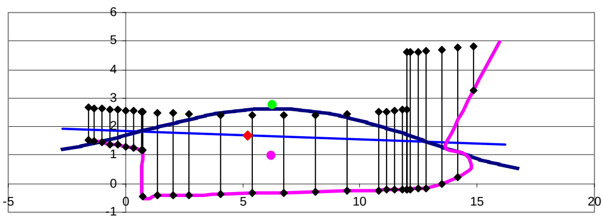

Figure 9 Wave Profile to obtain GZ Curve

In order to evaluate the loss of stability on waves of the ships referred in this paper, some calculations have been performed and some of them are presented in the figures 10-12. The wave values correspond to those indicated in the table 1. In the tables 8 –10, the stability reduction percentages due to the waves are presented. Some validation of the program used can be found in Pérez Rojas et al. (2003).

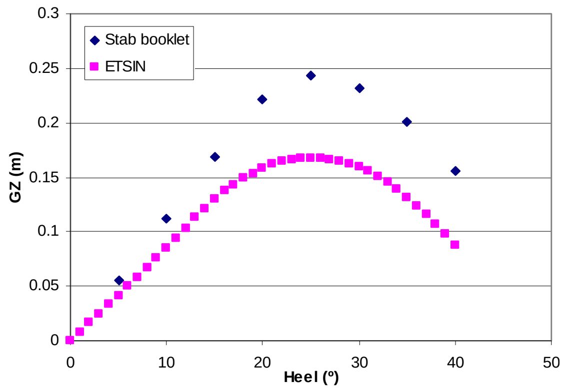

Figure 10 O Bahia Lost Stability on Waves

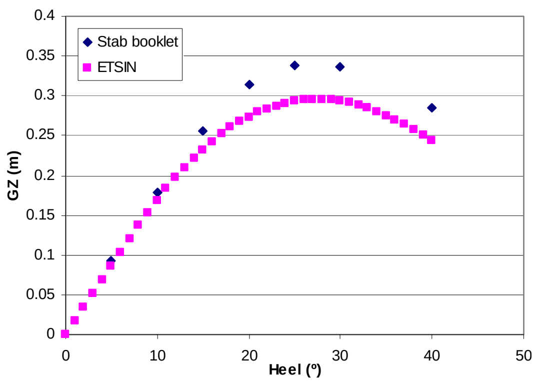

Figure 11 Enrique el Morico Lost Stability on Waves

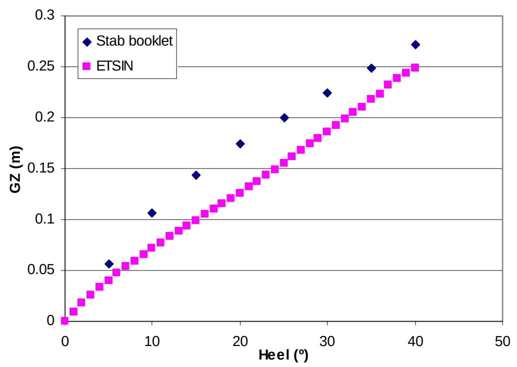

Figure 12 Nuevo Pilin Lost Stability due to Waves

It can be seen that the reductions due to waves are very significant, mainly on the O Bahia and Nuevo Pilin ships.

If these considerations with the wave are taken into account at the presumable accident loading and wave conditions, the following results, included in the table 11, are obtained. These results point out, once again, the precarious stability condition on waves for the O Bahia and Nuevo Pilin ships.

Table 8. O Bahia Reduction of Stability due to Waves

Ship	O Bahia			Criteria
Loading	Arriv.100%			
	w/o wave	w wave	%	
GM(m)	0.623	0.469	25	> 0.35
GZ_{30^o}(m)	0.213	0.159	25	>0.200
$GZ_{max}(\theta)$	25	25	0	> 25º
A_{30^o}	0.077	0.058	25	>0.055
A_{40^o}	0.108	0.081	25	>0.090
A_{40^o} -A_{30^o}	0.030	0.022	26	>0.030

Table 9. Enrique el Morico Reduction of Stability due to Waves

Ship	E. Morico			Criteria
Loading	fish.depart.			
	w/o wave	w wave	%	
GM(m)	1.091	0.99	9	> 0.35
GZ_{30^o}(m)	0.340	0.293	14	>0.200
$GZ_{max}(\theta)$	27	28	- 4	> 25º
A_{30^o}	0.12	0.105	12	>0.055
A_{40^o}	0.176	0.153	13	>0.090
A_{40^o} -A_{30^o}	0.055	0.048	14	>0.030

Table 10. Nuevo Pilin Reduction of Stability due to Waves

Ship	N. Pilin			Criteria
Loading	Arriv.20%			
	w/o wave	w wave	%	
GM(m)	0.659	0.511	22	> 0.35
GZ_{30^o}(m)	0.229	0.186	19	>0.200
$GZ_{max}(\theta)$	> 25º	> 25º		> 25º
A_{30^o}	0.067	0.051	23	>0.055
A_{40^o}	0.111	0.089	20	>0.090
A_{40^o} -A_{30^o}	0.045	0.038	15	>0.030

Table 11. Stability Values due to Waves at Accidents Loading Conditions

Ship	O Bahia	E.Morico	N.Pilin	Criteria
GM(m)	0.418	0.991	0.385	> 0.35
GZ_{30^o}(m)	0.095	0.3	0.055	>0.200
$GZ_M(\theta)$	21º	28º	40º	> 25º
A_{30^o}	0.047	0.106	0.022	>0.055
A_{40^o}	0.055	0.155	0.032	>0.090
$A_{40^o-30^o}$	0.008	0.049	0.011	>0.030

5. THE STABILITY UNDER THE IMO MSC/CIRC. 707

As it has been stated in the previous paragraphs, the considered ships lose a significant stability on waves and the accidents occurred without a very rough sea. However, the combination of different factors can lead to the disaster.

According to IMO (1995) the critical speed for the occurrence of surf-riding is considered to be 1.8·L1/2, which in our case is 6.6 knots and successive high wave attack are dangerous when the average wave length is larger than 0.8 · L and the significant wave height is larger than 0.04 · L. In the all tree cases, these two conditions are fulfilled. In the figure 13 and 14, from the mentioned Circular, the position of the O Bahia and Nuevo Pilin are indicated confirming the dangerous situation of these two ships on waves Enrique el Morico ship was out of the dangerous range of these diagrams

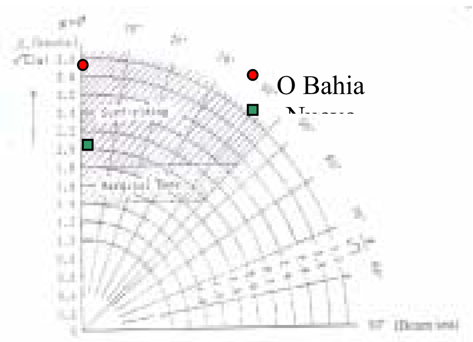

Figure 13 Dangerous zone due to surf-riding

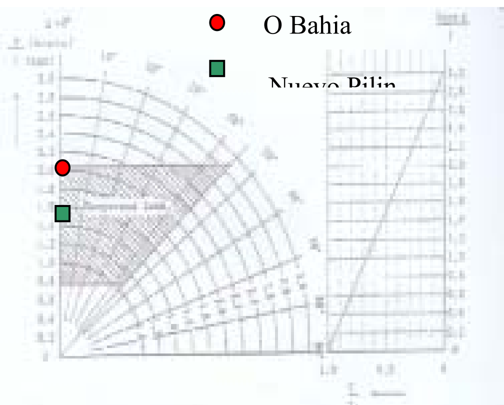

Figure 14 dangerous zone of encountering to high wave group

6. CONCLUSIONS

Due to the content of the previous paragraphs, the following considerations can be indicated:

- Some brand new small fishing vessels fulfil the IMO stability criteria very slightly.
- The stability calculations may have discrepancies that can lead to a not fulfilment of stability criteria, depending on the software and hull representation in the calculation.
- The ship lines of these ships originate a significant loss of stability on waves and are in danger under following and quartering seas.
- The likely cause for the casualties of the three ships presented in this paper could be a poor stability conditions and a very sensitive response to waves.

7. ACKNOWLEDMENTS

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8. DISCLAIMER

It must be emphasized that the opinions expressed in this paper are solely those of the authors and are not necessarily those of the Maritime Spanish Administration.

9. REFERENCES

Hall, T.A., 1997, “Stability of Capsized Fishing Vessels During Dive Rescue Operations”, Marine Technology, July 1997, Vol 34. no. 3, pp. 155-180.

Hashimoto, H. Umeda, N. And Matsuda, A., 2002, "Enhanced Approach for Broaching Prediction with Higher Order Terms Taken into Account". 6th. International Ship Stability Workshop, Webb Institute, Long Island (New York), October 2002.

IMO, 1995, "Guidance to the Master for avoiding dangerous situations in following and quartering seas", MSC/Circ. 707. October 1995

IMO, 1997, "Code for the investigation of marine casualties and incidents", Resolution A.849(20), November 1997.

Pauling, J.R.,1961, "Transverse stability of ships in a longitudinal seaway", Journal of Ship Research. March 1961.

Perez-Rojas, L., Abad, R.,Perez-Arribas, F. and Arias, C.,2003, "Some Experimental Results on the Stability of Fishing Vessels", 8th. STAB Conference, Madrid, September 2003, Proceedings, pp. 643-653.

Roberts, S.E., 2002, "Hazardous Occupations in Great Britain", Lancet 2002. pp 543-544.

Salvensen, N. Tuck, E. And Faltinsen, O.,1970, "Ship motions and sea loads", SNAME Transactions, Vol. 78.

Umeda, N. and Hamamoto, M., 2000, "Capsize of Ship Mpdels in Following/Quartering Waves – Physical Experiments and Non-linear Dynamics", Philosophical Transactions of the Royal Society of London, Series A, 358:1883-1904.