The characteristics of capsizing phenomena of Japanese fishing vessels

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ABSTRACT

The 2nd generation intact stability code is discussed at International Maritime Organization. The code shows 5 dangerous phenomena, pure loss of stability, broaching-to, dead ship condition, parametric roll, and acceleration. Authors carried out the free running capsizing model experiments in following and quartering heavy seas with more than 16 Japanese fishing vessels. The dangerous phenomena of the results were pure loss of stability, broaching-to and bow-diving. A parametric roll was not indicated.

Keywords: *Japanese fishing vessels, broaching-to, bow-diving, pure loss of stability, model experiments*

1. INTRODUCTION

In 2008, 135GT Japanese purse seiner was capsized at anchoring with parachute anchor. In 2009, 135GT Japanese purse seiner was capsized at quartering heavy seas. In 2010, Japanese trawler was capsized at head seas. More than 30 fishermen's lives are lost in these accidents. So, authors are conducting the free running capsizing model experiments using more than 16 Japanese fishing vessels.

The second generation intact stability criteria to be developed by the IMO are requested to cover 5 stability failure modes due to dead ship condition, pure loss of stability, broaching-to, parametric rolling and exceeding roll. Level 1 Vulnerability criteria was developed for calculating by handy calculator. So, characteristics of dangerous phenomena vary depending on the types of ships.

In this paper, we conduct the results of free running model experiments using Japanese fishing vessels. Secondly, the dangerous phenomena of capsizing are discussed. Finally, we conduct the characteristics of capsizing phenomena of Japanese fishing vessels.

2. MODEL EXPERIMENTS

2.1 *Experimental system*

In this research, either the Tele-tele System of Osaka University produced by Hamamoto et.al (1996) before 2009 shown in Fig.1 or the Model Motion Tracking System of National Research Institute of Fisheries Engineering produced by Matsuda et.al (2016) after 2010, shown in Fig.2 are used. Both of them, models were controlled for course keeping with autopilot of rudder gain 1 and constant propeller revolution. All model experiments followed Recommended Procedure of ITTC(2008). These model experiments were conducted at Marine Dynamics Basin of National Research Institute of Fisheries Engineering shown in Fig. 3. During the past 20 years, we conducted free running model experiments with not only Japanese fishing vessels but also European fishing vessels or commercial vessels.

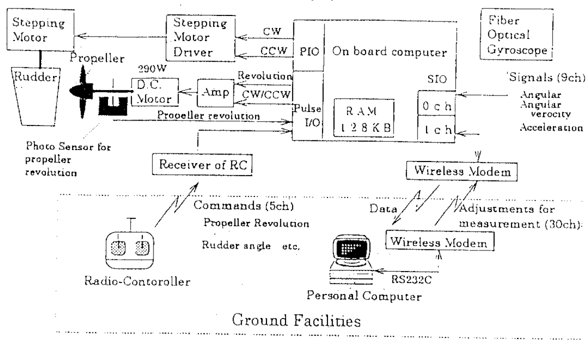

Figure 1: Tele-tele System

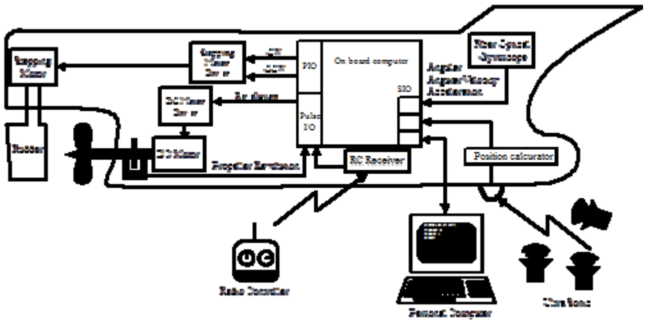

Figure 2: Model Motion Tracking System

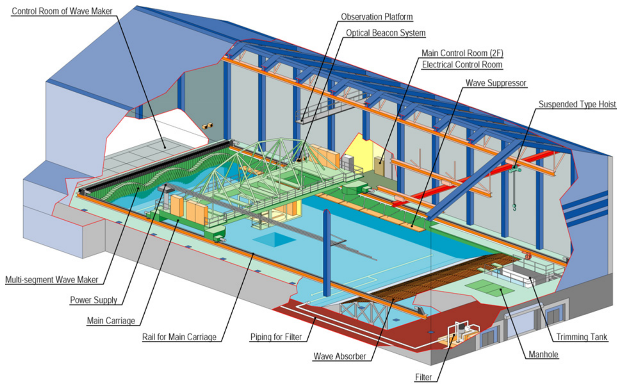

Figure 3: Marine Dynamics Basin

2.2 *Subject ships*

16 Japanese fishing vessels shown in Table.1 are used. Ship A to Ship H are purse seiner, Shi I to Ship L are trawler, Ship M is fishing vessel for set net, ship N to ship P are fishing vessel for Pacific saury and Ship Q is North European purse seiner. Some subject ships are shown in Figs.4-7. We conducted more than 2000 runs of capsizing free running model experiments.

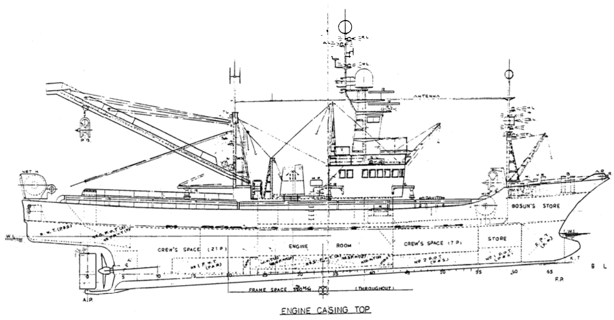

Figure 4: Ship A (135GT Purse seiner)

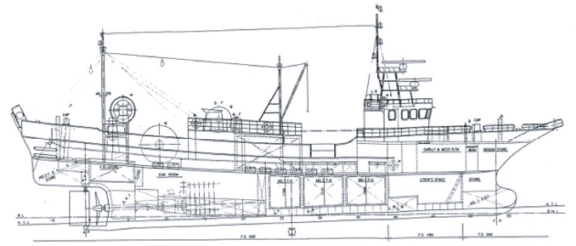

Figure 5: Ship I (Trawler)

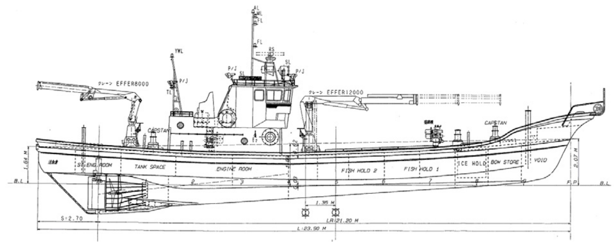

Figure 6: Ship M (Fishing Vessel for Set net)

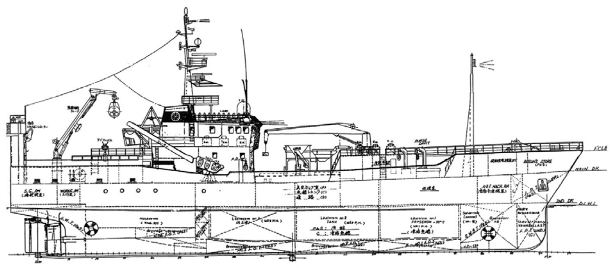

Figure 7 Ship Q (North European Purse Seiner)

Table 1: Subject ships

	Length (Lpp)	Breadth (B)	Depth (D)	Max Speed(Fn)
Ship A	34.5m	7.6m	3.07m	0.43
Ship B	29.0m	6.8m	2.6m	0.46
Ship C	28.8m	7.5m	2.6m	0.4
Ship D	30.0m	7.9m	2.78m	0.33
Ship E	29.0m	6.9m	2.58m	0.38
Ship F	23.0m	5.9m	2.15m	0.43
Ship G	21.2m	6.35m	2.41m	0.46
Ship H	20.35m	5.83m	1.76m	0.43
Ship I	26.85m	5.9m	2.6m	0.44
Ship J	26.85m	6.6m	2.85m	0.38
Ship K	17.8m	3.24m	2.24m	0.39
Ship L	11.35m	5.1m	2.1m	0.49
Ship M	21.2m	4.82m	1.26m	0.43
Ship N	21.35m	5.21m	1.22m	0.5
Ship O	19.8m	4.80m	1.99m	0.41
Ship P	22.4m	4.58m	1.71m	0.41
Ship Q	55.0m	12.0m	7.6m	0.24

3. EXPERIMENTAL RESULTS

3.1 *Experimental results*

Experimental results are shown in Table 2 including Umeda et.al (2009). Japanese fishing vessels were occurred pure loss of stability, broaching-to and bow-diving. But there is not only parametric roll but also harmonic roll. On the other hands, Ship Q was occurred harmonic roll and there is no pure loss of stability, broaching-to and bow-diving on the grounds of low forward velocity.

Table 2 Experimental results

	Pure loss of Stability	Broaching -to	Bow-diving	Parametric roll (Harmonic Roll)
Ship A	✓	✓		
Ship B	✓	✓	✓	
Ship C	✓		✓	
Ship D	✓			
Ship E	✓		✓	
Ship F	✓	✓		
Ship G		✓		
Ship H				
Ship I	✓		✓	
Ship J				
Ship K	✓	✓		
Ship L		✓		
Ship M	✓	✓	✓	
Ship N		✓	✓	
Ship O		✓		
Ship P		✓		
Ship Q				✓

3.2 *Pure loss of stability*

The time series of capsizing phenomena by pure loss of stability is shown in Fig.8 and in Photo 1. In this case, the model was running in quartering seas with same speed of wave velocity and continued to a dangerous situation which is midship at wave crest. Thus, it is considered that the model ship was capsized due to pure loss of stability.

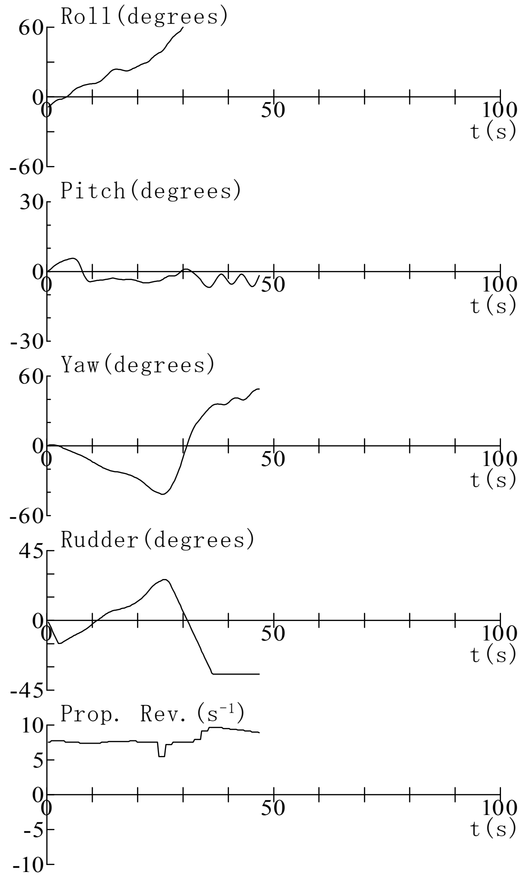

Figure 8 Pure loss of stability of Ship F (39GT purse seiner) (*Fn*=0.43, χ=–15degrees, λ/L=1.25,h/λ=1/9)

3.3 *Broaching-to*

The time series of broaching-to is shown in Fig. 9 and Photo 2. In this case, the model accelerated with following sea. After the surfriding, she could not keep the autopilot course and capsized.

3.4 *Bow-diving*

Typically, after the surfriding, extra power makes stable surfriding. But, if she has not enough height of bow, she dived into the front wave slope and had massive water on deck. Finally she capsized. The time series of bow-diving is shown in Fig. 10 and Photo 3. In this case, Ship N was occurred broaching-to without capsizing. There is no ship with capsizing of broaching-to and without capsizing of bow-diving. So, probably bow-diving is danger for Japanese fishing vessels than broaching-to.

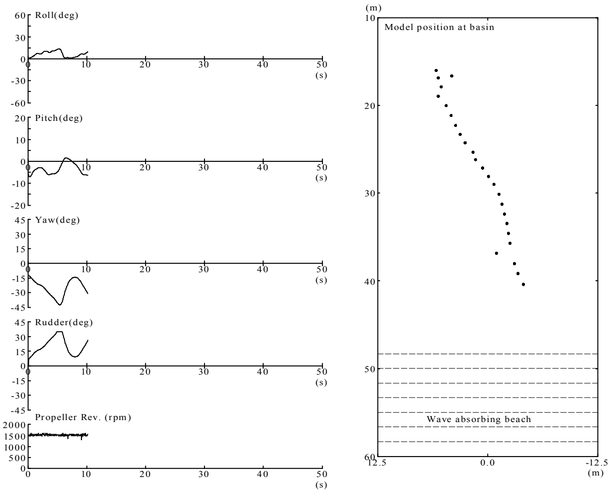

Figure 9 Broaching-to of Ship G (19GT purse seiner) (*Fn*=0.43, χ=–5degrees, λ/L=1.5,h/λ=1/9)

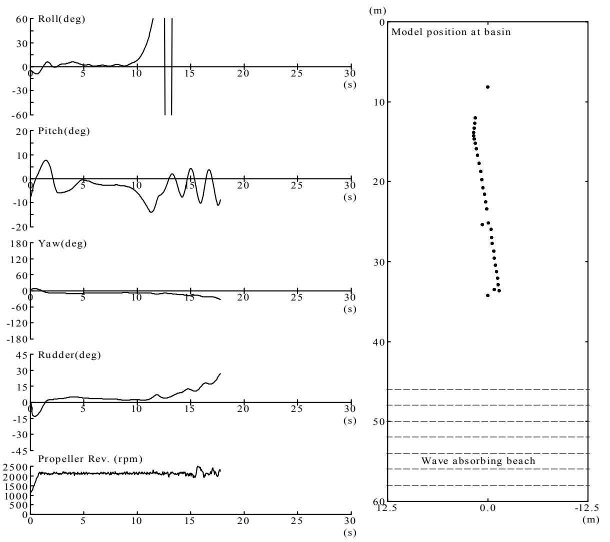

Figure 10 Bow-diving of Ship N (fishing vessel for Pacific saury) (*Fn*=0.50, χ=–5degrees, λ/L=1.5,h/λ=1/9)

4. CHARACTERISTICS OF HARMONIC ROLL

Japanese fishing vessels were occurred pure loss of stability, broaching-to and bow-diving. But there is not only parametric roll but also harmonic roll. On the other hands, European fishing vessel (Ship Q) was occurred harmonic roll. Hamamoto et.al (1995) studied that a ship with hard spring type GZ is occurred parametric roll. GZ curve of Ship Q is shown in Fig.11 and GZ curves of Japanese fishing vessels are shown in Fig.12. Fig.11 shows that GZ curve of Ship Q is a hard spring type. Fig.12 shows that all GZ curve of Japanese fishing vessels are soft spring type. So, Japanese fishing vessels are not occurred parametric roll and harmonic roll.

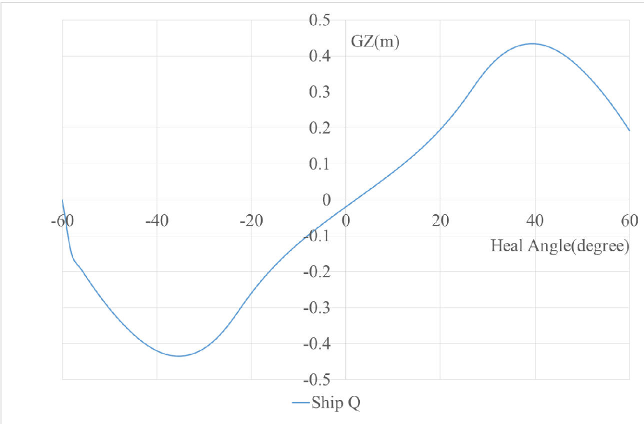

Figure 11 GZ curve of European Fishing Vessel

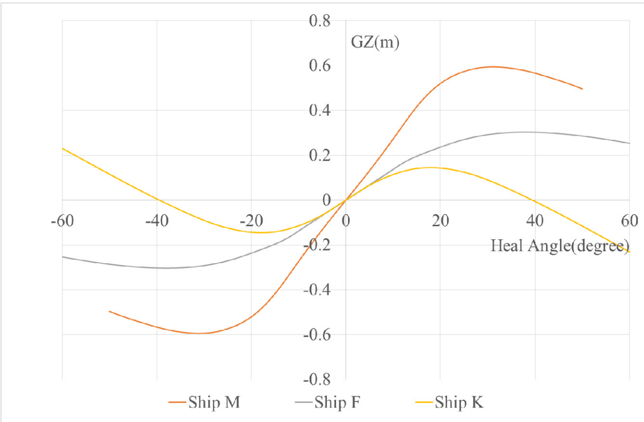

Figure 12 GZ curves of Japanese Fishing Vessels

5. CONCLUSIONS

In this study we conclude as follows.

1. Dangerous phenomena of Japanese fishing vessels are broaching-to, pure loss of stability and bow-diving.
2. Dangerous phenomena of a European fishing vessel of a hard spring type GZ is harmonic roll.
3. Japanese fishing vessels of soft spring type GZ were not occurred parametric and harmonic roll.

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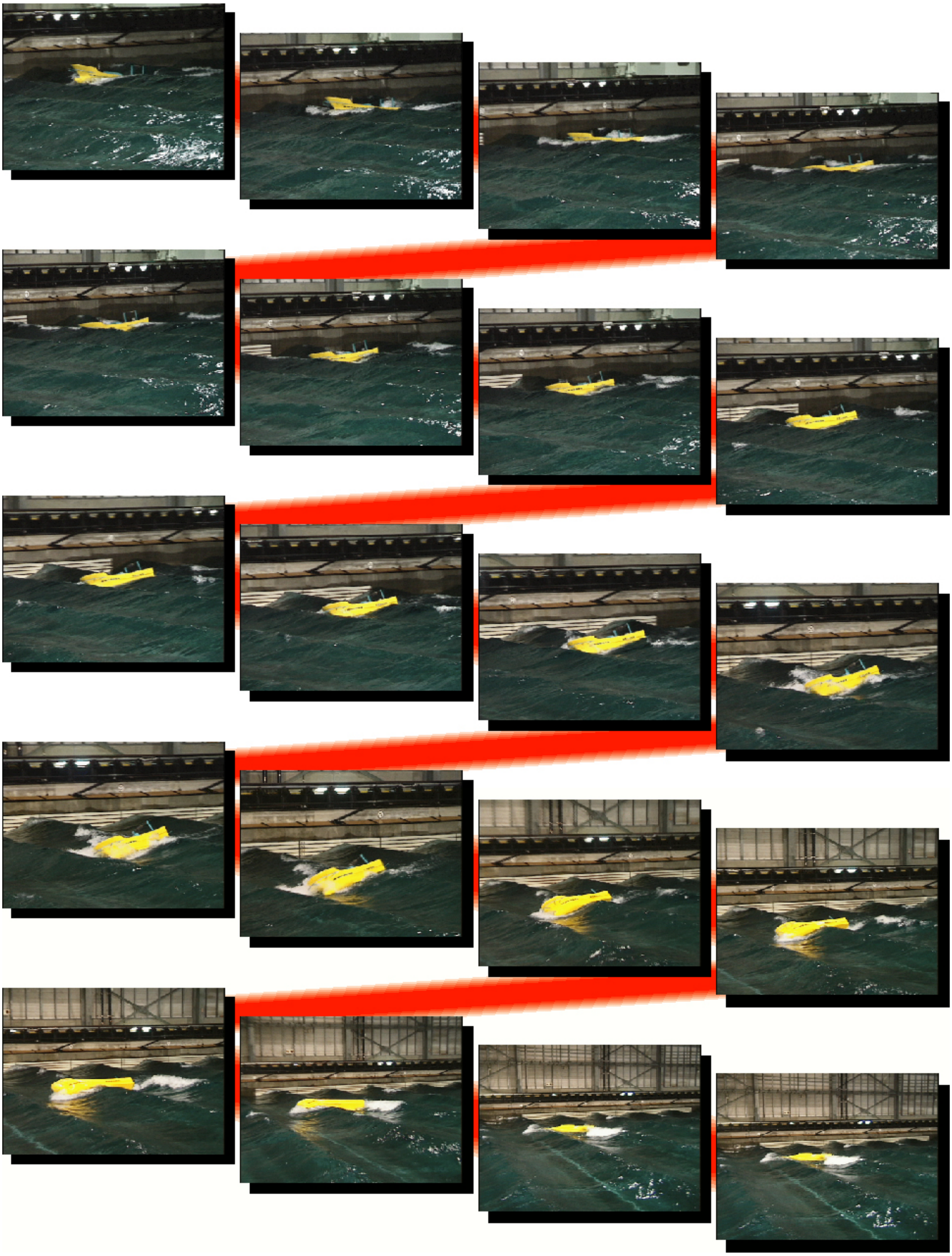

Photo.1 Pure loss of stability

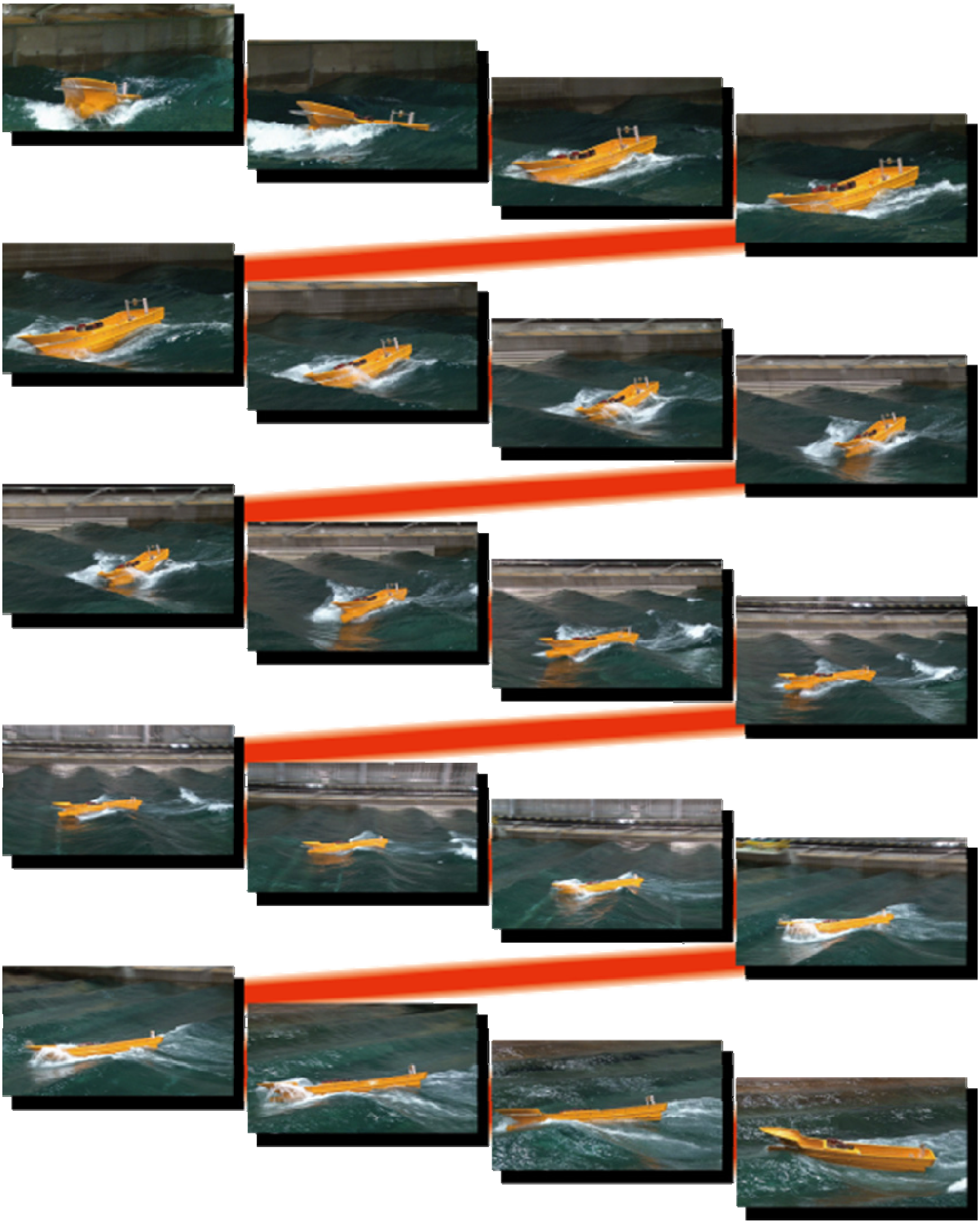

Photo 2. Broaching-to

Photo 3 Bow diving