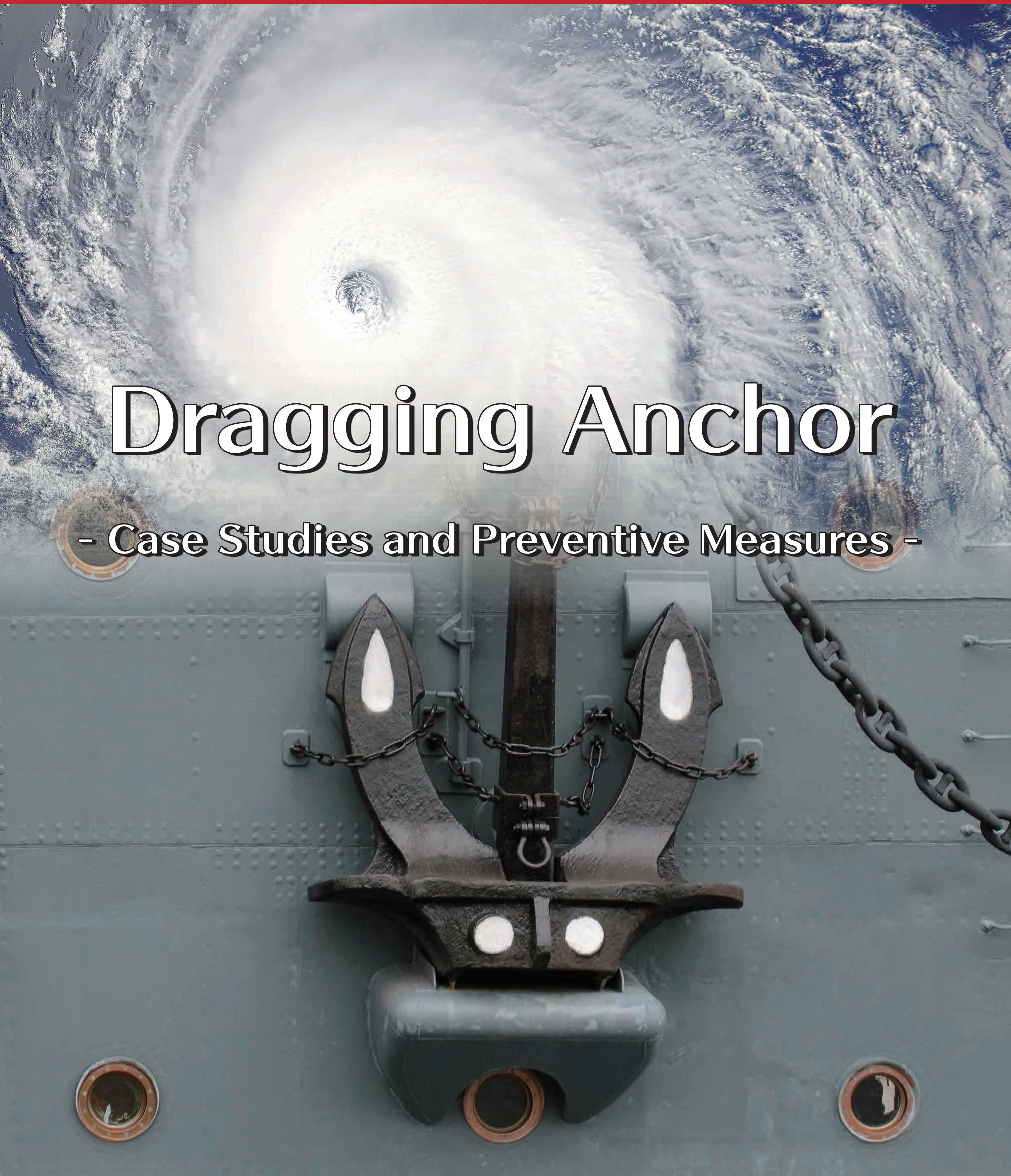
JAPAN P&I CLUB Vol.43 July 2018

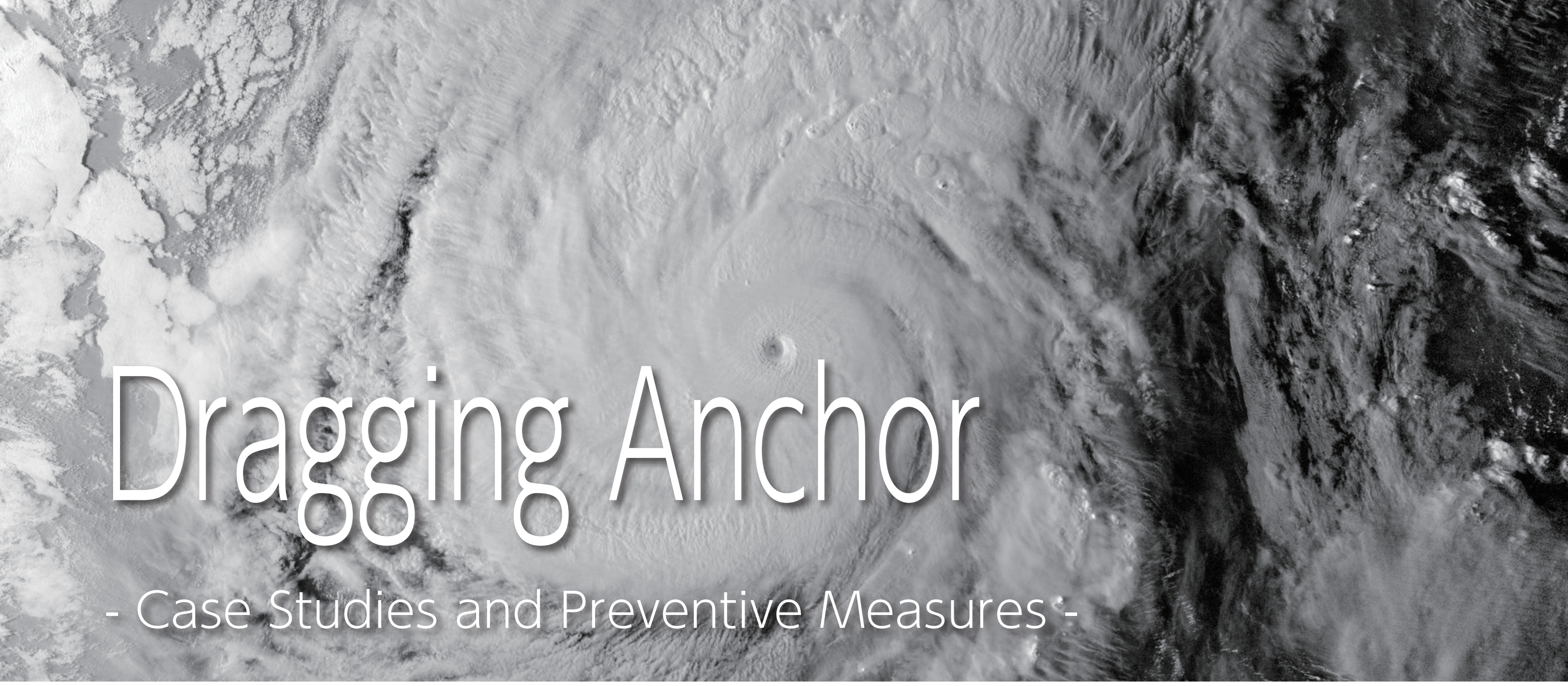
P&I Loss Prevention Bulletin

The Japan Ship Owners' Mutual Protection & Indemnity Association Loss Prevention and Ship Inspection Department



Dragging Anchor

- Case Studies and Preventive Measures -



Dragging Anchor

- Case Studies and Preventive Measures -

INDEX

01 § 1 Introduction

In the event of anchoring, it is common to carry out single anchor mooring, using one of the anchors outfitted on either side of the ship. However, due to strong winds from typhoons or violent storms, as a dragging anchor preventative measure, one must be ready to drop the snubber anchor on the opposite side (to the sea bottom), or carry out two-anchor mooring or ride at two anchors.

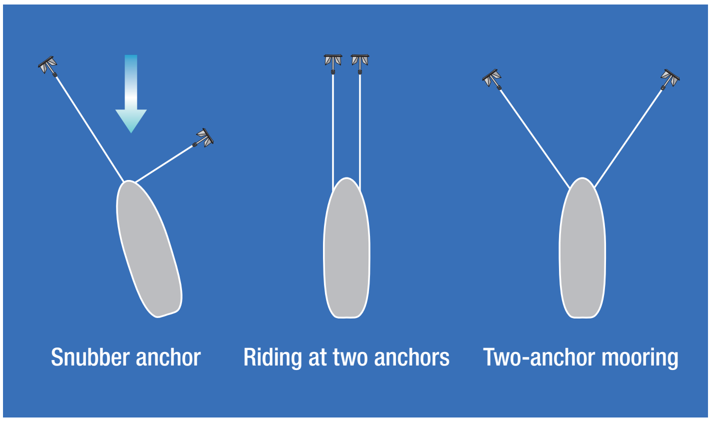


Fig. 1 Anchoring method

In order to learn from the Aomori - Hakodate "Touya Maru" ferry accident that occurred on 26th September, 1954, the anchor dragging mechanism, which will be introduced in §3 was studied and it was ascertained that once the JIS type anchor started dragging, the holding power of the anchor system was lost.

In addition, the Master decided on an anchoring method and length of anchor chain needed to veer, taking the following into account: space for anchorage, depth of the water, nature of the sea bottom, other ships' anchoring situations, expected maximum wind speed and tidal currents etc. However, this has not led to a significant decline in dragging anchor cases.

In 2012, we provided a lecture mainly focusing on the technical aspects of preventing an anchor from dragging and also issued the Loss Prevention Bulletin No. 25.

This time, we are going to introduce typhoon and dragging anchor cases, referring to "Typhoons and marine accidents" in the Maritime Casualty Analysis Report (Vol. 6), that was issued by the Marine Accident Inquiry Agency (MAIA) at that time in 2006.

Photograph 2
AC14 type anchor

Photograph 3
JIS type anchor

02 § 2 Typhoons

Accidents due to a dragging anchor are not only caused by Typhoons, but also occur during gales. However, according to statistics they predominantly occur when a typhoon has just passed. First, it is necessary to understand how typhoons move.

2−1 Definition of a typhoon (from the Japan Meteorological Agency website [available only in Japanese])

Typhoons are defined as follows.

Definition: "Atmospheric depression that comes forth in the tropical ocean is called 'tropical depression'. Among them, those which are found in the north-western part of the Pacific Ocean (sea area to the north of the equator and west from 180 degrees east longitude) or in the South China Sea, moreover, with a maximum wind speed within the region of atmospheric depression (10 minutes average) of more than approximately 17m/s (34 knots and wind force 8) are called 'typhoons'".

A typhoon also has characteristics whereby it is moved by the wind in the sky and heads north due to the rotation of the earth. Therefore, the typhoon gradually moves northward while being blown to the west at a low latitude, where regular easterly winds blow. Then, once it reaches middle and high latitudes, where strong westerly winds (heights of 8 - 13km and speeds of approximately 100km/h) are in the air, the typhoon proceeds north east at a high speed.

Also, regarding the force and the size of the typhoon which we frequently hear of in weather forecasts and so on, the Japan Meteorological Agency expresses the "size" and "strength" of a typhoon based on the wind speed (at an average within ten minutes). This can be seen in Tables 5 and 6. In addition, the range where there is a wind speed of more than 25m/s blowing or when it has the possibility of being that speed, it is referred to as the storm area. For example, it is expressed as a "very large and violent typhoon" when it is a typhoon with a maximum wind speed of more than 54m/s with more than an 800km radius of strong wind at 15m/s.

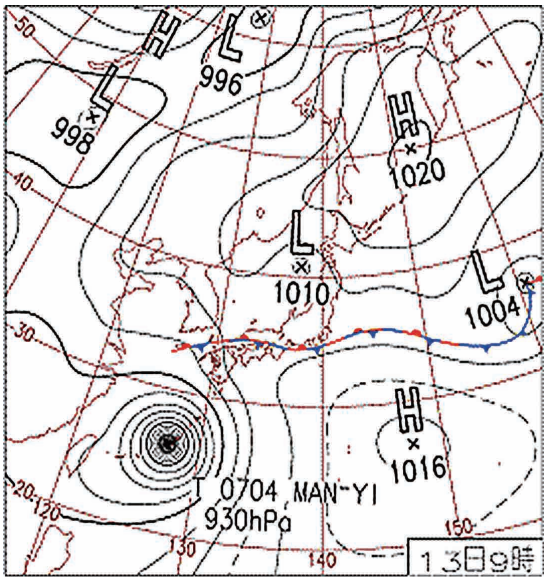


Fig.4 Surface weather chart at 9:00 on July 13th, 2007
(The centre of typhoon No.4, which is large and severely strong, found in the sea around Okinawa's main island)

Typhoon categorised by strength

Category	Maximum wind speed
N/A	Less than 33m/s (64 knots)
Strong	More than 33m/s (64 knots) but less than 44m/s (85 knots)
Severely strong	More than 44m/s (85 knots) but less than 54m/s (105 knots)
Violent	More than 54m/s (105 knots)

Table 5

Typhoon categorised by size

Category	Radius of more than 15m/s wind speed
N/A	Less than 500 km
Large	More than 500 km, but less than 800 km
Super large	More than 800 km

Table 6

Fig.7 shows a comparison of a typhoon's size with that of the Japanese islands. In the event of such a super typhoon appearing, a strong wind area with a wind speed of 15m/s will cover most of Honshu. Because a dragging anchor is often caused in the event of the wind speed exceeding 15m/s (approximately 30 knots), it is necessary to pay attention to the size of the typhoon.

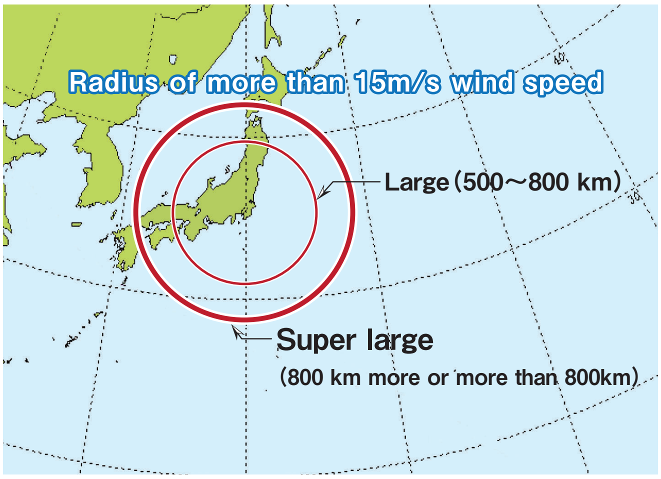


Fig. 7

In addition, the wind of a typhoon has the following characteristics.

Although there is a region called the "eye of the typhoon" where the wind is relatively mild close to the centre, the region surrounding the eyewall has the strongest wind. A typhoon is a swirling mass of air, which blows anticlockwise to the centre of the typhoon close to the ground. Moreover, it is common to observe the typhoon's right side blowing stronger when compared to the left side. This is because the typhoon's wind itself and the flow direction which moves the typhoon are identical in terms of the right side of the typhoon. To the contrary, it will be less strong on the left side of the typhoon, because it is reversed.

Furthermore, at the front right side of the typhoon, it is referred to as a "dangerous semicircle" due to the fact that vessels drift into the centre. On the other hand, it is known as a "navigable semicircle" on the left side of the typhoon because it is blown away from the centre.

Fig. 8

2−2 Number of typhoon landings (from the Japan Meteorological Agency website)

According to the Japan Meteorological Agency, “in the event that the centre of a typhoon approaches the coastline of Hokkaido, Honshu, Shikoku and Kyushu, it is defined as being ‘a typhoon that visited Japan”. However, if it goes back to the sea again only crossing small islands and peninsulas, it is said to be a “pass”. Tables 9 and 10 show the typhoons that have landed between 2001 and 2017. There are 10 typhoons that landed in 2004, which makes it a remarkable year. The average number of typhoons that landed within this specific 16 year period, except 2004, is 2.7 per year. Also, the typhoons that landed between July and October came to 92% of the total. Within those, the typhoons that landed among the months of August and September came to 60% of the total. On the contrary, there were no typhoons that landed between the months of November and April in sixteen years.

Number of typhoon landings in Japan (2001-2017)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly total
2017							1	1	1	1			4
2016								4	2				6
2015							2	1	1				4
2014							1	1		2			4
2013									2				2
2012						1			1				2
2011							1		2				3
2010								1	1				2
2009										1			1
2008													0
2007							1	1	1				3
2006								1	1				2
2005							1	1	1				3
2004						2	1	3	2	2			10
2003					1			1					2
2002							2			1			3
2001								1	1				2
Sum total	0	0	0	0	1	3	10	16	16	7	0	0	53
%	0%	0%	0%	0%	2%	6%	**19%**	**30%**	**30%**	**13%**	0%	0%	100%

Annual average number of typhoon landings over 16 years excluding 2004: **2.7**

92%

Table 9

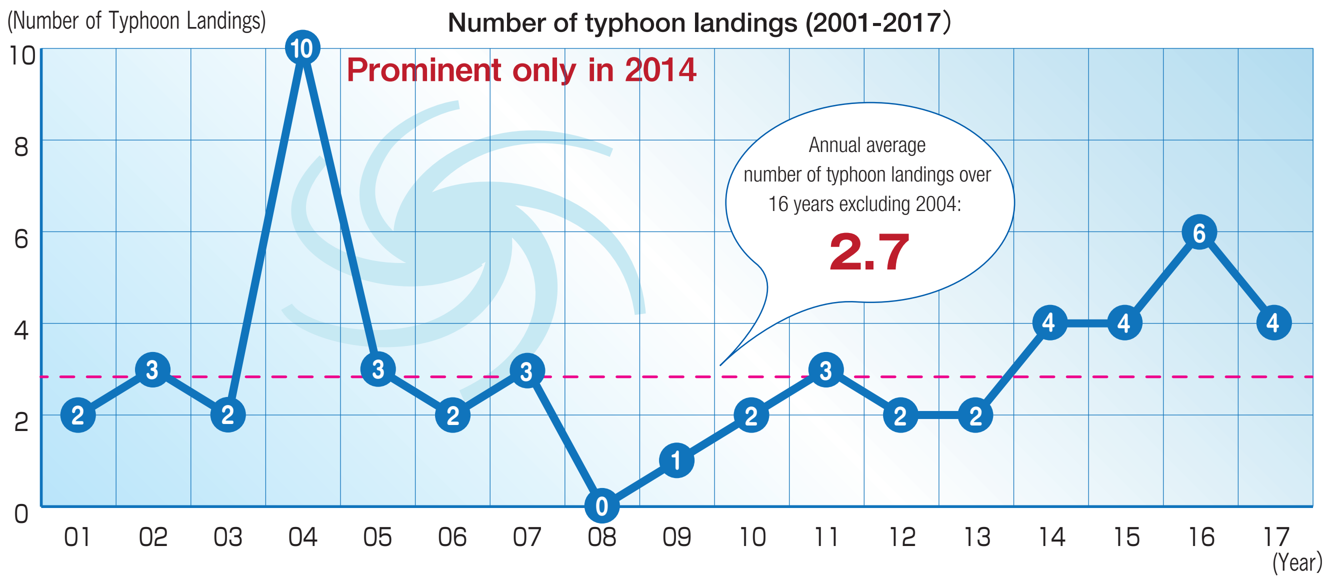


Table 10

2−3 The paths and the wind speeds of the typhoons that landed in 2004

The paths and wind speeds of ten typhoons that landed in 2004 are shown in Fig. 11 and Table 12. It was observed that the maximum instantaneous wind speed was more than 60m/s for typhoons No. 10, 18 and 22. Also, it was observed that the maximum instantaneous wind speed was more than 50m/s for eight typhoons except No. 11 and 15. The solid line indicates the typhoon path and the dotted line is the path in the event of a tropical dipression.

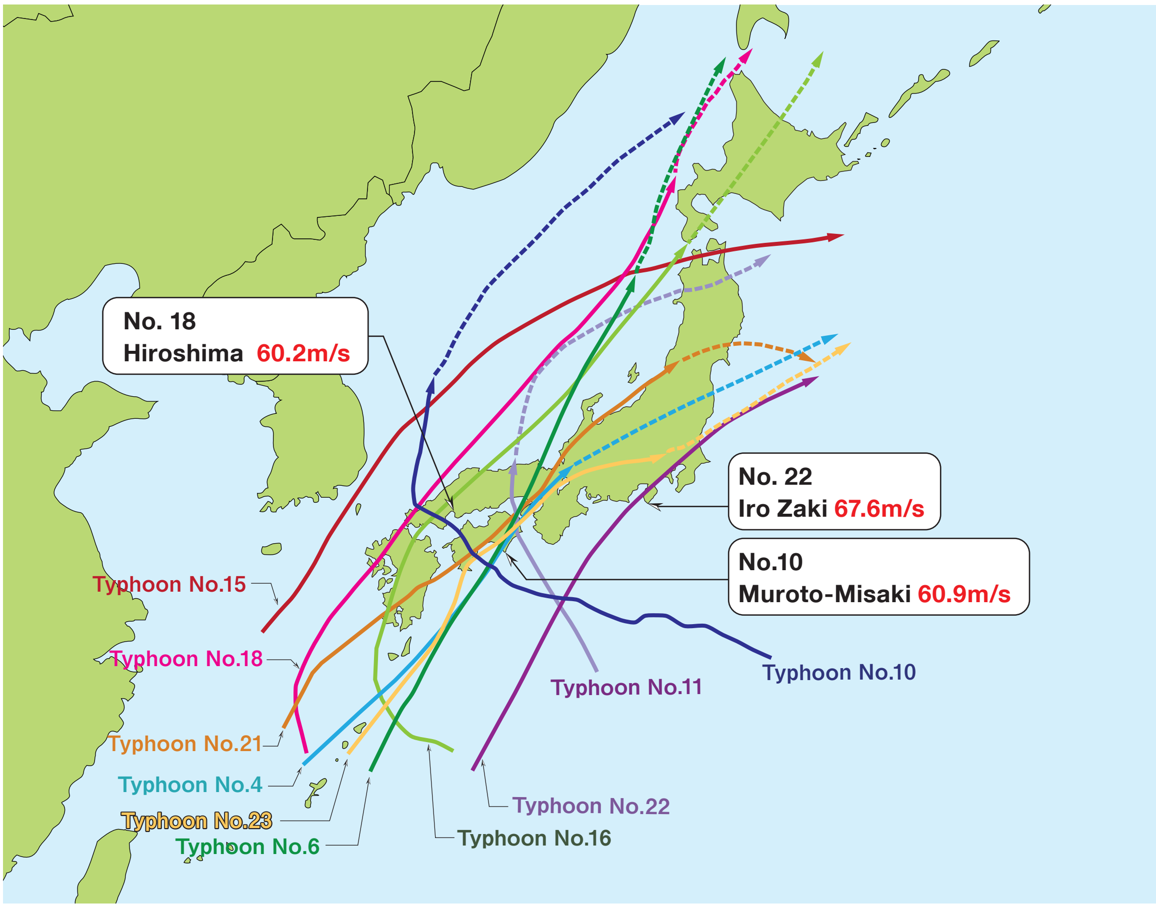


Fig. 11

Typhoon	Period	Maximum wind speed	Maximum instantaneous wind speed (m/s)	Meteorological Office
No. 4	June 11th	29.2	51.5	Miyako Island
No. 6	June 21st to 22nd	43.7	57.1	Muroto-Misaki
No. 10	July 31st to Aug. 2nd	47.7	60.9	Muroto-Misaki
No. 11	Aug. 4th to 5th	20.3	29.8	Shiono-Misaki
No. 15	Aug. 20th	27.1	48.7	Izuhara
No. 16	Aug. 30th to 31th	46.8	58.3	Muroto-Misaki
No. 18	Sept. 7th to 8th	33.3	60.2	Hiroshima
No. 21	Sept. 29th to 30th	31.5	52.7	Kagoshima
No. 22	Oct. 9th to 10th	39.4	67.8	Iro Zaki
No. 23	Oct. 20th to 21st	44.9	59.0	Muroto-Misaki

Table 12

Coastal vessels that experienced anchoring problems, following the passing of ten typhoons, are shown in Fig. 13 and Table 14. Approximately half of the number of ships anchored at Seto Inland Sea. In addition, 30% of the ships anchored at main sea areas such as: Tokyo Bay, Ise Bay, Mikawa Bay, Osaka Bay etc.

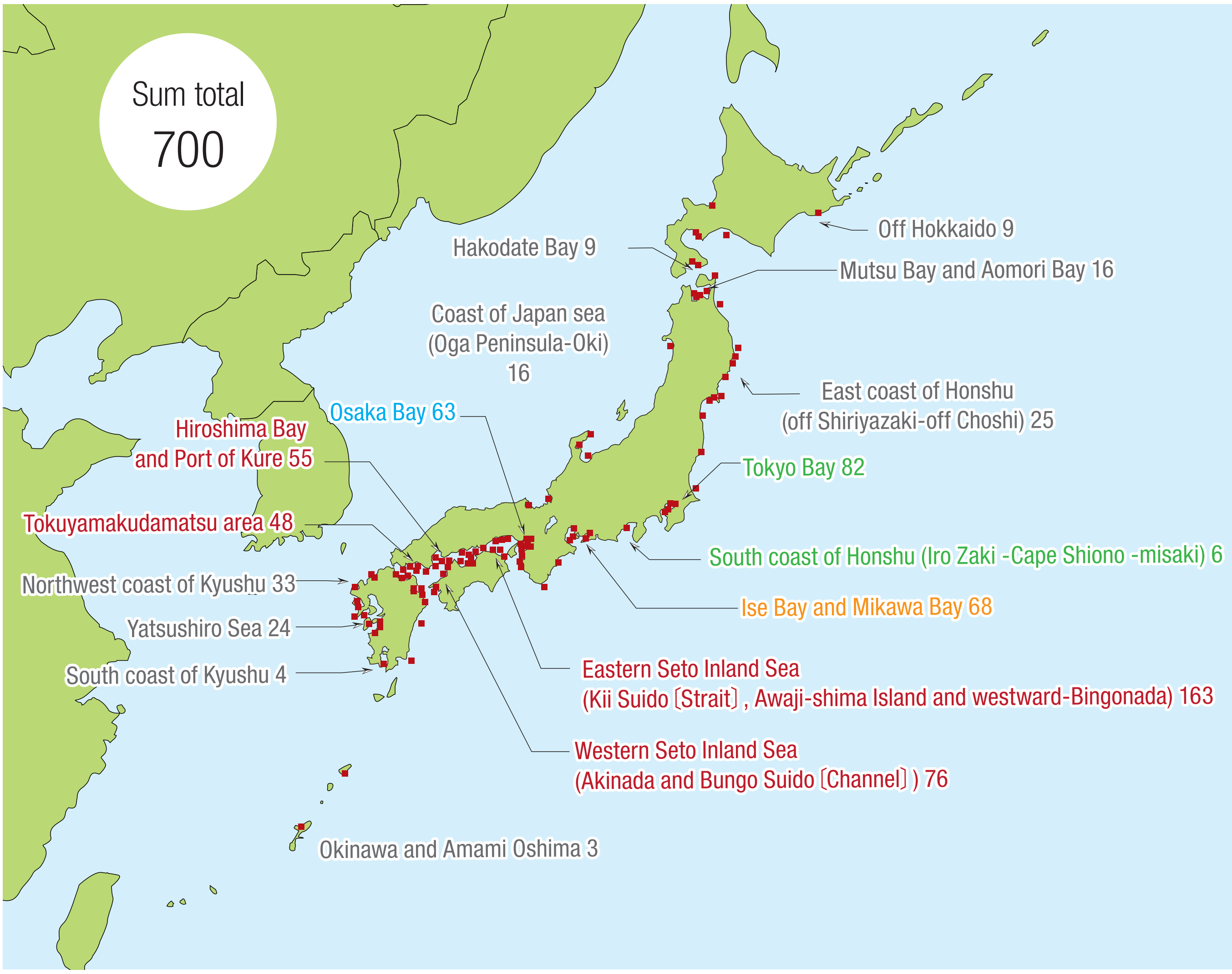


Fig. 13

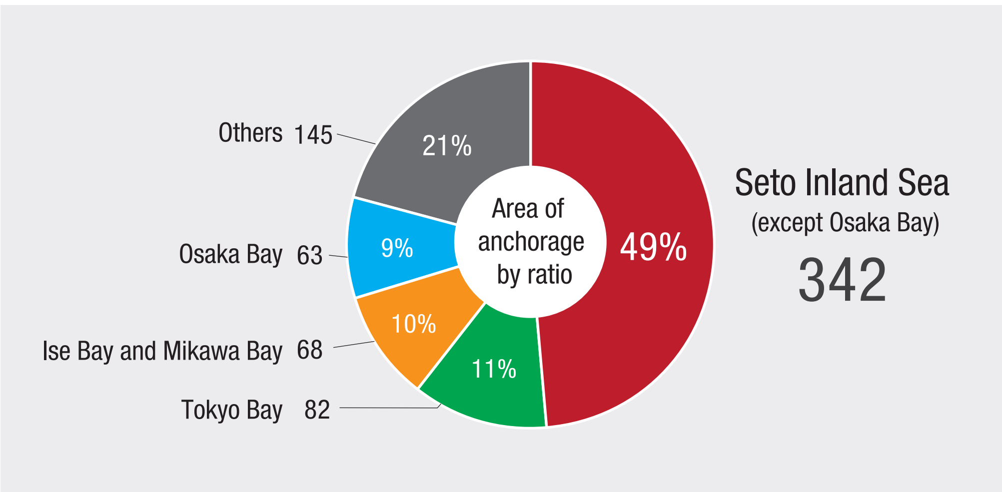


Table 14

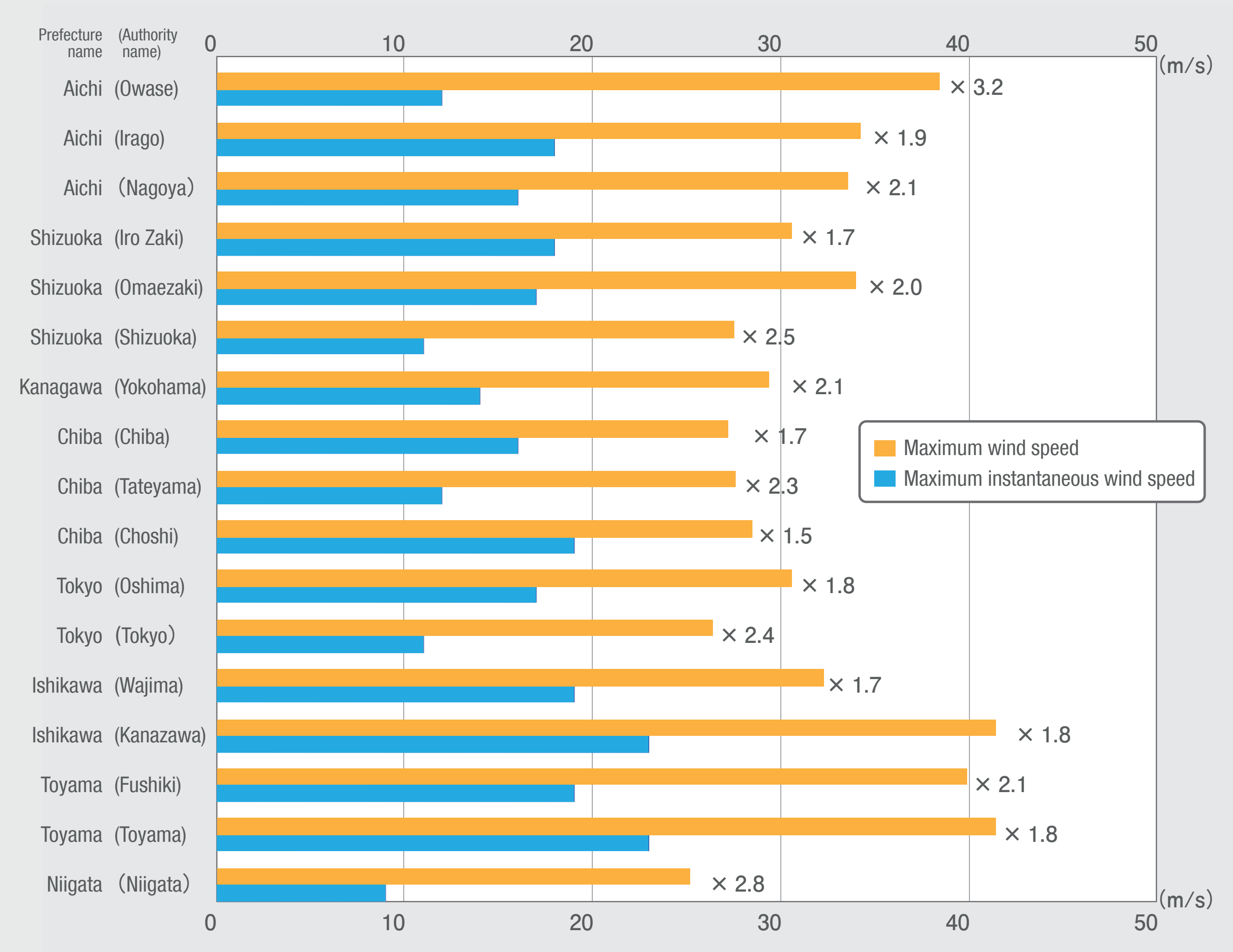


Table 15

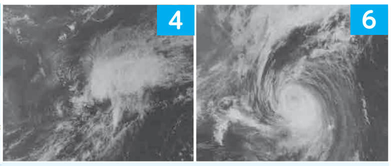
Following a comparison of the maximum wind speed (the maximum value of the 10 minute average wind speed) and the maximum instantaneous wind speed (the maximum value of the instantaneous wind speed) which were detected at each meteorological office, at the time when typhoon No.23 landed on October 20th and 21st, is shown in Table 15. Maximum instantaneous wind speed becomes 1.5 - 3.2 times greater the average wind speed.

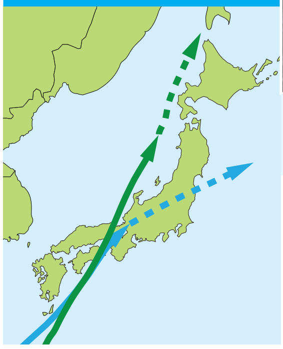
At sea, where there are few structures that stand against the wind, it is particularly necessary to estimate the maximum instantaneous wind speed to be at least 1.5 - 2 times that of the average wind speed.

2−4 Typhoon marine accidents in 2004

Typhoons have caused large-scale disasters, not only for ships, but also on shore. Figs. 16, 17, 18, 19, 20, 21, 22 and 23 indicate damage statuses.

No.4 and 6



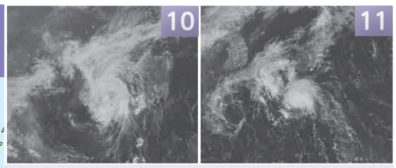


- June 10th to 22nd
- No. of deceased and missing: 5
- No. of totally or partially destroyed houses: 6

It brought damage to the Chubu, Kinki and Shikoku regions. Along with major disruptions caused to each form of transportation, part of the national highway in Tokushima prefecture was closed.

http://agora.ex.nii.ac.jp/digital-typhoon/wnp/by-name/200404/0/512x512/GOE904061106.200404.jpg
http://agora.ex.nii.ac.jp/digital-typhoon/wnp/by-name/200406/0/512x512/GOE904062003.200406.jpg

No.10 and 11

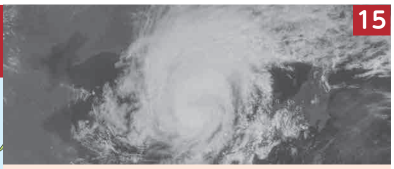


- July 29th to Aug. 6th
- No. of deceased and missing: 3
- No. of totally or partially destroyed houses: 32

It brought heavy rain mainly in the Shikoku regions, and continuously, it caused landslides and mudslides in Tokushima and Kochi prefectures.

http://agora.ex.nii.ac.jp/digital-typhoon/wnp/by-name/200410/0/512x512/GOE904080103.200410.jpg
http://agora.ex.nii.ac.jp/digital-typhoon/wnp/by-name/200411/0/512x512/GOE904080403.200411.jpg

No.15

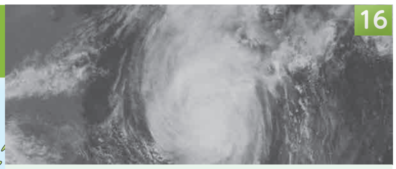


- Aug. 17th to 20th
- No. of deceased and missing: 10
- No. of totally or partially destroyed houses: 105

It brought extremely heavy rain, not only to the Kyushu and Shikoku regions, but a storm that swept each area on the Sea of Japan side from Kyushu to Hokkado.

http://agora.ex.nii.ac.jp/digital-typhoon/wnp/by-name/200415/0/512x512/GOE904081903.200415.jpg

No.16

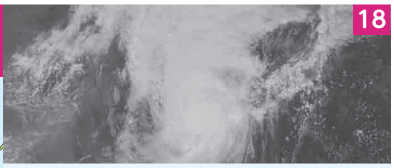


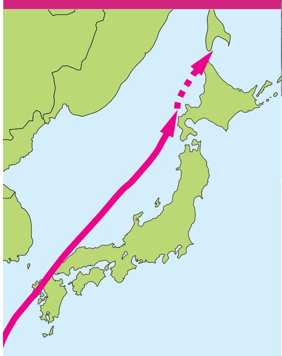
- Aug. 27th to 31st
- No. of deceased and missing: 17
- No. of totally or partially destroyed houses: 256

It brought heavy rain and flooding, due to high tide, to the Pacific coast of western Japan. A wide area of the Seto Inland Sea coast, such as Kagawa Prefecture, Okayama Prefecture and Hiroshima Prefecture were affected.

http://agora.ex.nii.ac.jp/digital-typhoon/wnp/by-name/200416/0/512x512/GOE904083003.200416.jpg

No.18





- Sept. 4th to 8th
- No. of deceased and missing: 46
- No. of totally or partially destroyed houses: 1,650

In the regions of Okinawa, Kyushu, Chugoku and Hokkaido, there were areas that recorded the highest instantaneous wind speeds. Buildings were damaged and trees were fallen in each area while a large number of people were injured.

http://agora.ex.nii.ac.jp/digital-typhoon/wnp/by-name/200418/0/512x512/GOE904090704.200418.jpg

No.21

- Sept. 25th to 30th
- No. of deceased and missing: 27
- No. of totally or partially destroyed houses: 893

She crossed the Kyushu and Shikoku regions, kept proceeding to the Kinki and Hokuriku regions and finished up in the Tohoku region.

http://agora.ex.nii.ac.jp/digital-typhoon/wnp/by-name/200421/0/512x512/GOE904092803.200421.jpg

No.22

- Oct. 7th to 9th
- No. of deceased and missing: 9
- No. of totally or partially destroyed houses: 435

The typhoon was not so big, however, the vicinity of the centre was accompanied by raging rain and wind. It caused sediment damage such as landslides, flooding and damage caused by gusts, from the Tokai region to the southern part of Kanto.

http://agora.ex.nii.ac.jp/digital-typhoon/wnp/by-name/200422/0/512x512/GOE904100803.200422.jpg

No.23

- Oct. 18th to 21st
- No. of deceased and missing: 98
- No. of totally or partially destroyed houses: 8,836

Because she crossed Honshu with a large force, she brought overflow to rivers, flooding and sediment damage to a wide area. There were a large number of the deceased and missing on a wide scale, mainly in Hyogo, Kyoto and Kagawa prefectures.

http://agora.ex.nii.ac.jp/digital-typhoon/wnp/by-name/200423/0/512x512/GOE904101803.200423.jpg

Fig. 16～23

Source: "Digital Typhoon Project" courtesy of the National Institute of Informatics

Table 24 indicates each typhoon marine accident situation that occurred in 2004 (as published in the Marine Accident Inquiry Agency [MAIA]).. The total number of marine accidents was 233, however, the number of marine accidents (72 accidents) and the number of vessels (88 vessels) affected by Typhoon No. 18 are remarkably prominent.

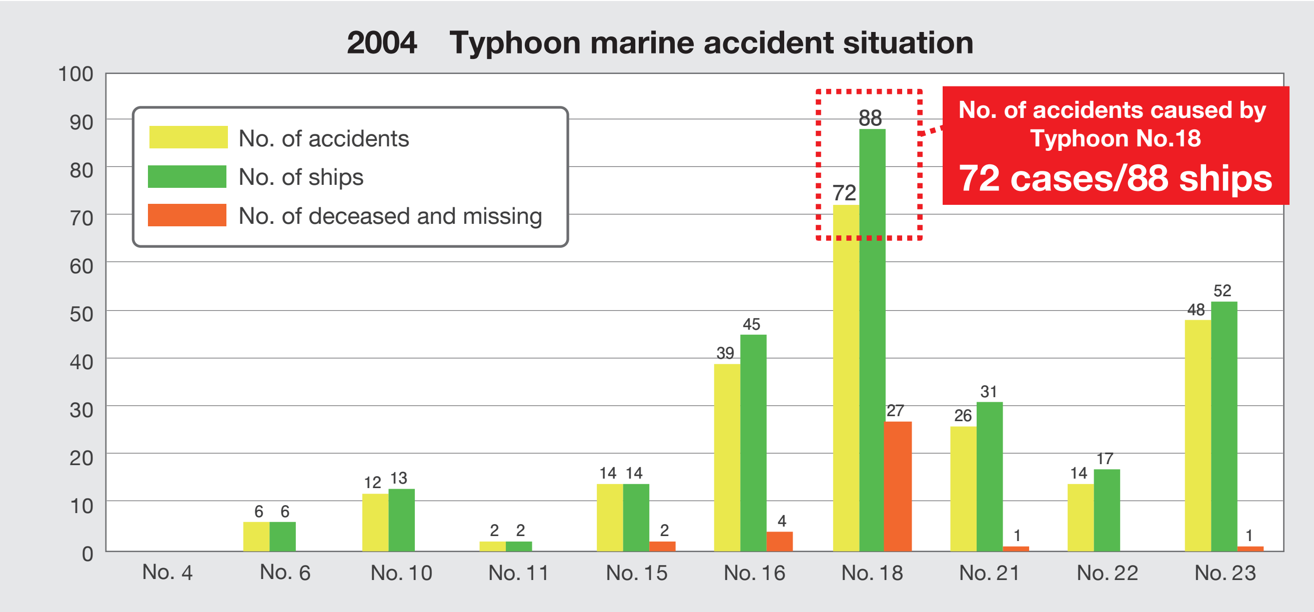


Table 24

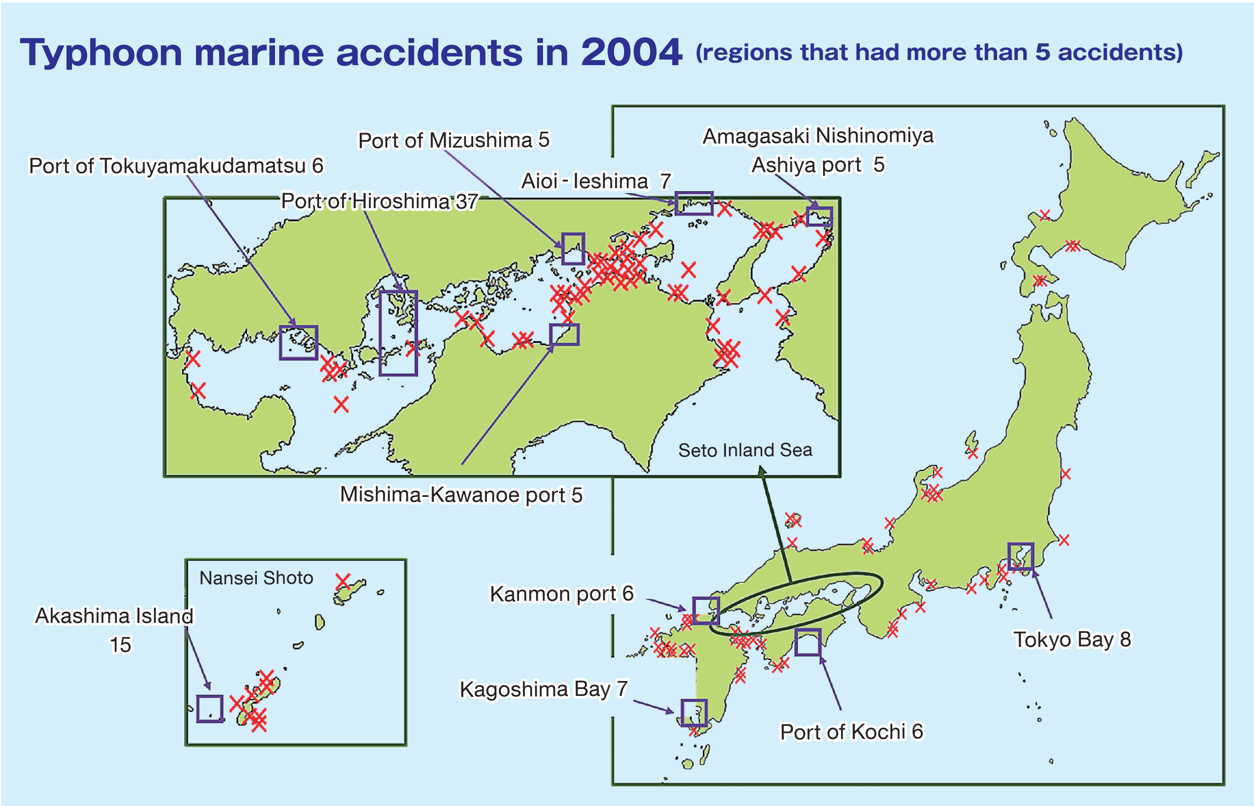


Fig. 25

= Summary of Typhoon No. 18 (From the Japan Meteorological Agency website) =

On the 28th of August 2004, approximately 09:00 Japan Standard Time (here in after referred to as JST), Typhoon No.18 which was formed in the sea around the Marshall Islands moved northwestward over the southern Sea of Japan and passed through the northern part of the main Okinawan island with great size and force on the 5th of September. Afterwards, she proceeded north, to the East China Sea and changed path to the northeast. At approximately 9:30 on the 7th of September, she landed in the vicinity of Nagasaki-city and passed through the northern part of Kyushu. In the afternoon of the 7th she reached the Sanin offing. Then, while accelerating northeastward up the Japan Sea, on the morning of the 8th she headed north on the western offing of Hokkaido with a storm area accompanying after. Then, after changing into an extratropical cyclone at 09:00 on the 8th, she reached the Soya Strait, while still growing.
Gale force winds with a recorded maximum instantaneous wind speed of 50m/s were observed in regions of Okinawa, Kyushu, Chugoku and Hokkaido, for example, 60.2 m/s in Hiroshima and 50.2 m/s in Sapporo. In addition, there was an area of the Kyushu region where heavy rain which exceeded 900mm was observed. Moreover, damage caused by high water levels on the coast of the Seto Inland Sea and on the coast of the Japan Sea from western Japan to northern Japan was also observed.
This typhoon caused damage to buildings and trees to fall in each area it passed. A large number of people were injured because of falling debris. Also, grounding accident of ships occurred one after another in western Japan.

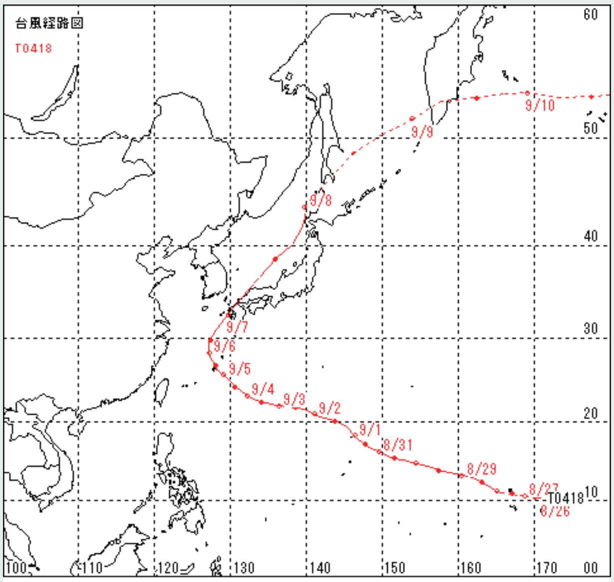
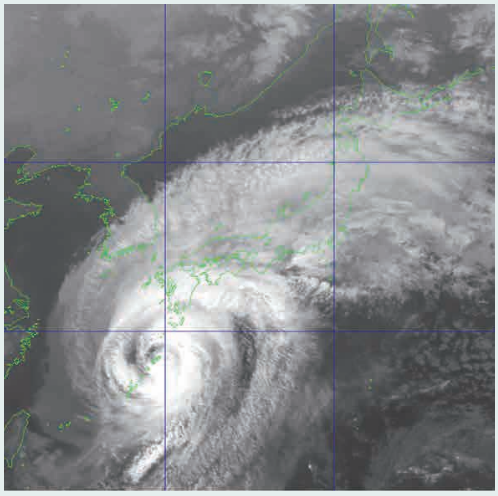


Fig. 26
The route of Typhoon No.18 in 2004



Photograph 27

Fig. 28 shows the routes of Typhoons No. 18 and 23. Moreover, the severe dragging anchor accident of the cargo ship "MV TRI ARDHIANT" (6,315 tons) and grounding accident of the training ship "Kaiwo Maru" (2,556 tons) may be familiar.

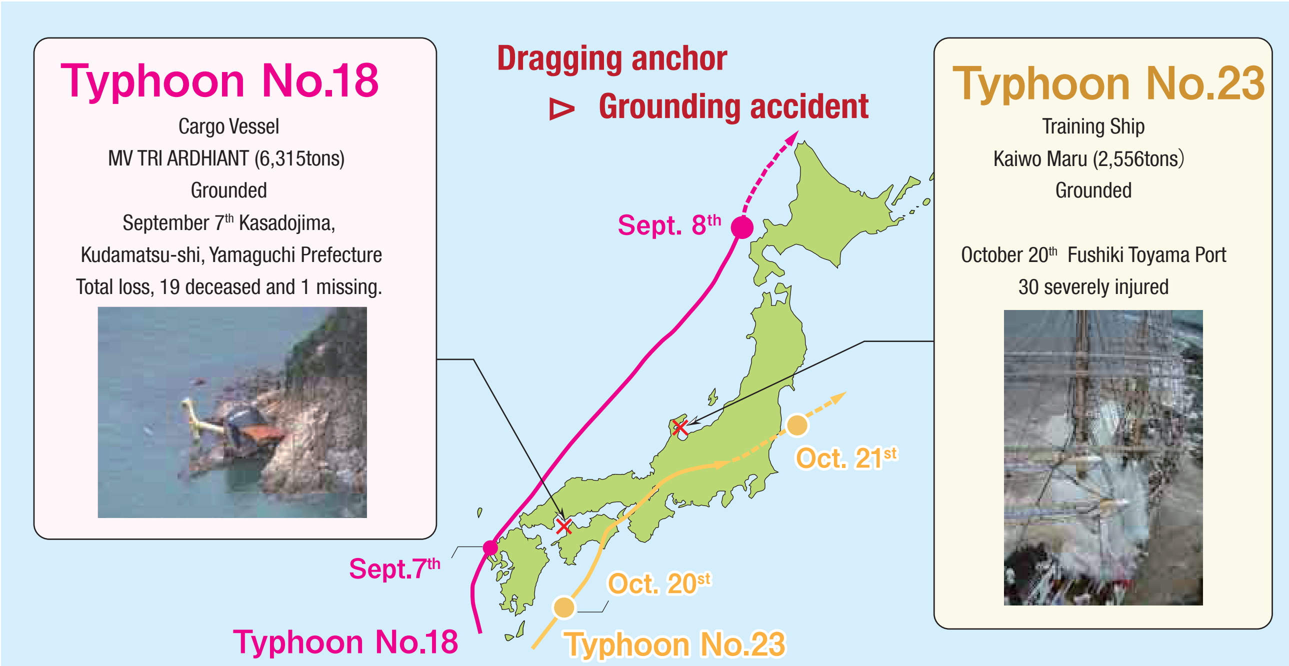


Fig. 28

Looking closely at 233 accidents due to the typhoons in 2004 "by type of case", the main aspects of typhoon maritime accidents will follow. The ratio of those accidents will be shown in Fig 29.

Detailed Breakdown of Marine Accidents

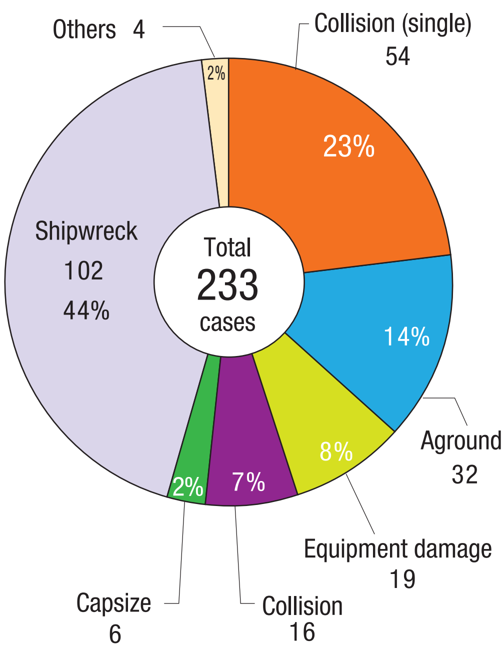


Fig. 29

＊ Collision (single)

- Whle moored at a pier, the hull collided with the quay due to strong winds.
- While berthing was in progress using the anchor, it collided with the quay because the strong winds did not allow for anchorage.

＊ Aground

- While anchored, grounded on a rocky stretch due to a dragging anchor and sinking.
- While turning round in the harbour, pressed by strong winds and therefore grounded in a swash.

＊ Equipment damage

- Due to the strong wind, the antenna at the top of the mast was lost.
- Because there was a danger of collision with another vessel due to dragging anchor, the anchor chain was cut off.

＊ Collision

- Pressed by dragging anchor, ships collide with other ships while anchored.

＊ Capsize

- Very stormy weather (at sea) was brought by typhoons approaching and fishing boats that were sailing out were discovered capsized.

＊ Shipwreck

- Propellers which made contact and were damaged by floating matter such as driftwood due to heavy rain.
- Towed objects drifting and being grounded in shallows due to a severed tow rope was cutted.
- A loss of a lamp door due to a direct hit from a high wave.

03 § 3 Dragging Anchor Cases

(From the Maritime Casualty Analysis Report [Vol. 6]: Typhoons and marine accidents issued by the Marine Accident Inquiry Agency [MAIA] in 2006)

3−1 The Aomori - Hakodate ferry "Touya Maru" accident

Touya Maru :
The Aomori - Hakodate ferry, 4,337 tons

Date, time and the point/location of occurrence:
22:45 JST on the 26th of September in 1954 in Hakodate Bay (during harbourage from the typhoon)

Weather at the time of sinking :
Rain, southwest wind, wind speed at 20m/s, wave height at 3m and 1 hour had passed since low tide had begun.

Accident summary

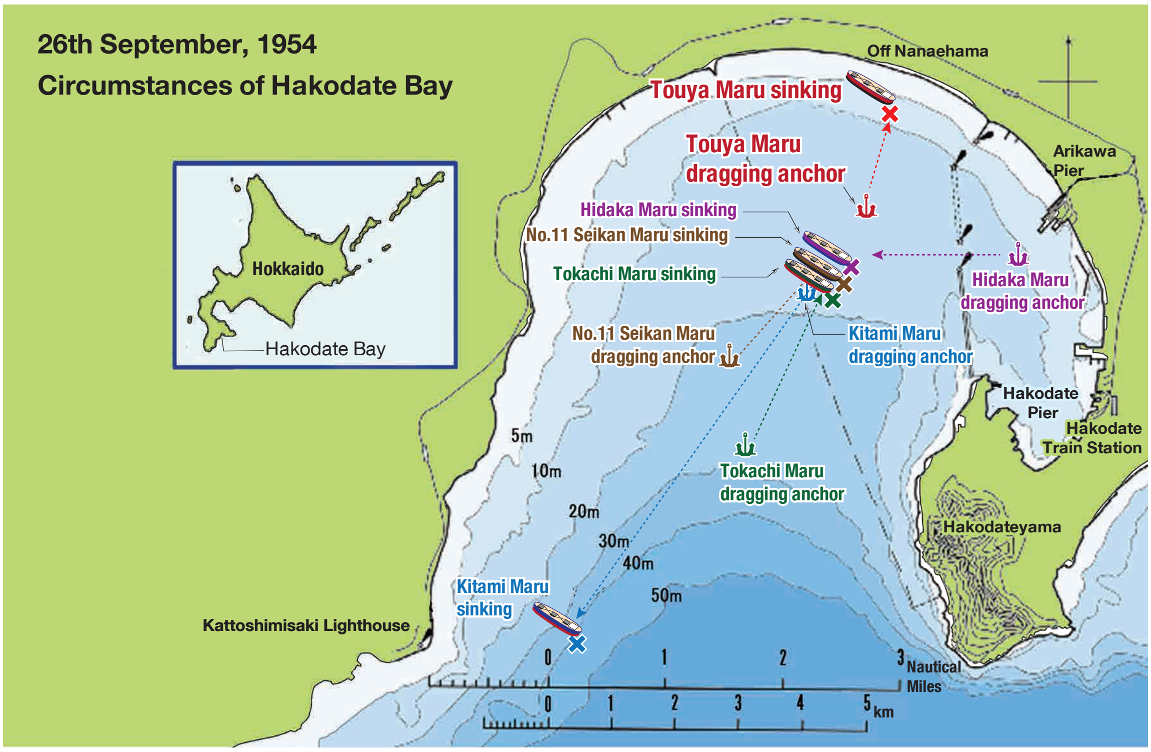


Fig. 30

Regarding the Aomori - Hakodate ferry, Touya Maru, the total number of persons on board was 1,314, (crew members: 111, passengers and so on: 1,203) with 12 freight cars loaded. While Typhoon No. 15 was approaching, Touya Maru departed Hakodate Pier from within the Port of Hakodate bound for the Port of Aomori. She was to take refuge at the Hakodate Bay because outside the Port of Hakodate had already been seeing very stormy weather (at sea), however, she dragged anchor due to a gale and high waves. Touya Maru therefore grounded in the shallows of Nanaehama in Hakodate Bay. She then capsized and sank which caused a total number of 1,155 deceased or missing persons including passengers etc.

Also, four other vessels from the Aomori - Hakodate ferry, namely, No. 11 Seikan Maru, Kitami Maru, Tokachi Maru and Hidaka Maru capsized and sank in Hakodate Bay in succession. The total number of deceased and missing passengers etc. came to be 275.

The state of affairs at Hakodate Bay on the 26th of September in 1954 is shown in Fig. 30. Hakodate Bay has a land shape that makes it less influenced by wind and waves because it is shielded by high mountains, when there is a northwest wind.

"However, the bay mouth is open widely towards the direction of the 'south-southwest'. Thus, because of the long fetch, in the event that a southerly wind blows continuously, high waves are thrusted into the bay as time goes by".

Typhoon No.15 (International name: Marie)

Typhoon No.15, Marie, formed at the north of the Yap Islands on the 21st of September and hit the Northern Osumi Peninsula from Kagoshima Bay on the 26th at around 14:00 JST at a very fast speed. Afterwards, she cut across the eastern part of Kyushu and passed through the region of Chugoku, at a speed of 100km/h.

On the 26th at approximately 08:00 she moved off of Sanin to the Japan Sea and grew as she headed north to Hokkaido. At 21:00 on the same day, she reached her peak then she passed off Suttsu in Hokkaido. She reached nearby Wakkanai City at around 0:00 on the 27th. Regarding the precipitation of this typhoon, there are some areas which exceeded 200mm like the regions of Kyushu and Chugoku, however, there were lesser amounts in other areas. Because the typhoon continued developing even after entering the Sea of Japan, a violent storm of more than 30m/s was blowing in each area of western Japan, Tohoku and Hokkaido.

Normally we rarely think that typhoons develop in the Sea of Japan at the end of September when the seawater temperature is lower. Therefore, it can be considered that the typhoon had in fact changed into an extratropical cyclone (a so-called "bomb low pressure" cyclone) from approximately 3:00 on the 26th of September when she landed in Kyushu.

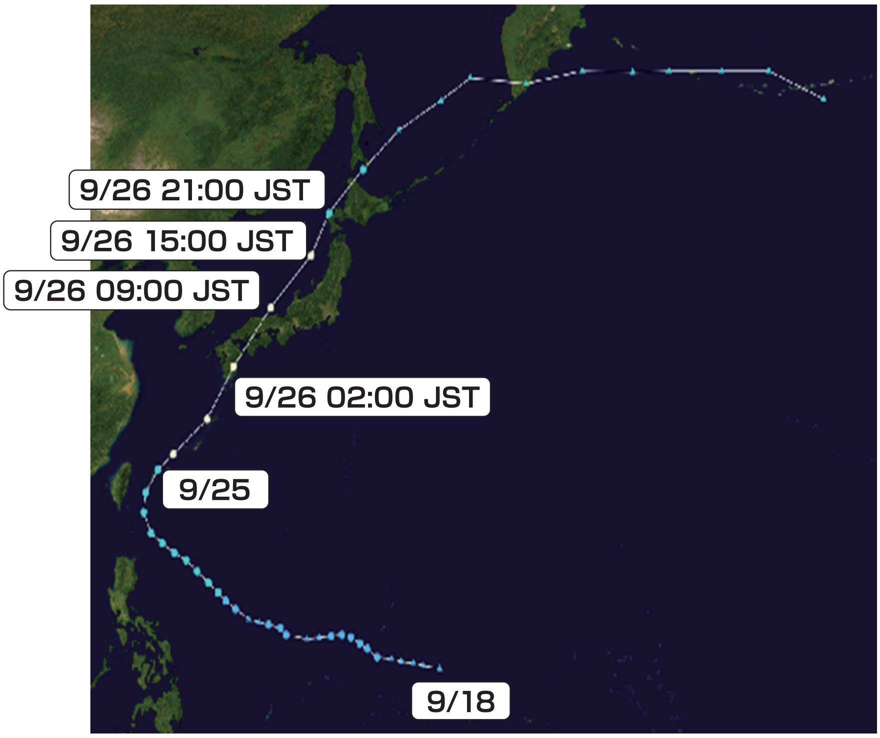
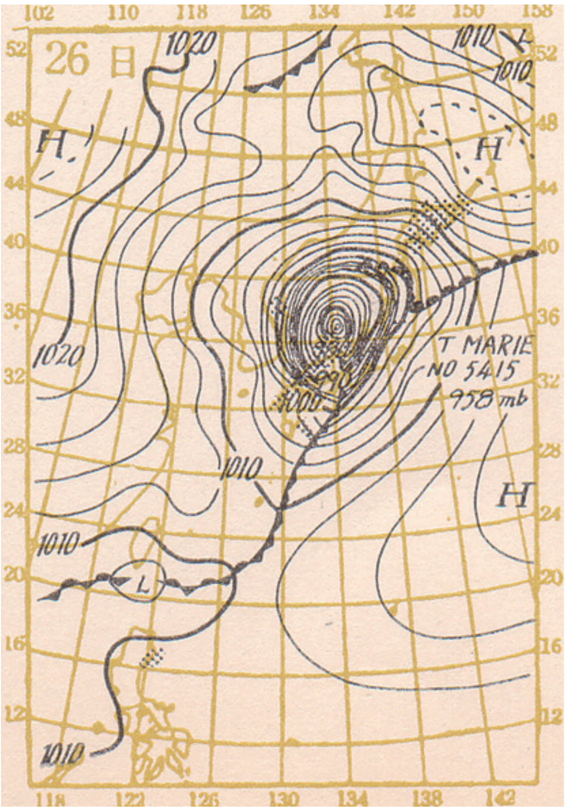
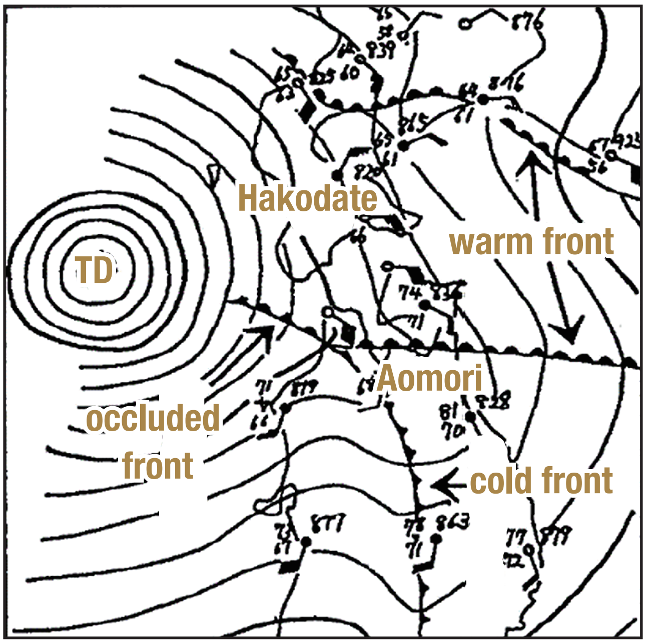


Fig. 31



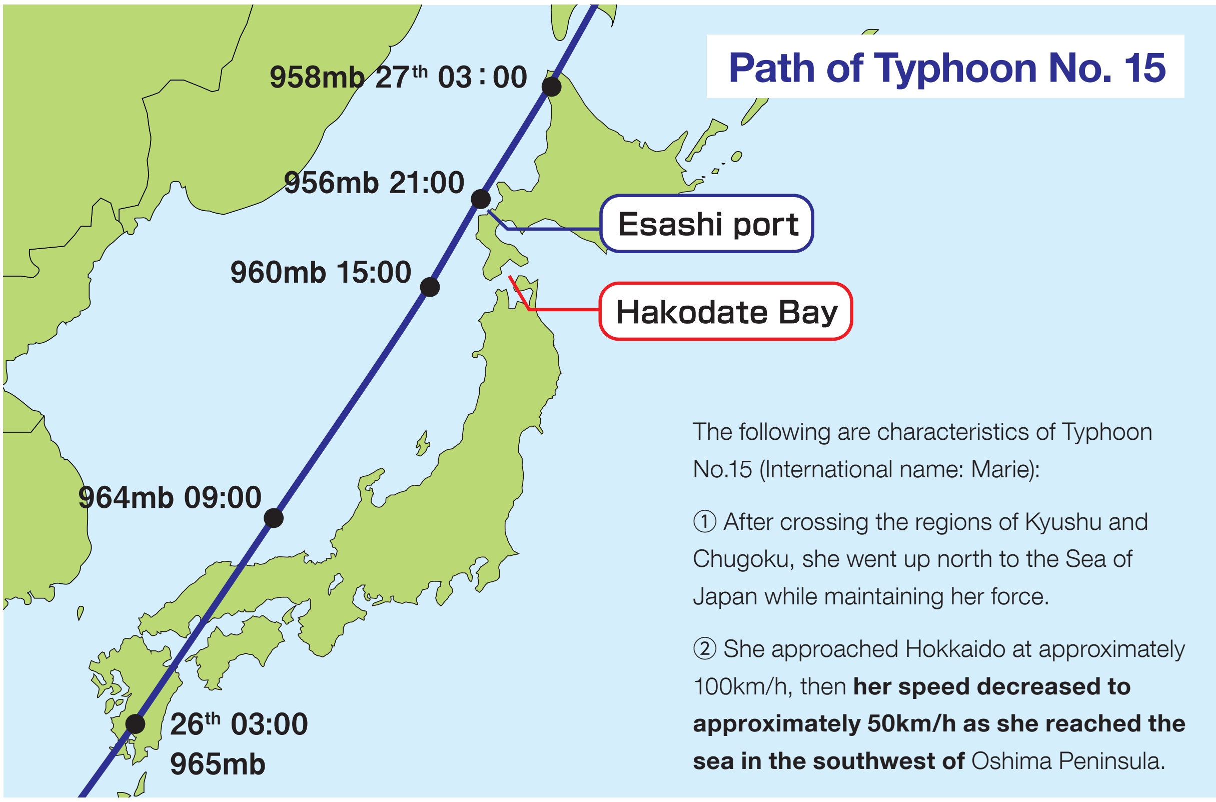
Sept. 26th 09:00 JST

Fig. 32



Sept. 26th 16:00 JST

Fig. 33



The following are characteristics of Typhoon No.15 (International name: Marie):

① After crossing the regions of Kyushu and Chugoku, she went up north to the Sea of Japan while maintaining her force.

② She approached Hokkaido at approximately 100km/h, then **her speed decreased to approximately 50km/h as she reached the sea in the southwest of** Oshima Peninsula.

Fig. 34

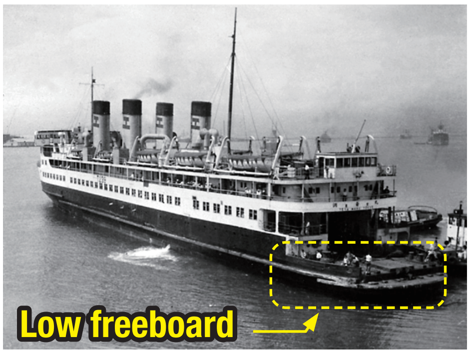
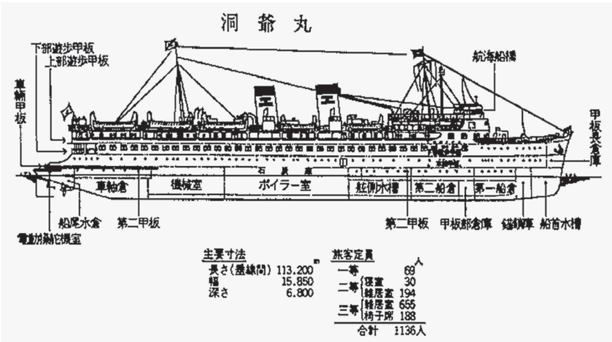
Photograph 35
"Capsized Touya Maru"

Photograph 36
"Bygone days of Touya Maru"

Movement of Touya Maru

The movement of Touya Maru on the 26th of September is as follows.

11 : 05	She moored Hakodate Pier (Aomori → Hakodate Port). “Typhoon No. 15 proceeded northeast 100km northwest of Noto Peninsula. According to the weather information, it was highly possible that it would pass to the south of Hakodate in the evening”.
14 : 40	Station for leaving port. (Leaving the Hakodate Pier bound for the Port of Aomori)
15 : 00	Because it was not possible to remove a movable bridge between the railway track and the ship due to a blackout, the Master decided to delay departure for the time being. Touya Maru was awaiting with passengers on board, while mooring. “Weather information: the typhoon passed the northern part of the Ou region or the southern part of Hokkaido in the evening and proceeded to the Kuril Islands at night”.
17 : 00	The wind suddenly weakened, sunny spells were observed in the sky and it would have seemed as if they had been swallowed up and had reached the centre of the typhoon. “At Hakodate Pier, there were no changes in wind direction for over one hour from 17:30. Then, the winds became stronger, but there were no changes in atmospheric pressure”.
17 : 40	It was decided that the ship depart at “18:30”.
17 : 59	“Weather information: the typhoon proceeded 100km northeast or north-northeast off Esashi Port offing”.
18 : 39	Departed Hakodate Pier from the port of Hakodate. While being blown by a south-southeast gale from her astern port side, she manoeuvred the normal route in the breakwater at full speed.
18 : 53	Passed the breakwater entrance nearby. It was confirmed that the port side bow took gale force winds and that the waves were also high.

18 : 55	She passed the breakwater lighthouse which was on her port side.
19 : 01	Anchored due to a violent storm and waves (two-anchor mooring with 8 shackles on her starboard side and 7 shackles on her port side). "There was a south-southwest wind at 25 - 30m/s, a gust at 40m/s and there were no changes in atmospheric pressure".
19 : 30	Along with pitching of the hull, car deck flooded from the opening of the stern.  Photograph 37  Fig. 38
19 : 50	The 7 shackles at port side were extended by 1 shackle to become 8 shackles on both sides. Flooding started in the engine room (machinery room).
20 : 00	Anchor dragging started. Flooding started in the boiler room.
20 : 10	Initial accident report was made to JCG via radio communications.
20 : 30	Operated the ballast pump, but shortly it became in vain. Flooding started in the steerage.
20 : 40	"The anemometer on the ship was recording gusts of 57m/s and a wave height of 6m".  Photograph 39
21 : 00	Ship heeled to the port side.  Photograph 40

21 : 40 Further heeled to the port side.

21 : 50 Main engine on the port side became inoperable, and the bilge could not be discharged. Ship's heel started shifting from port side to starboard side.

22 : 05 Main engine on the starboard side became inoperable and the vessel became trim by the stern due to flooding.

22 : 15 Passengers were instructed to wear life vests.

22 : 26 Grounded in the shallow off Nanaehama, with a 45 degree inclination to the starboard side.

Fig. 41

22 : 42 Blackout on board with a deluge of water flowing in.

22 : 45 Sinking after rolling over to the starboard side.

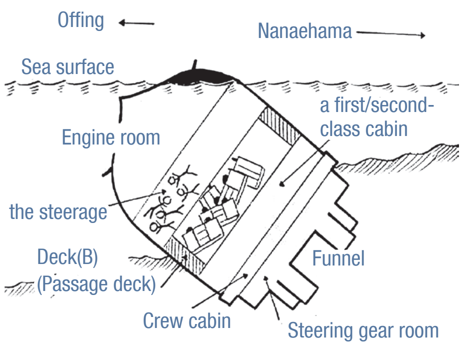


Fig. 42

Photograph 43

Sinking circumstances: location at a depth of 8.3m

The hull was parallel with the coast with a 135 degree inclination on her starboard side. The starboard side was buried in the seabed under mud with the port side bilge keel visible on the sea surface.

Later the Japan Meteorological Agency concluded that "the reason why the wind had weakened for a moment near the Hakodate Bay was because a cold air current, accompanying the cold front, offset the wind of field, and therefore, the cold front rapidly disappeared when it interacted with the wind field". Regarding the "wind becoming weak along with a mysterious westering sun", they announced that this was not caused by the typhoon as the centre of the typhoon passed the vicinity of the port of Hakodate.
Also, the four Aomori - Hakodate ferries, including Touya Maru, experienced groundings and capsized as a result of a dragging anchor.

Registered name of ship	No.11 Seikan Maru	Kitami Maru	Touya Maru	Tokachi Maru	Hidaka Maru
G/T	3,142 tons	2,928 tons	4,337 tons	2,911 tons	2,923 tons
Length	113.8 meters	113.7 meters	113.7 meters	113.6 meters	113.7 meters
No. of Crew	90	76	111	76	77
No. of Passengers	None	None	1,203	None	None
Loaded freight cars	45	46	12	35	43
Route	Hakodate → (Anchored in heavy weather)	Hakodate → (Anchored in heavy weather)	Hakodate → Aomori	Aomori → Hakodate	Aomori → Hakodate
Between 13:00 and 14:00: East-southeast 8-12m/s 999.2mb	13:20 Left port of Hakodate bound for port of Aomori Departed (Hakodate Pier)				11:20 Departed port of Aomori)
Between 14:00 and 15:00: East 15-17m/s 989.2mb	14:48 Because the waves rose could no longer sail and returned to port		14:40 Bound for port of Aomori S/B Station for departure	14:20 Departed port of Aomori	
Between 15:00 and 16:00: East 15-17m/s 986.6mb		15:17 Left wharf to shelter from stormy weather(Arikawa Pier) 15:30 Anchored (starboard anchor with 8 shackles)	15:00 Due to black out, adjustable shore ramp could not be removed. This caused a delay,and departure was suspended.		
Between 16:00 and 17:00: East 10-15m/s 985.2mb	16:02 Left wharf to shelter from stormy weather (Hakodate Pier) 16:25 **Anchored**				16:33 **Anchored** in the break water (starboard anchor with 5 shackles and port anchor with 5 shackles)
Between 17:00 and 18:00: South 12-15m/s 982.6mb	**Details are unknown because all crew deceased**		17:40 **Departed and bound for port of Aomori**		17:30 Commenced anchoring watch
Between 18:00 and 19:00: South 15-20m/s 982.6mb		18:40 Commenced anchoring watch Engine ready	18:38 **Departed Port of Hakodate (Hakodate Pier)**	18:50 **Anchored** (starboard anchor with 8 shackles and port anchor with 4 shackles)	
Between 19:00 and 20:00: South 15-20m/s 982.6mb		19:00 Used engine 19:30 Flood in engine room and boiler room	19:01 **Anchored** (starboard anchor with 8 shackles and port anchor with 7 shackles) 19:30 Flooded in car deck 19:50 Laid down both anchors with 8 shackles Flood in boiler room	19:30 Used engine Flooded in car deck	19:30 Used engine Laid down both anchors with 8 shackles

Registered name of ship	No.11 Seikan Maru	Kitami Maru	Touya Maru	Tokachi Maru	Hidaka Maru
Between 20:00 and 21:00: South 20-30m/s 979.9mb	20:00 **Sinking** from astern	20:20 **Dragging anchor** 20:45 **Weighing anchor commences in order to heave-to**	20:00 **Dragging anchor** Flood in boiler room	20:00 **Dragging anchor** Flood in boiler room 20:40 Drifted 1 nautical mile northeasterly by wind pressure and oscillates violently	
Between 21:00 and 22:00: South 15-20m/s 979.9mb		21:15 Heaved cable to 3 shackles and full speed ahead Heeled 10 degrees to port side	21:40 Heel increased on port side 21:50 Main engine on port side inoperable	21:50 Heel increased on starboard side	21:15 **Weighing anchor commences in order to shift outside of breakwater** 21:45 Weighing of the anchor completed and full speed ahead
Between 22:00 and 23:00: Southwest 15-20m/s 979.9mb		22:00 Heeled at 15 degrees starboard side 22:30 Engine inoperable, **rolled over** to starboard side, **sinking**	22:05 Main engine on starboard side inoperable 22:15 Instructed passengers to wear life vests 22:26 **Grounding in shallows and heeled at 45 degrees starboard side** 22:42 Blackout, large amount of seawater encroached 22:45 **Rolled over** to starboard side, **sinking**	22:20 Engine inoperable 22:30 Generator stopped (Blackout)	22:00 Flooded to car deck 22:10 Flooded in engine room and boiler room 22:25 After lowering anchor (starboard anchor with 4 shackles), entire anchor cable (10 shackles) was laid down
Between 23:00 and 24:00: Southwest 20-250m/s 981.2mb				23:41 Loaded cars were rolled over 23:42 **Capsized** on starboard side	23:00 Heeled at 10 degrees starboard side 23:35 Discarded anchor, but engine inoperable. Engine stopped 23:43 **Capsized**
Time of marine accident occurrence	20:00	22:30	22:45	23:42	23:43
Point of marine accident occurrence	257 degrees and 1,785m from Hakodate Port breakwater lighthouse	89 degrees and 2,900m from Kattoshimisaki lighthouse	257 degrees and 1,785m from Hakodate Port breakwater lighthouse	257 degrees and 1,785m from Hakodate Port breakwater lighthouse	257 degrees and 1,785m from Hakodate Port breakwater lighthouse
No. of deceased and missing	90	70	1,155	59	56

Note: The wind direction, wind speed and pressure are figures that are read at Hakodate Pier every hour on the hour.

Table 44

It is presumed that it was difficult to grasp the actual changes of the typhoon's state, because there was no means of observation via weather satellite, bar that of weather forecasts based on the information available from weather stations located in each region.

＝Quoted from the Marine Accident Inquiry Agency (MAIA) determination＝
Provisional translation Courtesy of the Marine Accident Inquiry Agency (MAIA) homepage

The Marine Accident Inquiry Commissioner's Office completed their survey in a short period of only 62 days following the occurrence of the accident. Appointing the 2nd navigation officer and the 2nd engineer of Touya Maru as examinees, appointing also the president of the Japanese National Railways (JNR), the chief of Aomori - Hakodate Railway Bureau, the chief of the Central Meteorological Observatory and chief of the Marine Meteorological Observatory in Hakodate as designated persons regarding the marine accident, filed an application for a trial to commence on the 27th November, 1954 at the Marine Accident Inquiry Agency in Hakodate.The first trial was concluded on the 15th of July, 1955. The decision regarding the second trial was concluded on the 9th of February, 1959.

Main text of judgement:
Although this accident occurred because the Master of Touya Maru neglected to carry out his duty, other factors include inappropriate operation management of the Aomori - Hakodate ferry company along with a general lack of understanding regarding the vessel's hull construction.

① Master's negligence of duty regarding shipping operation

- Even though the vessels are structured and equipped to the standards stipulated in the convention and law, it is necessary for the Master to pay extra attention to the safety of the vessel and lives of those on board, because it should be anticipated that navigating will be dangerous, in the event of encountering a typhoon.
- The Master should have departed as usual once the danger of the typhoon had passed.
- In the vicinity of the port of Hakodate, the wind veered and gradually increased from the southwest west between 22 - 25m/s, and turned into a squall at 32m/s. Thus, it could not be accepted that the typhoon had passed, as the barometric height decreased and stagnated. This accident was caused by the Master's negligence, who proceeded to set sail from the port of Hakodate bound for the port of Aomori while carrying a large number of passengers and cargo, under rough sea conditions.

② Hull construction

- Because there was a vessel that encountered such weather and sea conditions whereby sea waves flowed deep into the car deck of the vessel, whose hull structure was similar to this one, in the past, this hull structure was not appropriate, taking into consideration the actual operation to be carried out on this sea route.
- Regarding the accident, having not being able to have prevented flooding from the various openings on the cargo deck would have caused the subsequent sinking after rolling over. Thus, the inappropriateness of the hull construction is one of the factors concerning this accident.

③ Inappropriate operation management

- Despite such rough seas that could be expected to bring about great danger when navigating, the vessel continued operating on a fixed schedule and the operation continued as long as possible, without evacuating at an early phase, as would have normally been the case.
- The management department were of the opinion that it was enough to leave the safe operation of ferries to the Masters and that they should not intervene.
- There was no arrangement of personnel or personnel charged with authority in order take necessary care

and measures for the safe operation of the ship in the organization. In addition, there was no provision regarding emergency personnel arrangement and authority of management, in time of an emergency such as this.

- The management mechanism and policy for ferries had been properly carried out over the years, from when the government started managing this sea route until this accident occurred. It is not however appropriate for it to be managed by a shipping management company, when considering how dangerous this route is.

3—2 Cargo Vessel B Dragging anchor and grounding accident

Cargo Vessel B:
General cargo vessel with 2 cargo holds of 5,552 G/T

Date, time and location of occurrence:
30th of August 2004, 12:25 Japan time (JST), Yura-misaki offing of Ehime Prefecture

Weather at time of sinking:
rain, southeast wind: wind force 12, wave height 8m, end of ebb tide

Accident summary

Twenty Vietnamese crew were on board Vessel B, which departed the Port of Pohang of the Republic of Korea and arrived at the Port of Ohita via the Kanmon Straits on the 26th of August. Anchored in order to await berthing. The Master (Vietnamese) was at the age of 42 with 18 years of sea experience and 4 years as Master.
In the morning of the 28th, the Master knew that Typhoon No.16 was approaching Oita, between the 29th and the 30th, via weather information provided by NAVTEX and telex from the local agent. He decided to shelter from the typhoon by moving to another sea area. The vessel heaved up anchor in the afternoon, and the Master made a plan to start operating southward toward the Bungo Suido (Channel), while searching for an appropriate place to anchor.

The vessel heaved up anchor on the 29th of August at 09:55 JST, the Master started sailing southward along the Bungo Suido (Channel) as planned. However, due to the deep depth of the water that was also present in Uwakai etc. she continued southward and conducted single anchor mooring at a location of 92 meters depth of water in the bay of the southeast part of Yura-misaki offing of Ehime Prefecture at 14:40 on the same day. Afterwards, the wind direction changed to the southeast and sea waves encroached from the bay mouth that was exposed to the south. However, the Master continued to anchor without shifting from an early stage.
At 17:40 on the 29th, noticing that the anchor was dragging, the Master attempted to heave up the anchor in order to evacuate offshore. However, the vessel had no choice but shift off while dragging the anchor, and anchored again at 20:40, because it was not possible to weigh the anchor due to the extremely deep depth of water. At 11:30 on the 30th of August, the anchor was dragging again and Vessel B was grounded on the shore of Yurajima at 12:25 on the same day.
Four crew members who panicked and climbed down the stern deck and were carried away by the waves (one was

deceased and three missing). The remaining 16 crew members including the Master were rescued by the helicopters of the Japan Coast Guard and the Self-Defense Force. Photograph 45, Figs. 46 and 47 show the path of Vessel B and its anchor being dragged.

Photograph 45

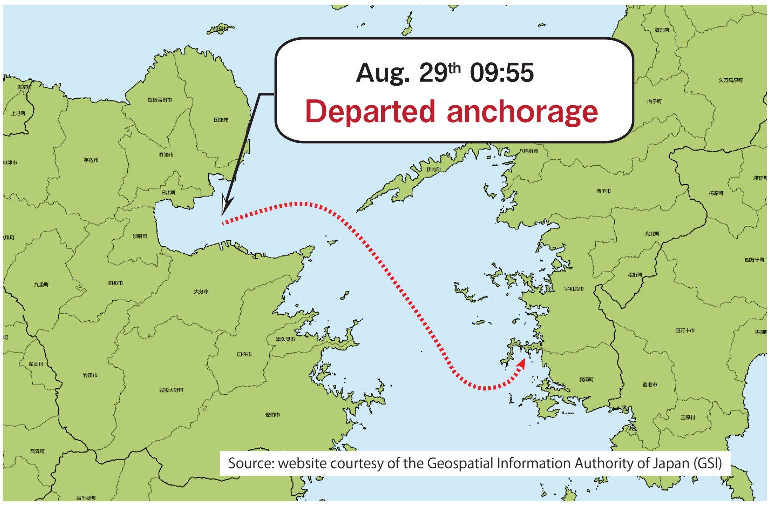


Fig. 46

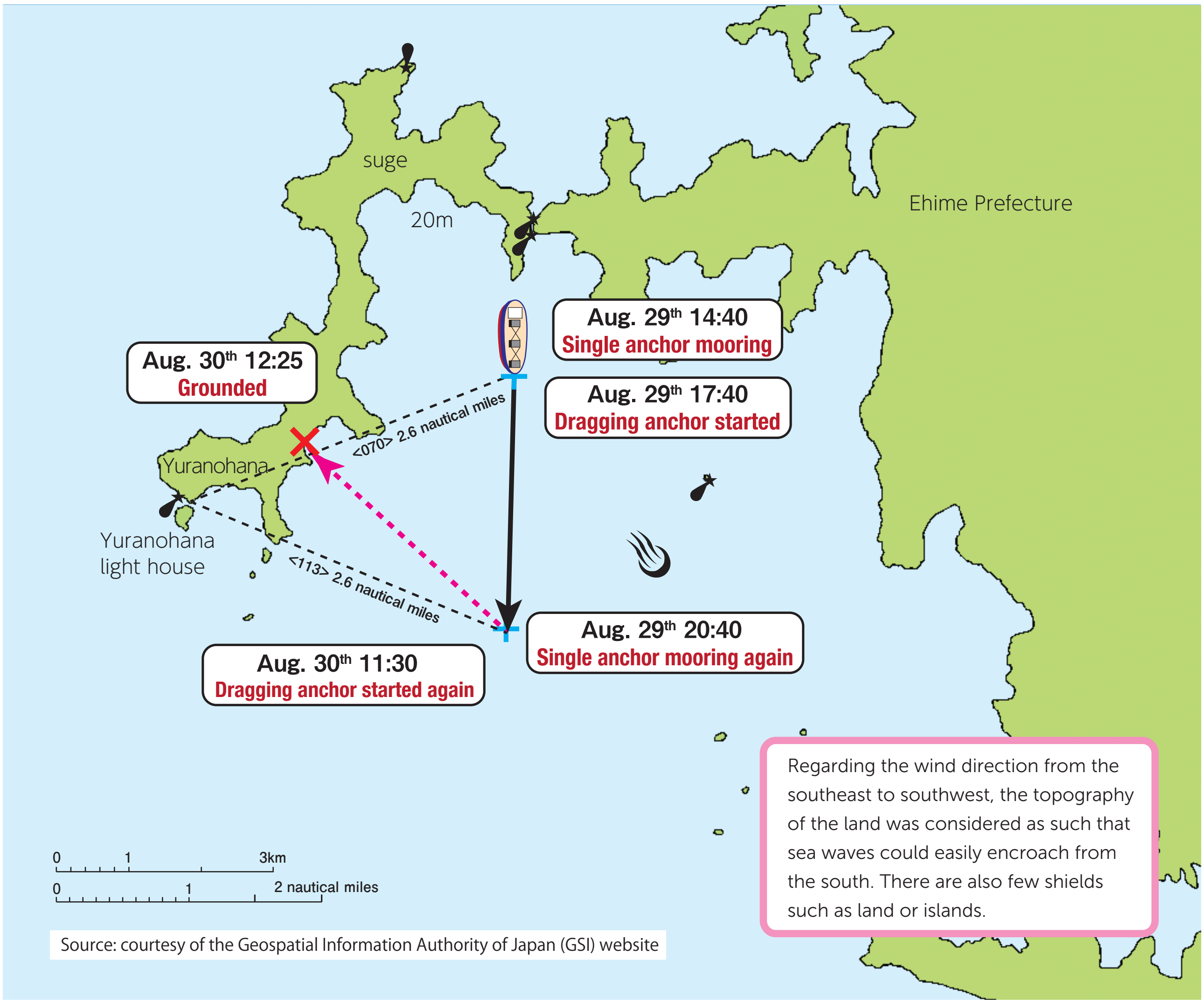


Fig. 47

Typhoon No.16 in 2004 (Asian name: Chaba)

〔Chaba: Naming country: Thailand, Meaning: Hibiscus〕

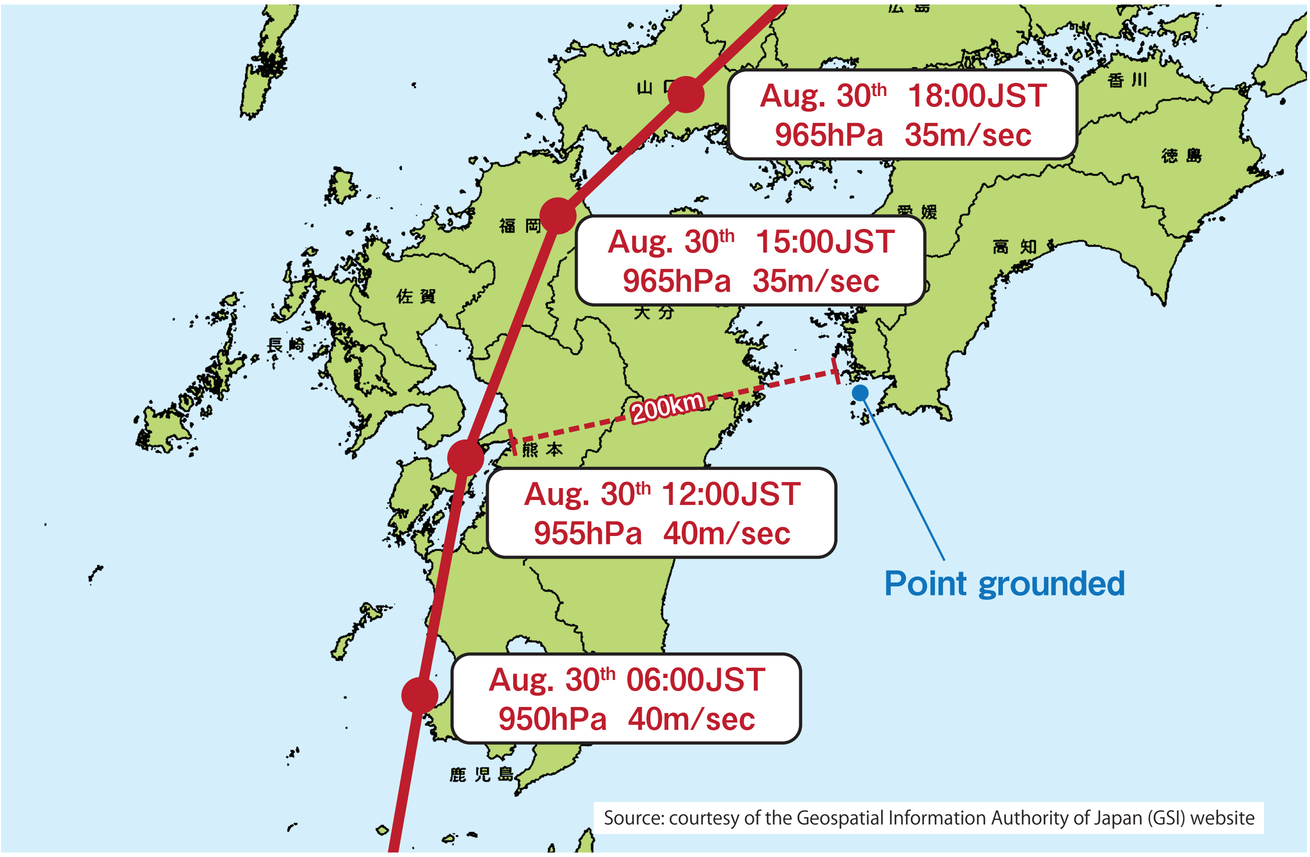


Fig. 48

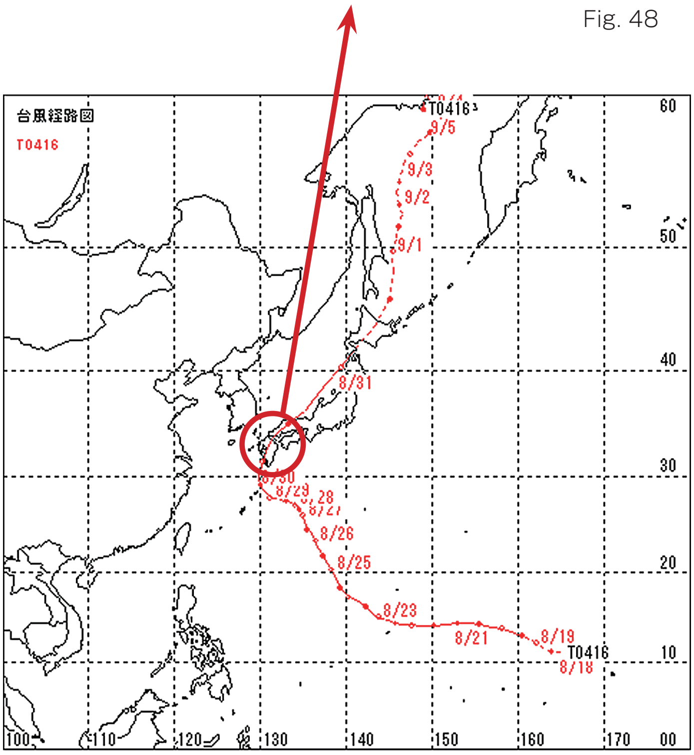
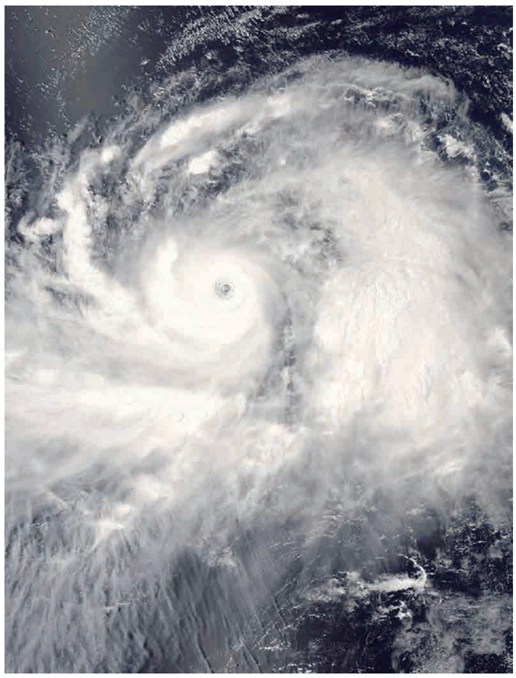


Fig. 49



Photograph 50

Typhoon No.16 at her peak (August 23rd)

910hp Maximum wind speed 155kts (80m/s)

Figs. 48 and 49 show the route of Typhoon No. 16 in 2004, which caused a case of dragging anchor.
On the 19th of August 2004, approximately 21:00 JST, the tropical cyclone in the sea around the Marshall Islands formed Typhoon No.16. Afterwards, the typhoon proceeded to the west while developing gradually. Then on August 23rd, she became 910hPa and 110knots (55m/s) at her peak and the strong wind area broadened. In Saipan, a maximum wind speed of 65m/s and a maximum instantaneous wind speed of 75m/s was observed.

At approximately 10:00 on the 30th of August, she landed as a “large and strong force” in the vicinity of Kushikino-city of Kagoshima Prefecture (Currently Ichikikushikino-city). Central pressure upon landing was 950hPa. Afterwards, she crossed Kyushu. The central location of the typhoon was in the vicinity of Amakusa of Kumamoto Prefecture at 12:00 on the 30th when Vessel B experienced a dragging anchor and grounding accident. Where it was located was approximately 200km from Yurajima, within the storm area and the wind speed was greater than 25m/s.
After that, typhoon No.16 landed again in the vicinity of Hofu-city of Yamaguchi Prefecture at approximately 17:30 on the 30th. It then increased in speed but later decayed and landed again near Hakodate-city of Hokkaido at around 12:00 on the 31st. Then, at 15:00 on the 31st, she changed into an extratropical cyclone in the eastern part of Hokkaido. She was the largest typhoon both in terms of force and size among the typhoons that landed in 2004.

Movement of Vessel B

August 26th 12 : 40	Entered into the outside port of Ohita from the Port of Pohang of the Republic of Korea. Lowered anchor at the point of anchorage in order to wait for berthing.
August 28th	In the morning of the 28th, the Master knew that Typhoon No.16 was approaching Ohita, between the 29th and the 30th, via weather information provided by NAVTEX and telex from the local agent. He decided to shelter from the typhoon by moving to another sea area. In the afternoon or on the following morning they heaved up the anchor and the Master decided to sail southward to the Bungo Suido (Channel), while searching for appropriate anchorage.
22 : 00	The first warning was issued by the harbour master of Ohita. “Regarding the ships at harbour, they must take measures that allow the ship’s personnel to be able to operate immediately if necessary. On top of that they must wait while paying attention to the movement of the typhoon while keeping in close contact with organizations on shore such as shipping agencies. They must also prepare for countermeasure of rough sea.
August 29th 9 : 55	Departed anchorage in the Port of Ohita and sailed southward to the Bungo Suido (Channel).
14 : 40	Started anchoring at 6.5 shackles on the port side at a point of 92 meters of water depth at <070>, 2.6 nautical miles from Yuranohama-Misaki Lighthouse.
16 : 00	The second warning was issued by the harbour master of Ohita.“Regarding the large vessels in the harbour, immediately evacuate to a safe area outside port in principle”.
17 : 00 (Approx.)	The wind direction changed from north east to south east and reached a wind force of 8. In addition, the waves from the south increased in height to 7 meters. Anchor cable was extended by one shackle.

17 : 40	Dragging anchor started. Tried weighing the anchor, but it was not possible to heave up it. Gave up weighing the anchor and started shifting to the south while using the engine under dragging the anchor.
20 : 40	Started anchoring at 8 shackles of the anchor cable at the point <113>, 2.6 nautical miles from Yura-misaki Lighthouse. Using the engine, countermeasures were taken to prevent anchor dragging against the wind.
August 30th 11 : 30	Wind force reached 12 due to the increase of southeast wind, and dragging anchor started in a leeward direction.
11 : 57	Distress alarm was activated via Emergency Position Indicating Radio Beacon (EPIRB) and Digital Selective Calling (DSC). Instructed the crew to wear life vests and muster at the bridge.
12 : 25	Grounded at the point of <066> 1,750m from Yuranohana Cape Lighthouse. At approximately 13:00, four panicked crew members left the bridge. When they climbed down the stern deck they were carried away with the waves and fell into the sea.

Photograph 51

The 16 crew members were rescued by the helicopters of the Japan Coast Guard and the Self-Defense Force. Among the four who fell into the sea, one was confirmed as deceased and three as missing.

= Quoted from the Marine Accident Inquiry Agency (MAIA) determination =
Provisional translation

Cause

① The selection of the anchorage was not conducted appropriately.

- If appropriate anchorage; where the depth of water is shallow and she was shielded from gale force winds and waves, was chosen, it was thought that the accident could have been avoided.

② Obtaining information on the typhoon and taking shelter by anchoring was insufficient.

- There were facts related to the process leading to the accident such as not obtaining the information about anchoring from the agency and only obtaining weather information by means of NAVEX. Also, not being able to use the anchor on the starboard side due to windlass failure was one of the causes of the accident.

The anchor and anchor cable outfitted on the ship were as follows:

Anchor:	JIS type Weight 3,300kgs
Anchor cable:	1 shackle was at 27.5m × 9 shackles per side 248m

Photograph 52
JIS type anchor

When tentatively calculating the minimum required length for an anchor chain, in 92m of water, an anchor chain with 513m (19 shackles) of length is required (at times of rough seas: $4 \times d + 145m$). Sheltering from stormy weather in a location which exceeds 50m in water depth is thought of as unsuitable.

3—3 Cargo Vessel C Dragging anchor and grounding accident

Cargo Vessel C :
Panamax bulker with cargo holds 36,080 tons
Loa : 224.0m

Date, time and point of occurrence :
On the 25th of July 2002, at 21:11 JST Shibushi Bay of Kagoshima Prefecture

Weather at the time of grounding :
Rain, east-northeasterly wind, wind force of 10, wave height at 5m and end of ebb tide

Accident summary


Photograph 53

Regarding dry bulk, Vessel C, the total number of crew members on board was 23 (four Indian nationals and 19 Filipino nationals) and 57, 474 tons of corn was loaded at the Port of New Orleans in North America. She entered into the Port of Shibushi, Kagoshima Prefecture, on the 23rd of July, 2002 in order to unload. At the Port, among the people disembarking were: 9 crew members (a chief officer [Indian national] and 8 others [Filipino nationals]) that disembarked and a total number of 5 crew members (the successor, a chief officer [(Indian national)] and 4 other crew members) relieved them and boarded. The crew arrangement at the time when the accident occurred was 4 Indian nationals made up of the Master, the chief officer, the chief engineer and the 1st engineer and 15 other Filipino nationals. (The number of crew members decreased by 4)

The Master boarded Vessel C as the Master at the Port of New Orleans on June 4th, after serving as a Master of several large cargo ships. The Master had a boarding history of 7 years as a Master in his 27 years of sea-service. During this period of time, the Master had experience calling at many different ports in Japan, however, it was the first time for him to enter the Port of Shibushi.

At Shibushi Port, the Shibushi Port Typhoon Response Committee was established with the purpose of preventing any accidents due to a typhoon at the port and the sea area in the vicinity.
This Typhoon Response Committee consisted of the Chairman of the Kagoshima Coast Guard Director who was the harbour master of Shibushi Port, governmental organizations such as Kagoshima Local Meteorological Observatory and Kyushu Regional Development Bureau Shibushi Port and Harbour Construction Office, regional organizations such as Shibushi Town, Police Station, Fire Station, Shibushi Port and Harbour Office etc, Kagoshima Licensed Pilot's Association and 43 other organizations and groups such as harbour related companies engaged in various businesses in the port. The committee used to hold a regular annual committee meeting in early July before the typhoon season came and attempted to inform all members on the typhoon countermeasure guidelines thoroughly regarding the warning issue and the communication system to ensure that the procedure for sending information to the ships in the harbour when a typhoon approaches was well known.
Regarding the warning system and recommendations to be issued by the Typhoon Response Committee, in the event that a possible accident is predicted to occur due to an approach of a typhoon to Shibushi Port, they are to hold a policy committee meeting, if necessary, in order to discuss how to spread typhoon information, prediction of the typhoon's path and its impact, grasp of the ships in the port, preparation for rough seas regarding ships, timing of evacuation recommendations and how to relay the information thoroughly and so on. Then, based on the outcome of the discussion and typhoon countermeasure guidelines, before it would become difficult to navigate the ships, the chairman would issue the warning and contact the ships in the port via each member.

Because the strong wind area of typhoon No. 9 was predicted to reach Shibushi Port within 48 hours, on the 23rd of July, at 15:00 JST, the Typhoon Response Committee recommended preparing for evacuation by issuing the first warning. Moreover, because the strong wind area was predicted to reach the port within 24 hours, on the 24th, at 13:00, they issued the second warning. They recommended that ships in the port take strict precautionary measures by taking shelter outside of the port and so on.

On the afternoon of July 23rd when the first warning was issued, the Master had a meeting with the person in charge at the local agent and decided to take shelter at Kagoshima Bay.
On the following day, July 24th, when the cargo was unloaded 17,194 tons, cargo handling was interrupted and the Vessel C left the wharf at 10:40.
The Master was thinking that he had not experience with entering Kagoshima Bay, it would take 11 hours as a round-trip and there was a risk of being close to the centre of the typhoon according to the forecast of the typhoon's path, then. He also judged that the force would decay judging by the information from NAVTEX. Because there was ample spare time until the typhoon approached, the Master decided to choose the anchorage according to the movement of the typhoon from the following three choices as his original plan: ① head for Kagoshima Bay, ② stay anchored at Shibushi Bay without navigating a direct course to Kagoshima Bay or ③ seek shelter offshore. As a result, at 11.30, the vessel dropped her starboard anchor at 6 shackles <056> 2.0 nautical miles off of Birou Island and 2.1 nautical miles off Shibushi south breakwater, light house <193>, where the sea bottom was sand with a water depth of around 25 metres.

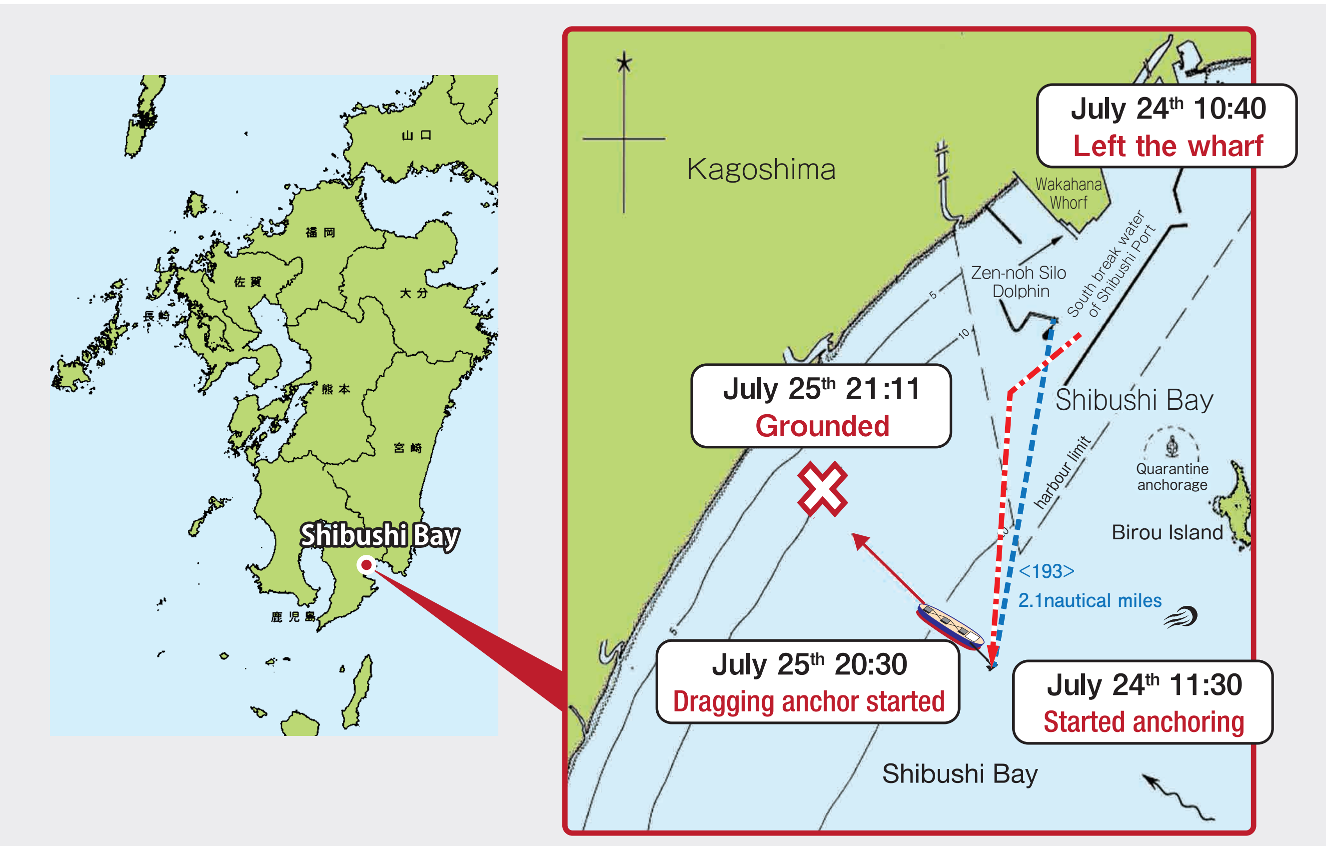


Fig. 54

Afterwards, partly because a similar size of ship, Vessel M started anchoring at Shibushi Bay, Vessel C also continued single anchor mooring with 6 shackles of anchor cable. However, contrary to expectation, the force of the typhoon did not decrease and Shibushi Bay gradually entered the storm area and the right semicircle of the typhoon. Due to

Photograph 55 EPIRB

Photograph 56　Breakage

the violent storm and swell encroaching on the Bay, at 20:30 on July 25th, dragging anchor occurred and they grounded at 21:11.

Regarding the damage, cargo holds, between No. 5 and No. 6, near the centre of the hull there was breakage and No. 2 Fuel Oil Tank under No. 5 cargo hold was damaged. Immediately, at the same time as he activated the distress signal by operating the EPIRB, the Master reported the distress to the Japan Coast Guard via international VHF radio communications.
The Master judged that there would be a danger of the damaged part of the hull ending up sideways. At 21:30, the Master commanded all of the crew to wear helmets and life vests in order to abandon the ship. Then they lowered the lifeboats outfitted on both sides of the deck respectively, all of the crew boarded the lifeboat on the starboard side (leeway side) and then they started to lower the lifeboat.

However, the lifeboat was violently beaten against the shell plating of Vessel C due to the gale force winds and high waves while lowering. Also, some crew were injured when their bodies were beaten in the lifeboat. Due to the constant buffeting, all of the crew evacuated from the lifeboat and jumped into the sea. As a result, although 15 out of 19 crew members managed to swim to the nearby coast, 4 (one second engineer, two ABs and one C/Cook) were deceased.

Path of Typhoon No. 9 in 2002: Asian name is FENGSHEN

On the 14th of July 2002, a tropical depression formed in the sea around the Marshall Islands and changed into Typhoon No. 9 accelerating in force and heading north. She took a westerly path in the vicinity of 15 degrees north in latitude and, by the 20th, reached the vicinity of 200 nautical miles southwest of Minami-Tori-Shima island and changed to a northwesterly path nearing the Ogasawara Bonin Islands while gradually increasing in speed.

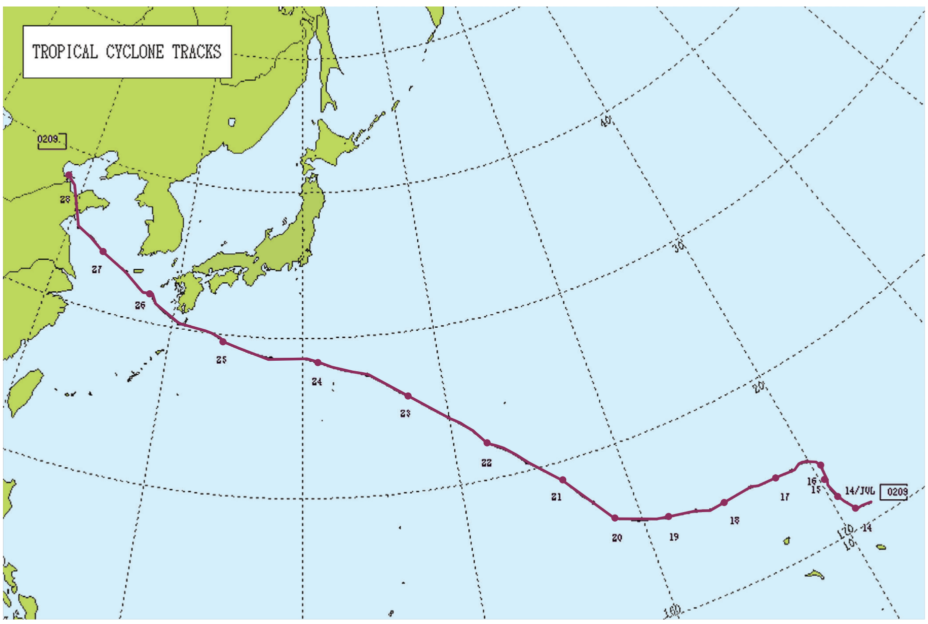


Fig. 57　Path of Typhoon No.9

(1) July 24th

Regarding Typhoon No.9, according to an observation at 00:00 JST, weather information provided by NAVTEX announced that at 03:00, she was located in the vicinity of the northeast at 100 nautical miles away from Chichijima Island of Ogasawara Bonin Islands. She developed into a "strong typhoon" with a central pressure of 945hPa and a maximum wind speed of 41m/s close to the centre. The storm area was 120 nautical miles moving northerly at 25m/s with a strong wind area of 250 nautical miles and a wind speed of more than 15m/s as she advanced into southern Kyushu taking a westerly path at 15 knots.

(2) July 25th

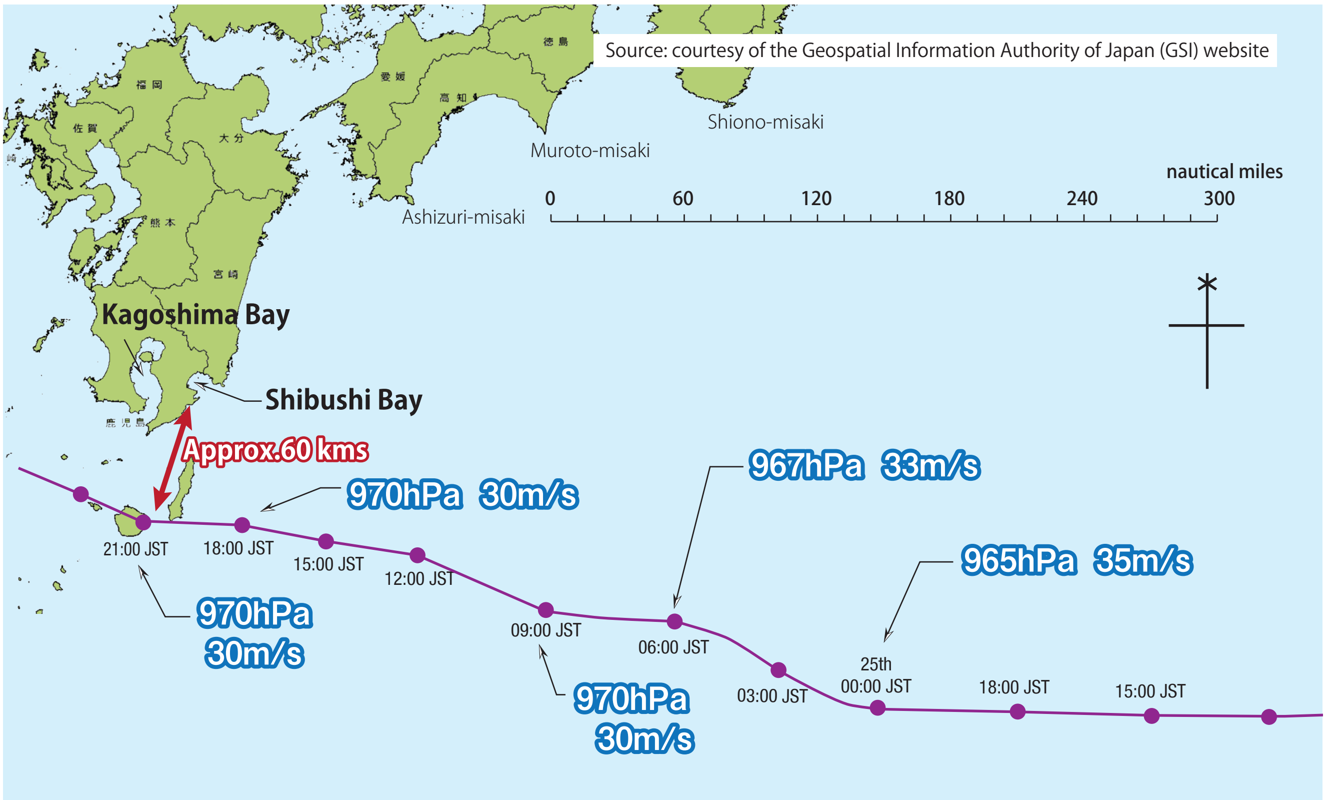


Fig. 58 Path of Tyhoon No.9

On the following day of the 25th, by 00:00, Typhoon No.9 was already in the vicinity of the east-southeast 350 nautical miles from Shibushi Bay, with a central pressure of 965hPa, a maximum wind speed of 35m/s, a storm area of 80 nautical miles and a strong wind area 250 nautical miles. She approached southern Kyushu taking a westerly path and maintained a speed of 11 knots. At 06:00, she reached the vicinity of 240 nautical miles east-southeast of Shibushi Bay and the bay was now in the strong wind area.

Later, by 09:00, Typhoon No.9 was located in the vicinity of <124> 191 nautical miles from the point where Vessel C had anchored in Shibushi Bay and the force had more or less decayed with a central pressure of 970hPa, a maximum wind speed of 30m/s, a storm area of 80 nautical miles and a strong wind area of 270 nautical miles. However, she moved west-northwesterly at a speed of 17 knots and was predicted to pass 50 to 60 nautical miles south of Shibushi Bay between 19:00 and 20:00, if she proceeded on the same path and at the same speed. There was even the possibility Shibushi Bay would be exposed the storm area, in particular the "right semicircle of the typhoon": "a Dangerous semicircle".

On the other hand, although the maximum wind speed was at 33m/s according to an observation at 06:00 by NAVTEX, by 09:00, it had decayed to 30m/s, according to further observation. Due to this, the international notation of Typhoon No. 9 was changed from a “T” to an “STS” (one category down). The maximum wind speed was also forecast to have decreased to 28m/s within the next 24 hours. (Note: please refer to the notes below)

Yet, the storm area of 80 nautical miles did not change, and, at 12:00, Typhoon No.9 was still located in the vicinity of <128> 135 nautical miles from the point where Vessel C had anchored. She proceeded west-northwest at 18 knots with increasing speed, maintaining a central pressure of 970hPa and a maximum wind speed of 30m/s. Then, it was highly likely that shortly Shibushi Bay would come in range of the 80 nautical mile storm area.

By 15:00, with the force of the typhoon still unabated and with a central pressure of 970hPa with a maximum wind speed of 30m/s, she approached the vicinity of <141> 93 nautical miles from the anchored point of the vessel. At approximately 16:30, she reached the vicinity of <150> 80 nautical miles (estimated position) from the anchored point, and the outer edge of the storm area encroached on Shibushi Bay.

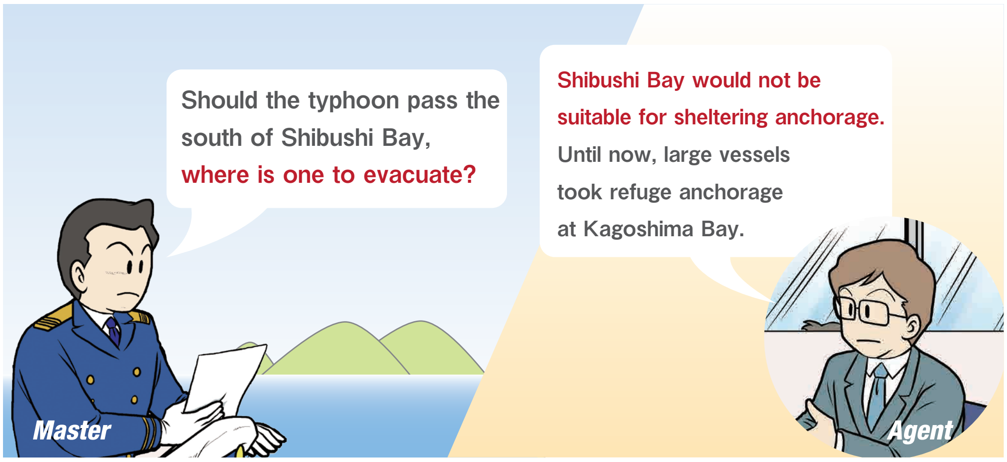
At 18:00, Typhoon No.9 reached the vicinity of 30 nautical miles southeast of Tanegashima Island of Kagoshima Prefecture which was in the vicinity of <162> 73 nautical miles from the anchored point. And then, she moved west. At approximately 19:30, she passed the vicinity of <180> 67 nautical miles from the anchored point, the closest she had been to Shibushi Bay. Furthermore, at 21:00, she reached Yakushima Island in the same prefecture.

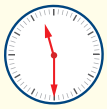
Note: In Japan, as explained in page. 2 - 3, it is categorized as a “Typhoon” when its maximum wind speed is greater than 17m/s (wind force 8) and as a “Tropical cyclone” when it is less than 17m/s. On the other hand, according to the international scale, typhoons and storms are classified into the following three categories.

① The maximum wind speed is more than 33m/s (wind force 12): **TYPHOON (T)**
② The maximum wind speed is more than 25m/s (wind force 10) but less than 33m/s: **SEVERE TROPICAL STORM (STS)**
③ The maximum wind speed is more than 17m/s, but less than 25m/s: **TROPICAL STORM (TS)**

In addition, a tropical cyclone that has a maximum wind speed of less than 17m/s is categorized as a TROPICAL DEPRESSION (TD).

Movement of Vessel C

July 21st 01 : 06	Vessel C arrived at Shibushi Bay. Anchored in the bay in order to adjust the time for berthing.
July 22nd 06 : 34	A pilot registered with the Kagoshima Licensed Pilot's Association embarked.
07 : 36	Berthed at the quay of Zen-Noh Silo Corporation and started cargo discharging work. Total of 9 crew members (the chief officer [Indian national] and 8 other members (Filipino nationals) disembarked. Total of 5 crew members (the successor chief officer [Indian national] and 4 other members [Filipino nationals]) embarked. Note: Decrease of four crew members
July 23rd 15 : 00	Because the strong wind area of Typhoon No.9 was predicted to reach Shibushi Bay within 48 hours, the Typhoon Response Committee issued the first warning and announced the recommendation of preparing for evacuation. Later, the Master and the person in charge at the local agent discussed the following items in their meeting.  As a result, the Master decided to leave the wharf on the following morning and shelter from the typhoon in Kagoshima Bay. At the same time, in order to carry out draft adjustment, the Master changed the discharging plan in order to complete the cargo discharge of No.2 and No.6. He also arranged for the ballast tanks to be filled so as to adjust departure condition fore draft 8.00m and aft 11.60m.
July 24th 10 : 40	After completing discharge of No.6 cargo, filling ballast was also completed. At the time when 17,194 tons had been unloaded, the cargo handling was interrupted in order for the ship to leave the wharf (with a remaining 40,280 tons still loaded).



11 : 30

After the pilot disembarked, the Master decided to anchor at Shibushi Bay without taking a direct course to Kagoshima Bay that was originally planned as a sea area of sheltering. The Master decided to observe the movement of the typhoon and anchor using the starboard anchor at 6 shackles at 2.1 nautical miles from south of the breakwater. The water was at a depth of 25m and the sand type was sea bottom sedimentary.
The reason for the change of plan, as mentioned above, was because the following three anchoring methods were planned. Paying attention to the movement of the typhoon, the Master decided to observe the situation while anchoring at Shibushi Bay.

- To anchor at Shibushi Bay
- Avoided sailing into the open sea to keep a distance between the ship and the typhoon
- To shelter at Kagoshima Bay

13 : 00

Because the strong wind area was predicted to reach Shibushi Bay within 24 hours, the Typhoon Response Committee issued a second warning.

In the evening, the Master got to know that a ship of similar size, Vessel M (38,567 tons), left the wharf in a similar way and started anchoring at Shibushi Bay.

July 25rd

06:00 (observed)

The strong wind area encroached on Shibushi Bay.
Typhoon No.9 was in the vicinity of <117> 243 nautical miles from the anchored point and she was proceeding west-northwesterly at 16 knots. Because Shibushi Bay had entered the storm area at 250 nautical miles, if she continued to proceed on course, it was estimated she would pass at approximately 50 nautical miles south of Shibushi Bay between 19:00 to 20:00.

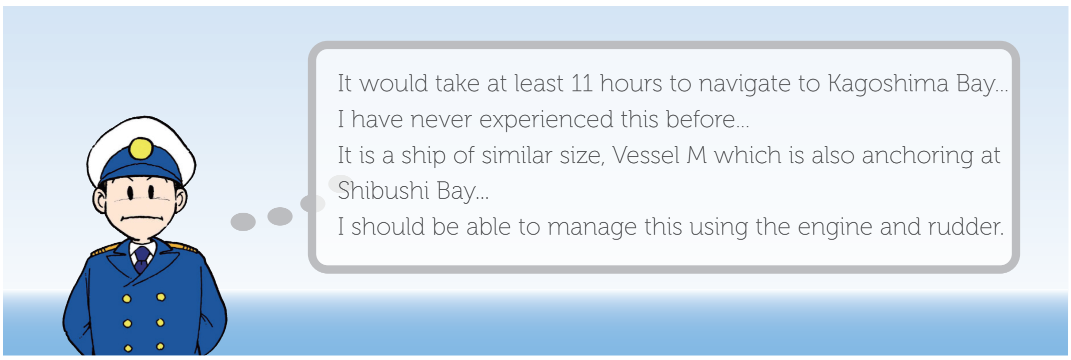
09 : 00 (observed)

There was a possibility that Shibushi Bay would enter the storm area of the right semicircle of the typhoon.
Typhoon No. 9 was proceeding west-northwesterly at 17 knots close to the vicinity of <124> 191 nautical miles from the anchored point and it was estimated that there was a possibility of Shibusi Bay entering the storm area of the right semicircle of the typhoon.

The Master only used the typhoon information provided by NAVTEX. Although the Master wrote down the position, path and speed of the typhoon on the nautical chart, he did not write down the fact that the ship was in a strong wind area or a storm area.
In addition, the Master obtained the following information from NAVTEX.

- Category of the typhoon was downgraded by one category from T to STS.
- It was forecast that the wind speed would decrease to 28m/s within the coming 24 hours.

Furthermore, because it was still observed that the wind speed was less than 10m/s and the wave height was at 2m, the Master decided to stay sheltered at Shibushi Bay.



12 : 00 (observed)	The Master obtained the information from NAVTEX that Typhoon No.9 was proceeding west-northwesterly maintaining a force of 970hp and a storm area of more than 30m/s.
 16 : 00	North wind suddenly became strong and the wind speed exceeded 15m/s. Also, the height of the swells which encroached the bay mouth increased. Anchoring watch was enforced, however, the Master stayed sheltering at Shibushi Bay without evacuating to the open sea.
16 : 24	Started use of engine keeping 6 shackles of anchor cable.
16 : 30	Shibushi Bay entered the storm area at the right semicircle of the typhoon.
17 : 00	Wind direction changed to northeast. Wave height at 3 meters.
19 : 30	The typhoon moved the closest at this point, with a wind direction now changed to east-northeast. Wind speed was 17m/s, maximum instantaneous wind speed was 28m/s and wave height was 5m.
 20 : 30	Started dragging anchor. Wind speed was 25m/s, the maximum instantaneous wind speed was 35 to 41m/s and the highest wave height was 8m.
 20 : 40	Confirmed anchor dragging via radar. Started weighing the anchor, but this became constrained when heaving the cable to 2 shackles of 6 shackles. It was because the cable was extremely tense, even with the engine at full speeded ahead. Tried to prevent drift by using the engine. Even if it was temporarily effective, it was not possible to stop it completely.
 21 : 11	Aft part was grounded at the point of south <238> 1.9 nautical miles from the breakwater in Shibushi Bay, water depth at 10m. Immediately after this, cargo holds between No.5 and No.6 near the centre of the hull were broken and the No.2 Fuel Oil Tank under the No.5 cargo hold was damaged. The Master judged that there was a possibility that the damaged aft part might rollover. Then, as was described above, at the same time of activating the distress signal via EPIRB, the Master reported the distress to the Japan Coast Guard by VHF.
 21 : 30	The Master commanded all crew to wear life vests and started abandoning ship with the lifeboat outfitted on the starboard side (leeway side). However, the lifeboat was violently beaten and damaged due to the gale and high waves. Because some were injured, all crew jumped into the sea, however, 4 crew members out of all 19 members were confirmed as deceased.

= Quoted from the Marine Accident Inquiry Agency (MAIA) determination =
Provisional translation

The following were analyzed as main accident causes.

① Insufficient realization regarding the typhoon

- Wishful observation that the typhoon's force would decay because of the typhoon information provided by NAVTEX.
- Lack of crisis consciousness regarding the entering of a storm area, changes of wind direction and encroachment of gale and high waves.
- Lack of awareness towards typhoons by the Master and each navigation officer

② Insufficient information of sea area for sheltering etc.

The Master decided to take refuge at Kagoshima Bay, because when the Master and the local agent had a meeting, the Master of Vessel C asked the person in charge of the local agent where he should sheltering and he was advised by that person that "Shibushi Bay was not suitable for sheltering anchorage. Until now, large vessels took refuge anchorage at Kagoshima Bay". In fact, as described above, the Master did not navigate to Kagoshima Bay and stayed anchored at Shibushi Bay.

- The Master made his judgement based on only what the local agent told him and typhoon information supplied by NAVTEX.
- Thus, there was insufficient typhoon information (such as the range of strong wind or storm areas, wind direction, wind speed etc.)
- One of the reasons to keep anchoring at Shibushi Bay was that it would take an extra 11 hours to sail in the storm to Kagoshima Bay and, once again, the vessel was to return the Shibushi Bay, if the typhoon was to pass.
- The Maser was hesitant to enter Kagoshima Bay, as he was not familiar with the area.
- According to typhoon information provided by NAVTEX, the category of the typhoon was downgraded by one rank to category "STS". With this information, the Master judged that the typhoon would decay naturally, however, the wind speed did not decrease and a large swell encroached into the bay again.

③ The Master had a false sense of security because a vessel whose size was similar was also anchoring.

- The Master felt a false sense of security, because a foreign registered Vessel M (38,567 tons) was anchoring at the Port of Fukushima off in the northeast part of Shibushi Bay.
- Vessel M was advised: "If there is a wind from the East, Fukushima port off in the northeastern area of Shibushi Bay should be suitable" by their pilot, and conducted single anchor mooring with 9 to 10 shackles at that port. Although she dragged anchor due to a violent storm and swell, she managed not to get grounded.

3－4 Questionnaire conducted by the Marine Accident Inquiry Agency (MAIA) for Masters of the coastal vessels that experienced sheltering from the typhoon

When the Marine Accident Inquiry Agency (MAIA) at that time issued their Maritime Casualty Analysis Report (Vol. 6): "Typhoons and Marine Accidents", they conducted a questionnaire for Masters of the coastal vessels that actually experienced sheltering from typhoon. Some of them are introduced here, as there were many practical comments.

There were many comments, such as
"Matters to note when sheltering from a typhoon"

- Paying attention to the distance between one's own vessel and the one anchored nearby, the Master was cautious regarding both the anchoring of his own ship and other ships.
- While the typhoon was nearby, the Master was careful to observe changes in wind direction following her passing and the strong wind that would be blowing back.
- Because a foreign registered ship tends to conduct single anchor mooring and can easily drag anchor, the Master tried not to anchor in the vicinity of those ships. He especially avoided being leeward in relation to the position of those ships.
- Using the engine, steering and thruster, the Master tried to stand bow against the wind.
- Commenced anchoring watch and stand-by of the engine at an early stage.
- Because a strong wind was predicted and there were many anchoring ships in a narrow anchorage, in an attempt to not cause horsing (yawing and swaying), the Master conducted two-anchor mooring in order to increase the holding power.
- The Master wrote down the vessel names of the anchoring ships nearby, in case there was an incident of dragging anchor, it would have been possible to contact the other ships via VHF or telephone.
- Estimated the wind direction at the time of maximum wind speed, and applied two-anchor mooring in that wind direction.

In addition, other specific comments will be introduced.

In the event of wind speed exceeding 35m/s, it is dangerous to carry out an anchoring work at foreward station. Thus, the Master judged it would be difficult to heave up anchor because it was in excess of 40m/s. Therefore, the Master weighed the anchor before the wind became strong and heaved-to while keeping course so as to receive the wind at the right ahead with a headway speed to some extent. (Large ferry)

The Master dared to conduct single anchor mooring, because Hakodate Bay was predicted to have high waves sooner or later. Because she dragged anchor at a wave height of 3m, the Master managed to keep not getting pressed by using the engine. Single anchor mooring is desirable, if we are to prevent collision accidents due to another vessel's dragging anchor. It is impossible to prevent accidents using two-anchor mooring. (4,000 G/T Coastal Tanker)

Because the wind speed exceeded 20 m/s, the chief engineer was stationed in order to prepare for S/B engine. While the hull was yawing in a "figure-of-eight" movement, the angular velocity of blowing back was faster than that of the large cargo ship, thus it was originally a mistake to judge that the holding power would be strong enough, which resulted in the subsequent response. At that moment, the Master should have judged that a strong wind force was to press instantaneously on the side of the vessel and prepared the engine and thruster. (Large ferry)

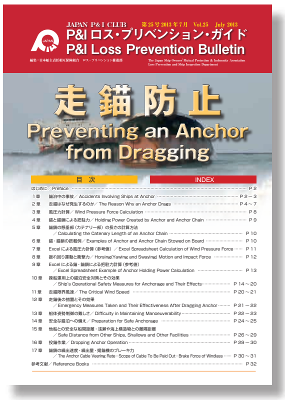
If the fore station operation was deemed to be dangerous at the time of weighing the anchor, pressure could have been prevented by using the engine. When contacting the Japan Coast Guard regarding anchorage location and to ascertain information about anchorage, they kindly responded and even gave information about where the typhoon was heading. (3,552 G/T Coastal Tanker)

Judging from the path of the typhoon, the Master carefully judged as to whether it was a suitable place to anchor by considering which direction the wind would blow and condition of gales and waves that may affect where the ship was planning to anchor. After having anchored, the Master made sure to write down the names, positions etc. of other ships nearby so that he may contact them immediately in case of an emergency. Regarding how harsh nature can be, it is a must to always consider countermeasures because one can never be well-prepared enough.

Because the vessel was too concerned with cargo handling, the commencement of sheltering was delayed. Cargo handling should have been suspended, and the crew should have taken refuge earlier evacuating to Mutsu Bay if it was possible. Off the coast of Kitaura (off the Oshika Peninsula) was not a suitable choice for anchorage because the kind of sea bottom was too rocky for anchorage, and fishing equipment was set up in the vicinity. Anchor as early as possible. It would be difficult to lower anchor as planned after the typhoon had come into close proximity and the wind force had increased. Also, it would be constraining to find a suitable position in relation to other ships. It is important to plan for anchoring not only for during the night but also during the daytime.

04 § 4 Mechanism of dragging anchor

The following are important extracts from our Loss Prevention Bulletin Vol.25 titled "Preventing an Anchor from Dragging" which was published on the 13th July, 2013. For details, please refer to this guide.



4−1 Accidents involving ships at anchor

Accidents involving ships at anchor usually occur when the anchor drags and the vessel drifts without holding power, leading to collisions and/or groundings or strandings. The following considerations should be taken into account:

①	It can take some time to realize the anchor is dragging, despite the fact that the ship is drifting.
②	It takes some time to weigh the anchor and restore the ship to full manoeuvrable condition, even though the ship may be drifting for that period.
③	During the period beginning with the detection of dragging to the time full control is achieved over the ship's manoeuvrability, the vessel may run dangerously close aboard, or into another ship or structure, or into shoal water.

Unless heavy weather causes the vessel to capsize, no serious accident should occur just because a ship is dragging its anchor, provided there is enough space around it for manoeuvrability and enough time available. The above three considerations may also be applied to the cases introduced in the previous chapter (excluding vessel capsize due to heavy weather).

4−2 The reasons as to why an anchor drags

A ship's anchor drags due to the impact of external forces on it which exceed the holding power of the anchor and cable. That is, dragging anchor occurs as a result of a relatively simple reason: "When an external force exceeds that of the anchor's holding power, it will drag".

Holding power < External force ▶▶ **Dragging anchor**

Empirical or Rule of Thumb Methods for Assessing the Minimum Required Length of Anchor Cable

The following is a well-known method for assessing the Minimum Required Length of Anchor Cable, however, factors related to ship type, actual wind speed etc. are not found in this method. It can be considered that those factors were consolidated in the process of formulating this method for the minimum required length of an anchor cable.

Japanese Publication Theory of Ship Operation

- Fine weather : $L = 3d + 90m$
- Rough weather : $L = 4d + 145m$

United Kingdom Publication Theory of Ship Operation

$$L = 39 \times \sqrt{d}$$

L : Minimum required length of anchor cable(m)

d : Water depth(m): up to a wind speed of around 30 m/s.

According to the Marine Accident Inquiry Agency (MAIA), at that time the wind speed and wave height which corresponds to the Japanese theory are introduced as simulation results and actual statistical data regarding the anchoring situation of 700 coastal vessels, when the landed typhoons (10 typhoons) passed in 2004, are documented in their publication titled Maritime Casualty Analysis Report (Vol. 6): Typhoons and marine accidents (in 2006). The findings are as follows. Naturally, because this theory or guideline will vary depending on the type of sea bottom and anchorage conditions regarding one's ship and the other ships, actual minimum required length of anchor cable is to be determined, with safety being the priority.

Fine weather

When, **L = 3d + 90m** → Wind speed 20m/s and wave height up to 1m

Rough weather

When, **L = 4d + 145m** →
- Ferries etc. Wind speed 25m/s and wave height up to 2.5m
- Others Wind speed 30m/s and wave height up to 2.0m

The above guidelines will vary depending on the type of sea bottom and the condition of sourrounding ships in anchorage.

In addition, in the publication of the Maritime Casualty Analysis Report, the simulation results are introduced and attempt to answer question regarding the difference in the anchoring limit between “being exposed to wind only” and “being exposed to wind and swell” concerning cases in (3-3) in reference to Vessel C.

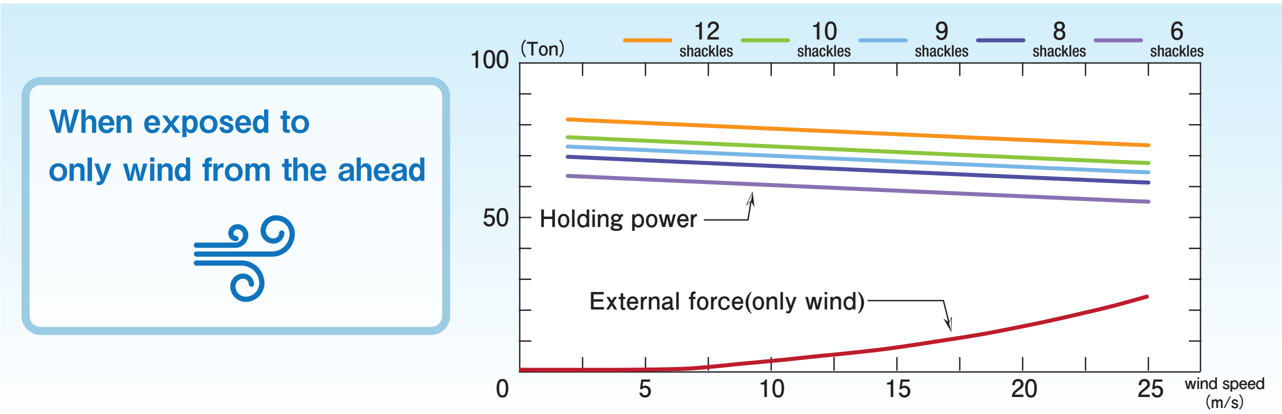


Fig. 59

As can be seen from the anchor holding power of the anchor and anchor chain, which will be referred to later, because the bottom part of the anchor chain decreases when wind pressure increases, it was found that the anchor does not drag until the wind speed is 25m/s and when the minimum required length of anchor chain in the water is more than 6 shackles, although anchor holding power does decrease.

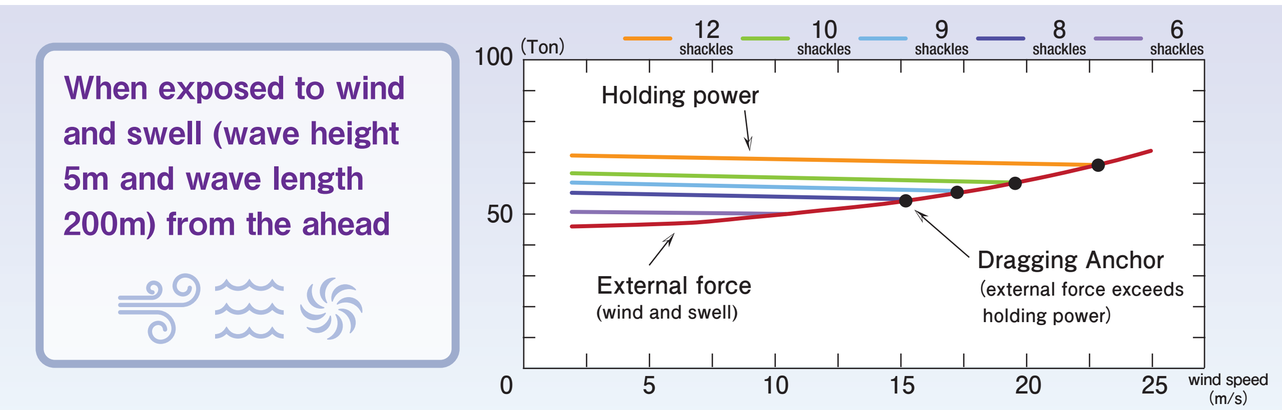


Fig. 60

In the event that a swell is added, due to Wind pressure force + Wave drift force (the force at which a wave moves a floating object), the anchor chain tension reaches approximately 50 tons at a wind speed of 10m/s and exceeds its holding power at 6 shackles at this point in time. Also, it was revealed that the anchor drags at 8 shackles at a wind speed of 15 m/s and at 12 shackles at a wind speed of 25m/s.

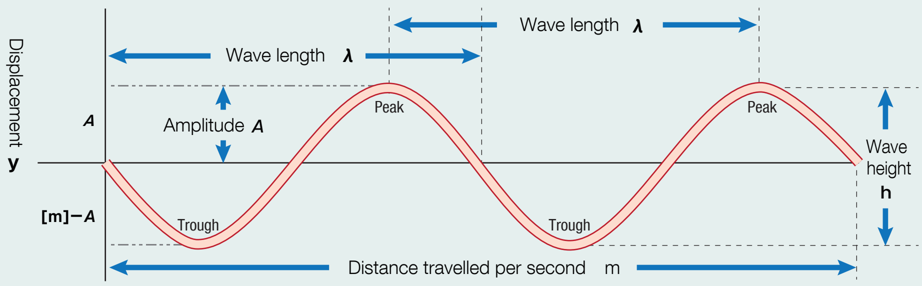
Don’ t underestimate “swell” and “wave height” which may cause ship motion during anchoring.

Watch out for wind and for waves ! !

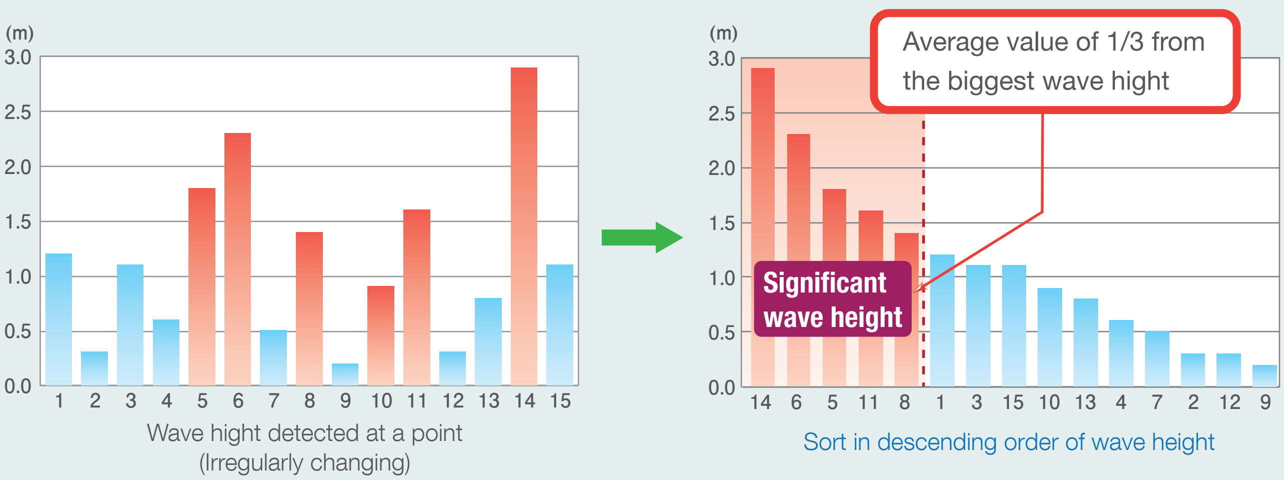
- Be careful regarding changes in wind direction, when a typhoon or windy atmospheric depression approaches.
- At sea, where there are few structures against wind, it is estimated that the maximum wind speed will be be1.5-2 times stronger than the average wind speed.
- The higher the swell becomes, the greater the danger of dragging anchor will be, remarkably. Anchor at a position where the encroachment of a swell is expected is to be avoided. Occasionally, the maximum wave height may be 1.5-2 times of that of the significant wave height (*1).

*1) Significant wave height (from the Japan Meteorological Agency website)

Choose 1/3 of the wave observations (within a timeframe of 20 mins.) in descending order from the top. Of those, the average wave height and period becomes the significant wave. According to this definition, this is also referred to as the “1/3 maximum wave”.

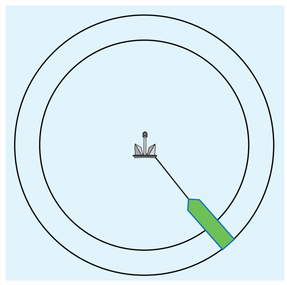
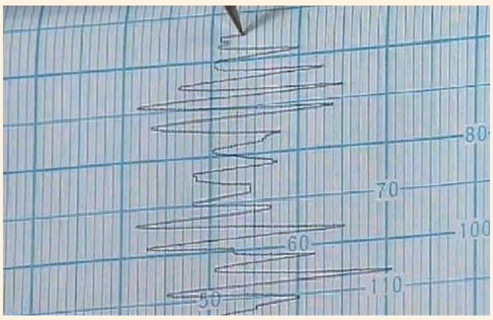


Graph expressing waves: in the event that two waves are generated per second



4−3 Detection of dragging anchor

There are conventional methods to check for anchor dragging:

①	Check the ship's position, to confirm whether it is located outside of a turning circle (see Fig. 61).  Fig. 61 Turning Circle
②	The bow cannot stand against the wind.
③	The ship's side against the wind has not changed.
④	Check to see that there is no slacking of chains, just before a ship's side is about to turn against the wind.
⑤	Check as to whether there are extraordinarily large vibrations coming from the anchor chains.
⑥	In the event that the course recorder does not show a sine curve movement. Photograph 62 shows the course record when being anchored while being exposed to wind at a wind speed of 8 m/s, when the author was on board a Pure Car Carrier (PCC). It is difficult to tell if it is a sine curve movement or not.  Photograph 62

The above methods remain well-tried but, of course, only confirm that the anchor is dragging. They do not predict when dragging is likely to commence.

= Actual ship movement at the time of anchor dragging =

With GPS now being commonplace, a recent study analysis shows that anchor dragging is a phenomenon that consists of two different stages. This study points out that anchor dragging started before it was detectable, prior to conventional methods of dragging anchor detection today (the first stage: dragging anchor with yaw and sway). (Note: this is not applicable when the anchored point is precisely written down, whereby even a slight change in the ship's position can be grasped.)

The first stage: dragging anchor with yaw and sway

The yaw and sway motion of a ship during anchoring is often compared to a "figure-of-eight" pattern. (Part "A" in the diagram to the right shows that the anchor is not dragging.) It has been found that as wind pressure force begins to exceed the anchor's holding power, the ship yaws and is pressed transversely, as shown in area "B" in the diagram. Also, it should be relatively easy to control the manoeuvrability of a ship and weigh the anchor).

The second stage: Anchor dragging caused by wind pressure

Where wind pressure force gradually becomes stronger, one side of the ship turns against the wind and is then pressed and moves transversely at a certain speed, as shown in area "C" in the diagram. The conventional method of detecting anchor dragging takes place at this stage. At this stage, it is getting difficult (more time is needed) to weigh the anchor and if weighing the anchor cannot be accomplished, it is almost impossible to start manoeuvring.

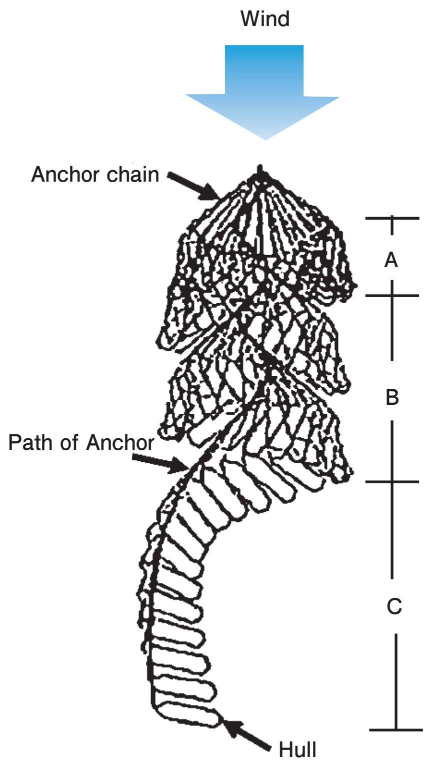
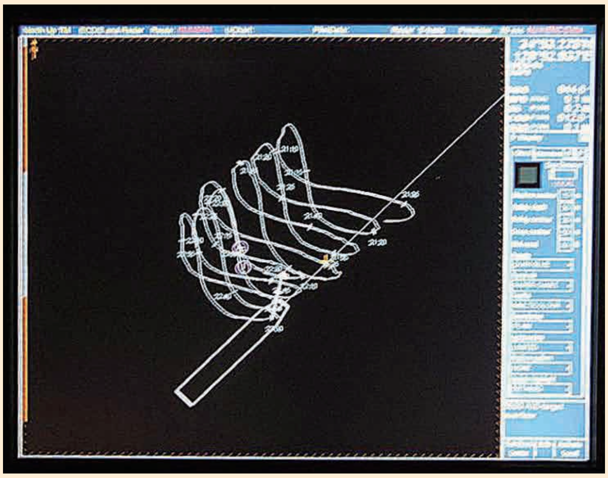


Fig. 63

Using tracking devices that display location information such as GPS, ECDIS and RADAR, it is now easy to detect anchor dragging during the first stage. When an anchor does drag now, in addition to the usual methods of detection concerning dragging anchor, it is desirable that "early prediction" and "early detection" of a dragging anchor be the norm and that "safety countermeasures are taken as early as possible".

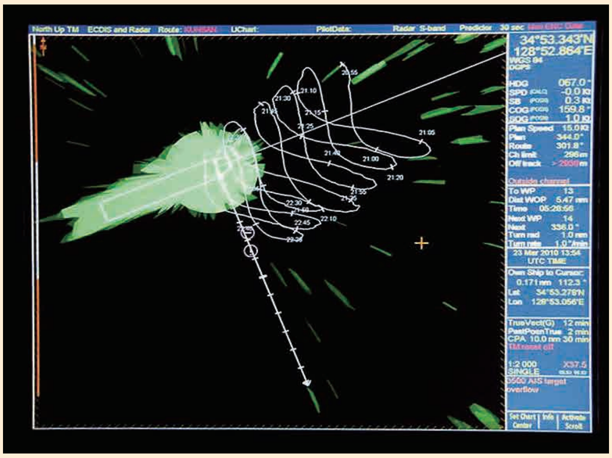
Photographs 64, 65 and 66 are actual displays of the ECDIS and RADAR when the author was on board the Pure Car Carrier (PCC). It was possible to grasp the actual ship's movement using the ship's position record and the electronic displays.

Display of ECDIS and RADAR



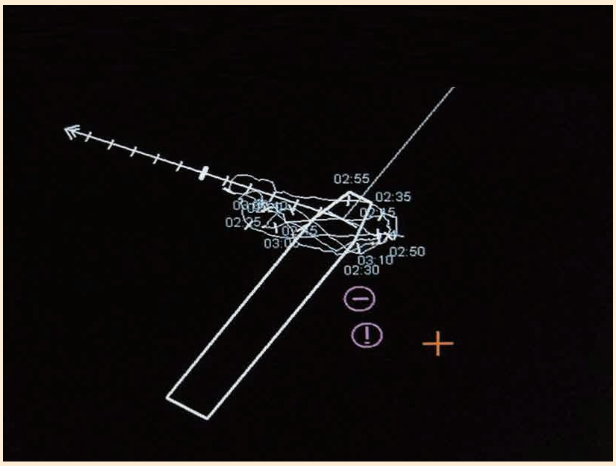
Photograph 64

Using the ECDIS display, it is possible to view the full size of the hull by narrowing in on the display range. Also, GPS tracks are shown for approximately 60 minutes.
This helps us understand the first stage in more detail: Dragging Anchor with Yaw and Sway.



Photograph 65

Similarly, the RADAR range was set to 0.75 nautical miles and the track of the GPS was set for 60 minutes.
This helps to solidify understanding of the first stage: Dragging Anchor with Yaw and Sway.



Photograph 66

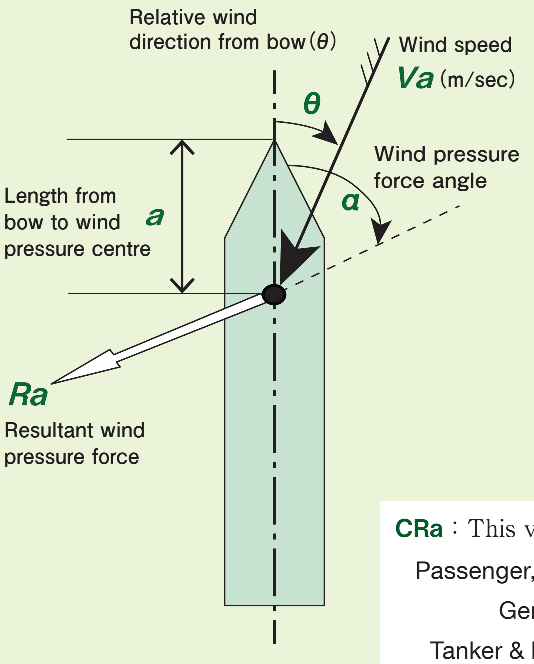
Because there were no other vessels at anchorage, an anchor dragging wind pressure experiment was conducted. The hull faced sideways to the wind direction instantly and was pressed at a speed of 3 to 4 knots, thus more time was required for weighing the anchor.

4－4　Wind pressure force

In order to have a grasp of the external forces that cause anchor dragging, we must have an understanding of the wind pressure force. Wind pressure force can be calculated with the following “Hughes Formula”.

Hughes Formula

$$Ra = \frac{1}{2} \times \rho \times CRa \times Va^2 \times (A \cos^2\theta + B \sin^2\theta)\ /1000\ (ton)$$



θ	: Wind direction from bow [degree] (Relative Wind Direction)
Va	: Headwind speed [m/sec]
ρ	: Air density [0.125 kg・sec / m⁴]
A	: Ship’s projected area from bow above waterline [㎡]
B	: Ship’s projected area from side above waterline [㎡]
a	: Length from bow to wind pressure center [m] (Point of Action)
Ra	: Resultant wind pressure force [kg] → divided by 1,000 to be "ton" (Total Wind Force)
α	: Wind pressure force angle [degree] (Angle of Action)
CRa	: Wind pressure force coefficient (this can be calculated by the following formula)

CRa : This varies for different ship types, as follows.

Passenger, PCC, Ctnr	: $1.142 - 0.142\cos 2\theta - 0.367\cos 4\theta - 0.133\cos 6\theta$
General cargo	: $1.325 - 0.050\cos 2\theta - 0.350\cos 4\theta - 0.175\cos 6\theta$
Tanker & bulk carrier	: $1.200 - 0.083\cos 2\theta - 0.250\cos 4\theta - 0.117\cos 6\theta$

Resultant wind pressure force is proportional to the square of wind speed.

It is difficult to calculate for wind pressure force at a specific time instantly when manually calculating. However, it is easy to calculate the wind pressure force once the formula has been input into a PC. Examples for reference using Excel are shown in Table 67.

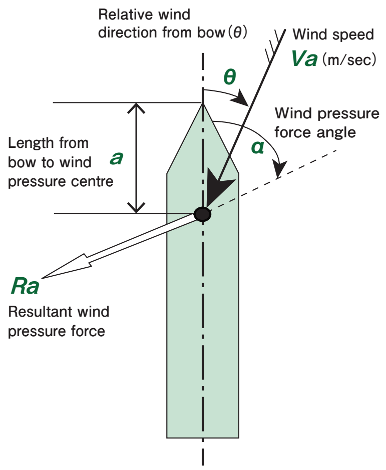
Wind Pressure Force Cal. : Just Reference

1 This formula calculates the wind force of your vessel at the wind speed.
2 The wind force coefficient in each kind of ship is calculated automatically.
3 Input the following data

Loa (m)	200	
(Projected area (Front)) (m2) (A)	800	
(Projected area (Side)) (m2) (B)	5,800	
(Wind Speed) (m/s)	19.5	(Ave.Wind Speed × 1.25 or 1.50)
(Kind of ship) (Passenger, PCC, Ctnr:1 General Cargo : 2 Tanker, Bulker: 3)	1	

＊ Input Wind Speed by below ref. data

Less than 8 m/s	: Ave. Wind Speed
Strong Wind : 8 ～ 13m/sec	: Ave. Wind Speed × 1.25
Storm Wind : More than 13m/sec	: Ave. Wind Speed × 1.50



RESULTS

(θ) Wind direction from bow (deg)	(Ra) Total wind force (t)	(RL) Longitudinal(t)	(RT) Transverse(t)	(a) Point of action(m)	(α) Angle of action(deg)	(CRa) Factor
0	14.26	14.26	0.00	58.20	0.00	0.75
10	20.84	18.50	9.60	62.80	27.43	0.92
20	43.23	30.23	30.90	67.40	45.62	1.31
30	80.39	40.60	69.38	72.00	59.67	1.65
40	118.01	40.06	111.01	76.60	70.15	1.73
50	139.78	29.83	136.56	81.20	77.68	1.58
60	145.98	18.21	144.84	85.80	82.83	1.35
70	150.59	9.95	150.26	90.40	86.21	1.22
80	159.95	4.46	159.89	95.00	88.40	1.19
90	165.41	0.00	165.41	99.60	90.00	1.20
(Impact)	85.56	Wind Force on Front (θ = 0) × 6, Tanker/Bulker × 4))				

(CRa)		
1	2	3
0.500000	0.750000	0.750000
0.660925	0.922400	0.871994
1.035993	1.313421	1.151506
1.387500	1.650000	1.400500
1.528709	1.732710	1.479010
1.445025	1.575075	1.390836
1.263500	1.350000	1.249500
1.120549	1.215025	1.161670
1.060798	1.191369	1.144983
1.050000	1.200000	1.150000

Impact Force :
Wind Force on Front × 5 ～ 6 for PCC/CTNR/Passenger ship, × 3 ～ 4 for Tanker/Bulker

Table 67

Regarding the calculating formula in the table, the following were used.

Calculation Formula in Above table

Total Wind Force

$$Ra = \frac{1}{2} \times \rho \times CRa \times Va^2 \times (A\cos^2\theta + B\sin^2\theta) / 1000 \text{ (ton)}$$

Longitudinal Force

$$RL = Ra \times \cos\alpha$$

Transverse Force

$$RT = Ra \times \sin\alpha$$

a Point of Action

$$a = (0.291 + 0.0023 \times \theta) \times Loa$$

α Angle of Action

$$\alpha = \left\{1 - 0.15 \times (1 - \theta/90) - 0.8 \times (1 - \theta/90)^3\right\} \times 90$$

Wind Pressure Co-efficiency (CRa)

1 $1.142 - 0.142\cos 2\theta - 0.367\cos 4\theta - 0.133\cos 6\theta$ (Passenger Ship / PCC / Container)
2 $1.325 - 0.050\cos 2\theta - 0.350\cos 4\theta - 0.175\cos 6\theta$ (General Cargo)
3 $1.200 - 0.083\cos 2\theta - 0.250\cos 4\theta - 0.117\cos 6\theta$ (Tanker / Bulker)

Impact Force

PCC/CTNR/Passenger Ship	Wind Pressure on Front × 6
Bulker	Wind Pressure on Front × 4

4－5　Holding power created by anchor and anchor cable

Holding power created by anchor and anchor cable

H (Holding power created by anchor and anchor cable) $= Ha + Hc = \lambda a \times Wa' + \lambda c \times Wc' \times l$

H : Holding Power Created by Anchor and Anchor cable (kgs)
Ha : Holding Power Created by Anchor (kgs)
Hc : Holding Power Created by Anchor cable (kgs)
Wa : Anchor Weight in Air (kgs)
Wc : Anchor Chain Weight per m in Air (kgs)
Wa' : Anchor Weight in Water (kgs) = 0.87×Wa (kgs)
Wc' : Anchor Chain Weight per m in Water (kgs) = 0.87×Wc (kgs)
l : Minimum Required Length of Anchor cable (m)
λa : Anchor Holding Factor
λc : Anchor Holding Factor

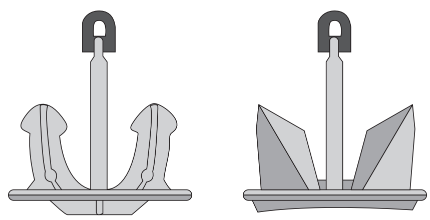
Anchor holding power during anchoring is the sum of “holding power by anchor” and “frictional force of anchor cable lying on the sea bottom”.

The holding factor of an anchor or anchor cable (λ a and λ c) is different depending on the type of anchor or type of sea bottom. The anchor holding factor (λ a) and anchor cable holding factor (λ c) of a JIS type or AC14 type are shown in Tables 68 and 69 respectively.

λ a : Anchor Holding Factor

Type of Anchor	Sand	Mud	Dragging Anchor
JIS	3.5	3.2	1.5
AC14	7.0	10.6	2.0

Table 68



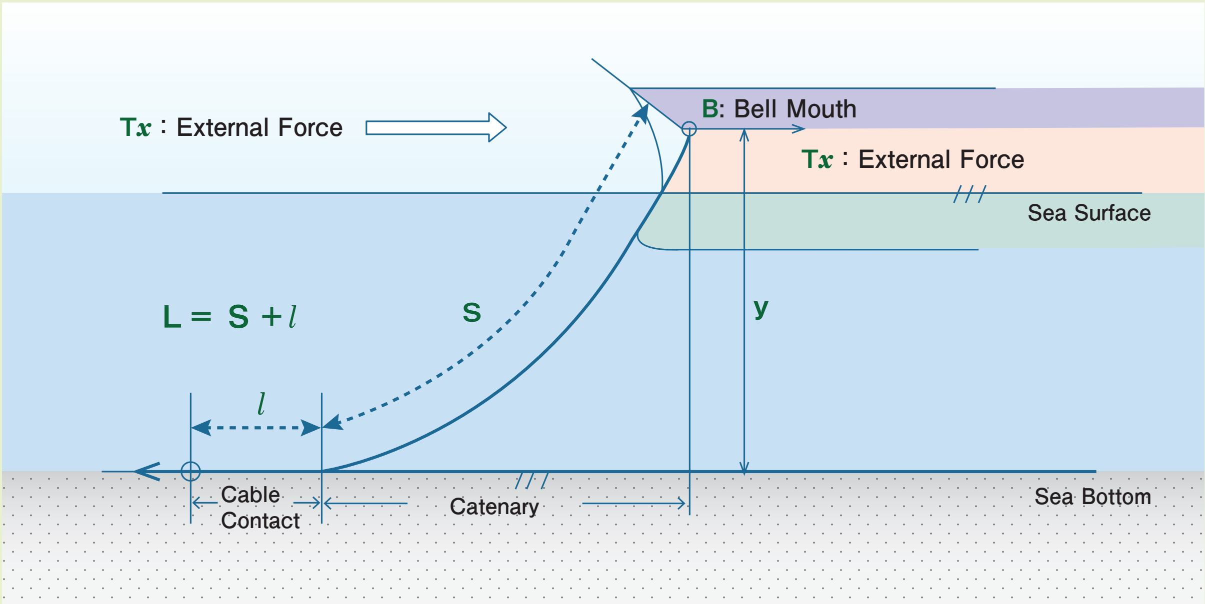
JIS　　AC14

λ c : Anchor Chain Holding Factor

λ c	Holding	Dragging	
		Sand	Mud
	0.75 ～ 1.0	0.75	0.60

Table 69

In addition, a representation of the anchor and anchor chain in the sea when external force was applied can be seen in Fig. 80. The catenary forms the suspension part of the anchor chain, from the anchor chain outlet (outside of hawsepipe) of the bow to the sea bottom.



S : Catenary length against the external force (m)
y : Water depth + hawsepipe height from sea surface (m)
l : Minimum required contacted length of the cable (m)
L : Minimum required length of anchor cable ($S + l$)
T_x : External force (kgf))

Fig. 70

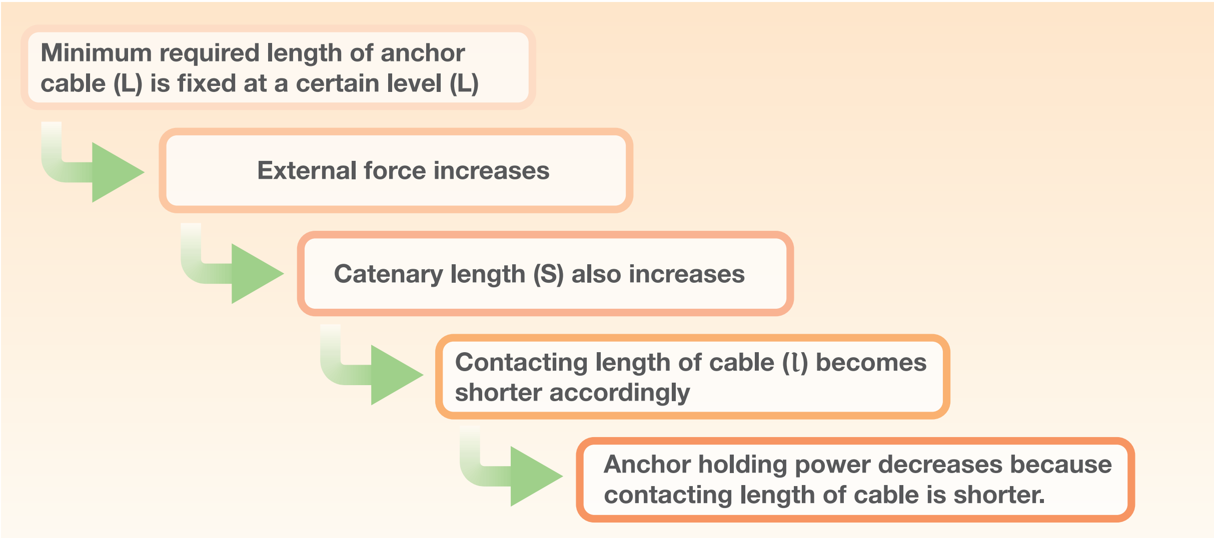
The catenary length of an anchor cable can be calculated with the following calculating formula.

Calculating the Catenary Length of an Anchor Chain

$$S = \sqrt{y^2 + 2\left(\frac{T_x}{Wc'}\right) y}$$

S : Catenary length against the external force (m)
y : Water depth + Hawsepipe height from sea surface (m)
Wc' : Anchor cable weight per m in water (kgs)
= 0.87 × Wc (kgs)
T_x : External force (kgf)

With the above mentioned formula, the more external force (T_x) increases, the longer the catenary is.
Therefore, under the condition that Minimum Required Length of Anchor cable is fixed at a certain level, as there is the following relationship, if External Force increases while the Anchor cable is fixed, the anchor holding power decreases, which leads to a vicious circle.



Also, it is not easy to manually calculate the catenary length and decrease of anchor holding power along with an increase in external force. Similar to the calculation used for external force (wind pressure force), the calculation result will be instantly displayed once the formula is input in the Excel File.

When entering data on holding factor coefficient, observed wind speed, and type of sea bottom coefficient, etc. be on the safe side when entering the data and do not over rely on it as it is intended to be a guide. Tables 71 and 72 show catenary length and calculation examples of anchor holding power.

Anchor Holding Power Calculation : Just Reference

1 The formula in this page are to calculate the holding power of your vessel's anchor and anchor cable.

2 In case of External Force<Anchor Holding Power (Wa' × λa), required length of cable is to calculate by following formula.
Required Length of cable = 3 × d + 90 m (Only External Force < Wa' × λa)

3 Expected total external force should be input by Maximum Impact force. For PCC/CTNR Ship : Wind Pressure on front × 5 ～ 6, Other type of ship : Wind Pressure on front × 3 ～ 4 times

＊ IE) As per Wind force Cal., Relative Wind Direction θ=0 : 15ton : Max Impact Force 15 × 5 ～ 6 for PCC/CTNR= 75 ～ 90 tons

Input Data

Expected total external Max. force (MT) : (T x Impact Force)	85.56	
Anchor weight (MT) in Air : (Wa)	10.5	
Anchor chain weight in Air (MT/m) : (Wc)	0.166 ton	
Kind of anchor (1: JIS, 2: AC14)	2	
Total Length (Shackles) of using Chain on board	12 ss	
Water depth (m) : d	20.0 m	
Hawsepipe height from the sea surface (m) : h	5.0 m	
Anchor Holding Factor: (λ a)	AC14	7.0
Anchor Chain Holding Factor : (λ c)	1.0	

Result of Calculation

Total height (Bottom to Hawsepipe): (y)	25 m	
Catenary length against the external force : (S)	174 m	
Minimum Required Contacted length of the chain : l	150 m	
Minimum Required Length of Anchor Chain : L = S + l	324m	12ss

Notice

Keep Anchor Watch Strictly

Anchor Holding Factor (λ a) : Use Calculation Formula or Input by manual.

Anchor Chain Holding Factor (λ c) : 0.75 ～ 1.0

Table 71

Calculation Formula in above table

- Anchor Holding Factor (Subj. to Kind of Sea Bottom)

λa : 3.0 (JIS)
: 7.0 (AC14)

λa : Anchor Holding Factor

Type of Anchor	Sand	Mud	Dragging Anchor
JIS	3.5	3.2	1.5
AC14	7.0	10.6	2.0

λc : Anchor Cable Holding Factor

	Holding	Dragging	
		Sand	Mud
λc	0.75 ~ 1.0	0.75	0.60

- Anchor Chain Holding Factor

λc : 0.75 ~ 1.0

- Total height (Sea Bottom to Hawsepipe)

y : d + h

Water Depth (d) + Hawspipe Height from Sea Surface (h)

- Catenary Length Against the External Force

$$S : S = \sqrt{y^2 + 2\left(\frac{Tx}{Wc'}\right) y}$$

- Anchor Weight in Air (Wa), Anchor Weight in Water (Wa')

$(Wa') = Wa \times 0.87$

- Anchor Cable Weight per m in Air (Wc), Anchor Cable Weight per m in Water (Wc')

$(Wc') = Wc \times 0.87$

- Minimum Required Contacted Length of the Cable

$l : Tx = Wa' \times \lambda a + Wc' \times \lambda c \times l$

$$: l = \frac{Tx - Wa' \times \lambda a}{Wc' \times \lambda c}$$

- Minimum Required Length of Anchor Cable

$L : L = S + l$

- In case of $Tx < Wa' \times \lambda a$

$: L = 3 \times d + 90$ (m)

Table 72

4−6 Countermeasures to prevent an anchor from dragging in stormy weather

Conventionally, there are guidelines, such as those listed below that serve as countermeasures against an anchor dragging in stormy weather. Consider the following reasons and remarks.

① Make the deep draft

Reason The ship's weight will increase, and the chance of the vessel horsing will decrease. Also, a decrease in wind pressure area can decrease the impact of external forces.

Remarks Consider increasing ballast quantity and hull strength.

② Even keel, or by the head (trim by bow) if possible, is to be applied.

Reason Horsing (yaw and sway) motion can be limited when wind pressure centre is moved to the stern.

Remarks Consider increasing ballast quantity and hull strength. Maintain propeller immersion.

③ Veer anchor cable

Reason Because holding factor between the anchor cable and sea bottom increases and catenary length increases, it is effective for improvement of anchor holding power and mitigation of impact force added to cable.

Remarks It takes 3 minutes heave-in one shackle (longer time taken during rough seas). The longer the veered anchor cable, the more time it will take.

④ To drop the other anchor as a snubber anchor

Reason It is effective to drop the snubber anchor because it can halve the amount of horsing (yaw and sway) motion which will decrease the amount of impact force on the anchor by approximately 30 to 40%.

Remarks Consider length needed for a second cable. One and a half times the depth of water will be needed. Consider the possibility of cable fouling, particularly when pitching heavily.

⑤ From the outset of anchoring, deploy both anchors

Reason Anchor holding power increases when riding at two anchors. Two-anchor mooring restricts horsing (yaw and sway).

Remarks There is a danger that the anchor cables may tangle. Two-anchor mooring is not flexible when the wind direction changes.

⑥ Main Engine, steering in combination with bow thruster

Reason It is an effective way to suppress horsing (yaw and sway) when an attempt is made to stand bow against the wind, using a combination of dead slow ahead speed and steering.

Remarks It is necessary to have in-depth meetings with the engine department. Ensure that the bow thrusters are kept submerged when the ship is pitching and rolling. Loosen the anchor chain temporarily by manoeuvring forward, and note that any sudden increase in tension may break-out the anchor when the hull falls leeward, which may lead to anchor dragging.

Of the above guidelines, we simulated ③ Veer anchor cable and ⑥ Main Engine, steering in combination with bow thruster (as per the situation of Vessel C, Case 3-3).

= "Increase of anchor holding power in the event of a veered length of the anchor cable" for single anchor mooring =

An increase in critical wind speed when the anchor chain was veered due to strong wind, during anchoring with a windlass at 6 shackles (distance of 151 meters from hawsepipe, with Hawsepipe being 25m from sea bottom) of a Pure Car Carrier laden with 6,000 units was calculated as a simulation under the following conditions:

= Calculation conditions =

Anchor weight in air (**Wa**) : 10.5ton Holding factor (λ **a**) 7.0
➡ Anchor weight in water 9.135 tons (**Wa'**)

Anchor chain weight per m in air (**Wc**) : 0.166 ton/m Holding factor / (λ **c**) 1.0
➡ Anchor weight in water 0.144 ton/m (**Wc'**)

Water depth + Hawsepipe height from sea surface (**y**)
: 25.0m

Length of one shackle of anchor cable : 27.5m

Projected area (front) (**A**) : 800 sqm

The wind force coefficient (**CRa**) : 0.75

Air density (ρ) : 0.125kg/sec^2/m^4

① When the anchor cable is constantly fixed

The external force is increased when keeping the anchor cable at 6 shackles and the catenary length of the anchor cable is enlarged. However, once the external force reaches 63.9 tons (wind speed at 16.9m/s), the anchor cable consists entirely of catenary which means that the only anchor holding power is by the anchor itself. When calculating backwards the wind speed to be given a critical wind speed, and dividing the critical wind speed by 1.25 to 1.50 and then replacing it with the average wind speed, 11.3 to 13.5 m/s will be the anchoring limit.

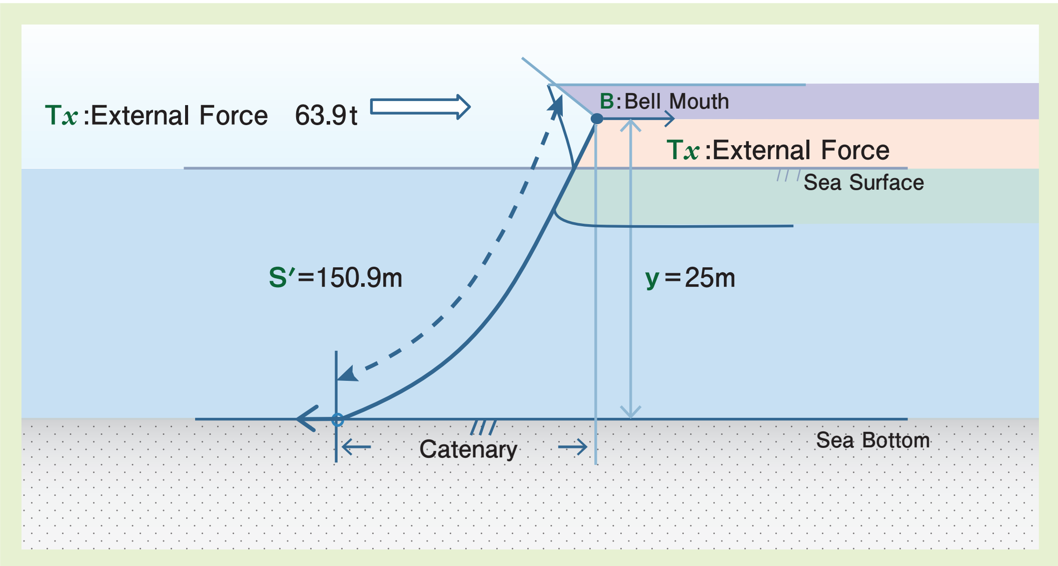


Fig. 73

(Calculation basis)

Before veering the anchor cable, the ship is moored exclusively with the anchor. This can be compared to the anchoring limit, as the anchor holding power is equal to the external force (impact force). The anchor cable is assumed to have formed a catenary with no cable lying on the sea bottom. Before determining the critical wind speed, the wind force from ahead must be calculated. It can be demonstrated that the impact force (which, in this case, is the same as the anchor holding power) should be divided by 6.

Anchor holding power = external force (impact force) : 63.9 tonf
➡ Wind force from ahead 10.65 tonf
Catenary length (S') : 150.9 m (5.5ss)

Calculate critical wind speed against wind force on front (110.65 tonf) from the Hugh's formula to find the critical wind speed and average wind speed as follows.

Critical wind speed : 16.9 m/sec
Average wind speed: 11.3 m/sec ~ 13.5 m/sec

* The critical wind speed can be converted into the average wind speed which can be solved by dividing the critical wind speed by1.5 or 1.25.

These average wind speeds are the maximum limits under which the vessel in this example can lay safely at anchor without any more force being exerted on the anchor and cable system than it can withstand.

② Situation after one additional shackle of cable is veered

The critical wind speed was simulated assuming that seven shackles of anchor cable were veered.

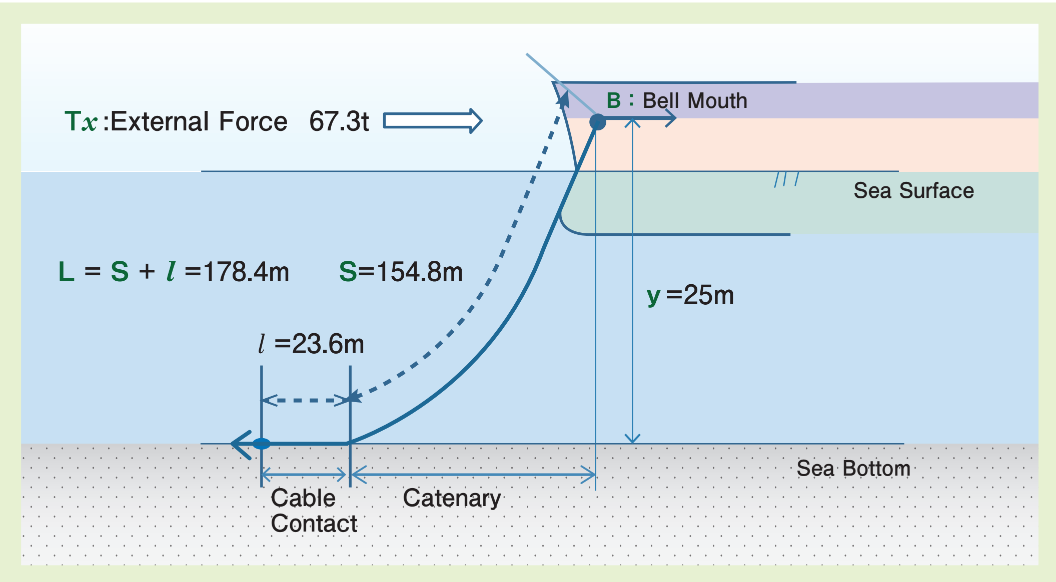


Fig. 74

When calculating the critical wind speed assuming that one additional shackle of anchor cable is veered, the ship can withstand an external force of up to 67.3 tons (wind speed at 17.3 m/s). (This external force is balanced assuming that 23.6m of veered anchor cable is contacting the sea bottom. If the external force is greater than this, part of the anchor cable will be contacting the sea bottom. However, the total anchor holding power will be smaller than the external force, and the ship will drag anchor.)
Similarly, replacing it with average wind speed, it becomes 11.5m/s to 13.8m/s. Even when compared with 6 shackles being veered, only an average wind speed of 0.2 to 0.3m/s was applicable.

(Calculation basis)

After a further shackle of cable was veered, the critical wind speed increased. Only part of the longer cable system will lay along the sea bottom with the remainder forming part of a new catenary, which will now be longer as it will be extended by the increased external force caused, in turn, by the increased critical wind speed. Veered length of the cable (laid over the sea bottom) (l) was calculated by the quadratic equation from the calculation formula as below.

$$S' + (27.5m - l) = \sqrt{y^2 + 2 \times \left[\frac{Wa' \times \lambda a + Wc' \times \lambda c \times l}{Wc'}\right] \times y}$$

S' : Catenary length before one shackle is veered : 150.9m

l : Veered length of the cable (laid over the sea bottom) (this is to be calculated)

Veered anchor cable contact	:	23.6m
Catenary	:	3.9m
Total	:	27.5m

③ When the anchor cable is completely veered to 12 shackles

Similar to the above, when calculating the critical wind speed assuming that all additional shackles (12 shackles) of anchor cable have been veered, the ship can withstand up to an external force of 86.3 tons (wind speed at 19.6 m/s). However, replacing it with the average wind speed, it becomes 13.1m/s to 15.7m/s. Even compared with the assumption that 6 shackles are veered, only an average wind speed of 1.8 to 2.2 m/s was applicable.

(Calculation basis)

(**S**) Catenary length	:175.0m
(**l**) Contacted length of the cable (laid over the sea bottom)	:155.0m (+22.4 tonf)
(**L**) Total length of anchor cable	:330.0m (12ss)
The holding power created by the anchor and cable system Total	:86.3tonf (Impact force)
	➡ Wind force from front 14.38tonf

Critical wind : 19.6 m/sec
The average wind speed can then be calculated as13.1 m/sec ~ 15.7 m/sec
(This is an increase of 1.8 ~ 2.2 m/sec)

In summing up; from the viewpoint of the ship commander, even veering anchor cable as a countermeasure of dragging anchor cannot be considered highly effective for increasing anchor holding power. This is because wind gusts and does not blow in a constant direction or speed, thus it is also worth considering the necessity of weighing the dragging anchor in time of an emergency, just in case.

Importantly for those on the bridge, the critical wind speed does not increase as much as might be expected even if the anchor cable is veered considerably.

= Combination use of main engine, steering and bow thruster =

Countermeasures to be taken under rough sea conditions, using a combination of the main engine, steering and bow thruster, will be examined.

① Use of the bow thruster

In order to avoid horsing (yaw and sway), it may be necessary to use a bow thruster, if one was outfitted on the ship. In this situation, it is necessary to consider the influence on the generator as a result of outputting from the bow thruster or when changing load frequently.

Regarding a pure car carrier laden with 6,000 units, the wind force on front at a force of 16m/s (it will be time at 1.50 = 24m/sec, if under the gusting at storm) is 22 tons. Because 80% of the horsepower (one ton ≒ 100PS) is necessary, the following amount of power from the bow thruster will be required.

$$\boxed{22 \text{ tons} \times 0.8 \times 100 = 1{,}760\text{PS}}$$

② Combination use with main engine

In theory, it is assumed that ship operating using both the main engine and the steering in order to stand the hull against the wind can limit horsing (yaw and sway) and reduce tension on the anchor cable. However, from a practical perspective, a situation that requires the use of an engine will mean that it is getting closer to critical wind speed for anchoring. In addition, according to the usage of the engine, the anchor chain may repeatedly slacken and then become taut, which may rather increase the impact force and lead to dragging achor.

The result simulated using the case of Vessel C above in 3-3 is introduced in the Maritime Casualty Analysis Report (Vol. 6): “Typhoons and Marine Accidents”. The conditions for simulation are shown in Tables 75.

(Simulation method)

Ship's particulars			
Loa	224.0 m	Draft (fore)	8.00m
Length between perpendiculars	215.0 m	Draft (aft)	11.60m
Total width B	32.2 m	Mean draft	9.80m
		Block coefficient of fitness (Cb)	0.821

Classification of speed force		
Classification	Speed (full load / ballast)	Engine rpm (revolution per minute)
Navigation full speed (Nav. Full)	14.0 knots	75～77 r p m
Harbour full speed (S/B Full)	10.3/11.0	56 r p m
Half ahead eng. speed	8.9/9.6	48 r p m
Slow ahead eng. speed	7.4/8.0	40 r p m
Dead slow ahead eng. speed	5.5/6.0	30 r p m

Conditor of external force	
Wind speed	25m/s
Wind direction	East-northeast (direction of 67.5 degrees)
Wave height of swell/wavelength	5m/200m
Wave height of swell and wavelength incident angle	Direction of 118 degrees

Table 75

Photograph 76 This was not the actual simulator used.

(Simulation method)

By rotating the propeller during horsing (yaw and sway) motion, in order to supply the need for holding power against the force, propeller thrust power applicable to the ship speed in flat water of 6 to 14 knots was given. Then, an evaluation was conducted using the following calculation, in the event of giving the propeller thrust power.

◉ Maximum of cable tension (Tmax) ◉ Maximum of holding power (FAmax) ◉ Minimum of holding power (FAmin)

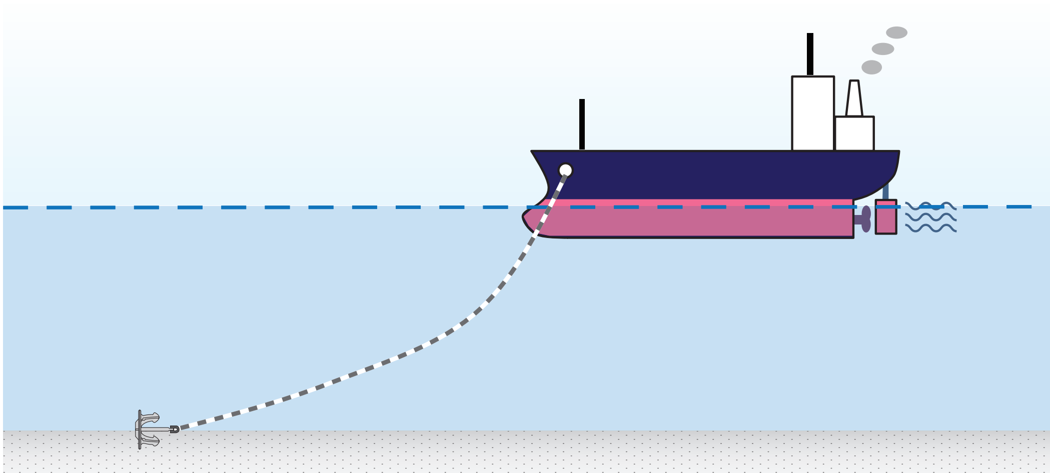
The method of evaluation will be described below. A summary of it is shown in Table 77.

When Tmax does not exceed FAmin : (Tmax < FAmin) ⇒ "Non-dragging of anchor"

When Tmax exceeded FAmin : (Tmax > FAmin) ⇒ "Dragging anchor"

Anchorage in heavy weather using engine Simulation results						
Anchor cable Veered	Propulsion / judgement	Equiv. to 6kt (D.Slow) Dead slow ahead eng. speed	Equiv. to 8kt (Slow) Slow ahead eng. speed	Equiv. to 10kt (Half) Half ahead eng. speed	Equiv. to 11kt (S/B Full) Harbour full speed	Equiv. to 14kt (Nav. Full) Navigation full speed
6 shackles	Tmax (tons)	51.1	48.8	50.0	0.0	0.0
	FAmin (tons)	16.2	48.8	48.8	64.2	64.2
	FAmax (tons)	52.6	56.5	64.2	64.2	64.2
	Judgement	**Dragging anchor**	**Non-dragging of anchor**	**Excess thrust**	**Excess thrust**	**Excess thrust**
8 shackles	Tmax (tons)	51.9	48.8	58.8	0.0	0.0
	FAmin (tons)	22.1	48.8	21.4	70.2	70.2
	FAmax (tons)	58.6	62.5	70.2	70.2	70.2
	Judgement	**Dragging anchor**	**Non-dragging of anchor**	**Excess thrust**	**Excess thrust**	**Excess thrust**
12 shackles	Tmax (tons)	48.8	48.8	61.2	0.0	0.0
	FAmin (tons)	13.6	48.8	48.8	82.2	82.2
	FAmax (tons)	70.6	74.6	82.2	82.2	82.2
	Judgement	**Dragging anchor**	**Non-dragging of anchor**	**Excess thrust**	**Excess thrust**	**Excess thrust**

Table 77

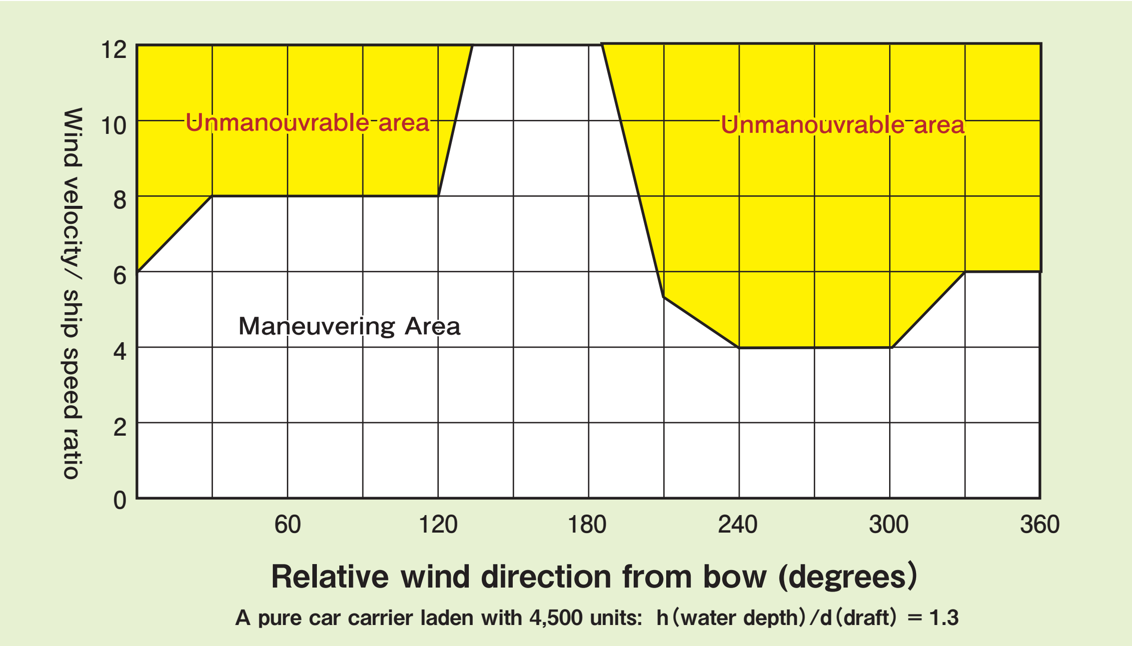


Regarding Vessel C case, the Master started to use the engine before anchor dragging started. Under the 25m/s wind speed condition, it was possible to prevent anchor dragging with engine thrust power at the slow ahead engine speed (Slow Ahead), but there was a shortage of thrust power when it was set to Dead slow ahead engine speed (D. Slow Ahead). However, the thrust power was too large at more than Half Ahead engine speed (Half Ahead) which caused the anchor to drag as a result.

Vessel C attempted to control the ship's posture by setting the engine to full speed, however, she was exposed to the wind from the Unmanouvrable area during dragging anchor caused by wind pressure, which will be referred to below, and as a result, she was presumably grounded without the Master being able to control the ship's posture.
In addition, because the wind does not blow in the same direction and speed, it is necessary to fully understand that wrong usage of an engine may rather lead to greater impact force.
In the event that large vessels can evacuate to the open sea, it would be ideal to refuge at a point away from the typhoon by heaving up anchor rather than staying anchored while using the engine.

4−7 Difficulty in maintaining manoeuvrability after dragging anchor has started

If the ship swings broad on to the wind and begins to move to leeward, considerable time and space may be required before effective control can be restored by using the main engine, rudder and bow thruster. In addition, when the propeller is working the effect of the bow thruster will be decreased by about 20% per 1 knot of ahead speed. (Ahead speed at about 5 knots, turning round yields no affect even when setting to full power.) It is important to understand the Unmanouvrable area of the ship.



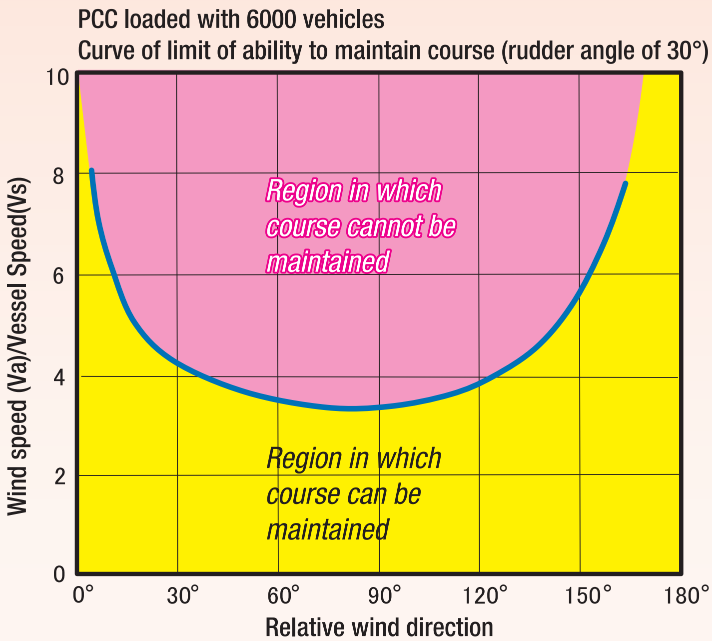
Graph 78

Graph 78 indicates the Unmanouvrable area of a pure car carrier laden with 4,500 units. This illustrates the limitations on manoeuvrability imposed by various wind strengths compared to the vessel's speed. Numbers entered in the vertical axis are wind speed per ship's speed and the wind force angle is entered along the horizontal axis. Except for when being exposed to tailwind from the stern direction, it is an Unmanouvrable area area if the wind speed is more than four times that of the ship's speed.

For example, in the event of turning round to the starboard side (windward) by being exposed to wind from the starboard side, it is impossible to change course at more than an 8 of wind velocity/ship speed ratio. On the other hand, in the event of turning round to the port side (leeward) by being exposed to wind from the port side, it is impossible to change course at a 4 of wind velocity/ship speed ratio. The cause is the transient change due to the mutual influences of wind pressure moment, water resistance moment and steering moment.
With a wind speed of 20m/s, the ship's speed would have to be more than 5 knots (2.5m/s), in order to stand a chance of stemming the wind. If it is more than 5 knots, the bow thruster will cease to be effective.

Note: A difference in a ship's speed will permit as to whether the vessel can maintain a given course. This should not be confused with limit for course keeping. The limit for course keeping is an area whereby it is not possible to keep on course if the wind velocity/ship speed ratio is large during the voyage. It is different from limitation of manoeuvring by rudder.

The graph on the right shows the limit for course keeping, the area whereby it is or is not possible to keep on course at the rudder angle at 30 degrees. Once the wind velocity/ship speed ratio exceeds 3.7, it will be in an area whereby it will not be possible to keep on course because of the relative wind direction from bow. This should not be confused with limitation of manoeuvring by rudder.



Graph 79

4−8 Safe distance from other ships, shallows and other facilities

There is no definite criteria regarding a safe distance to keep from other ships, shallows and other facilities. The reasons are as follows.

The following items are to be considered, when focusing on the area of sea one is to use for restoring the ship's posture using a combination of the main engine, steering and bow thruster promptly after discovering a dragging anchor.

①	A radius of swinging circle	A circle with a radius of minimum required length of anchor cable + the ship's Loa
②	Speed of dragging anchor under wind pressure force:	approximately 3 - 4 knots
③	Required time to weigh anchor:	In general, an anchor cable will be retrieved at a rate of about 9 m/min and to retrieve 1 shackle takes about 3 minutes. It may not be possible to heave in a taut cable continuously, thus prolonging the operation of weighing anchor.
④	Time needed for preparing the main engine:	Early S/B Eng.
⑤	Time required to obtain speed ahead needed to restore the ship to full manoeuvrable condition after being exposed to wind from the leeward	

Compared with the situation of weighing the anchor during dragging anchor with yaw and sway (the first stage) and then regaining control of the hull, with weighing the anchor after the anchor has dragged caused by wind pressure, the simulation result indicates that approximately 3.5 times the amount of water area on the leeward side will be required.

Simulation of the time full control is achieved over the ship's manoeuvrability following dragging anchor: Case study

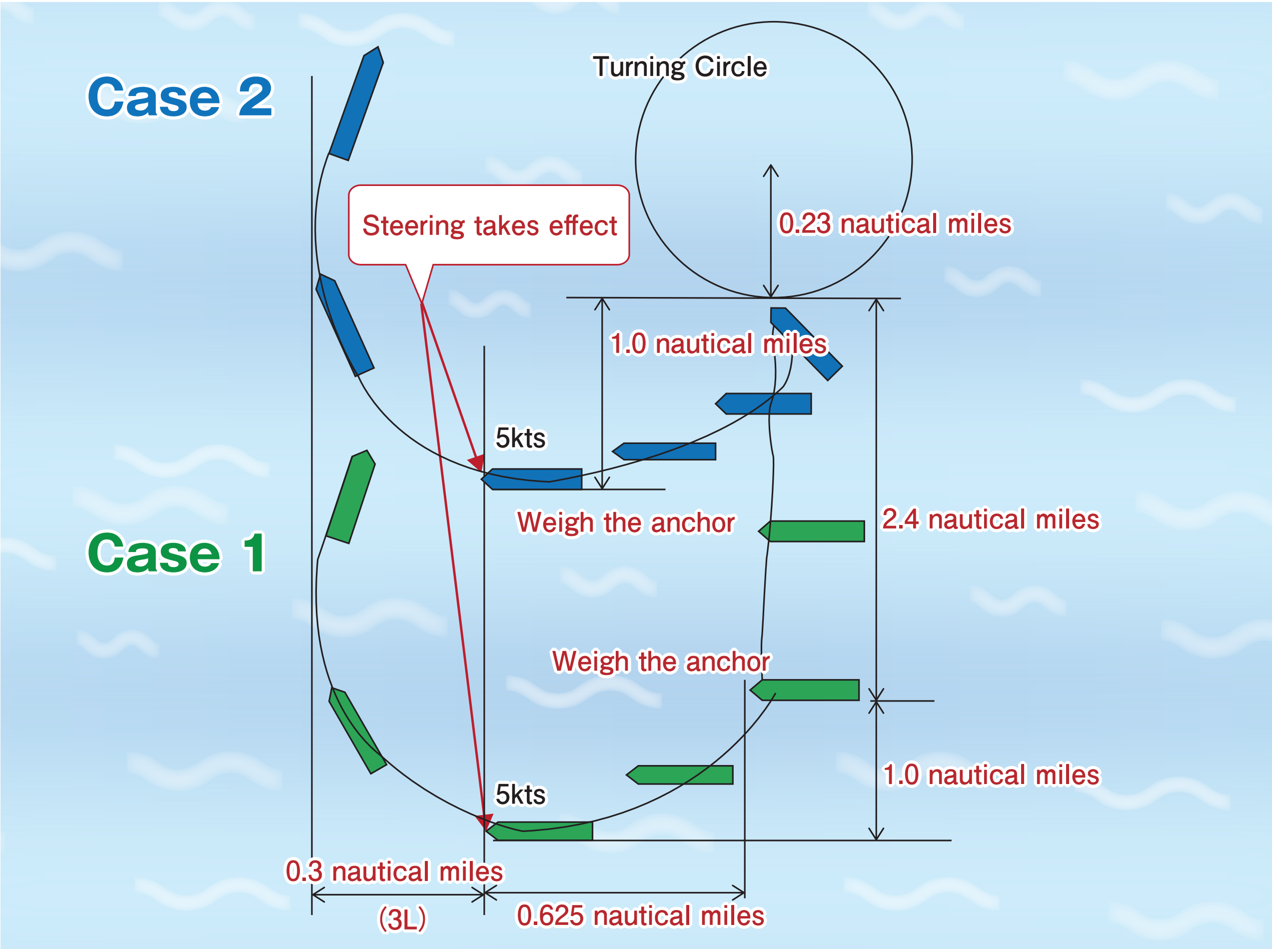


Fig. 80

Case1 Weighing anchor after dragging anchor is detected

In the case of Fig. 80

The ship's LOA is 200m.

- She is lying at anchor with 8 shackles.
- Time to weigh anchor is 1.5 times longer than is usually required.
- During that period, the ship is being brought to leeward at 4 knots.
- After weighing anchor, it takes 15 minutes until the ship's speed reaches 5 knots.
- In the interval, the ship's side has been pressed by the wind.
- The main engine and bow thruster are ready prior to dragging anchor.
- Whilst weighing anchor, both are available. The wind speed was at 20m/sec.

It has been clarified that accidents may be caused, if there is no navigable water area with 3.63 nautical miles to the leeward direction and 0.925 nautical miles in the horizontal direction. It would be difficult in many cases to secure this size of water area when needing to shelter from a typhoon.

1 Turning Radius of the Circle is:

8 shackles (220 m) + 200 m = 420 m = 0.227 nautical miles

2 Time needed for weighing the anchor:

After dragging anchor caused by wind pressure starts, it is no longer possible to manoeuvre the ship. The anchor cable recovery rate in moderate weather is known to be 9m per minute. Therefore, it would take about 24 minutes to weigh anchor in moderate weather. However, in this situation, it would take 1.5 times as long or about 36 minutes.

In this interval, the distance which the ship is pressed to leeward = 4 knots x 0.6 hours = 2.400 nautical miles (distance covered in 36 minutes at 4 knots).

3 After the anchor is aweigh, a further 15 minutes elapse before the vessel's speed reaches 5 knots. During this period, the vessel will drift about 1 mile to leeward (distance covered in 15 minutes at 4 knots).

0.25 hours × 4 knots = 1.000 nautical mile

Leeward direction: 3.627 nautical miles (6,717m) is necessary.

4 The distance sliding transverse

Advance at 5 knots is (3L) = 0.300 nautical miles

(0 knot + 5knots) ÷2 × 0.25 hours = 0.625 nautical miles

Horizontal direction: 0.925 nautical miles (1,713m) are required

Case2 Started to weigh the anchor during dragging anchor with yaw and sway

In the case of Fig. 80

If weighing the anchor at the early stage of dragging anchor with yaw and sway, it may be possible to weigh the anchor almost right away using the engine for operation to weigh the anchor accordingly. Even if the vessel has entered into an unmanouvrable area and, even worse, exposed to wind from the side, as long as the following water area both for leeward direction and sliding transverse are secured, it is possible to achieve full control over the ship's manoeuvrability.

Leeward direction: 1.230 nautical miles (2,278m)

Horizontal direction: 0.925 nautical miles (1,713m)

Most accidents such as collisions and groundings involving ships occur when an anchor drags because an insufficient amount of sea area was not secured.

05 § 5 Conclusion

Three different cases and mechanisms of dragging anchor were introduced. We are sometimes forced to anchor to shelter from stormy weather such as from large swells and wave heights exceeding 5 meters.
However, as can be seen from the introduced cases, even though there were opportunities to evacuate from the sea area away from the typhoon, a large number of accidents were caused due to a lack of weather information.
In the case of large vessels that had a method of riding at two anchors and two-anchor mooring, it is concluded that mainly single anchor mooring was decided on because of the difficulty of ship handling.
Therefore, it is a requirement that as much weather information be available as possible in order better ensure safety.
Also, the Master should not be alone in making a judgement, it is also necessary for operators and ship management companies to support the Master. Even if dragging anchor is already under way, the ship’s posture may be adequately controlled if it is detected at an early stage.

References

- Maritime Casualty Analysis Report (Vol. 6):
  Typhoons and marine accidents issued by Marine Accident Inquiry Agency (MAIA) in 2006
- Marine Accident Inquiry and Safety Investigation Association, "Determination record by Marine Accidents Inquiry Agency"
- Theory and Practice of Ship Handling, by Dr. Kinzo Inoue
- Japan Captains' Association, DVD "Safety Maneuvering in Restricted Water Area"
- Ship Handling, by Dr. Keinosuke Honda
- Ship Handling, by Dr. Satoshi Iwai
- Study of Ship Anchoring Supporting system (Kobe University)

Reference documents were provided by:

- Japan Captains' Association
- Nippon Yusen Kabushiki Kaisha
- Japan Marine Science Inc.


The author

Capt. Takuzo Okada
Master Mariner
General Manager
Loss Prevention and Ship Inspection Dept.
The Japan Ship Owners' Mutual Protection & Indemnity Association

JAPAN P&I CLUB
日本船主責任相互保険組合
Website http://www.piclub.or.jp

- **Principal Office (Tokyo)** 2-15-14, Nihonbashi-Ningyocho Chuoh-ku, Tokyo 103-0013, Japan
  Tel : 03-3662-7229 Fax : 03-3662-7107
- **Kobe Branch** 6th Floor Shosen-Mitsui Bldg. 5, Kaigandori Chuoh-ku, Kobe, Hyogo 650-0024, Japan
  Tel : 078-321-6886 Fax : 078-332-6519
- **Fukuoka Branch** 6th Floor Meiji-Dori Business Center 1-1, Shimokawabata-machi, Hakata-ku, Fukuoka 812-0027, Japan
  Tel : 092-272-1215 Fax : 092-281-3317
- **Imabari Branch** 2-2-1, Kitahorai-cho, Imabari, Ehime 794-0028, Japan
  Tel : 0898-33-1117 Fax : 0898-33-1251
- **Singapore Branch** 80 Robinson Road #14-01B SINGAPORE 068898
  Tel : 65-6224-6451 Fax : 65-6224-1476
- **Japan P&I Club (UK) Services Ltd** 5th Floor, 38 Lombard Street, London EC3V 9BS U.K.
  Tel : 44-20-7929-3633 Fax : 44-20-7929-7557

Translated by : YUZEN Translation LLC