Reference （Definitions of accident types ）

・Grounding ：When a vessel mounts an underwater feature (e.g., a coast or reef)

・Stranded ：When a vessel's hull contacts a sandy seabed without causing damage to the vessel or crew/passengers

・Safety obstruction ：When dangerous tilting (e.g., from improper loading) creates an imminent risk of capsizing

・Navigation obstruction ：When events like engine failure increase risk, even without immediate danger

Of the two "sinking" accidents shown in Figure 3, one was the passenger ship sinking off the west of the Shiretoko Peninsula in April 2022 (hereafter, the "Shiretoko passenger ship sinking accident").

Because a small passenger vessel sinking in severe weather poses an extremely high risk to lives, it is essential for operators to continuously implement preventive measures while fully understanding the **operating area's characteristics and associated risks**.

3. The characteristics of the operational areas

Following the Shiretoko passenger ship sinking accident, the Shiretoko Passenger Ship Sinking Accident Countermeasures Study Committee (under the Ministry of Land, Infrastructure, Transport and Tourism) issued "Comprehensive Safety and Security Measures for Passenger Ships" in December 2022, recommending measures tailored to "each company's and operating area's unique conditions." Likewise, the JTSB's report stresses the need for prevention measures based on "operational area characteristics."

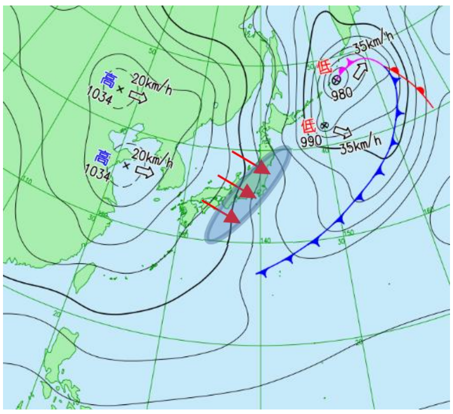
To ensure safe navigation, masters and crew must fully understand and master their vessel's inherent traits and handling quirks, such as hull structure and operability, and gain firsthand knowledge of the features and risks of sea where operators sail their own ships. This principle also is applied to safety managers who is responsible for the safety of overall their business and operation managers who is responsible for overall operational management under the management system.

Below are representative examples of the characteristics of passage area (namely, operational risk factors which influence essentially on the safety of navigation) that small passenger vessel operators should understand to ensure safe operation.

(1) Risks from meteorological and sea conditions

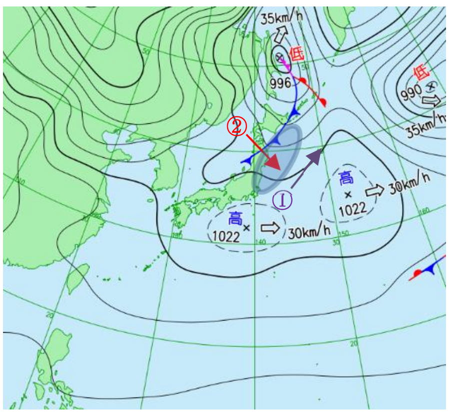
1) Open-ocean areas

i) Meteorological influences such as "monsoons" and "developed low-pressure systems with cold fronts" pose a flooding/sinking risk



（Figure 4: Example of pressure configuration during **winter monsoon gusts**）

Source: Japan Meteorological Agency website



（Figure 5: Example of pressure configuration after **a cold front**）

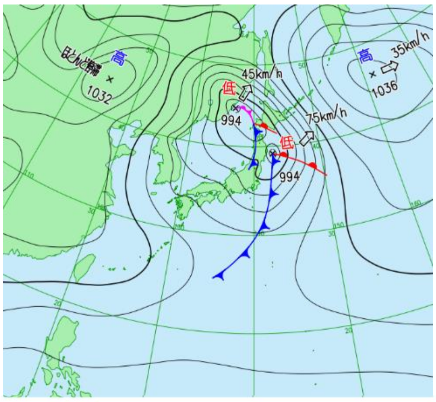
Source: Japan Meteorological Agency website

・In the Sea of Japan coastal area during winter, a high-pressure area in the west and a low-pressure area in the east create closely spaced isobars that produce a steep pressure gradient. **<u>A northwest seasonal wind</u>** <u>(Figure 4, red arrow)</u> blows, and the light blue ellipse shows the general wind path.

・When **a cold front** extending from a developed low passes, the wind direction may change suddenly. For example, Figure 5 shows the wind shifting abruptly from southwest (purple arrow ①) to **<u>northwest</u>** <u>(red arrow ②)</u>, with the light blue ellipse indicating the

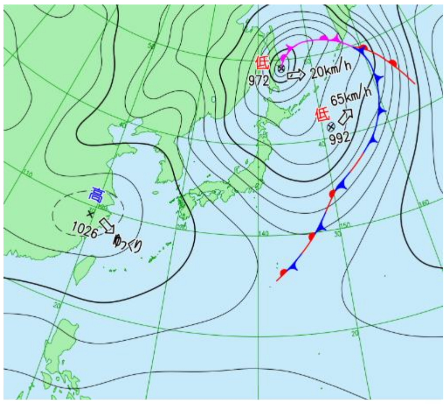
(*Note: The Shiretoko passenger ship sinking accident occurred when a cold front passed, causing a sudden wind to change that exposed the ship to high waves from the northwest or west.)

・In addition, from winter to spring, low-pressure systems move along both the Sea of Japan and Pacific coasts, bringing rain, snow, and strong winds. Operators should also be alert to "**<u>twin-cell low-pressure systems</u>** (Figure 6)," mid-latitude cyclones that rapidly develop from the East Sea of Japan toward the Kuril Islands (with the central pressure dropping by 24 hPa or more within 24 hours, also called "**<u>bomb cyclones</u>**; Figure 7"), and "**<u>regional seasonal winds</u>** (Figure 8)."



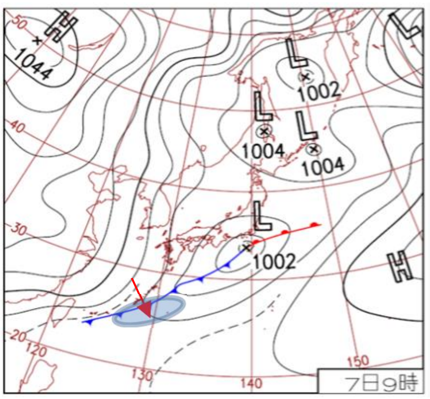
（Figure 6: Example of twin-cell low pressure system patterns）

Source：Japan Meteorological Agency website



（Figure 7: Example of bomb cyclone patterns）

Source：Japan Meteorological Agency website



（Figure 8: Example of atmospheric pressure patterns in Nansei Island region） Source：Japan Meteorological Agency website

・ Figure 8 illustrates an example of atmospheric pressure pattern during the seasonal wind "Ningwachi Kajimai," which occurs from March to May around Okinawa Island and the Sakishima Islands.

The 'Ningwachi Kajimai' occurs when a rapidly developing low-pressure system with a front moves through the East China Sea after the area between the Okinawa Main Island and the Sakishima Islands has been covered by high pressure, resulting in a sudden shift from a southerly wind to a strong northerly wind (red arrow in the left figure).

When strong maritime winds are expected to generate high waves with the pressure pattern as described above, it is crucial to closely monitor **weather warnings and advisories, including wind speed and wave height information from the Japan Meteorological Agency**. Even after pressure patterns weaken, it is essential to confirm that sea conditions have stabilized and manage operations accordingly.

ii) Effects of ocean wind waves and swells from offshore 【Flooding/Sinking Risk】

Even if the weather and wind conditions in the operating area are calm, “wind waves” generated by typhoons or intense low-pressure systems can travel long distances as “swells.” These swells may develop into “high waves,” affecting navigation.

In general, the formation and changes of wave motion, including wind waves and swells, are as follows.

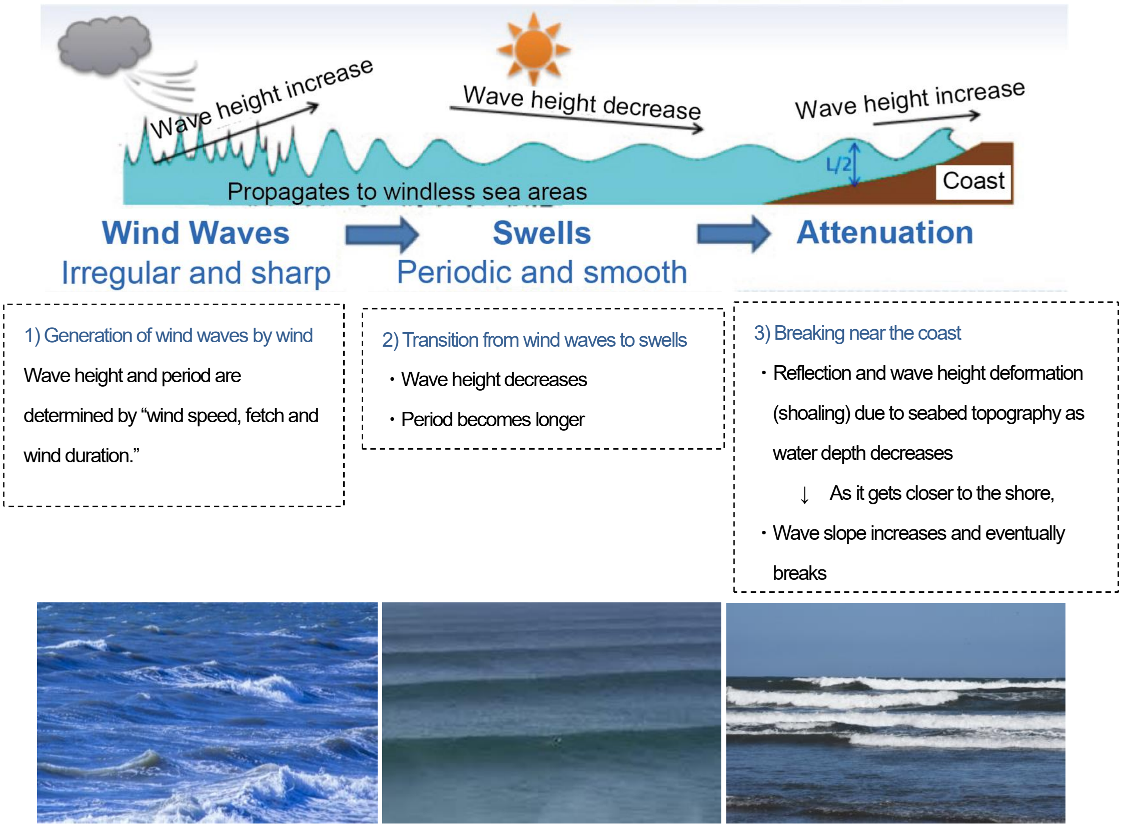


Figure 9 -Source: Japan Meteorological Agency, “Overview of wave forecasts & verification of high wave cases” (modified)

The breaking waves mentioned as number 3) on the right side of Figure 9 are also called "shore waves."

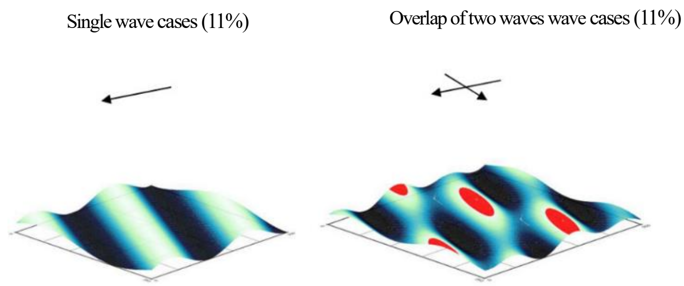


Figure 10-Source: Nadao Kono & Ayako Yamane, (2018), Addition of “information on hazardous rough sea areas for navigation” to Wave forecast maps. Meteorological Bulletin, 85, 1-12.

Offshore, waves from multiple directions can overlap, creating complex sea surface patterns and suddenly generating large waves (red areas in Figure 10).

In particular, sharp, pyramid-shaped "cross waves" can have short or irregular periods with sudden upward force, posing a risk of severe vessel instability and capsizing.

Another concern is "rogue waves," which occur when multiple waves align in period and phase, combining into a single wave several times higher than the significant wave height (see note). Statistically, one in 10 waves reaches 1.27 times the significant wave height, one in 100 waves reaches 1.61 times, and one in 1,000 waves reaches twice the height. Waves twice the significant wave height are estimated to occur about once every two hours.

Note: The significant wave height is the average height of the highest one-third of observed consecutive waves at a certain point.
It closely matches the wave height estimated by experienced observers and is commonly used in weather and wave forecasts by the Japan Meteorological Agency.

BACK TO BASICS!

In the Shiretoko passenger ship sinking accident, the master lacked sufficient understanding, knowledge, and experience regarding the weather and sea conditions of the area, leading to an inadequate ability to assess navigation safety. Lessons from this and similar accidents highlight the following fundamental actions.

【Weather and Sea Condition Assessment】

- Do you understand the weather and sea conditions of the operating area based on accumulated information and experience?
- Can the master and operations manager assess departure feasibility using weather charts and meteorological data?
- Do the master and operations manager accurately understand the wind speed and wave height limits set in the operating standards?
- Are weather observation methods based on natural phenomena and animal behavior used to predict local weather patterns?
- Is the latest weather information from the Japan Meteorological Agency or private providers checked before departure?
- Is the Maritime Safety Agency's "Marine Conditions Display System" used to supplement weather and sea condition information?
- Are real-time weather and sea condition monitoring apps utilized during operations?
- Is communication between the master and operation manager ensured regarding weather conditions and navigation decisions?

↓

【Operational Decision-Making】

- Do you understand your company's operational standards and prioritize safety when making departure decisions?
- Do you ever decide to depart without clearly determining an alternative course when worsening weather and sea conditions are expected?
- Have you established a system to designate and utilize port of refuge in case rough weather makes navigation difficult?
- Is there a cooperative framework with local operators for sharing weather and sea condition information and making operational decisions?
- Is a safety culture in place that respects the master's decisions to suspend operations, turn back, seek shelter, or make an unscheduled stop?

（Column 1） Operational standards

Passenger ship operators are required by the Maritime Transport Act to establish “Safety management regulations” and develop “Operational standards” to implement them effectively.

In the Shiretoko passenger ship sinking accident, the operator had set the following wind speed and wave height limits in the “Operational standards” for deciding whether to operate. If any of these conditions were likely to be met, the vessel was required to suspend departure, turn back, seek shelter, or make an unscheduled stop.

1） **Departure decision (based on port observations): Wind speed: 8 m/s or higher, or wave height: 0.5 m or higher**
2） **Departure decision (based on expected conditions during navigation): Wind speed: 8 m/s or higher, or wave height: 1.0 m or higher**
3） **Operational navigation decision (for stopping, turning back, etc.): Wind speed: 8 m/s or higher, or wave height: 1.0 m or higher**

Despite the likelihood of reaching condition **(2)** during navigation, the vessel was still allowed to depart.

↓

How can wind speed and wave height be accurately assessed on-site before departure?
One useful reference is the “**Beaufort scale of wind force**,” described below.

For example, the "Operational standards" in the Shiretoko passenger ship sinking accident set a threshold of **8 m/s wind speed**. Let's see how this is classified in the Beaufort scale. (Note: The scale ranges from 1 to 12, but only a portion is shown in the table below.)

Beaufort Scale	Explanations	Equivalent wind speed		Reference wind speed (meter)
		knot	meter/second	
0	Mirror-like Sea surface	< 1	0~0.2	-
1	Small ripples appear like fish scales, but no foam on the wave crests.	1~3	0.3~1.5	0.1(0.1)
2	Small waves begin to foam, still short but distinct. The wave crests appear smooth and unbroken.	4~6	1.6~3.3	0.2(0.3)
3	Larger small waves. The wave crests start to break, and foam appears glassy, with occasional whitecaps.	7~10	3.4~5.4	0.6(1)
4	Small but longer waves. Whitecaps became quite frequent.	11~16	5.5~7.9	1(1.5)

Beaufort Scale	Explanations	Equivalent wind speed		Reference wind speed (meter)
		knot	meter/second	
5	Medium-sized waves, becoming more distinct and longer. Many whitecaps appear, sometimes accompanied by spray.	17~21	8.0~10.7	2(2.5)
6	Larger waves foam, with foamy crests expanding in various places and frequent spray.	22~27	10.8~13.8	3(4)
7	Waves grow larger, and the white foam created by breaking wave crests begins to streak and drift downwind.	28~33	13.9~17.1	4(5.5)
8	Somewhat smaller but longer large waves. The streaks of breaking wave crests start turning into sea spray, and the foam forms distinct streaks that are blown downwind.	34~40	17.2~20.7	5.5(7.5)

Figure 11- Source: Japan Meteorological Agency, Beaufort scale (excerpt)

Figure 12- Source: Japan Meteorological Agency, Beaufort wind scale (modified)

Figure 11 shows that 8 m/s corresponds to **Beaufort Scale 5** (red box).

Reference wave heights for offshore areas indicate waves reaching approximately 2.0 m**,** with a maximum of around 2.5 m**.**

The sea surface condition at this level generally appears as shown in Figure 12 (photo).

Therefore, if "8 m/s wind speed or 1.0 m wave height" is set as the threshold in Operational Standards 2) and 3)**,** once wind speed reaches 8 m/s**,** wave height is also likely to exceed 1.0 m**.**

The Beaufort scale classifies 1.0 m wave height within Scale 3 (around 5 m/s) to Scale 4 (see purple box). The corresponding sea surface conditions generally appear as shown in Figure 13 (photo)**.**

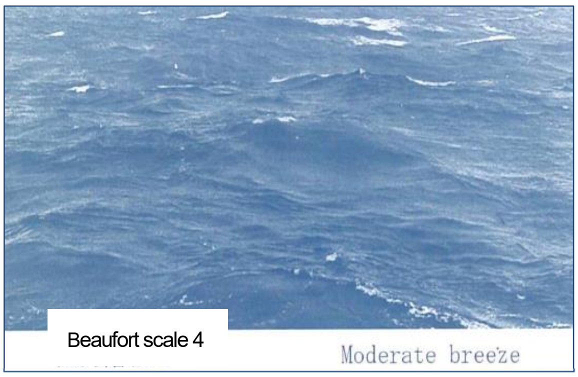


Figure 13- Source: Japan Meteorological Agency, Beaufort wind scale (modified)

Thus, if 0.5 m wave height or around 5.5 m/s wind speed is observed in the port, **offshore waves may already be reaching 1.0 m**. Regardless of the 8 m/s threshold, prioritizing safety and making flexible operational decisions (such as canceling operations) in advance is crucial.

→ Have you established appropriate operational standards for your company while prioritizing passenger safety? Do you consider flexible operations, such as canceling departures even if conditions are below the threshold based on weather and sea forecasts?

2) Coastal Waters

i) Impact of river mouth currents on high waves [risk of flooding/capsizing/sinking]

・ Near large river mouths, complex "river mouth currents" form due to a mix of river flow, nearshore currents, and tidal currents. These currents can cause high waves not only when river water levels rise but even in normal conditions due to interactions with nearshore currents and seabed topography.

・ "Swells" generated by typhoons or deep low-pressure systems can transform into surf waves ("Iso-nami") in shallow coastal areas. When these waves collide with river mouth currents, they can create high waves, requiring careful attention.

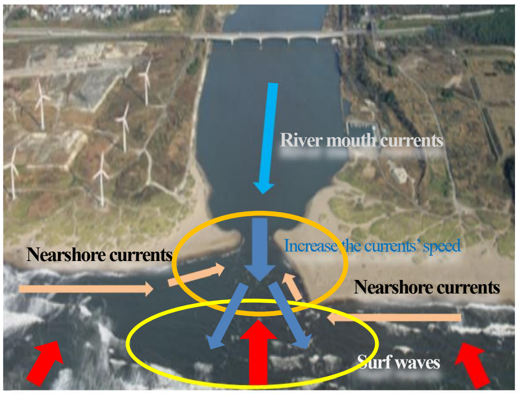


Figure14-The river mouth of Omono River (modified)

・ In Figure 14, the orange circle at the river mouth indicates the area where "**river mouth currents**" occur, while the yellow-circled area extending offshore shows the general region where "**high waves caused by surf waves and river mouth currents**" form.

・ Additionally, even in lakes connected to the open sea via waterways (such as Lake Hamana, Shizuoka), high waves can occur offshore from the waterway exit due to the effects of surf waves and tidal currents.

ii) Impact of surf waves on high waves [risk of flooding/capsizing/sinking]

・Even in areas without the influence of river mouth currents, high waves caused by "**surf waves**" require careful attention.

・ When returning to port while sailing toward the shore, surf waves may act as "following waves," causing waves to crash into the stern of the vessel.

iii) Impact of High Waves Near Coral Reefs [risk of flooding/capsizing/sinking]

・ In "coral reef" areas such as the Nansei Islands, shallow waters extend from the coastline, transitioning into deeper waters beyond the elevated edge of the reef.

This elevated edge is called a "reef crest," where breaking waves form, creating high waves similar to surf waves.

(Column 2) Steering impact of following waves

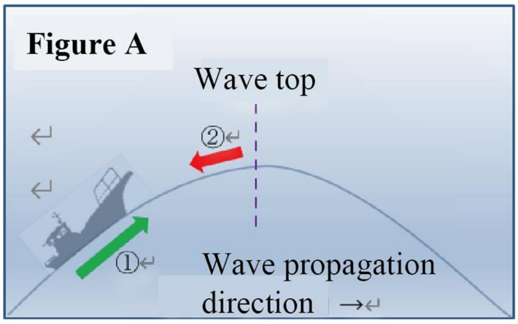
When sea conditions deteriorate rapidly, vessels may encounter surf waves as "following waves" from the stern not only during offshore navigation but also when returning to shore in coastal areas. If this occurs, maintaining a low speed that preserves steering control (scudding) can help reduce vessel movement. However, improper handling may result in capsizing or sinking in an instant.

When waves come from behind, there are two significant risks: "Pooping Down," where waves crash over the stern, possibly damaging the rudder and stern structures, and "Broaching," which happens when waves strike at an angle from behind. Of these, "**Broaching" poses the greatest danger.**

【Broaching】

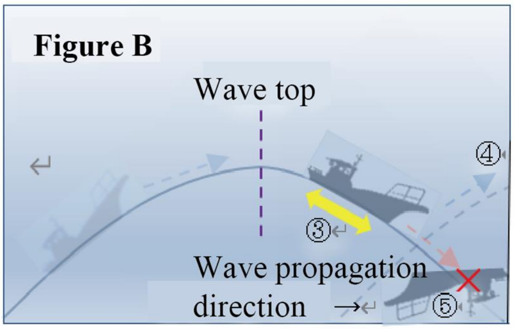
Broaching is a phenomenon that occurs when a vessel encounters "following waves" from the stern, where the wave speed slightly exceeds the ship's speed. As the vessel surfs down the wave slope, its speed nearly matches the wave speed, resulting in a loss of steering control. This leads to sudden yawing and severe heeling, causing the vessel to lose stability and increasing the risk of capsizing. Broaching is more likely to occur in a "diagonal following wave" condition, where waves approach the stern at approximately 20 to 40 degrees.

To avoid this phenomenon, the following maneuvering techniques are necessary:



As shown in Figure A, just before the wave crest, "increase speed ①" while climbing the wave slope, keeping the vessel attached to the wave's surface. "Reduce speed ②" just before reaching the wave top.

* Ensure **frequent speed adjustments** to avoid plunging into the wave trough (descending slope).



As shown in Figure B, if the vessel enters the descending wave slope, adjust speed to "minimum steerageway" and allow the wave to pass ③. Then, increase speed ④ to climb the next wave slope.

* If the vessel remains on the descending slope with speed nearly matching the wave, it may lose steering control, leading to sudden yawing, excessive heeling, and ultimately capsizing ⑤.

A fundamental preventive measure is to thoroughly adjust the course to **avoid receiving diagonal following waves** from the stern.

In contrast to following waves, when encountering rough seas from the bow, methods such as "Heave-To" (a maneuver to maintain the vessel's position in rough seas) or using a "sea anchor" (a parachute-like device deployed to the sea to resist the waves and keep the bow facing them. We can also call parachute anchor) can be used to drift.

Note: "Heave-To" refers to a maneuver in rough seas or during a tsunami, where the ship's bow is angled 2-3 points (about 30 degrees) to the waves. This technique maintains the vessel's posture and minimal rudder speed while riding out the waves.

BACK TO BASICS!

Accidents where small vessels of various types are flooded, capsized, or sunk due to surf waves and other following waves are common. Especially in the operation of small passenger vessels carrying lives, it is essential to avoid careless departure decisions based on overconfidence or complacency, and to always prioritize safety by adhering to the basic principles of safe navigation.

- ➢ Do you have a good understanding of the weather and sea conditions, areas, and points where high waves are likely to occur in the operating area?
- ➢ Are departure decisions made with safety as the top priority, considering the weather and sea conditions at the planned return time?
- ➢ Do you check the watertightness of openings, such as verifying the closure status of access points, during pre-departure inspections?
- ➢ Is there any vulnerability in your vessel's hull structure when facing waves coming from the stern?
- ➢ Does the master have the knowledge and skills for rough weather navigation, including avoiding broaching phenomena?

(2) Risks related to seabed topography

1) Presence of reefs, rock formations, and tidal effects in coastal navigation areas 【risk of grounding/stranded】

・ In coastal waters with sunken rocks, rock which covers and uncovers, other rocky formations or exposed reefs factors such as dense fog, deviation from designated routes leading to position misjudgment, and wind or tidal currents may increase the risk of grounding or stranded.

・ In shallow waters, spring tides can reduce the under keel clearance (UKC), increasing the risk of stranded.

• The visual representation of sunken rocks, rock which covers and uncovers, rock awash, which are key components of reef structures, is shown in Figure 15 below.

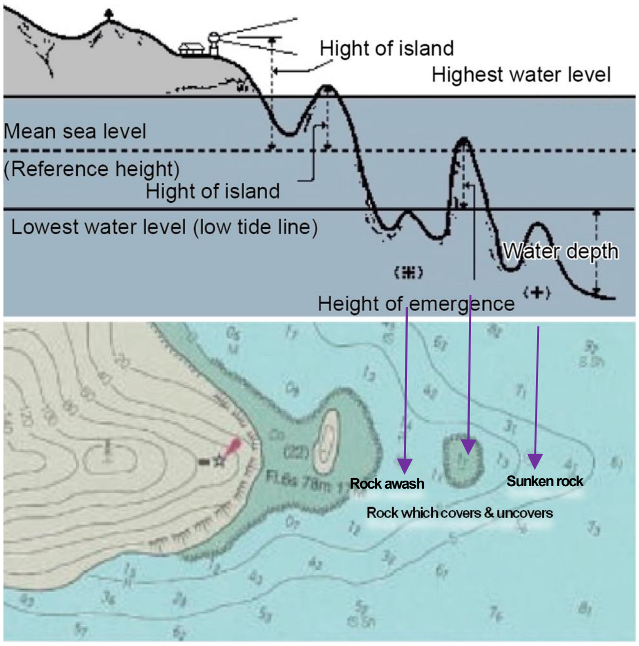


Figure 15-Source: "Depth and elevation reference chart" from Japan Coast Guard website (modified) https://www1.kaiho.mlit.go.jp/KAN1/soudan/kijun.html

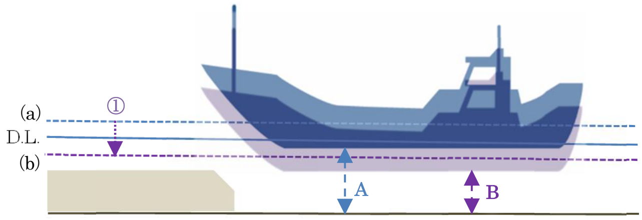
・ "Sunken rock" is a rock located below the chart datum (lowest astronomical tide) and remain submerged at all times.

・ "Rock which covers and uncovers" refers to rocks situated between the lowest and highest water levels, submerging at high tide and exposing their peaks above the surface at low tide.

・ "Rock awash" describes a rock whose peak aligns with the lowest water level at low tide, making it continuously washed by waves.

・ The mechanism of contact in shallow waters due to tidal effects (spring tide) is as follows.

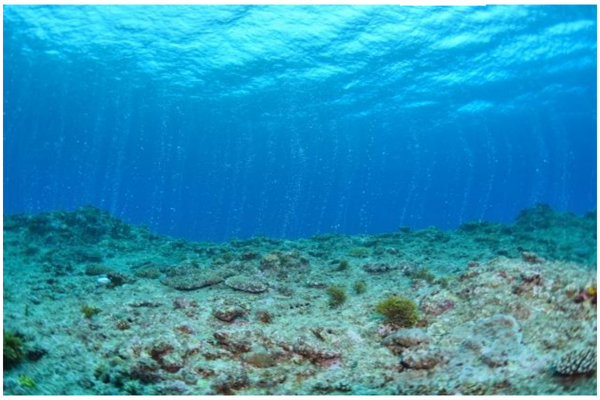
(Figure 16)



1. The draft of the vessel (blue silhouette) shown in Figure 16 is assumed to be the distance from the tidal level (a) above the datum level (D.L.) to the bottom of the hull.

2. The **under-keel clearance** (**UKC**) at that time, from the ship's bottom to the seabed, is represented by the vertical blue arrow A. In this case, the seabed elevation on the left side of the figure can be cleared.

3. However, if the water level drops below the datum level (b) due to the effect of a **spring tide** (purple arrow ①), the UKC of the same vessel (purple silhouette) is reduced to the vertical purple arrow B.



4. In this situation, continuing navigation would lead to contact with or grounding on the seabed elevation on the left side of the figure. Additionally, insufficient tidal planning can result in a low UKC against the D.L., increasing the risk of contact sunken rocks or grounding. Even when navigating at high tide, if the UKC above the peak of an uncovered rock is insufficient, there is a risk of contact or grounding.

BACK TO BASICS!

The year before the Shiretoko passenger ship sinking accident, the same vessel ran aground after deviating from the designated route without recognizing the presence of rocks and reefs. Grounding accidents can cause severe secondary damage beyond hull damage, including risks to human life and marine pollution. Therefore, a structured approach is necessary to ensure that masters and crew thoroughly understand the seabed topography, tidal currents, and tidal effects in the operating area.

- Does the master have a clear understanding of the location of reefs in shallow waters of the operating area?
- Are the positions of reefs registered in the vessel's GPS plotter?
- Are clearing lines for reefs registered in the GPS plotter?

- Are you operating the GPS plotter with an understanding of its positioning accuracy?
- Are you using the nautical electronic reference chart (new pec) with awareness of shoreline display errors?
- Can the master and crew identify reef locations using surrounding landmarks instead of relying solely on navigation aids?
- Can the crew steer and maintain course while considering the unique wind and tidal currents of the operating area?

- Does the designated route have sufficient clearance from the shore, considering shallow waters and wind/tidal effects?
- Are you deviating from the designated route to navigate closer to the shore for sightseeing or to shorten the route?
- Have you obtained tidal and current information for the day before starting operations?

（Column 3） Clearing Line

When navigating near the coastline, it is essential to set a "clearing line" in advance on nautical charts, GPS plotters, or radar screens to prevent grounding on reefs or stranded.

- A clearing line is used to separate dangerous and safe zones by establishing **bearing lines or equidistant lines from prominent landmarks** on nautical charts (or GPS plotter screens). It helps prevent grounding in shallow or narrow waters.
  By setting a clearing line, deviations into dangerous areas can be immediately detected without frequent position checks, allowing the operator to focus on navigation.

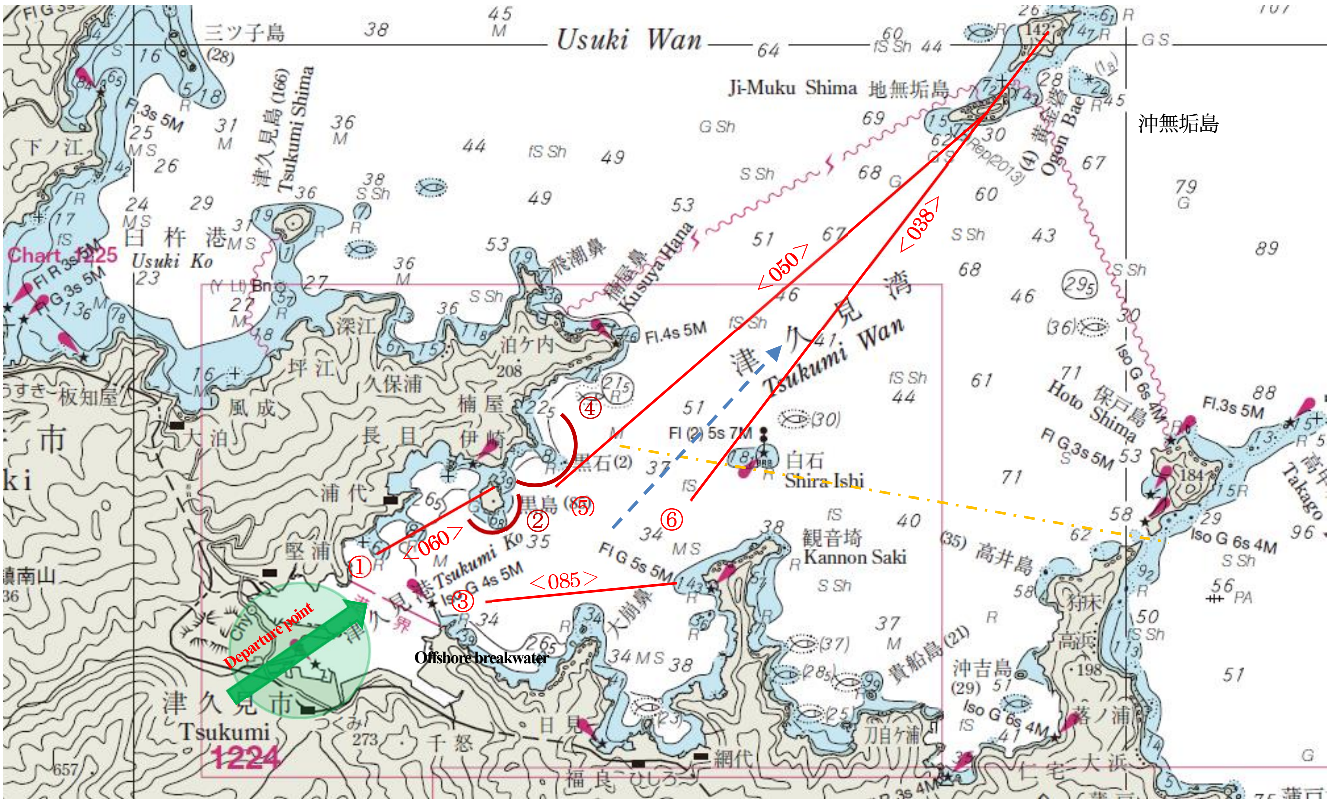


Figure 17- Resource: Japan Coast Guard website （nautical charts W151 modified）
https://www1.kaiho.mlit.go.jp/TUHO/tuho/html/tuho/pdf/2016/hoseizu/2016-39-577-W151.pdf

Figure 17 illustrates an example of a clearing line for a route departing from Tsukumi Port, Oita, toward open waters (blue dashed line).

For a while after departure, maintaining a steady course is challenging due to avoidance maneuvers. Additionally, the narrow coastal waters contain shallow areas with sunken rocks ("+" symbol), the prominent rock above water "Kuroishi", and the "Shiroishi" isolated danger mark. To prevent grounding in an uncertain course state, clearing lines ①–⑥ have been set.

1. Immediately after departure, navigate with caution regarding **clearing line** ① (a true bearing of 060° connecting Kuroshima's peak and the edge of the shallow area with sunken rocks). If Kuroshima's peak exceeds a true bearing of 60°, the vessel enters the danger zone.

2. After passing the harbor breakwater's tip at a true bearing of 180°, avoid entering the inside of **clearing line** ② (a hazard avoidance circle equidistant from Kuroshima's peak to the shallow area). Additionally, pay attention to **clearing line** ③ while navigating.

3. After passing Kuroshima, navigate without entering the inside of **clearing line** ④ (a hazard avoidance circle based on the cape northwest of Kuroishi). Sail between **clearing line** ⑤ (a true bearing of 050° connecting Chimuku Island's peak and the intersection of clearing line ④) and **clearing line** ⑥ (a transit line on a true bearing of 038°, connecting Okinuku Island and Chimuku Island's peaks and extending to the shallow area west of Shiroishi). Once past the yellow line connecting Kusuyahana and Hoto Island, the vessel enters wide area, allowing for steady course alignment as needed.