航海氣象講座之十二 超級巨浪對船隻的影響
https://youtu.be/n0LjSi4fVHE?si=4jK2hAbpQpMMnh4Z
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超級巨浪的形成
當船隻遇到從右下角來的大浪時,浪會打到船身並反彈,與後面的中浪產生來回運動,從而形成高達 30 米的超級巨浪。這種超級巨浪可分為超級波峰和超級波谷兩種,都會對船隻造成嚴重損害。

超級巨浪對船隻的影響
當船隻遇到超級巨浪時,會產生劇烈的橫搖,甚至直接撞擊在浪上。如果遇到超級波谷,容易造成船體折斷。此外,大浪還可能導致貨櫃掉落海中和螺旋槳飛車,使船隻失去動力,陷入漂流。

應對超級巨浪的方法
文章建議在遇到大浪時,船隻應該在大浪過去後，再進行大角度轉向,避免在浪頭上操作。同時還需要觀察波浪週期,選擇在大浪過後的時機進行操作,以確保船隻安全。
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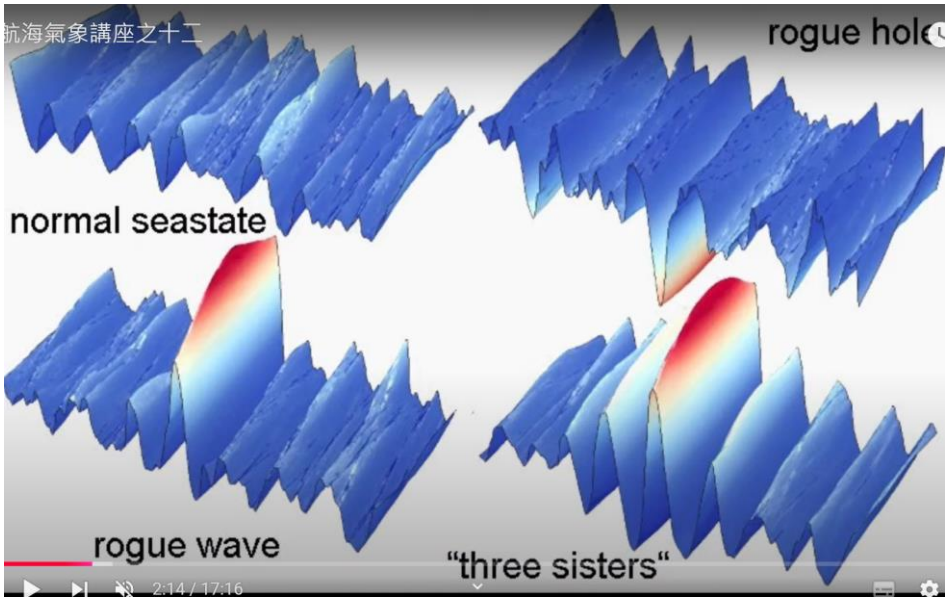
這是航海氣象講座的第十二講，在繼續談發明輪貨櫃落海的 case 之前，應該要對海上的巨浪有所瞭解。這關鍵的地方，超級巨浪對船隻來說，看看圖上船現在是什麼方向行進，船現在是由右下角往左上方前進(也是短浪 Short Waves 的方向，黃色箭頭)，遇到船頭來的浪(中浪，橘色箭頭))打到船身上，就把它反彈回去，浪打到船頭也是會反彈，遇到前面的大浪跟它後面的中浪來來回回的運動，(可能加上海底地形引起的浪頭加高)，就產生了超級巨浪。

巨浪一來，船一騎上去，當然就是會產生劇烈的橫搖(負的 GM 值)，或是直接就撞擊在浪上面，就是下圖左下角的超級巨浪。如果巨浪有 30 米的高度的話，浪就達到駕駛台了。超級巨浪有兩種形式，一種是左下角超級的波峰 Rouge Wave，跟右上角的超級波谷 Rouge Hole，當然船如果是結構不夠強的話，遇到超級波谷，就是兩頭高中間下去，本來貨櫃船經常是在 Hogging 舯拱，現在變成 Sagging 舯垂，就是船中垂下去，就容易折斷。反之，散裝船經常是在 Sagging 舯垂，現在遇到超級波峰 Rouge Wave，變成 Hogging 舯拱，就是船中拱起來，就容易折斷。

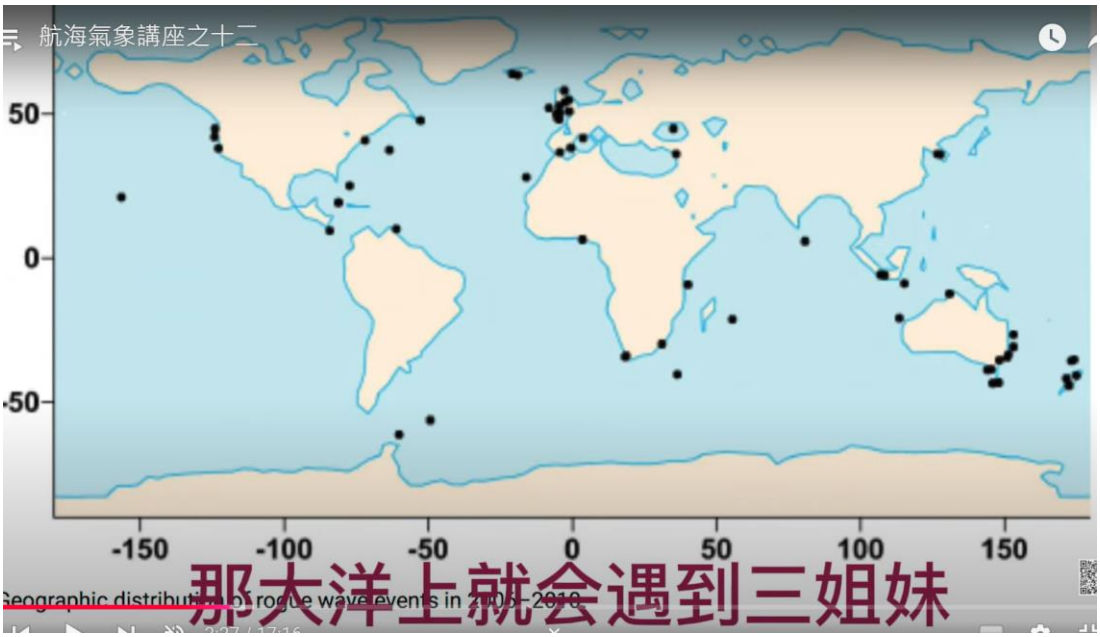


大浪的話，還不見得能夠把船抬得起來，但是超級波谷的話，反而更容易造成船隻的折斷。在超級巨浪好發區域，以前看過是在陸地的附近，所以來來回回的小浪，也有時候是岸邊反射的浪。打到岸邊後，入射再反射/折射，產生的小浪跟颱風帶來的長湧，加上後面的風浪，造成瘋狗浪。在野柳的海邊，不知卷走了不少人。

在大洋上面，這些來回的小浪，可能是風吹起來的，因為一個氣旋下來，產生很多三角交叉的浪。大洋上就可能會遇到三姐妹 three sisters，三姐妹，船隻如果遇到大浪習慣正頂的話，三姐妹第一個浪比較小，船可以穿過突破，等突船破了第一個浪(撞擊後)，船速已經慢下來，因為撞到東西。等到三姐妹第二個浪過來，會把船身抬高，等船身從第二個大浪的浪頭往下衝的時候，遇到了真正的對手，就是第三個(三姐)的大浪。這時候如果船隻是正頂(下衝角度變大，大浪跨過船頭)，船頭的機具跟貨櫃很可能就受損，如果船隻是偏頂的話，這時

候造成的負 GM，很可能就是什麼參數橫搖，劇烈的向左右的搖晃，其實貨櫃晃落海都還好(人沒事)，在大浪中，不但貨櫃會落海，

螺旋槳如果被抬離水面，不必完全露出來水面，就是只有二分之一葉片抬離水面的時候，此時第三個大浪來，船頭撞進去，船頭(拔不出來)都埋在海水裡面，船尾被抬離水面，沒有辦法及時落下海裡，螺旋槳吃不到海水的阻力，就會造成飛車，飛車就是主機空轉，沒有吃到海水。



一飛車，主機的保護機制就是跳掉，停掉燃油供給，要不然可能會把什麼，大軸/曲拐軸/鋼套都戳破了，這時候大風大浪，主機又失去動力，這時候船員除了拼命啟動主機以外，其實就已經聽天由命，希望風浪趕快過去(等三天)，輪機員趕快啟動主機，這時候最好不要再有同步橫搖的發生(貨櫃落海)，所以跑船始終都是冒險的事業。

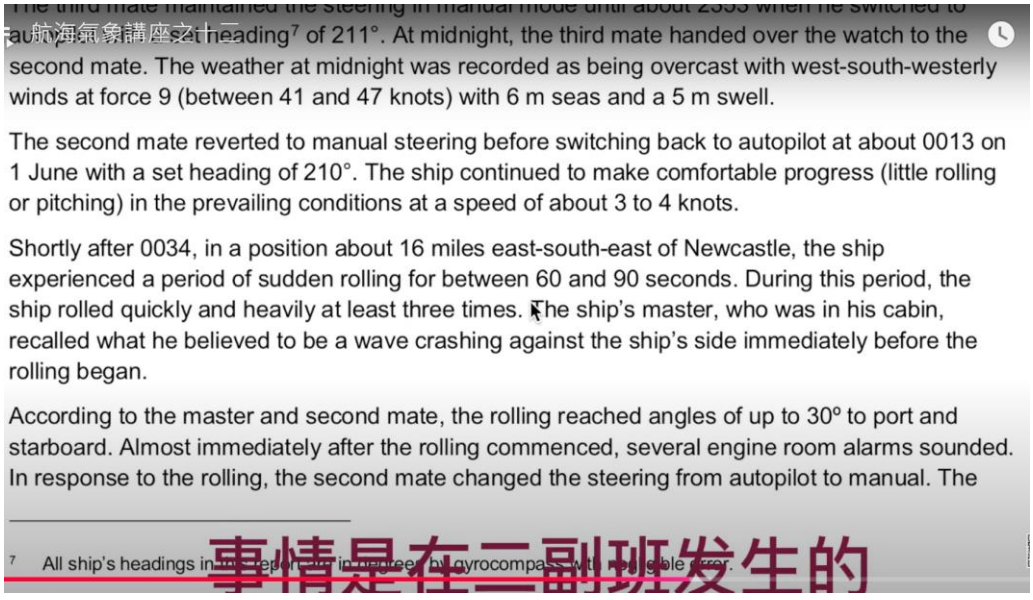
上圖是超級大浪好發區域，

1. 最多是 Biscay bay 比撕開灣 三百六十 miles 是法國西岸的外海，北大西洋的一個海灣，比斯開灣出名風高浪急，是由於灣內的大陸架延伸至頗遠的外海，導致比斯開灣較為淺水。
2. 二是澳洲東部包括: 布里斯班 Brisbane，雪梨 Sydney，墨爾本 Melboune 等，發明輪出事的地點。
3. 左上角溫哥華出來的 JUAN DE FUCA
4. 依次為 TEHUANTEPEC 台灣台北:在墨西哥與瓜地馬拉中間的海灣
5. 美國東岸紐約，南非好望角，
6. 值得注意的是地中海裡面有四個區域。

看這條船好像是叫 ONE APUS 還是什麼海聯雨燕號，跟發明輪住艙後面三個 bay 的貨櫃輪落海

的情形不一樣，他可是從船頭到船尾，差不多每個 bay 都有櫃子落海，不是左邊就是右邊，情形就不可能是因為 lashing Force 的問題，發明輪只有影響到船尾的櫃子，因為機艙的震動，主機經常在飛車的震動，引起 lashing Gear 鬆掉鬆脫。海聯雨燕號全船的 lashing 都鬆掉是不太可能，唯一的原因就是什麼失去動力，在海上面漂流，漂流造成船隻負的 GM，不要看這些船動不動都是 50 米 60 米寬，要知道船越寬，雖然 GM 越好，是在浸水的時候，在動態平衡有波浪過來，船越寬，你吃到浮力變形，水下體積變形的影響就越大，時候正的 GM 就迅速就變成負的 GM。(還有一個原因是遇到 rouge wave)

所以，船在靜水的時候，大家拼命要破壞什麼? GM。超大型貨櫃船的靜態穩定度。
等到動態的穩定度變化時候(風浪大)就吃足了苦頭，所以，還需要經過時間的淬煉，等對於這些動態的穩定度，尤其是超大型貨櫃船有一定的瞭解以後，才知道應該要怎麼做(船隻設計/排艙)，才能夠避免這些危險。事實上是，不管懂不懂動態的穩定度變化，長榮兩萬四千 TEU 的船都已經下水了，所以跑船始終都是冒險的事業。



好，看看這海聯雨燕號號稱是 1 萬 4 千 TEU 的新巴拿馬極限船，下水的時候，剛下水第一個航次在太平洋中間，就已經減速到十節。在 11 月 30 號，船隻在大洋中航行最危險的時候，就是在荒天中掉頭，因為掉頭的時候，一定會橫浪，橫浪的話，就可能會發生什麼失去 GM，

造成參數橫搖的發生，話說在大風浪中掉頭，依照現在我對理論上面的瞭解，應該是在大浪過去以後掉頭，因為船在波峰上面，GM 是最少，穩定度最差。要等船經過大浪以後，趁浪小的時候，趕快用大車大舵掉頭，這時候不會有負的 GM 的情形發生，所以大車大舵用下去，都是安全的，這就是在荒天操船的要點，船騎到浪頭上的時候，不要輕舉妄動。
要做大角度的轉向掉頭之前，一定要先觀察波浪的週期? 是三個大浪八個小浪? 還是兩個大浪九個小浪? 至少要觀察半個鐘頭以上，算出波浪正確的週期。在大浪過後，再做轉向的操作。

下面再回頭看到發明輪出事的 case，現在看看出事時候的情況，事情是在二副班發生的，三副交班的時候是西南西的風，風力九級/六米的浪/五米的湧(六米的浪應該是 12 級的風，加上五米的湧，浪加湧就可能 11 米高)，九級風西南西的風向跟什麼? 跟南太平洋洋流的流向剛好相對，這也是在南非的南端好望角(經常出事的地方，情形一樣)，二副改成手操舵，又把它改成自動舵。在 0013 的時候，航向設為 210 度，這時候船速已減到三到四節，很舒服的前進，只有一點點的 rolling and pitching，在過了半個鐘頭後，0034 時，Newcastle 東南東 16 海浬的位置，船隻遭到 60 跟 90 秒之間的快速橫搖，就是搖了一分半鐘啦，在這期間船隻的橫搖非常快速三次，三次大浪就是三姐妹吧，船長在他的房間回憶說，他相信有個大浪打在船邊(三姊吧)。

就在橫搖開始的時候(大姊)，有大浪打在船邊，我們的瞭解，應該是船已經騎到浪上面了(二姊)，失去 GM 的時候，才會激烈的橫搖，所以船長的記憶不一定是對的，依據船長跟二副的報告，左右兩邊搖到 30 度，搖 30 度，在海上雖然是不好過的，可是也是經常發生的事情，不一定會掉櫃子。

就在橫搖開始之後，機艙的 alarm 開始叫起來，這當然是什麼油水櫃裡面的油位不夠/水位不夠等，因為船隻搖了 30 度(產生自由液面)，要不然就是什麼吸不到燃油? 要抽水/抽油抽不到? alarm 就開始叫。二副把它改成手操舵，此時二副報告，有聽到甲板上有噪音，懷疑有 LASHING 損害，他就打開甲板燈，觀察到有幾個貨櫃已經受損倒掉，可能在住艙後面已經落海。

這就在時候主機忽然跳掉，船隻的轉速歸零。(前面講解過，推測應該是先飛車，然後櫃子才落海)，要知道現在船本來就已經是以三四節的速度慢速在前進(調整船期)，即使是這樣，遇到劇烈的橫浪，主機還是會飛車/跳掉。0036 分，在此時船長到了駕駛台，看報告是在 0034 分開始搖，船長過了兩分鐘就上駕駛台，然後機艙的輪機員就去處理機艙的 alarm。

在 0040 時，過了四分鐘，船長就完成了損害的評估。是不是效率太高了，只有四分鐘的時間，船頭船尾怎麼看得完，況且風浪又這麼大，根本就看不見，所以做船長，我們是不建議上甲板去檢查任何東西，誰知道下一個大浪來是甚麼時候?，你人在哪裡? 所以最可能的，0040 時就只有檢查到駕駛台後面，眼睛看得到的地方，任何事件的發生，不管船上發生任何

再重大的事件，都要以人命安全為優先，像報告寫的就不盡情理，也不可能做得到，這是作為船員的自覺之一。

Hello everyone, this is the twelfth lecture of our maritime meteorology seminar. Before we continue discussing the case of the fall of the cargo container ship due to excessive rolling, we should have some understanding of the giant waves at sea. Here we come to a critical point, the super rogue waves. For ships, when we see how the ship is moving, it is heading from the lower right corner to the upper left corner. When the wave hits the ship from the front, we bounce it back. This back and forth motion between the large wave in front and the medium wave behind creates this super rogue wave. When the ship climbs onto this wave, it will experience severe rolling or even collide directly with the wave, known as the lower left super rogue wave.
If this giant wave is 30 meters high, it would reach the bridge of the ship. There are two types of these super rogue waves: one is the super crest, which is the lower left corner, and the other is the super trough, the upper right corner. If a ship with insufficient structural strength encounters the super trough, it will be higher at both ends and lower in the middle, causing what used to be hogging in container ships to now become sagging, making it prone to breaking. Large waves may not necessarily lift the ship, but super troughs are more likely to cause the ship to break. On these super rogue waves, which we used to observe near the coast, the back and forth small waves sometimes hit the shore, causing diffraction, reflection, and refraction, generating small waves along with the long waves from the sea and the wind waves behind, creating this windward wave. Near the wild seas, many people have been swept away. The back and forth small waves on the open sea might be caused by the wind, as when a cyclone comes down, there are many intersecting waves. On the open sea, there will encounter the three sisters. If a ship is accustomed to plowing through big waves, it can break through the first small wave. However, once the ship is damaged by the first wave, the ship's stability is reduced, making it vulnerable to the second wave lifting the ship's body higher, and when the ship's body rushes down from the crest of the second big wave and faces the real opponent, which is the third sister's big wave. At this time, if the ship is bow-on, the machinery and containers at the bow are likely to be damaged.
If the ship is off-center, there may be severe rolling to the left and right. In fact, you might end up in the sea. Not only will the containers fall into the sea in rough waves, but if the propeller is lifted off the water and not fully submerged, then when the third big wave comes, the bow of the ship will collide

and be buried in the sea, causing the stern to be unable to lift off the water and unable to descend in time. This will create resistance to the water, leading to the propeller racing without catching water. The protection mechanism of the main engine is to shut down to prevent damage, otherwise the main shaft could break, the propeller could bend, and even the steel casing could be punctured. In this situation, with strong winds and waves, the main engine loses power. At this point, the crew, besides desperately trying to salvage the machinery, just have to resign to fate, hoping the storm will pass quickly and the engineer will quickly start the main engine. At this point, synchronous rolling should not occur anymore. So, running a ship is always a risky business. Looking at this ship, it seems to be called 1UPUS. Next to this ship, we see three to five Q container ships parked, with three times the amount of container wheels falling into the sea. The situation with the falling wheels is not the same as usual. Either left or right, a cabinet falls into the sea. This situation cannot be due to the issue of trimming.

Regarding the cabinets at the stern of the ship, due to the vibration of the engine room, the main engine often causes the gear to slip loose during propeller racing. It is unlikely that all the ship's trim tabs are loose, and the only reason is the loss of power at sea, causing drift. Drifting causes the ship's negative GM. Don't overlook these ships, which are constantly 50 to 60 meters long. Keep in mind that the wider the ship, the better the GM is when it's close to the water. However, in dynamic balance, when waves come, the wider the ship, the more it deforms under the buoyancy and the greater the impact of underwater volume deformation. At this point, the GM turned negative due to vibration. Everyone must work hard to destroy the static stability of these ultra-large container ships when close to the water. Wait until the dynamic moment to endure the consequences. Therefore, it takes time and experience to understand the dynamic stability of ultra-large container ships in order to know how to avoid these dangers. Let's take a look at this 14,000-ton ship, claiming to be a new Panama ultra ship. When it was first launched, it slowed down during the first voyage in the middle of the Pacific. On November 30, the ship sailed in the open ocean, the most dangerous time, in rough weather, because turning around during rough weather can lead to cross waves, which can cause the loss of GM and result in severe rolling. In strong winds...

Turning in the waves according to our current theoretical understanding should be after the big waves have passed because the ship is less stable on the wave. It is best to wait until the ship has passed the big waves, and quickly turn the steering wheel when the waves are smaller. At this time, there will be no

negative stability situation, so turning the wheel is safe. This is the key point of maneuvering in rough seas: do not make light movements when riding the wave, make a large turn before turning, and observe the wave cycle - whether it's three big waves followed by eight small waves or two big waves followed by nine small waves. It's necessary to observe for at least half an hour to determine the correct wave cycle before taking action after the big waves.

Now, let's look back at the case of the incident involving the ship's wheel. The incident occurred during the handover from the Third Officer to the Second Officer. There was a southwesterly wind of force 9, with waves of 6 meters and swells of 5 meters, matching the direction of the South Pacific current. This incident happened near the southern tip of Africa, where accidents frequently occur. The Second Officer changed to manual steering and then to automatic steering, setting the heading at 210 degrees at 0013. The ship was sailing at 3 to 4 knots comfortably with minimal rolling and pitching. When the rolling started, a large wave hit the side of the ship. Our understanding indicates that the ship had already ridden the wave and lost stability before the violent rolling occurred.

Therefore, the Captain's memory may not be accurate. The Captain and the Second Officer reported a roll of 30 degrees to the left and right. A 30-degree roll at sea, although not comfortable for people, is a common occurrence and does not necessarily result in items falling over. After the rolling began, alarms in the engine room started ringing. This could be due to low oil and water levels in the tanks, as the ship rolled 30 degrees, preventing fuel and water from being drawn, triggering the alarms. The Second Officer switched to manual steering, and reported hearing noise on deck suspecting damage to the containers. He turned on the deck lights and observed that several containers were damaged and may have fallen overboard. At this moment, the engine suddenly jumps and the ship's speed drops to zero.

You see, the ship was already moving slowly at three or four knots, so even in such rough waves, the engine still stalls. At this time, at 0036 hours, the captain arrived at the bridge. We can see that things started to shake at 0034 hours. The captain went to the bridge two minutes later, and then the engineer in the engine room went to deal with the alarm, so after four minutes, the captain completed the damage assessment. That is, by 0040, the efficiency was really high, taking only four minutes. With the bow and stern of the ship completely out of sight and such rough weather, the captain advised against going up to the deck to check anything, who knows when the next big wave will hit. When you arrive, wherever you are, the most likely thing is to only check the area visible from

behind the bridge. This is where the event occurred. Regardless of any major events on board, the priority is the safety of the people. Reports like this may not fully make sense, and it may not be possible, but as crew members, it is our duty to do so conscientiously.