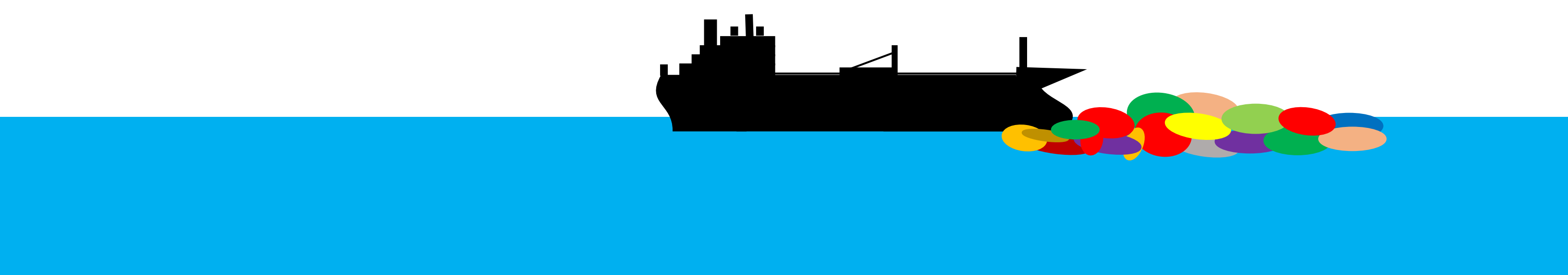
PREVENTION OF ACCIDENTAL SHIP GROUNDINGS

Shane Sankaranarayana
CINEC Campus
www.cinec.edu



Prevention of accidental ship groundings

Research based suggestions to eliminate accidental ship groundings

Shane Sankaranarayana

CINEC CAMPUS Beyond A Graduate

www.cinec.edu

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Executive summary

This paper aims to carry out a detailed analysis of ship groundings with the intention of identifying the reasons for groundings and to suggest preventive measures to reduce such accidents.

Accident investigation reports of last 12 years published by nine flag States were analysed. Out of these nine flag States, seven flag States were within the top ten [1] of the flag States in terms of gross tonnage.

47% of the ships grounded had three navigating officers and a master. Which means possibility of encountering fatigue due to noncompliance with work and rest hours was less than the other ships with a smaller number of navigating officers. But still 16% of the groundings took place probably due to fatigue caused by noncompliance with work and rest hours. The number of groundings due to fatigue are more or less equal on ships with '3 navigating officers', '2 navigating officers' and '1 navigating officer'.

Only 7% of the strandings had taken place while an inexperienced officer was on duty. 56% of the groundings had taken place while the master was at the con of the vessel. Most of the groundings had taken place while experienced and high-ranking officers were on duty.

Highest number of the groundings had taken place while the vessel was enroute and groundings while a pilot onboard is also considerably high. 13% of the groundings had taken place after dragging anchors.

Number of bulk carrier groundings are considerably higher than other types of ships. Most of the bulk carriers were grounded while within or closer to port areas.

Lack of situational awareness, poor bridge resource management practices, noncompliance with ship's SMS and possibly, complacency, fatigue due to autonomy/boredom has a higher impact on ship strandings.

Based on the outcomes of the research, number of suggestions are made where the IMO, ship operators, seafarers and ports should consider adopting and complying for the purpose of reducing ship groundings in future.

1. Introduction

Grounding/stranding is physically the same action as beaching, but with the significant difference that beaching the vessel is an intentional action and under comparatively controlled conditions, whereas stranding is accidental [2]. Grounding ranges from soft touch of the bottom of a ship with the seabed to running hard aground on rocky seabed which may cause constructive total loss of a ship. Grounding accidents can have wide-ranging effects on the ship, the port or navigational route, and the wider economy. In extreme cases, they can lead to the loss of human lives on board, the complete blockage of a port or maritime passage, and/or severe environmental impacts [3].

Oil tanker Exxon Valdez ran aground in Prince William Sound, Alaska, spilling 11 million gallons of oil and making the one of the largest environmental disasters in the U.S. history [4], which caused damages to the marine environment, ship and cargo. This was not the largest oil spill in the world but, it is the most widely discussed ship grounding which created one of the largest scale environmental disasters. Passenger ship Costa Concordia ran aground about two decades after the incident of Exxon Valdez losing 32 lives [5]. Most recently in 2021 container vessel Ever Given ran aground on the banks of the Suez Canal for a week, causing an estimated £7bn loss each day in trade owing to ships stuck on either side, and up to £10.9m a day for the canal [6].

Even though, Exxon Valdez and Costa Concordia ran aground due to human error decades ago, still, after having satellite position fixing methods and modern technology for navigation, Safety & Shipping revive 2022 [7] states that the top three causes of total losses of ships over the past decade (2012 to 2021), were foundering (52%), grounding (18%) and fire/explosion (13%) accounting for more than 80% of ship’s losses. Therefore, the frequency of groundings remains still high.

Therefore, risks of ship groundings remain still high. This research is an in-depth analysis of ship groundings in order to identify preventive measures for the safety of ships, cargo, people and marine environment.

2. Aims

Irrespective of the sizes and the 'trading limits' of the vessels, all navigating officers must have good knowledge and competency to safeguard vessels against strandings. The aims of this research are to analyse the ship groundings based on the accident investigation reports issued by flag States and coastal Administrations on ship groundings and contacts of ship's bottoms with submerged objects to identify:

- reasons for ship groundings
- whether the existing training is sufficient and
- to make suggestions to eliminate/reduce groundings

3. Methodology

Accident investigation reports of the following Administrations and by other Administrations on behalf of the following were analysed which were available in their own websites and in the Global Integrated Shipping Information System (GISIS) of International Maritime Organization (IMO).

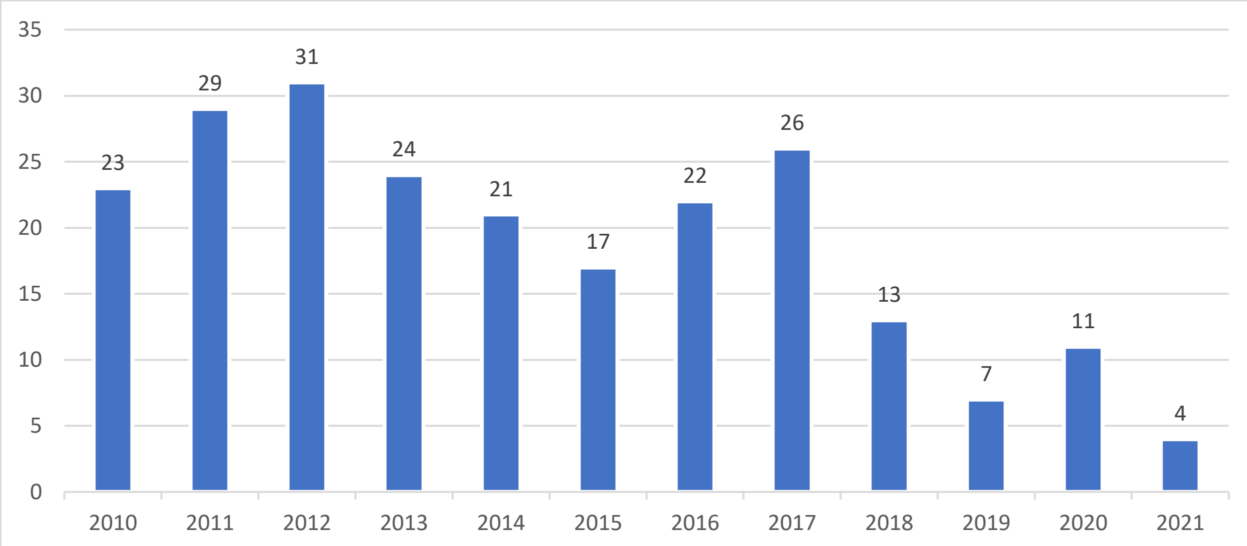
a) Bahamas
b) Cyprus
c) Hong Kong
d) Liberia
e) Malta
f) Marshal Islands
g) Panama
h) Singapore
i) United Kingdom

Groundings occurred from 1st of January 2010 to 31st of December 2021 were considered and data gathering completed on 4th June 2022, which means the accident investigation reports made available after this date are not considered in this research. Accident investigation reports involving all the merchant ships considered, excluding the following vessels;

a) Fishing vessels
b) Warships
c) Dredgers, drilling vessels and other similar types
d) Tugs and
e) Other vessels which do not apply the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW Convention)

4. Number of groundings occurred annually

In accordance with the GISIS of IMO and the websites of the Administrations those who carried out the accident investigations, there were 228 ship groundings within the Administrations considered within the 12-year period.

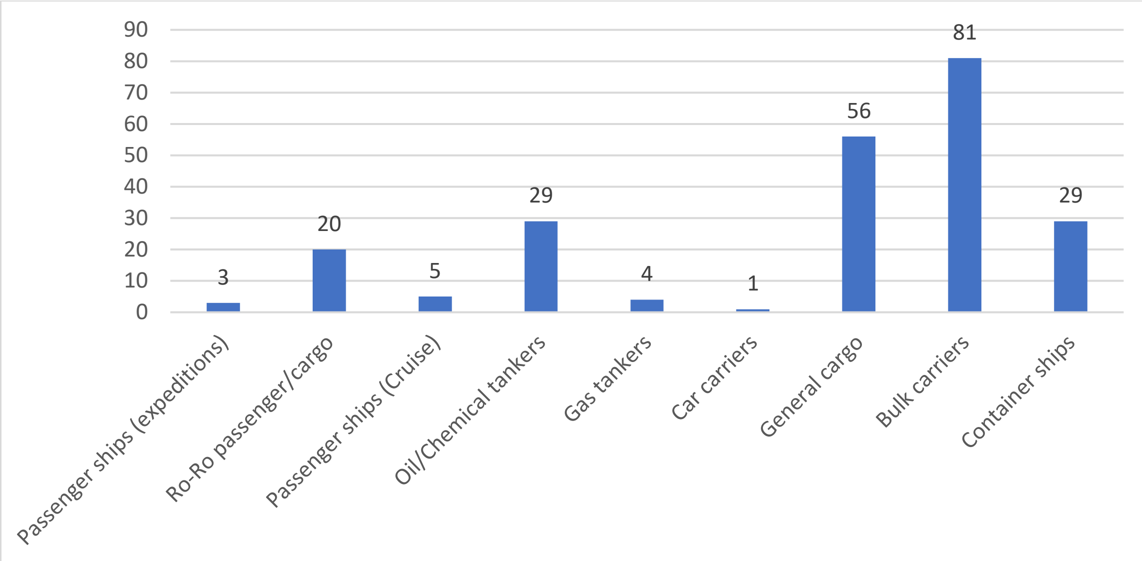


Number of groundings occurred annually
Graph – 1

5. Types of ships grounded

5.1 Types of ships with and without accident investigation reports (total groundings)

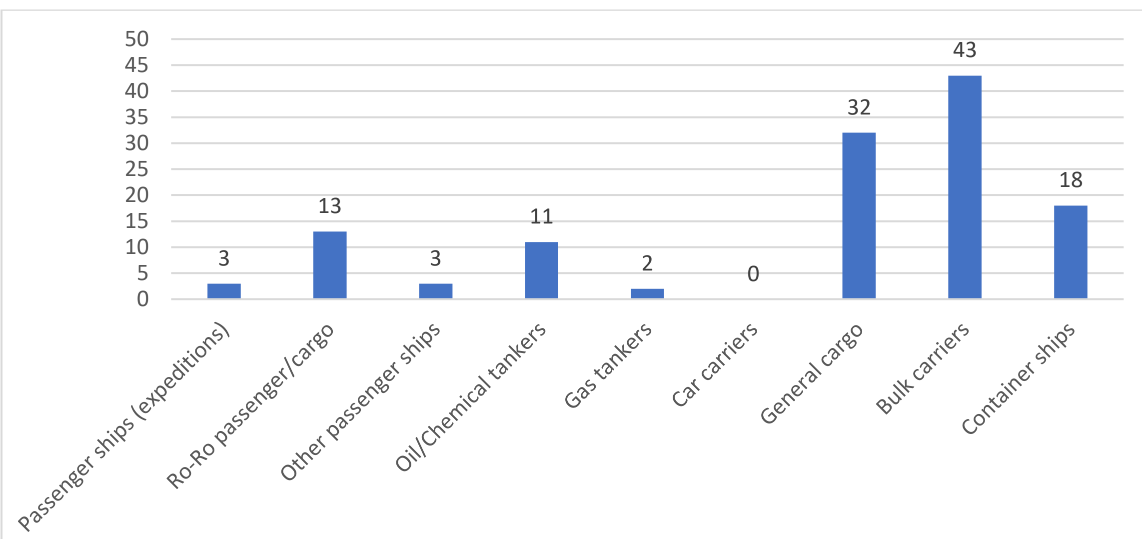
Even though the GISIS of IMO has information such as date of grounding, types of ships grounded, locations of groundings etc. for all the groundings, no detailed accident investigation reports were available to download in considerable number of groundings. The Graph – 1 (above) and Graph – 2 (below) includes all the ship groundings including the accidents without accident investigation reports.



Types of ships stranded
Graph – 2

A detailed study on ship groundings can be carried out only when the full accident investigation reports are available. Out of the above 228 accidents, accident investigation reports of only 125 groundings (in English) were available to download in the above-mentioned websites. Therefore, this research is based on the detailed accident investigation reports of these 125 groundings only, i.e. only these 125 accidents were analysed hereafter.

5.2 Types of ships grounded where the accident investigation reports available



Types of ships grounded (accident investigation reports available)
Graph – 3

In the above Graph - 3, general cargo ships include;

- Conventional general cargo ships
- Refrigerated cargo ships
- Multipurpose ships and
- Palatized cargo carrying ships

In addition to the normal bulkers, the bulk carriers include;

- cement carriers and
- aggregate carriers

Oil/Chemical tankers include;

- Oil tankers
- Chemical tankers
- Oil/chemical tankers and
- Asphalt / bitumen tankers

During the period considered among the said Administrations, bulk carriers were the highest risk vessels for grounding and the second were the general cargo ships. Bakhsh [8] says that grounding was the single biggest cause of bulk carrier losses over the past 10 years (between 2011 and 2020). Which means while the frequency of bulk carrier groundings is high, most of the bulk carriers were lost not due to any other reasons but due to strandings.

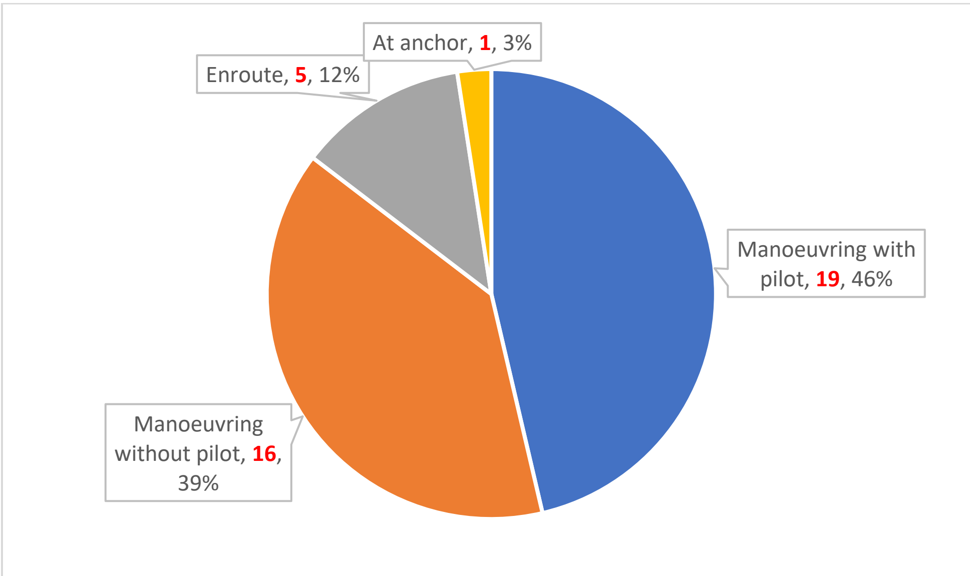
6. Seafarer human error

Out of the above 125 groundings 108 (86.4%) groundings were caused due to human errors of seafarers. It includes groundings while pilotage, during mechanical failures, groundings during heavy weather etc. But these 108 accidents could have been avoided if proactive measures were taken by the navigating officers and the masters based on professional judgments.

Out of these accidents due to human error, at least 104 accidents had taken place due to lack of situational awareness of the seafarers. Out of these 104 strandings, 40 strandings (32% of the total groundings) had taken place due to lack of ship's positional awareness, which is the most important information need to be aware by the navigating officers to avoid grounding. Fatigue and effects of alcohol also will cause to lose situational awareness. But, said 40 strandings exclude the groundings due to lack of situational awareness caused by fatigue (due to noncompliance with the work and rest hours) and possible effects of alcohol. Which means the duty officer was sleeping or doing some other work on the bridge or not on the bridge or not interested in monitoring the ships position during the said accidents.

7. Poor bridge resource management (BRM) practices

Whether it was a primary contributory factor or not, in total there were 41 groundings which involved poor bridge resource management practices. These groundings occurred during the following occasions;



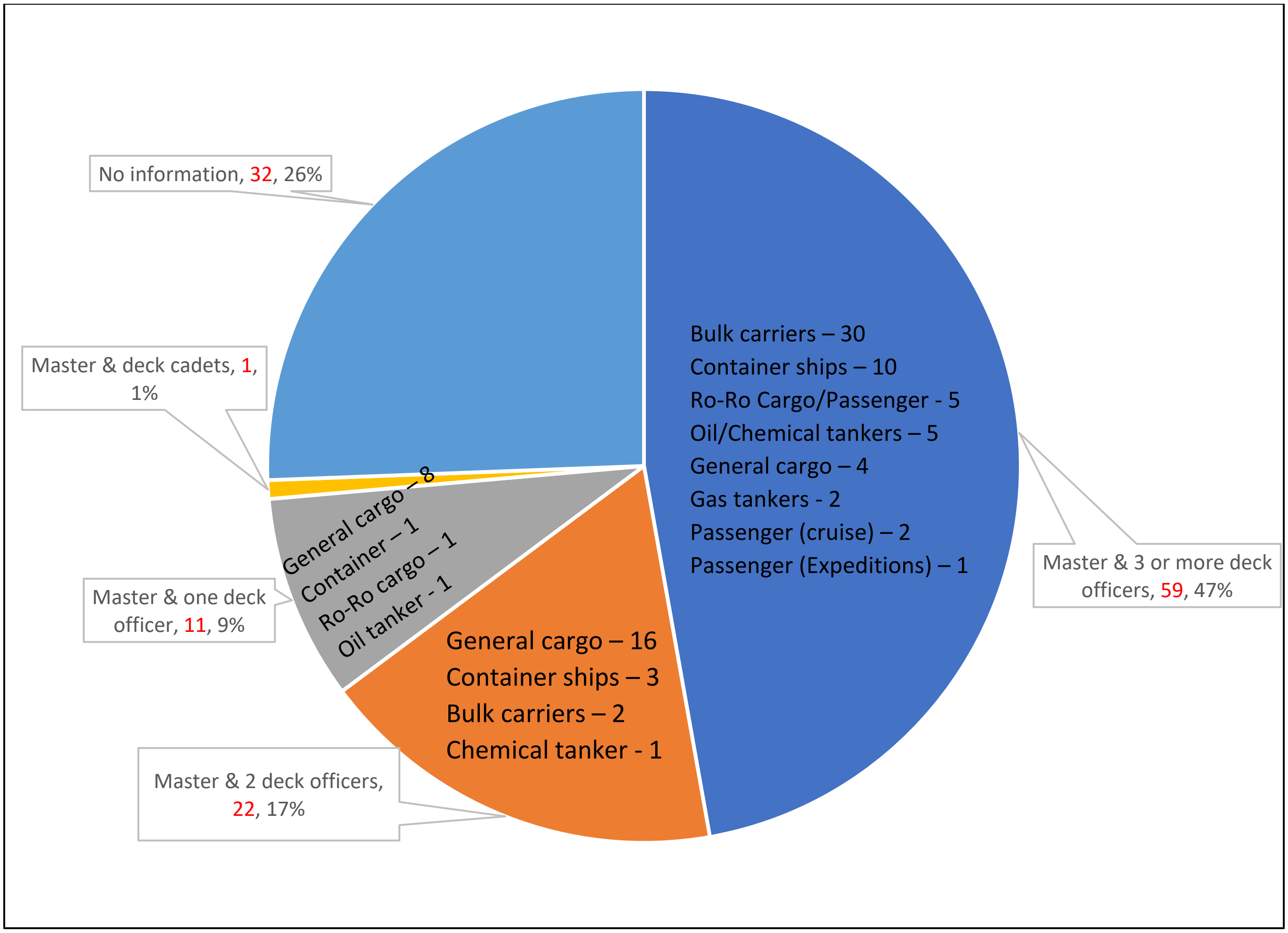
Occasions of poor bridge resource managements
Graph - 4

Manoeuvring means steering various courses and proceeding with changing speeds for berthing or unberthing or anchoring or leaving anchorages. It is a norm to have more people involved when manoeuvring a vessel, such as the master, duty officer, helmsman, pilot etc. Therefore, it is obvious that accidents due to poor bridge resource management likely to encounter while manoeuvring rather than other occasions. Most importantly, most of the groundings due to poor BRM practices had taken place while a pilot was onboard.

Enroute means during the normal sea passage (basically, passage between the pilot disembarking point of the departure port and the pilot embarking point/anchorage of the arrival port).

8. Number of navigating officers onboard against types of ships

It is important to identify the number of navigating officers onboard the grounded vessels because higher the number of navigating officers lesser the possibility of encountering fatigue and lesser the workload as the navigating watch and the work can be shared among the navigating officers.



Number of navigating officers onboard against types of ships

Graph – 5

Most of the vessels (59 vessels) were having a master and 3 or more navigating officers onboard at the time of grounding. Out of these 59 ships, 30 ships were bulk carriers. General cargo ships were the highest among the other three categories.

Masters who are onboard with at least three navigating officers do not keep routine bridge watches at sea or at anchorages. The bridge watch is shared between the three navigating officers.

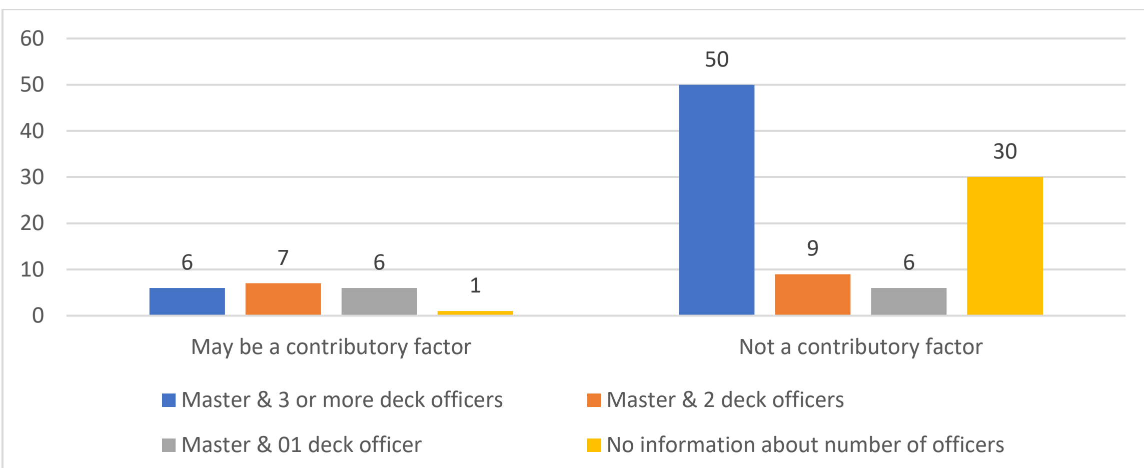
On ships with master and two navigating officers, sometimes the two deck officers keep the bridge watches 6 hours on duty and 6 hours off duty basis per day. On board some ships, master also share the bridge watch so that they keep the watches 4 hours on duty and 8 hours off duty basis.

On ships with master and one navigating officer, bridge watch is shared between the two, as 6 hours on duty and 6 hours off duty per day.

There is a high possibility of experiencing fatigue (due to lack of rest) on ships with master and two or lesser number of navigating officers during the sea passages depending upon the work load they have apart from the navigational watch. But most of the groundings had taken place while the vessels were manned by a master and at least three navigating officers. Most importantly, bulk carriers are having considerably high number of casualties while manned with 3 navigating officers.

9. Seafarer fatigue due to noncompliance with work and rest hour requirements as a contributory factor against the number of navigating officers

Whether it was the primary cause for the accident or not, in total there were 20 groundings (16% of the total groundings) that may have caused due to the effects of fatigue out of the total 125 strandings.



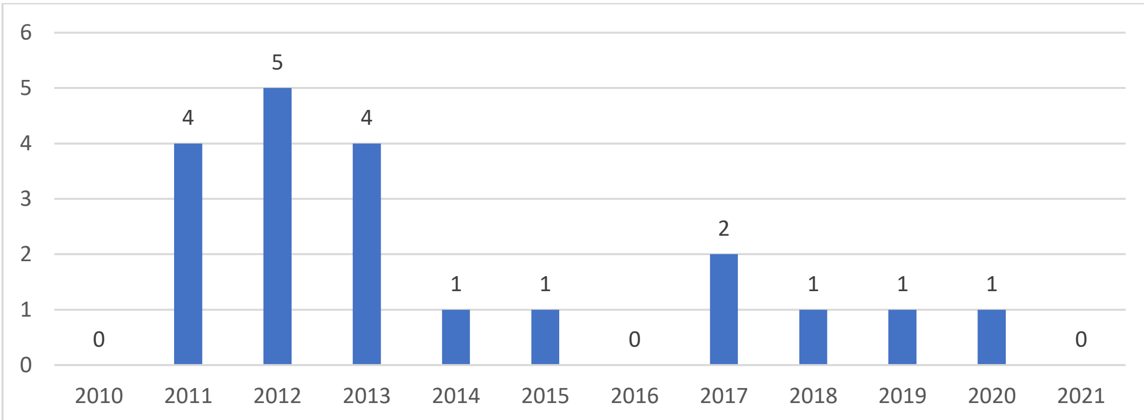
Seafarer fatigue as a contributory factor against the number of navigating officers
Graph – 6

Even though it may have caused fatigue, following grounding incidents are not included in the above graph;

- 07 groundings that took place possibly due to effects of alcohol and
- 03 incidents with no information about compliance with the work and rest hours

Not much connection can be found between the number of the navigating officers onboard and the fatigue of seafarers due to noncompliance with work and rest hours. Only 20 accidents had taken place possibly because of fatigue during the period. That is also more or less evenly distributed between 'master with 3 or more watchkeeping officers', 'master with 2 watchkeeping officers' and 'master with one watchkeeping officer'.

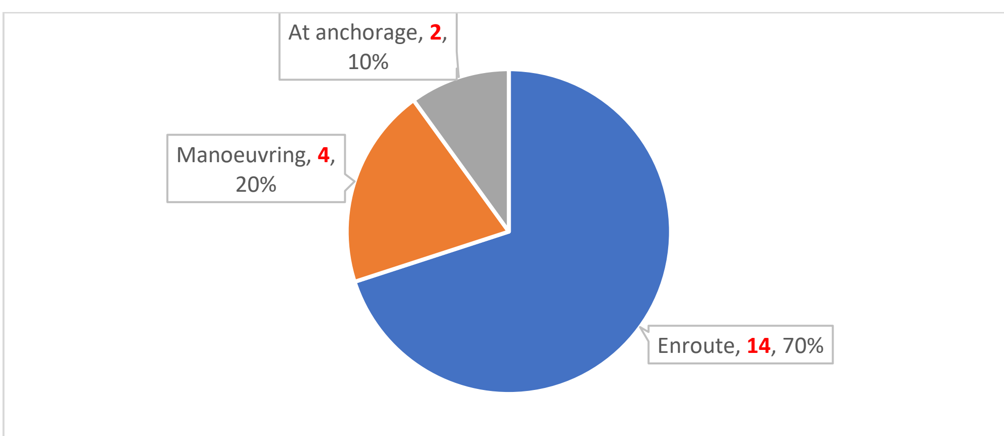
The following graph shows the number of groundings took place annually over the 12-year period possibly due to fatigue.



Groundings possibly caused due to fatigue (noncompliance with work and rest hour periods)
Graph - 7

The groundings possibly due to fatigue (due to noncompliance with work and rest hours) are declining most probably, due to the proper implementation and compliance with the work and rest hour requirements adopted by IMO and International Labour Organization (ILO).

9.1 Occasions of groundings due to fatigue caused by noncompliance with work and rest hours



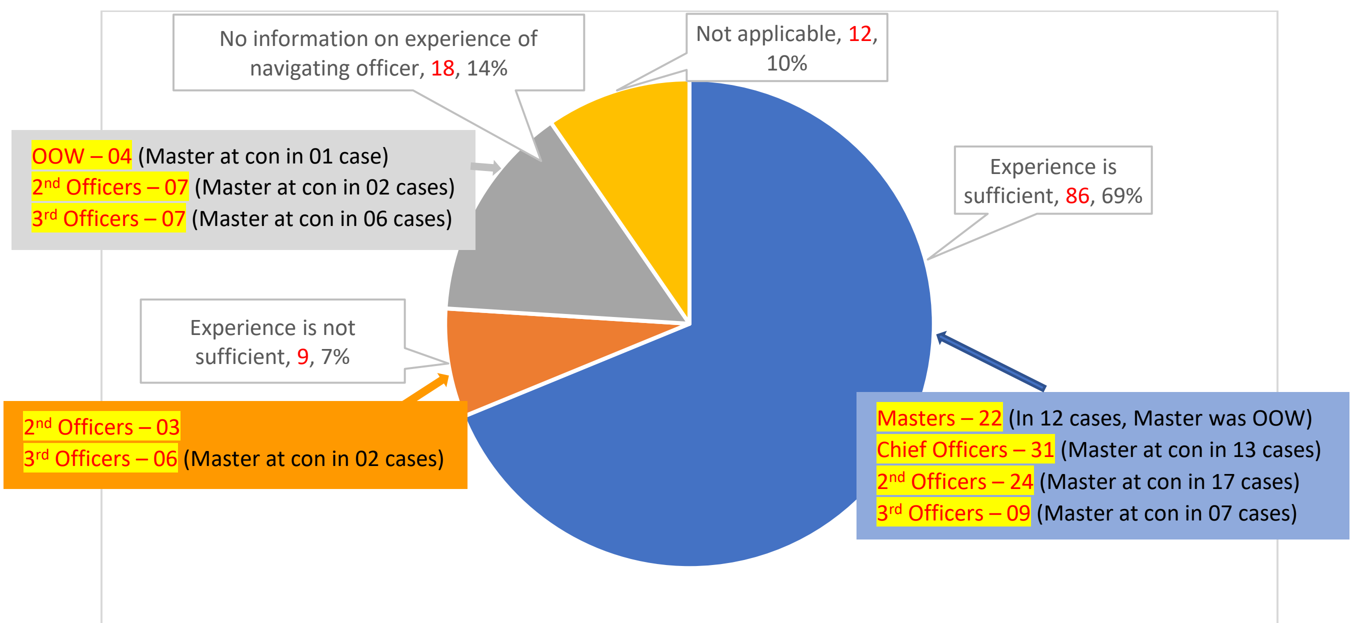
Occasions of groundings possibly due to fatigue
Graph - 8

Most of the groundings due to possible effects of fatigue (due to noncompliance with work and rest hours) had taken place while the vessels were enroute.

10. Experiences and ranks of the navigating officers who were on duty at the time of groundings

Competency in navigation is the key to safe navigation. Navigators need to gain more and more sailing experience to improve competency. At the same time, they need sea experience to be promoted to higher ranks as well. Therefore, higher competency can be expected from experienced navigating officers and high-ranking navigating officers.

It is important to identify whether there is a connection between the experience of the navigating officers and the ship groundings. STCW Convention requires 06 months of bridge watch keeping experience to be eligible for the certification as an Officer in charge of a Navigational watch on ships of 500 GT or more (operational level) [9]. In this research, sea experience is considered sufficient for 3rd officers and 2nd officers, if they had further six months of experience after the certification as navigating officers. Rather than academic training, practical experience/training is required in order to avoid ship groundings, as it is a matter of maintaining a situational awareness on the vessel's progress along the passage. That is why the experience is considered sufficient after further 6 months after becoming an officer.



Experience and rank of the navigating officers at the time of grounding
Graph – 9

In the above graph, not applicable includes groundings which may not be avoidable by the actions of the navigating officers and masters who were on duty at the time of grounding, such as;

- situations where the groundings may not be avoided with the competency of the seafarers
- groundings even after the best possible actions were taken by the onboard staff
- groundings after mechanical failures where the accident may not be avoided with the competencies of the watchkeepers
- groundings after conflicts on board etc.

Out of the 22 groundings that had taken place while master was at the con, 12 groundings had taken place while the master was doing the watch (master himself was the officer of the watch). The other 10 accidents had taken place beyond the control of the officer of the watch even though an officer was available on the bridge during grounding, such as;

- late decisions to leave berth to avoid rough weather
- sailing through rough weather with weather faxes, Navtex etc. out of order
- dragging of anchors for a long period of time before running aground where the master could have saved the vessel if called for salvage in ample time etc.

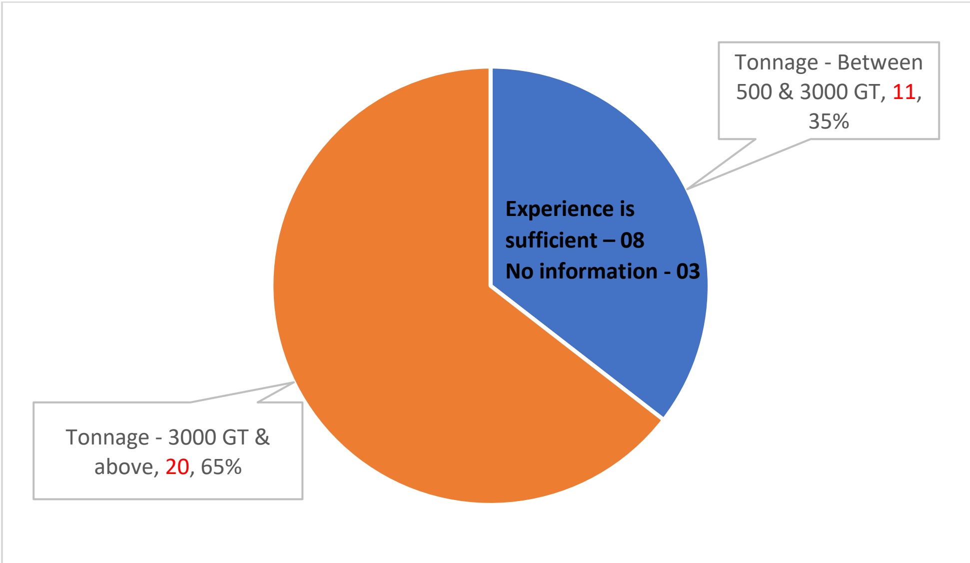
69% of the groundings had taken place while the bridge watch was maintained by sufficiently experienced officers and/or masters. It is interesting to note that in total, 70 (56%) strandings had taken place while the master was at the con. Finally, even though 9 strandings had taken place with inexperienced officers, master was at the con in two occasions.

There were number of accident investigation reports without any clarification on the sea experience of the watchkeeping officers involved. In the graph above, they are categorised as 'No information', except for masters, chief officers and junior officers with chief officer certification. Because;

- To be eligible for the chief officer's certificate, navigating officers need to have 12 months of sea experience after certification as navigating watchkeeping officer on ships of 500 GT or more
- To be eligible for master certification, navigating officers need to have further sea experience after the first certification as an officer or after becoming a chief officer.

Therefore, even though without any information about the sea experience, all watchkeeping officers with the chief officer's certification or above are considered as sufficiently experienced.

But to be certificated as a chief officer on ships of between 500 GT and 3000 GT engage in unlimited trading, further sea experience after certification as watchkeeping officer is not required. Since the highest number of strandings had taken place while chief officers were on duty, need to clarify whether these groundings had occurred due to lack of experience of chief officers on ships of between 500 GT and 3000 GT. Therefore, the 31 accidents involved while chief officers were keeping the watches are further analysed to identify the tonnage of the ships and experience of the chief officers.



Tonnages of the ships grounded during chief officer's watches

Graph – 10

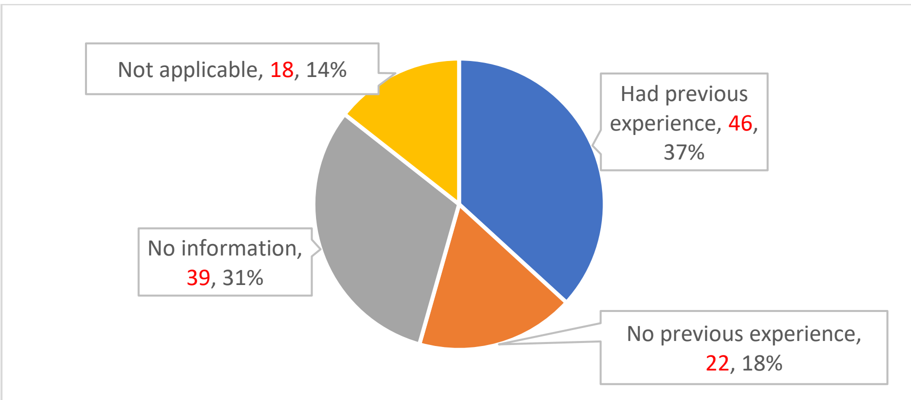
Among the 31 accidents considered, only 11 groundings had taken place by ships of between 500 and 3000 GT while chief officers or officers with chief officer's certification were on duty. Out of these 11 groundings, 08 accidents had taken place with chief officers having sufficient experience after the first certification. That means, out of the 31 groundings that took place while a chief officer was on duty, the chief officers were sufficiently experienced in 28 groundings.

With regards to collisions and groundings, one of the main areas is the level of crew's experience [10]. Which means lack of experience is the main cause of ship collisions and groundings. Further The Swedish Club says, collisions are often caused by a combination of inexperience and systematic issues in the organisation. At the same time, among other things, Carine, Lakshmi, Isabelle and Rana [11] also says that major causes of accidents come from deficiencies in knowledge (lack of experience). But when it comes to groundings alone, it is very surprising to note that most of the groundings were taken place while experienced and high-ranking officers were on duty.

11. Previous experiences of the masters / watchkeeping officers around the geographical areas where the vessels were grounded

Theoretically speaking, accidents due to strandings may be reduced if the navigating officers and the masters had visited the same geographical locations during previous voyages on the same vessel or on other vessels. Because they can take proactive measures to avoid groundings as they are familiar with the sea area. Therefore, it is good to examine whether the navigating officers or the masters had visited the locations where the vessels were grounded in previous voyages.

In considerable number of the accident investigation reports no information were given on the experience of the master or the navigating officer around the grounded area during previous voyages. In the graph below, 'Had previous experience' means in accordance with the information in the investigation reports most probably the master or the navigating officer on duty at the time of grounding had visited the area at least once prior to the date of the incident.



Previous experience of the master or navigating officer of the geographical area where the vessels were grounded

Graph - 11

In the graph above, 'Not Applicable' means the groundings that cannot be avoided with the former experience in the area, which include but not limited to;

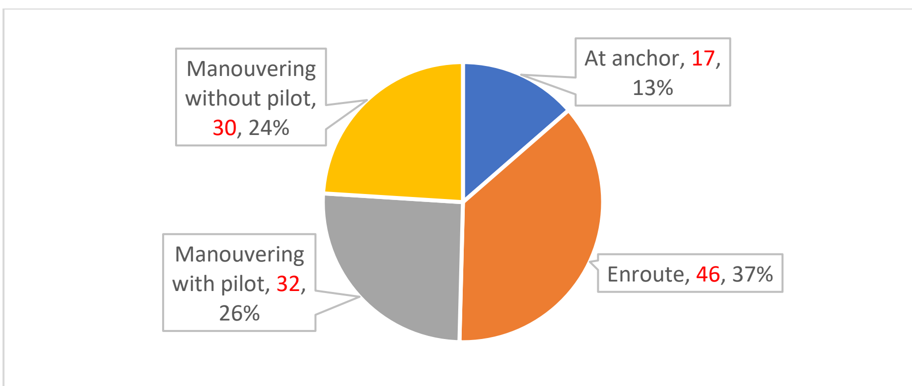
- Groundings due to mechanical failures where the grounding cannot be avoided even the navigators had visited the same area
- Grounding while dragging anchor but no actions were taken as no sufficient bunkers were onboard
- Grounding due to unconventional design of navigating bridge
- Grounding after conflicts onboard
- Grounding due to errors made by tugs

By referring to the graph above, it is very difficult to identify the impact of previous experience of the navigating officers in the grounded area on ship groundings, as no proper information could be found in 31% of the cases.

But, with the available limited information, 37% of the groundings had taken place while the vessel was navigated by an officer with previous experience in the area or while the vessel was under the command of a master who had previous experience around the area. Only 18% of the groundings had taken place without previous experience in the area.

Even though most of the scholarly articles state that the accidents (in general) can be reduced with the experience, when it comes to ship groundings alone, it is the opposite, higher the experience higher the risk of grounding.

12. Occasions of groundings



Occasions of groundings
Graph - 12

Highest number of groundings had taken place while the vessels were on their normal sea passages (enroute).

12.1 Reasons for groundings while manoeuvring without pilot

Among other ships, manoeuvring without pilot includes;

- 07 Ro-Ro passenger ships,
- 02 passenger ships and
- 02 passenger ships engaged in expeditions.

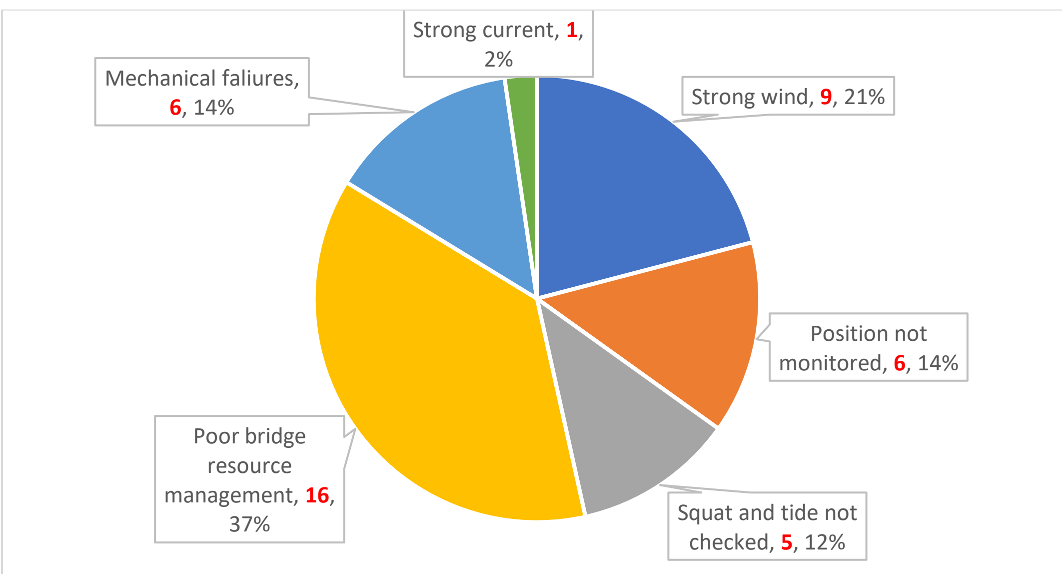
Usually, special training on ship manoeuvring, berthing and unberthing is provided by the ship owners and managers to the masters on passenger ships and Ro-Ro passenger ships. At the same time, the masters on these types of ships have pilot exemption certificates as well, so that they themselves can berth and unberth the vessels without taking pilots. That means out of the 30 accidents took place while manoeuvring without a pilot, the master may have received extra training than required by the STCW Code in the 11 cases above. That is the reason to specially highlight the above three categories of ships.

Groundings that took place while manoeuvring without a pilot also include three groundings that took place while trying to leave the berth during strong winds in order to go to sea for safety. These three groundings could have been avoided if the master could take the decision to go to sea well early.

Most of the groundings had taken place due to combined effects of multiple reasons. The common reasons were:

- Strong winds and current
- Position not monitored (with paper charts or ECDIS)
- Squat and tides not considered
- Poor bridge resource management
- Mechanical failures

The following graph illustrates the number of above mentioned combined multiple reasons for ship groundings occurred without pilots.

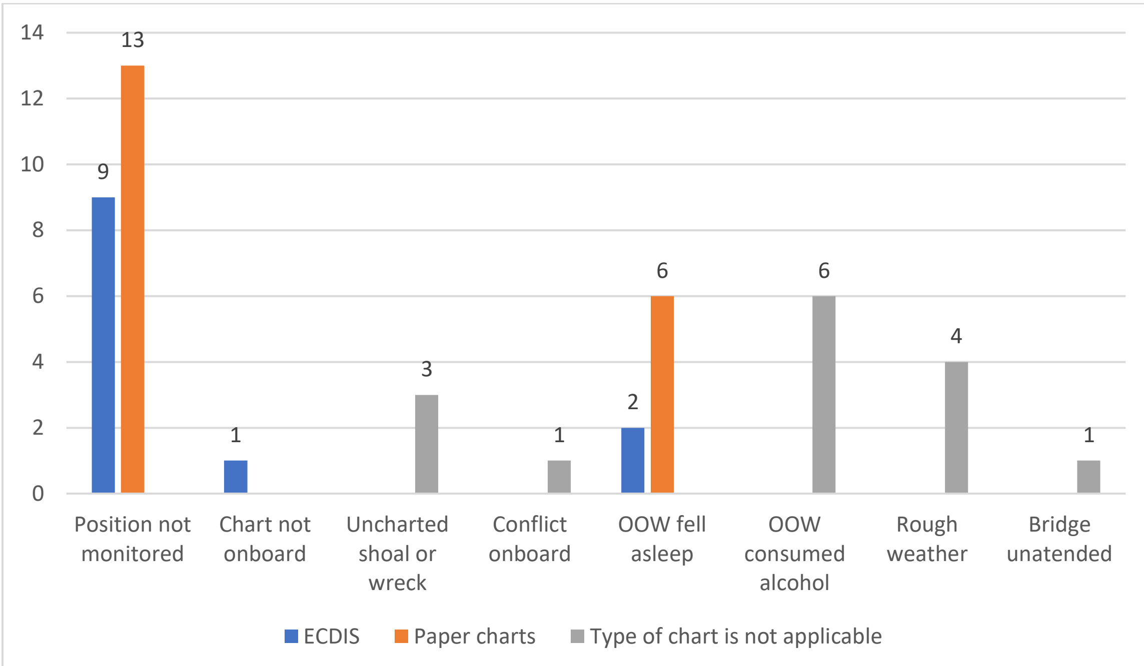


Combined reasons of ship grounding while manoeuvring without pilot onboard

Graph – 13

It is not required to mention that poor bridge resource management (BRM) had a part to play (primary or secondary) in most of the groundings while manoeuvring without a pilot.

12.2 Reasons for groundings while enroute



Reasons for groundings while enroute
Graph – 14

In the above graph, among other things, 'Position not monitored' include:

- 08 occasions where the passage was initially made over charted shallows. Out of these 08 incidents, 04 passages were planned with ECDIS and 04 with paper charts.
- 02 occasions where the OOW was using mobile phone
- 05 occasions where the OOW may have affected by the effects of fatigue

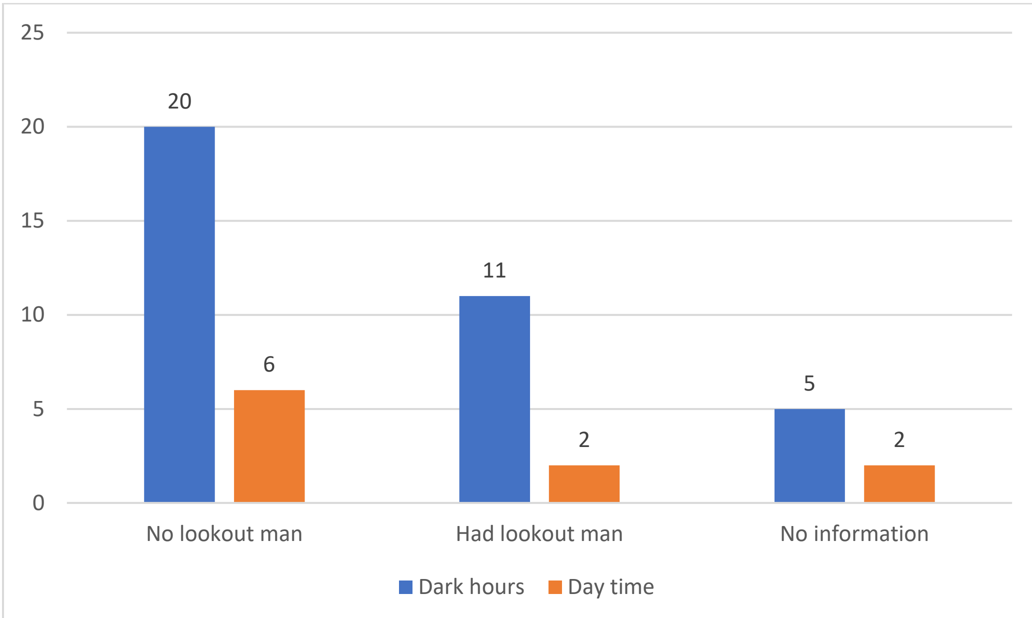
'Uncharted shoal or wreck' include 02 groundings over uncharted shoals and 01 incident hitting against a sunken wreck. No Notices to Mariners (NM) were issued with regards to the sunken wreck, but it was lighted with a buoy and warnings were sent by coast guard over the VHF.

'OOW fell asleep' includes 06 occasions where the OOW may had affected by the effects of fatigue due to noncompliance with work and rest hour requirements.

'Rough weather' includes 01 occasion where the Master was affected by the effects of fatigue during rough weather conditions.

12.2.1 Use of a lookout man while enroute

Sometimes groundings can be avoided by having a lookout man in addition to the navigating officer. Following graph shows how the additional lookouts were maintained while the vessels were enroute.



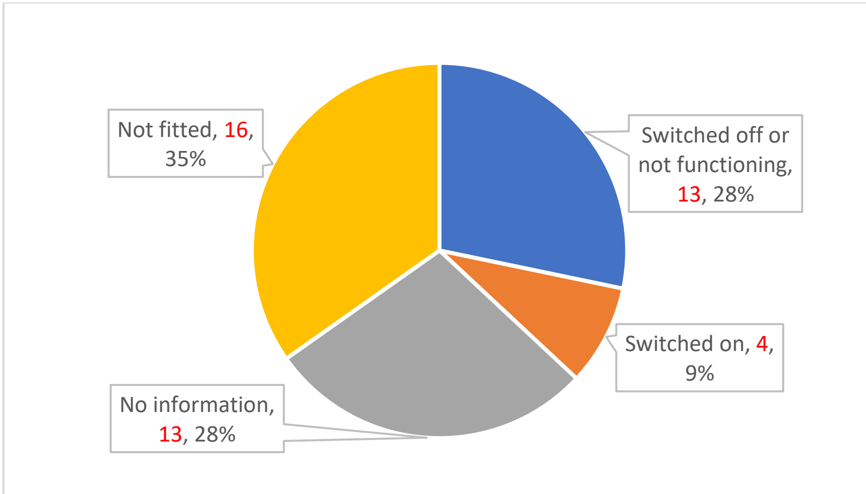
Lookout while enroute

Graph – 15

In total there were 26 groundings occurred without a dedicated lookout man, out of which 20 accidents had occurred during hours of darkness. Out of this 20, at least 17 accidents could have been avoided if a lookout man was available on the bridge.

12.2.2 Use of Bridge Navigational Watch Alarm System (BNWAS) while enroute

The purpose of a bridge navigational watch alarm system (BNWAS) is to monitor bridge activity and detect operator disability which could lead to marine accidents. The system monitors the awareness of the Officer of the Watch (OOW) and automatically alerts the Master or another qualified OOW if for any reason the OOW becomes incapable of performing the OOW's duties [12]. The bridge navigational watch alarm system shall be in operation whenever the ship is underway at sea [13]. But still master may switch off the BNWAS when the master and/or pilot is on the bridge while manoeuvring, as the BNWAS may disrupt the concentration on safe navigation. Without doubt, this shall be in operation while enroute.



Use of BNWAS while enroute

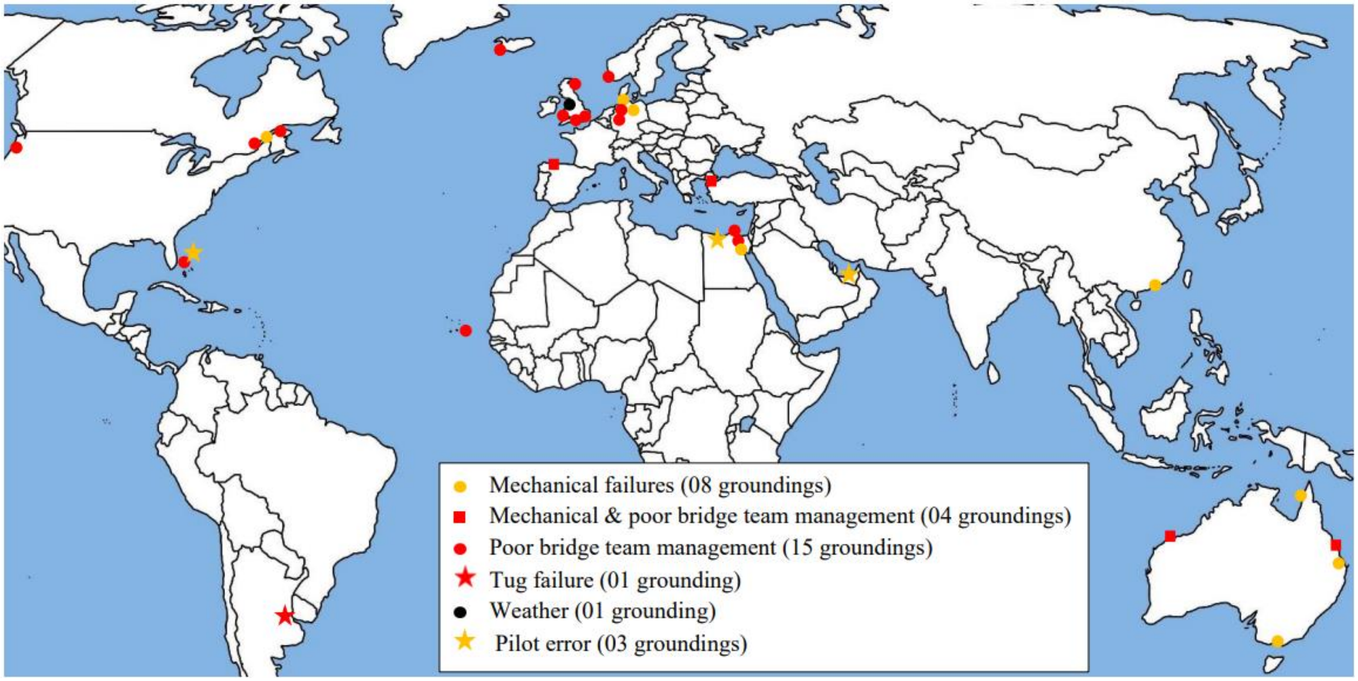
Graph - 16

In the above graph, not fitted means it was not compulsory to carry a BNWAS onboard at the time of grounding.

In considerable number of occasions, the BNWAS was switched off or not functional. All the above 13 groundings which occurred while the BNWAS was 'switched off or not functional' could have been avoided if it was in operational mode.

12.3 Reasons for groundings with pilot/s onboard

During the period considered, there were 32 groundings with pilot/s onboard. The causes and the geographical locations of the groundings were as follows;



Places of groundings with pilot onboard

Map – 1

In total there were 12 groundings due to mechanical failures of the vessels while the pilot was onboard. The types of the mechanical failures were as follows:

Steering failures	- 06
Total power failures	- 02
Main engine failures	- 03
Rudder angle indicator failure	- 01

Same as grounding while manoeuvring without a pilot, one of the main causes for grounding with pilot is also poor BRM practices onboard. In total there are 19 groundings that took place which involved poor BRM practices.

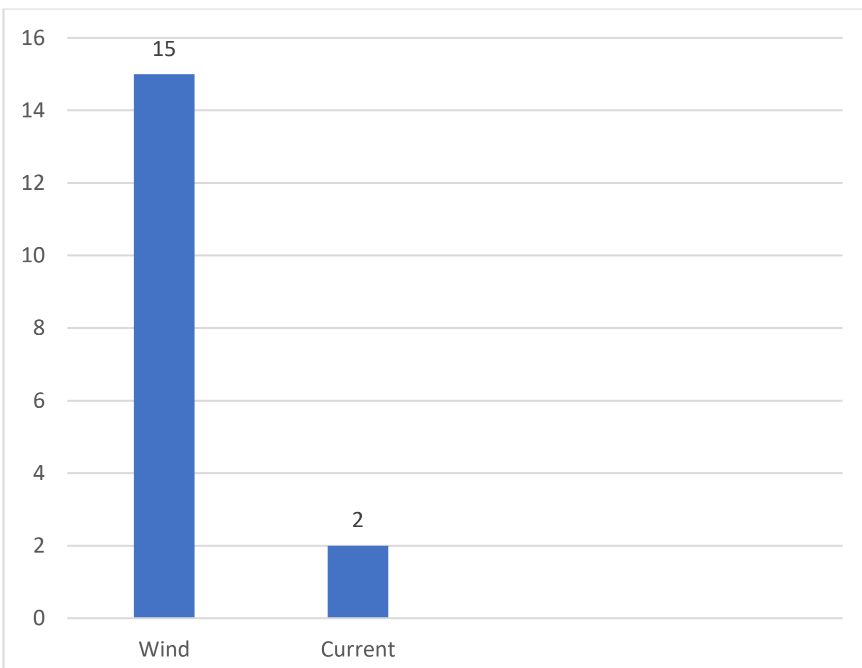
12.4 Groundings after dragging anchors

A ship may drag her anchor because of wind or current or both. To avoid dragging, masters need to comply with good anchoring practices, which includes selecting a good holding ground in a sheltered area and paying out sufficient cable length. Mostly, the number of cables to let go for anchoring is decided by seafarers. But, in certain situations this will be beyond the control of the seafarers when there is no sufficient sea room available to pay out long cable lengths. At the same time, sometimes the selection of good holding grounds also will be beyond the control of seafarers if a good holding ground in a sheltered area is not available and still, ships are required to anchor in whatever the available areas. Therefore, vessels may drag anchors if anchored in unsheltered areas and without sufficient cable lengths.

Dragging anchor is not that uncommon at sea. Mostly what happens in case of dragging is, that, it will be identified from the very biggening and take necessary measures to re-anchor or stop further dragging or go back to sea for drifting. Therefore, it is a good seamanship practice to maintain an effective anchor watch to monitor the position of the vessel. STCW Code states that an appropriate and effective watch or watches are required to be maintained for the purpose of safety at all times, while the ship is at anchor or moored [14]. During the period considered there were 17 groundings that took place after dragging anchors.

12.4.1 Main causes for the anchors to drag

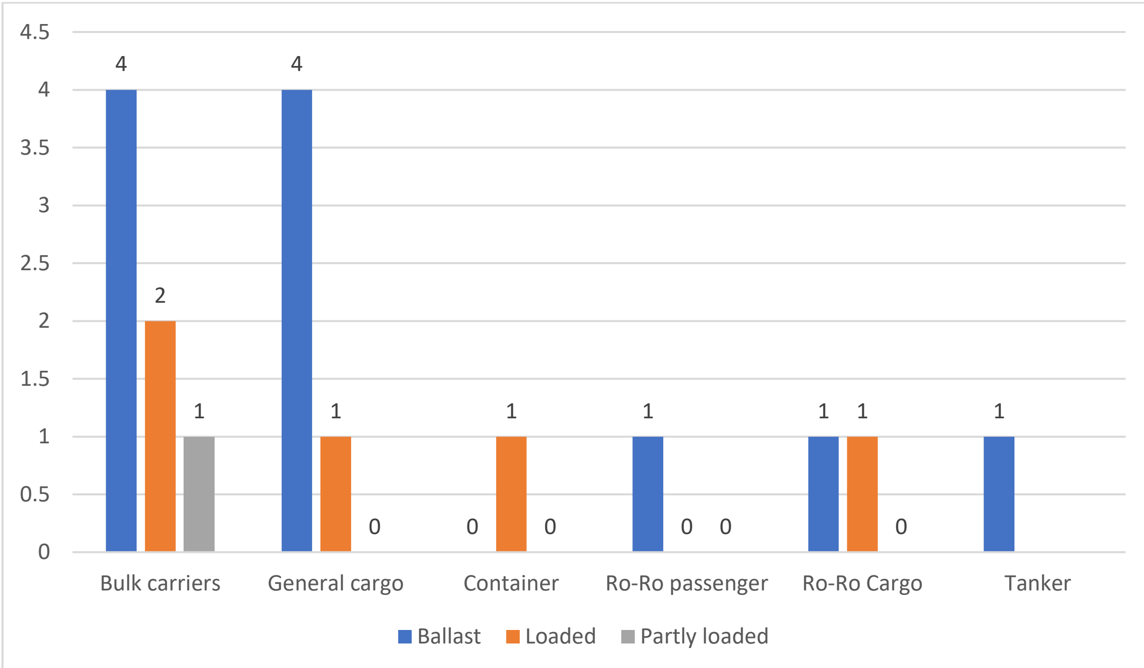
Out of the said 17 groundings, 15 were caused due to severe wind conditions.



Main causes for the anchors to drag

Graph – 17

12.4.2 Types of ships dragged anchors before grounding



Types of ships dragged anchor before grounding and their loaded condition

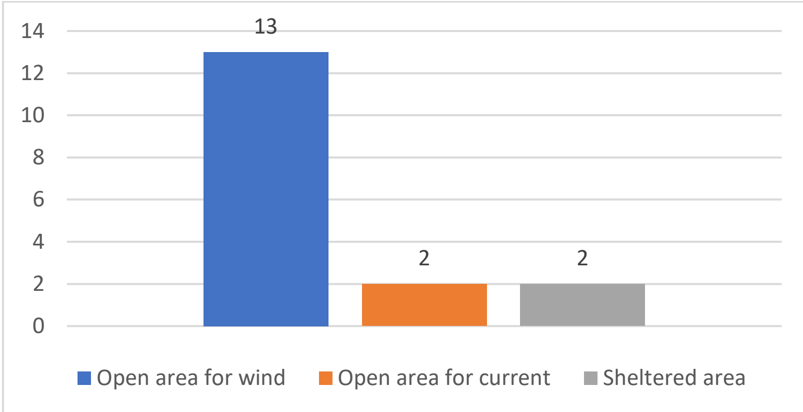
Graph – 18

Out of the above 17 strandings, two general cargo ships and two bulk carriers ran aground during repositioning the vessel after dragging or suspected dragging of anchors.

There may be a considerable draft difference on bulk carriers and on general cargo ships during loaded and ballast conditions depending upon the size of the ship. This will increase the windage area of the vessel when in ballast. That may be the reason for the higher number of bulk carriers and general cargo ships to drag anchor when in ballast.

At the same time, it is interesting to note that even though the windage areas of tankers in ballast, container ships and Ro-Ro ships are high, the number of groundings after dragging anchors are less than the bulk carriers and general cargo ships in ballast. Most importantly, no tankers ran a ground after dragging while in the loaded condition.

12.4.3 Anchored area

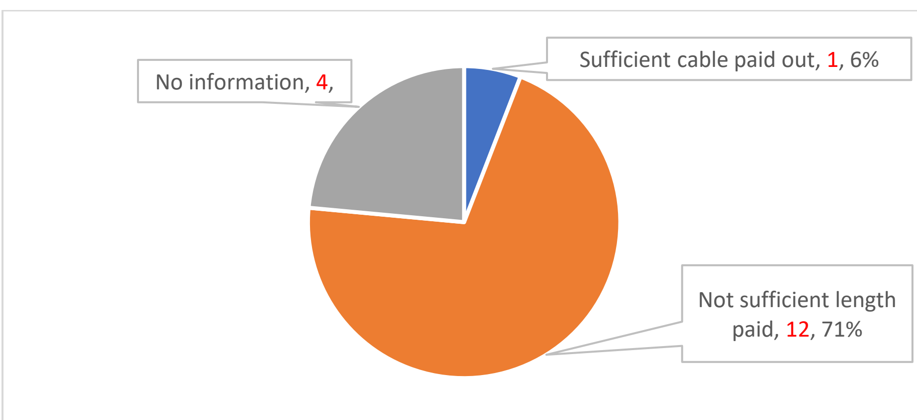


Anchored areas
Graph – 19

13 dragging had taken place while anchored in unsheltered areas for wind. Two vessels anchored in sheltered areas for wind ran aground while repositioning of the vessel due to suspected or actual dragging of anchor during strong winds.

12.4.4 Length of the anchor cable paid out

When a vessel is expecting strong winds or currents, more cable length shall be paid than in good weather conditions. In rough weather conditions, the cable length should be 4 times the water depth plus 150 metres [15]. Following graph illustrates the sufficiency of the cable lengths paid out by the vessels dragged anchors based on this statement of the Skuld P & I Club.

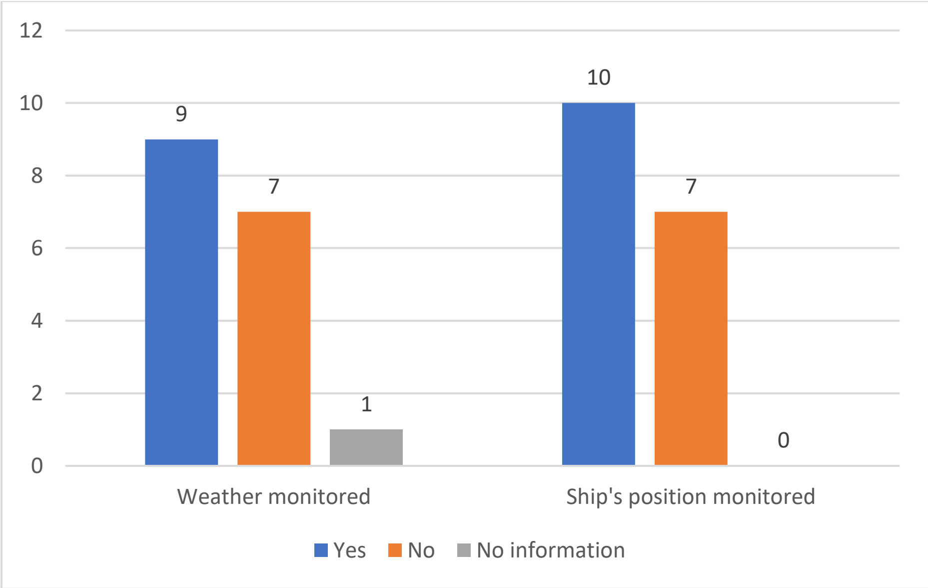


Cable length paid out
Graph – 20

Most of the vessels had run aground without having sufficient cable length paid out for the expected weather conditions.

12.4.5 Safe anchor watchkeeping

As mentioned above, dragging anchors are not uncommon, but the duty navigating officer must maintain a good watch in order to identify the dragging and take immediate actions to safeguard the vessel. At the same time, watchkeeping officers need to monitor and predict the weather conditions so that early actions can be taken before the weather conditions are deteriorated. Following table shows how many numbers of vessels had maintained and how many number of vessels had not maintained good watches during the vessels were at anchor.



Safe anchor watchkeeping

Graph – 21

In considerable number of occasions, the weather and the positions of the vessels were not monitored by the duty officers.

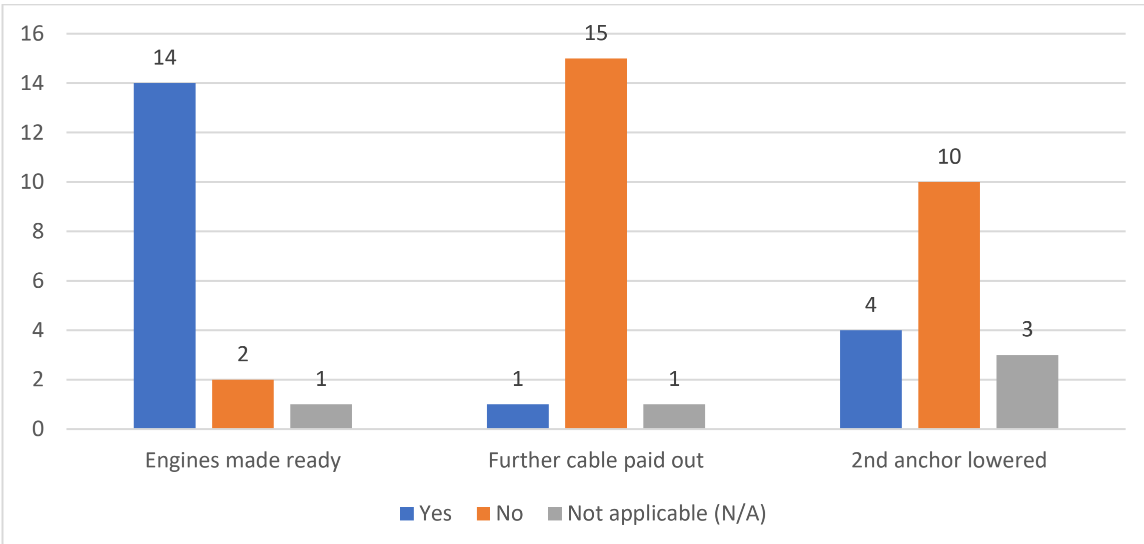
12.4.6 Emergency handling while dragging

Finally, if the dragging is unavoidable, still the groundings could have been avoided if the situation was handled effectively. In case of dragging an anchor, a professional mariner may;

a) use the engines to restrict the dragging while staying with the same anchor
b) lower further cable with the aid of engines

c) drop the 2nd anchor underfoot (dropping the other anchor to touch the sea bottom and apply the brakes)
d) heave up the cable and re-anchor with the aid of engines
e) consider of heaving up and heading to an open area for drifting

During these 17 anchors dragging situations, most of the occasions the engines were made ready in a timely manner but, in most of the cases the 2nd anchor was not tried out and had not considered to lower the same cable further to increase the cable length paid.



Emergency handling while dragging
Graph – 22

In the case of making engines ready, N/A includes one occasion where the engines were under repairs at the time of dragging.

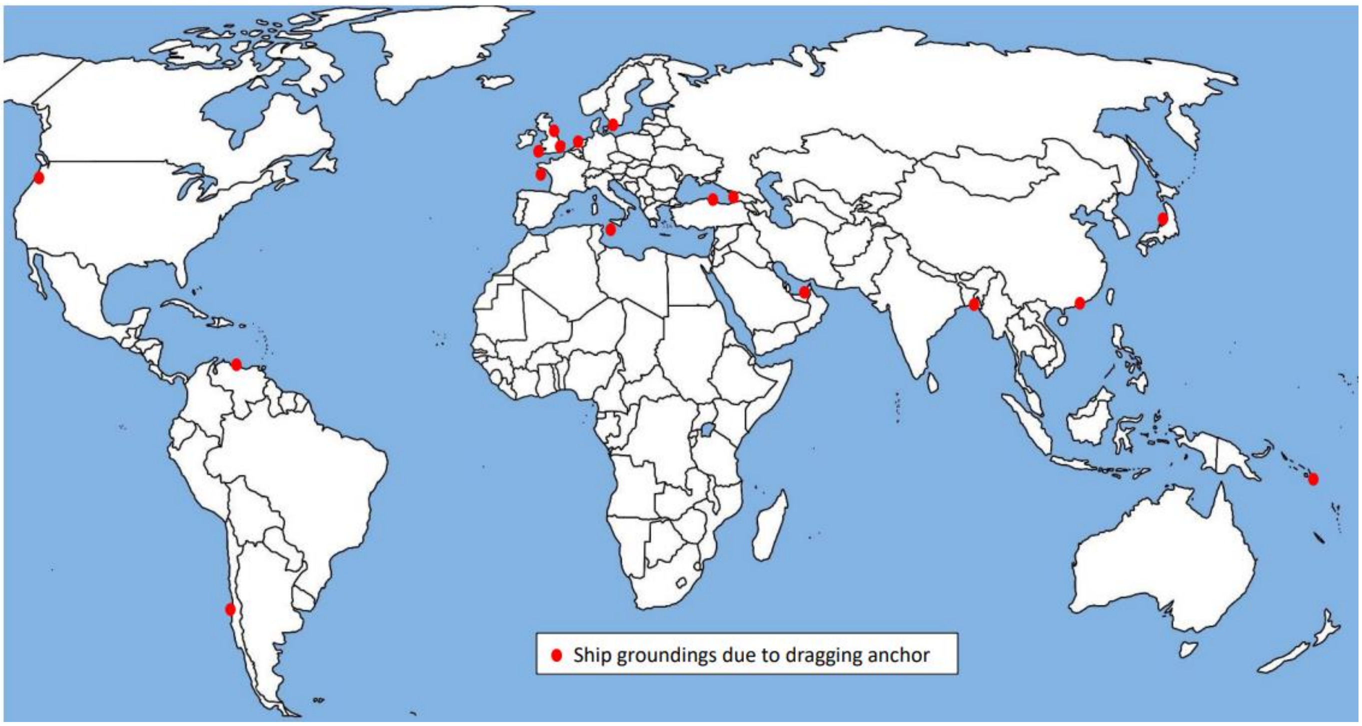
There were occasions where the engines made ready but malfunctioned before running aground. These are considered as "engines made ready" since the malfunctioning of the engine is beyond the control of the navigating officers.

With regards to paying out further cable, N/A includes one situation where the cable was parted while dragging the anchor.

In the case of lowering the 2nd anchor, N/A includes situations where the second anchor was not available, or the second anchor was out of order.

12.4.7 Geographical locations of groundings after dragging anchors

Comparatively a higher number of anchors dragging had taken place around Northwest European waters. That could be due to higher traffic density, frequent high winds and strong currents experienced by this region.

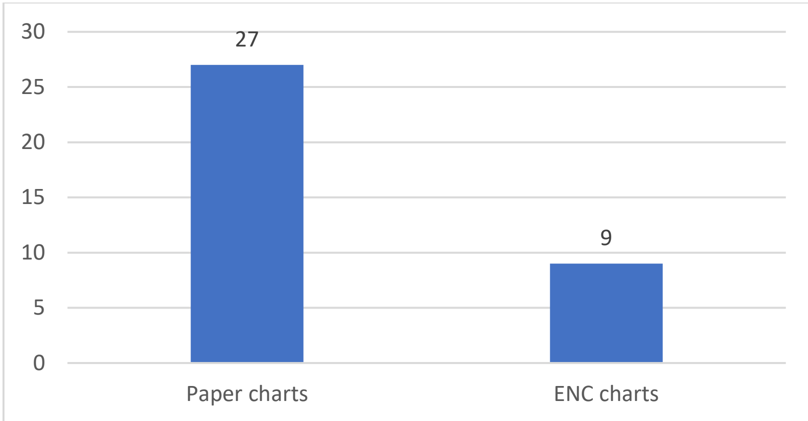


Locations of groundings after dragging anchors

Map – 2

13. Poor passage planning

Even though the errors that initiated during planning a passage can be identified and rectified during the passage with proper monitoring of a vessel's position and with good situational awareness, poor passage planning could be an initial invitation for a grounding. Out of the 125 groundings, 36 accidents had occurred with poor passage plans.



Poor passage planning
Graph – 23

Whether it was a primary contributory factor for the groundings or not, good seamanship practices and internationally recognized standard practices where not followed during passage planning process in the above 36 occasions.

While planning passages with paper charts, during four occasions the passage was made over charted shallows/islands. Other than that, the most common mistakes made on paper charts during planning include:

- No-go areas were not appropriate or not marked
- No parallel indexing
- No margins of safety or clearing lines
- Passages made close to shallows while having sufficient sea room around

While planning passages with ENC charts, there were 04 occasions where the passage was made over charted shallows and other most common mistakes include:

- Audible alarms disabled or set to zero level or not functional
- Wrong safety contour settings
- Route safety check not caried out
- Recommended routes were not used
- Route monitoring function was not activated

Apart from the most common errors mentioned above, there were other errors such as ENC auto load function disabled, look ahead function switched off, required ENC not ordered, warning messages repeatedly displayed were overlooked by navigating officers etc.

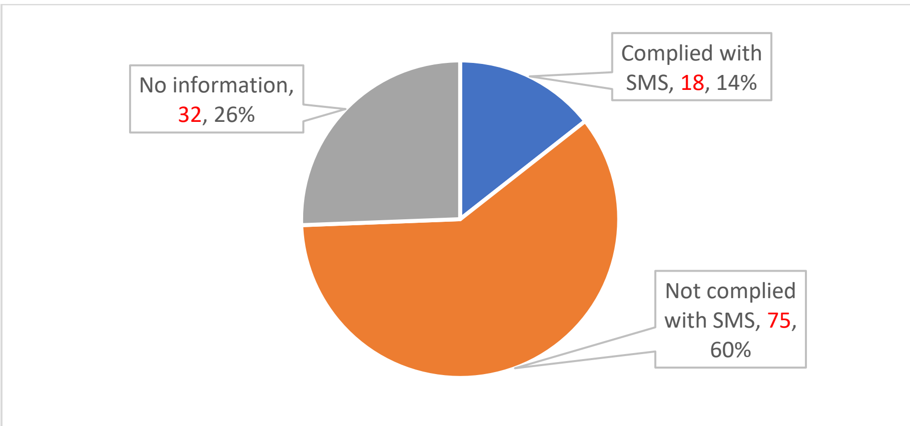
In the case of using both, paper charts and ENCs there were number of occasions where the master had not approved the planned passages before the commencement of the passage.

14. Compliance with ship's Safety Management System (SMS)

The ISM code became compulsory from 1st July 1998 for passenger ships, tankers, gas tankers, bulk carriers and cargo high speed craft of 500 GT and above. For other cargo ships and mobile offshore units of 500 GT and above, it became compulsory from 1st July 2002 [16].

The ISM Code requires every company to develop, implement and maintain a SMS with the aim of ensuring safety at sea, preventing human injury or loss of life, and avoiding damage to the environment, in particular to the marine environment, and to property [17].

SMS is a structured and documented system enabling the company personnel to effectively implement the company safety and environmental protection policy [17]. For every work onboard, safe procedures are provided in the ship's SMS, which is a ship specific document. Therefore, compliance with the ship's SMS is very important to avoid accidents onboard.

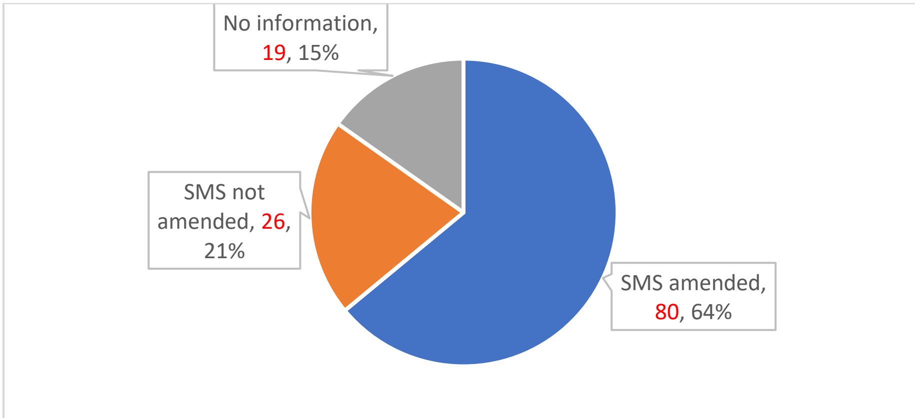


Compliance with ship's SMS
Graph – 24

Out of the total 125 accidents, whether it was a primary contributory factor for the grounding or not, ship's SMS was not complied in 60% of the occasions.

15. Amendments for the SMS after the accident

The SMS shall be a "Living" or a "Breathing" system which includes, but not limited to effective communication, motivation, proactive thinking, evaluation, continuous reviewing and amending when necessary. Companies must encourage their masters to review the SMS effectively and proactively [18]. This revive is carried out in order to enhance the efficiency of the ship's SMS. Because ship's SMS may require amending due to the dynamic nature of the ships and any initially unforeseen risks may be identified and precautionary measures can be taken proactively.

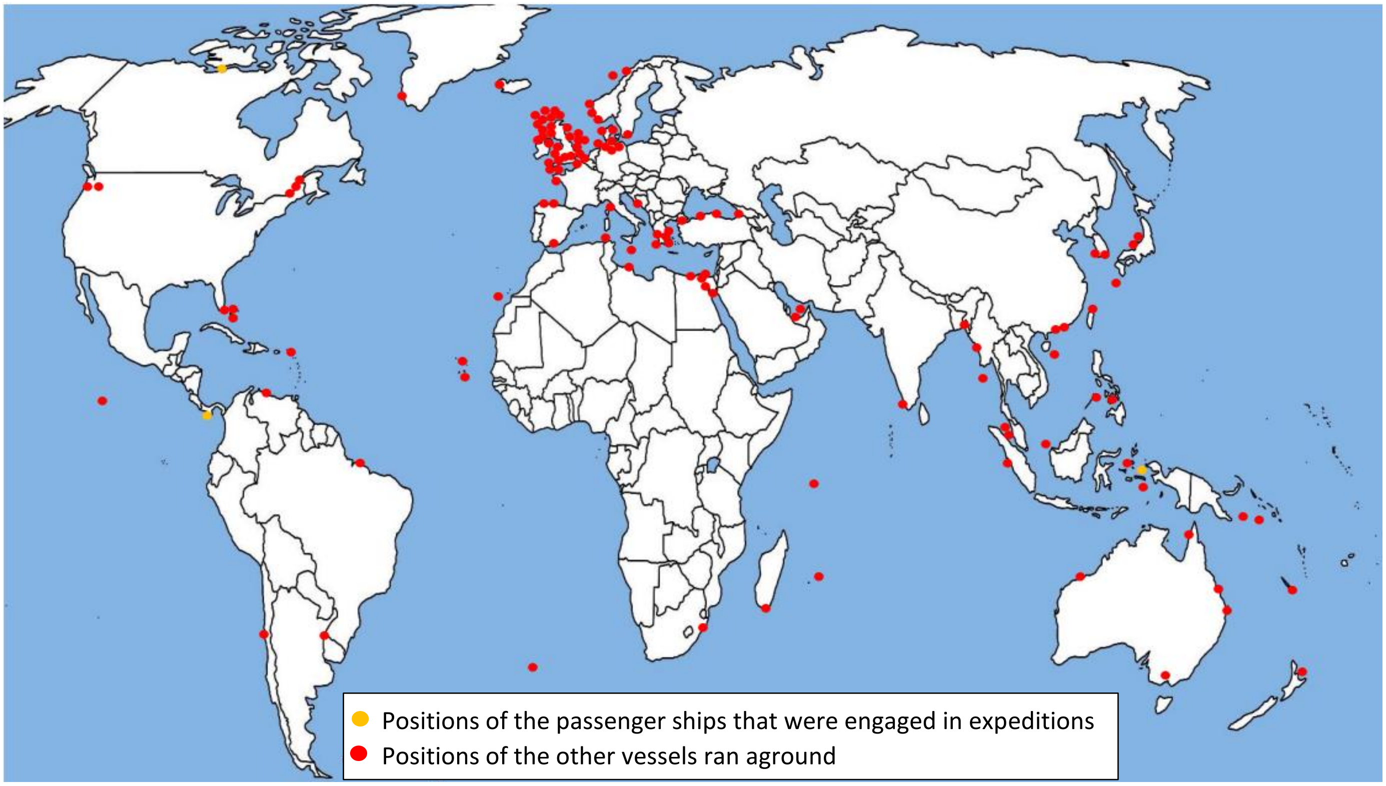


Amendments for the SMS after the accident
Graph – 25

Existing SMS was amended after the stranding in 64% of the accidents. Some of these groundings may have been avoided if the SMS was reviewed proactively before grounding. The existing SMS was amended in considerable number of ships after the accident means that there could have been a failure in the review process of the SMS.

16. Geographical locations of groundings

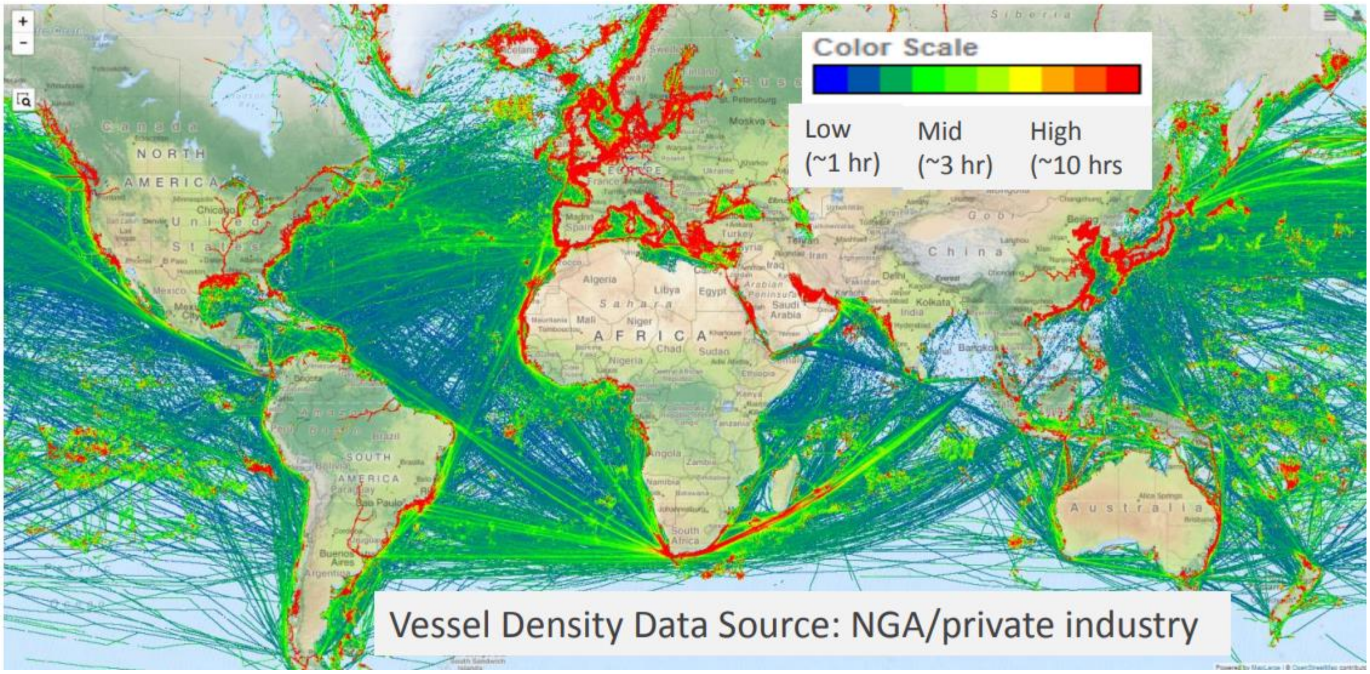
It is worthwhile looking at the geographical locations of ships grounded in order to identify whether there is a connection between frequency of groundings and the geographical locations.



Geographical positions of the ships grounded

Map - 3

Most of the groundings had taken place around the European region. In order to identify whether these groundings had taken place in remote locations or in busy traffic routes, need to compare the above Map – 3 with the shipping traffic density around the world. The following Map – 4 illustrates the shipping traffic density around the world.



Traffic density around the world (for October 2020) [19]

Map – 4

When comparing the above Map – 3 and Map – 4, most of the groundings were taken place in or closer to common shipping routes and in areas where the traffic densities are high. But only four vessels had grounded while taking actions to avoid collisions with other traffic. These also could have been avoided if the duty officer maintained a good situational awareness, that means checked the ship's position frequently and assessed the situation.

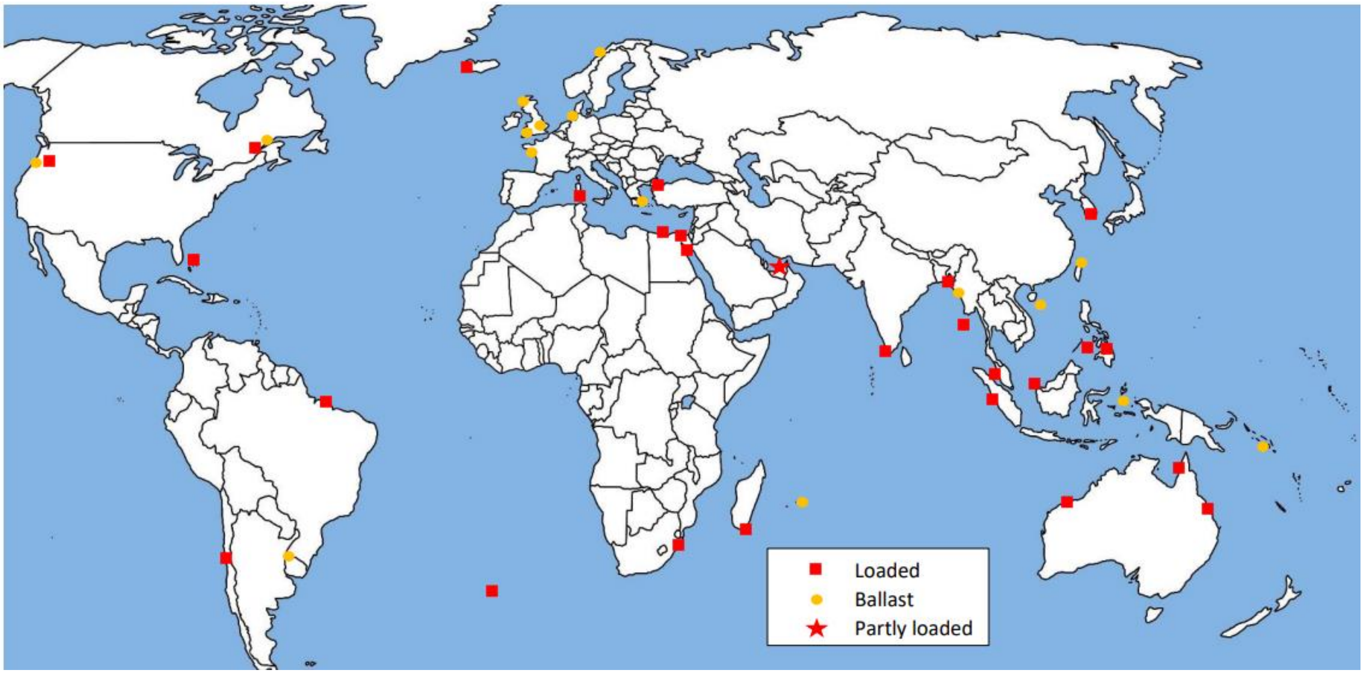
At the same time, it is interesting to note that the total number of groundings around European waters are comparatively higher than other high traffic density areas such as East Asia, Gulf of Mexico, Singapore strait etc. this is also confirmed by Gard P & I (Protection & Indemnity) Club. They say that Singapore Strait, Malacca Strait, Ningbo and Shanghai approaches facilitate the highest traffic flows in the world yet rank low for incident rates [20].

17. Grounding of bulk carriers

As the number of bulk carrier groundings are considerably higher than the other types of ships, it is important to study the groundings of the bulk alone, to identify the reasons and to identify measures to rectify.

Since the loaded draught of a bulk carrier differs considerably from the ship's ballast draught, groundings of the bulk carriers are categorised as loaded, partly loaded and ballast in the figure below:

- **Loaded** includes occasions where the vessel was fully loaded or loaded closer to the maximum carrying capacity
- **Partly loaded** means loaded closer to 50% of the vessel's carrying capacity and
- **Ballast** means draught is closer to the ballast draught.



Geographical locations of bulk carrier groundings

Map - 5

Out of the total 43 bulk carrier groundings;

- 26 accidents had taken place while the vessel was closer to fully loaded condition
- 16 accidents had taken place while the vessel was in ballast condition and
- 01 accident had taken place while the vessel was partly loaded

In accordance with the map above, bulk carrier groundings are scattered around the globe and mostly closer to common shipping routes with high density of traffic.

It is important to note that out of these 43 bulk carriers groundings;

- 19 groundings had taken place while manoeuvring the vessel for departing or arrival or anchoring when the vessel was closer to a port
- 06 grounding had taken place due to dragging anchor while in anchorages
- 01 incident had taken place while looking for an emergency anchoring for main engine repairs during the sea passage (not closer to a port)
- 15 groundings had taken place during the sea passage

- 02 accidents took place beyond the control of seafarers (one due to a conflict onboard and one while experiencing rough weather while at anchor)

Out of the above 19 accidents occurred while manoeuvring, in 14 situations there were pilot/s onboard. That means, when considering total grounding with pilot/s onboard, 44% of them were bulk carriers.

In 25 situations (19 occasions while manoeuvring and 06 occasions while at anchorage) the vessels were closer to a port. Even though when considering all types of ships, most of the ship groundings had taken place while enroute, when considering bulk carriers alone, 58% (out of the total 43 bulk carrier groundings) of the bulk carrier groundings had taken place not while enroute but closer or within port limits/areas.

18. Discussion and suggestions

IMO made the carriage of Electronic Chart Display and Information System (ECDIS) mandatory from 1st July 2012 for certain types of new ships constructed after that date and adopted phasing-in the requirements for existing ships [13].

STCW'78 as amended 2010 require all the navigating officers to have at least type specific ECDIS training [22] if keeping navigational watches onboard ECDIS fitted ships from 1st of January 2017. Therefore, even if the generic training on ECDIS is done, still, flag States require the navigating officers to do type specific training on ECDIS if the vessel is fitted with a different type of ECDIS.

There is a gradual decline of number of groundings. This could be due to the combined effects of;

- ECDIS which gives an additional support, surveillance and reduction of workload onboard while planning passages and during navigation
- the compulsory training on the operation of ECDIS adopted by IMO
- safety precautions observed by flag States, ship owners, ship operators and seafarers and
- various safety measures adopted by port operators

But, when considering the trends globally, as the risks are still high, stakeholders need to observe further safety precautions to reduce number of ship groundings further.

It is important to note that even though most of the groundings had taken place in or close to heavy traffic areas, traffic was not a contributory factor in these ship groundings other than on four occasions, that also could have been avoided if the navigating officer maintained the positional awareness. But The Swedish Club [22] says that between 2013 and 2017 most groundings occurred due to, among other things, while taking evasive actions to avoid collisions. Therefore, need to conduct further research about this matter in order to come to a conclusion.

18.1 Human errors of seafarers

86.4% of the groundings had taken place due to human errors of seafarers. Seafarers had not complied with the ship's SMS in 60% of the groundings whether it was a primary contributory factor for the grounding or not. Similarly, ship's SMS was not complied in 67% of the cargo related accidents whether it was a primary contributory factor or not [18]. No need to discuss again the importance of compliance with the ship's SMS as it is well known within the industry. Groundings due to various causes can be eliminated by complying with the SMS (provided proper procedures are included in SMS), which include but not limited to:

- Poor passage planning
- Incorrect navigation watchkeeping practices
- Poor anchor watchkeeping practices and emergency handling while dragging anchors
- Heavy weather
- Fatigue etc.

But, still, in number of cases SMS was not complied with. IMO introduced the ISM Code with the aim of eliminating human error. But still the seafarers are not properly complying with the ISM Code. Because of that, still the accidents continue to occur due to human errors. Therefore, the advantages of adopting the ISM Code are lost as the accidents continue to happen due to human errors.

The existing SMS was amended in 64% of the accidents after the grounding. Similarly, in case of cargo related accidents also existing SMS was amended after the accident in 61% of the occasions [18]. The most probable cause could be that the shipowners and masters had not taken proactive measures in reviving the SMS periodically and implementing onboard prior to the accident. Since the prevention of SMS related accidents were discussed in detail and suggestions are made to improve the existing practices in the article on 'Prevention of occupational and other accidents during cargo related operations onboard' [18] the same suggestions are listed below in order to reduce human errors without further explanations;

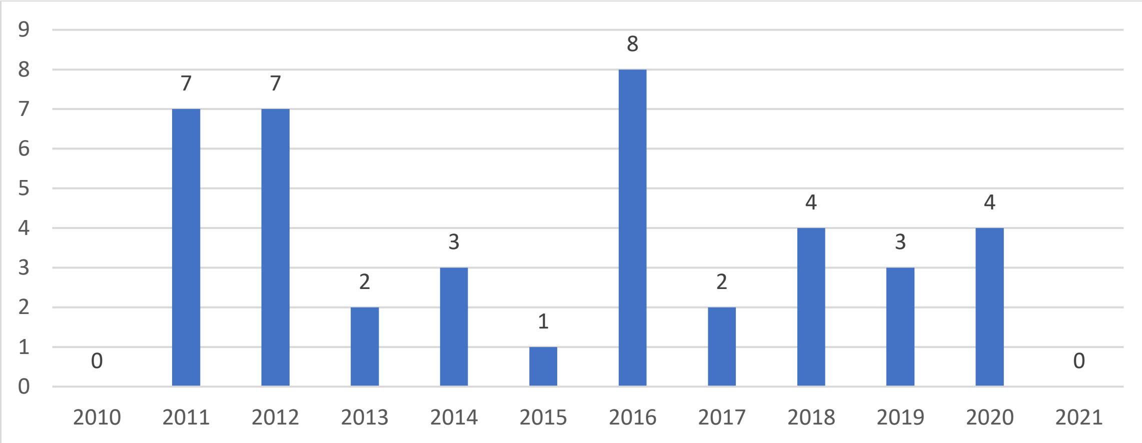
a) IMO should consider of making it compulsory to approve the SMS by a competent authority or recognized organization subjected to master's periodical reviews.
b) Companies must encourage their masters to review the SMS effectively and proactively.
c) Compulsory SMS reviews shall be carried out during the internal ISM audits onboard both by the master and the internal auditor.

d) Companies and the senior management onboard shall concentrate more on implementing the SMS onboard proactively and maintaining a safety culture always. This will eradicate the use of alcohol during watchkeeping hours and keeping watches after consuming alcohol, which is already restricted through the STCW Code, flag States and ship owners.
e) If the SMS is amended, companies must convey it to masters and deck officers (through emails) who are on leave, so that, they can be updated themselves about the changes before going onboard again.
f) Same as the near misses, IMO should consider of making it compulsory to report 'unsafe practices' to the company. The company shall analyse both near misses and unsafe practices effectively and proactively to identify the risks involved. Analysing of near misses and unsafe practices shall be audited during the ISM audits of the company.
g) Port states, flag states, ship owning companies should consider of having awareness programmes for seafarers to make them understand the risk involved in noncompliance with SMS, most suitably with the aid of case studies.

18.1.1 Poor bridge resource management (BRM) practices

Even though IMO had issued recommendations on BRM through STCW'78 as amended in 1995 [23], training on BRM for operational level officers (Table A-II/1 of the STCW Code) became compulsory through the Manila amendments to the STCW Convention in 2010 which came into force from 1st January 2017.This is a positive measure taken by IMO to ensure the junior officers are given proper training on bridge resource management.

At the same time, along with the Manila amendments, IMO introduced resource management for chief officers and masters through the Table A-II/2 of the STCW Code which again came into force in 1st January 2017. Therefore, junior officers and senior officers may have received training on bridge resource management only after 1st January 2017. During the period considered, malpractices in managing bridge resources had taken place annually as below;



Grounding due to poor BRM
Graph – 26

By referring to the above graph it is little difficult to identify whether there is an impact by the resource management training introduced by the Manila amendments. Probably it is too early to make an assessment.

It is also important to note that only 41 malpractices in BRM had taken place which caused groundings, but no collisions and contacts are considered in this research. Number of accidents due to direct or indirect contribution of poor BRM would be much higher if other types of accidents are also considered. Therefore, stake holders should take immediate actions to improve BRM practices of the seafarers and pilots further.

18.1.2 Availability of a lookout man during hours of dark and use of BNWAS

Out of the 26 groundings incurred without a dedicated lookout man, 20 accidents had occurred during dark hours.

The STCW Code states that the officer in charge of the navigational watch may be the sole lookout in daylight and that is also after considering several factors which might hamper the safe navigation. This means, a lookout man is required during the night watches.

On some occasions when the deck work is piling up, the masters may prefer to assign the night lookout man for day work specially on ships with smaller number of crews. But this is contradictory to the requirements of the STCW Code.

IMO introduced Bridge Navigational Watch Alarm System (BNWAS) to reduce marine accidents due to incapacitation of the officer of the watch. The BNWAS will monitor the bridge activity and detect operator disability which could lead to marine accidents. The system monitors the awareness of the Officer of the Watch (OOW) and automatically alerts the Master or another qualified OOW if for any reason the OOW becomes incapable of performing the OOW's duties [12]. By 1st January 2018 all the ships of 150 GT and upwards are required to be fitted with a BNWAS [13] & [24].

13 groundings had occurred when the BNWAS was switched off or not functional. Which means the last option available to keep the OOW awake was also lost. Probably, at least if the BNWAS was kept in working condition and switched on, these 13 accidents could have been avoided even though a dedicated lookout man was not available. Having said that, the carriage requirement of BNWAS does not replace the requirement to have a dedicated lookout man during hours of darkness. Therefore, whether a BNWAS is used, need to have a dedicated lookout man during hours of darkness.

The ship owning and management companies and the ship masters are required to strictly comply with the requirements regarding the use of BNWAS and assigning of dedicated lookout men during hours of darkness. If assigning a lookout man during hours of darkness is not possible due to important deck work, ship masters must be encouraged to inform the company so that additional person/s may be employed onboard for a particular period until the important deck work is completed.

18.2 Fatigue, complacency and situational awareness

Apparently, there were only 20 groundings that had taken place possibly due to fatigue caused by noncompliance with work and rest hours. In accordance with the MSC.1/Circ. 1598 of IMO, fatigue may occur due to various reasons, such as;

- Lack of sleep and rest due to noncompliance with work and rest hours, sleep disorders and quality of sleep
- Work routines does not balance with body clock/Circadian rhythms
- Psychological and emotional factors which include monotony and boredom
- Poor health and wellbeing due to illnesses or lack of food with nutritional value or lack of exercises
- Stress due to personal issues or interpersonal relationships onboard
- Medication and substance use such as alcohol or medicines or caffeine
- Age of the seafarer
- Shift work and work schedules onboard
- Workload
- Jet lag
- Ship design
- Environmental factors etc.

Out of the above causes, fatigue caused only due to few reasons may be identified during an accident investigation. These may include;

- Lack of sleep and rest due to noncompliance with work and rest hours
- Jet lag
- Ship design
- Environmental factors etc.

Fatigue caused due to most of the other reasons may not be able to identify during an accident investigation. In accordance with the IMO guidelines on fatigue, a fatigued person may be identified as they show certain signs of fatigue. But, to identify this, the accident investigation must be conducted just after the accident. As it may take couple of days or couple weeks for the accident investigators to board a vessel and conduct an investigation, fatigue caused only due to limited reasons may be identified by referring to records available onboard and other staff onboard. Therefore, at present there are no mechanisms to verify whether an accident had occurred due to fatigue caused by other reasons than noncompliance with work and rest hours, jet lag, ship design etc. Industry needs to develop mechanisms to identify fatigue that are caused due to other causes during an accident investigation and the same shall be effectively practiced onboard ships while handing over watches.

Training on seafarer fatigue is included in Table A-VI/1-4 of the STCW Code for certification in personal safety and social responsibilities. This can be considered sufficient for the support level staff. Table A-II/1 and Table A-II/2 of the STCW Code requires the operational level and the management level staff onboard to be competent in leadership as below;

- Operational level officers - *Application of leadership and teamworking skills*
- Management level officers - *Use of leadership and managerial skill*

In accordance with the two Tables, while obtaining the above competencies, both must have knowledge, understanding and proficiency (KUP) in;
'A knowledge of related international maritime conventions and recommendations, and national legislation'.

As the 'Guidelines on fatigue' issued through MSC.1/Circ.1598 by IMO, can be included in the above KUP, training for junior officers and senior officers onboard on fatigue can be considered sufficient.

But when considering the below facts;

- 32% of the groundings had taken place due to lack of positional awareness (Chapter – 6)
- In 47% of the groundings there were three bridge watch keeping officers and a master onboard the vessel (Graph – 5)

- 69% of the groundings had taken place while an experienced officer was on duty (Graph– 9)
- In 37% of the groundings the duty officer or the master had visited the grounded area in previous voyages (Graph – 11)
- 37% of the groundings had taken place while enroute (Graph – 12)
- Out of the 20 groundings took place during dark hours without a lookout man, at least 17 accidents could have been avoided if a lookout man was available on the bridge (Graph – 15)

Can be assumed that there is a probability that most of these accidents may have a connection with complacency or fatigue caused by monotony/boredom.

Complacency in itself is a deceiving and unwarranted satisfaction with a given level of proficiency, which leads to stagnation and unknowing deterioration of proficiency [25] and complacency has been recognised as a cause of maritime accidents [26]. One may encounter complacency when engage in routine work and also when becoming experienced specially when the same work is done without any incident. Therefore, there is a possibility of experiencing complacency on board vessels engaged in trading around the same area and with the same crew in rotation who are well experienced.

In accordance with the Maritime Coastguard Agency (MCA), UK [27] there are many possible reasons for complacency, but common reasons are:-

- the same work has been repeated satisfactorily many times in the past without any incidents
- the operator has insufficient experience or knowledge to recognise when a situation has changed
- poor briefing before taking up duty
- forgetting something
- inadequate monitoring/checking of the situation
- poor teamwork, alerting, communications
- fatigue

Same as fatigue, the feeling of complacency may also lead to disastrous situations. Therefore, navigators need to know the signs of complacent persons in order to take proactive measures to ensure the safety. In accordance with the National safety council of USA [28] signs of complacency includes;

- Dissatisfaction with your work and/or lack of motivation
- Missing steps in work processes
- Frequent near-misses or incidents
- Changes in attitude

- Noticeable increase or decrease in communication
- Tardiness for meetings or shifts

Companies and senior management onboard shall take appropriate actions to eliminate complacency from ships. In order to eliminate complacency, MCA, UK [27] recommends the following;

- update situational awareness regularly
- get regular input from the team
- give/receive an effective briefing at handover
- actively look for problems
- use checklists effectively
- get help if don't understand a situation
- always follow company procedures
- never assume everything is working fine
- never expect something to be alright just because it always has been in the past

No documents could be found on mitigation of complacency issued by IMO even though complacency is a topic that is widely discussed in the maritime industry. 'IMO model courses' that are used for seafarer training address complacency, but these 'Model courses' are not compulsorily used in maritime training programmes. Therefore, IMO should consider of developing guidelines on elimination of complacency as well. In the meantime, ship operators shall consider of adhering to the recommendations made by MCA, UK.

It is the natural tendency of the human brain to become excessively alert after an incident or accident, brood over it for passage of time and during the period of normalcy the level of alertness erodes as the work becomes more of routine thus setting the conditions for the next cycle of complacency trend [29]. Therefore, single training on complacency and fatigue may not be sufficient. IMO should consider of making it compulsory to discuss topics on complacency and fatigue during training sessions onboard. Use of resent case studies will make it more fruitful in such training sessions.

To mitigate complacency and fatigue due to monotony/boredom apart from the guidance provided by IMO and the MCA, the shipowners and operators should consider of;

- rotating the officers and masters within other ships in the company if possible. Now it is a common practice with most of the ship owners to keep senior officers specially the masters with the same ship assuming that it will be safer as he knows everything on the ship. This may not be applicable for Ro-Ro passenger ships and other passenger ships touching the same ports routinely. Probably, may require further research on this.
- conducting motivational programmes over zoom or Microsoft Teams or any other video conferencing facility as sending instructors/trainers onboard is very costly.

- having social events between the ships in the fleet. Such as games, quiz competitions over video conferencing facilities.
- selecting compatible nationalities who can socialize with each other and live onboard.
- having frequent training sessions and discussions on identifying and prevention of fatigue and complacency during safety committee meetings.
- making the onboard training on complacency and fatigue compulsory.

Lack of situational awareness is one of the major causes of ship strandings. Therefore, industry need to address the means of gaining and maintaining situational awareness. MCA [27] states to consider the following in gaining and maintaining situational awareness;

- always look out for problems
- make sure procedures, risk assessments and checklists etc. are up to date
- plan effectively
- know what to do before you start a task
- ask for input from the team members
- advise and help the team
- communicate effectively
- value input from others
- address the problems noticed
- never assume all are working fine
- do not put someone in a situation beyond their capacity
- do not carry on regardless
- never assume someone else's intentions

Situational awareness is not discussed further as the same is addressed in detail in research on 'Prevention of Occupational and other Accidents During Cargo Related Operations Onboard' [18]. Stakeholders shall consider of conducting training and discussions on situational awareness also during onboard training along with complacency and fatigue as mentioned above.

18.3 Dragging of anchors

Ship's anchors are not designed for open water anchoring. The anchoring equipment is intended for temporary mooring of a ship within a harbour or sheltered area when the ship is awaiting berth, tide, etc [30]. Ship's anchors have limited holding powers, which means anchors are designed to hold up to a certain limited current and wind force only. Anchor will start dragging if the current or the wind exceed these limits. Below are some important points to note, in case of anchoring in a sheltered area based on DNV Class Rules and IACS Recommendations [31]:

- Tolerable maximum velocity of current is 2.5m/s (5 knots)
- Tolerable maximum velocity of wind is 25m/s (48 knots)

- Anchors will hold better with no waves
- Length of chain paid out at least with scope 6–10 and
- Good holding ground

However, many anchoring locations are outside sheltered waters, and an equivalent environmental envelope, including wave loads. In unsheltered areas the maximum limits that an anchor may hold are [31]:

- Current velocity: max. 1.5m/s (3 knots)
- Wind velocity: max. 11m/s (21 knots)
- Significant wave height: max. 2m

Therefore, masters need to take precautionary measures if a vessel is expecting winds higher than 48 knots in a sheltered area or expecting wind speed more than 21 knots in an unsheltered area. Likewise, if the predicted currents and wave heights are above the mentioned designed limits, they need to take precautions in advance.

Ship's masters and port operators shall be well aware of the above design limitations of anchors and anchor cables. Table A-II/2 of the STCW Code states that the mates and the masters on ships of 500 GT and above shall have KUP in;

- *choice of anchorage; anchoring with one or two anchors in limited anchorages and factors involved in determining the length of anchor cable to be used*
- *dragging anchor; clearing fouled anchors*

When referring to above, training on safe anchoring procedures for the ship masters and mates can be considered sufficiently addressed by the STCW Code. But, with regards to anchor losses, Gard P & I club [32] states that a growing number of anchors losses reported in recent years and officer's lack of awareness of the classification societies limitations imposed when the anchoring equipment was approved was a frequent cause. Therefore, IMO should consider of adding the 'design limitations of anchors, cables and windless' to the Table A - II/2 of the STCW Code as a KUP that the mates and masters shall gain. So that the masters can take preventive measures when expecting higher forces than the designed limitations.

At the same time, companies, ship operators and flag states shall consider of having awareness programmes to further educate the ship masters with regards to design limitations of anchors, cables and windlasses.

Port authorities shall consider of educating their Vessel Traffic Service (VTS) operators and others engage in monitoring vessels with regards to design limitations of anchors. Even though this is a ship specific factor, they may issue safety warnings to ships and may take other preventive measures if they have general idea about the design limitations of anchors.

Most of the masters are reluctant to drop the second anchor underfoot because of the fear that the anchor cable will be fouled. But marine accident investigators recommend [33] and ship operating companies suggest (through their SMS) to drop the second anchor underfoot to restrict dragging. At the same time, when the engines are ready, if further cable length is available and sufficient sea room is available, lowering further cable could be a good option to prevent dragging provided the designed limitations are not exceeded. Therefore, ship operating companies should encourage and educate their masters on the importance of using the second anchor underfoot or lowering further cable to restrict dragging the anchor.

18.3.1 Safe watchkeeping during an anchorage

Ship management and ship owning companies shall ensure that the safe watchkeeping procedures with regards to monitoring of ship's position, weather condition, engine readiness, maintaining of situational awareness, calling the master in advance is properly and adequately addressed in ship's SMS. Ship masters shall ensure that the safe anchor watchkeeping procedures provided in the SMS are effectively complied and proactive decisions are taken in changing circumstances.

18.4 Steering gear failures

Whether it was the primary cause for grounding or not, there were 18 groundings that took place after mechanical failures. Out of these 18 groundings, 06 accidents had occurred after steering gear failures. Only the preventive measures against grounding after steering gear failures are discussed as various options are available for the navigating officers to safeguard ships in case of steering failures rather than other types of machinery failures.

In accordance with the International Convention for the Safety of Life at Sea (SOLAS Convention) ships are required to be equipped with a main steering gear and an auxiliary steering gear and also it further states that an auxiliary steering gear is not required if the main steering gear comprises of two or more identical power while certain other additional requirements are complied with [35]. At the same time, in case of emergency, emergency steering can be done from the steering gear compartment. Apart from these requirements, there are various modes of steering such as follow-up mode and non-follow-up mode. Therefore, if one steering system or steering mode is not working, the duty officer can try the other steering system or steering mode. No need to switch to emergency steering from steering gear compartment if the other steering system or steering mode is working.

Deck officers and ratings may require some training on the use of all the steering systems and steering modes onboard a ship, without which may find difficulties in maintaining very accurate courses specially in confined waters. Therefore, ship operators and masters must ensure that all the navigating officers and deck ratings are familiar with these steering mechanisms available onboard.

SOLAS Convention states that apart from the routine tests and checks, emergency steering drills shall take place at least once every three months in order to practise emergency steering procedures [34]. Therefore, probably ship operators and masters may consider of providing training on steering with available steering systems and steering modes (which should include change over between modes and steering by these modes) along with the emergency steering drills.

18.5 Adequacy of existing training to avoid ship strandings

Following are the key factors to be considered in avoiding strandings:

- Plan safe passages clear of navigational hazards
- During the passage and at anchor monitor the position of the vessel frequently
- Assess the situation continuously and take early action/s

Planning a safe passage is the first element in avoiding grounding. Voyage planning or passage planning includes plotting ocean tracks on charts, taking into account;

- *Restricted areas*
- *Meteorological conditions*
- *Ice*
- *Restricted visibility*
- *Traffic separation schemes*
- *Vessel traffic service (VTS) areas*
- *Areas of extensive tidal effects* [38]

Planning a passage by considering above all is beyond the competency of junior navigating officers. But formerly it was a customary practice and now it is made mandatory by the companies through their SMS for the 2nd officer to plot ocean tracks on charts under the supervision of the master.

Even though a safe passage is planned well away from navigational dangers, duty officers may not be able to maintain the vessel on the planned track because of various reasons such as when taking actions to avoid collisions, due to current and wind. Therefore, while following the planned safe passage, duty officers need to frequently monitor the ship’s position.

Monitoring the position alone is not sufficient, need to have a continuous process of assessing the situation to detect early warnings and to take corrective measures appropriately.

Training requirements for the navigating officers and masters on ships of 500 gross tonnage or more are provided in the following Tables of the STCW Code:

- Table A-II/1 - Officers in charge of navigational watch
- Table A-II/2 - Masters & chief mates

Therefore, the provisions listed in the above two tables are required to be discussed to identify the adequacy of training with regards to the position fixing, assessing the situation, plotting ocean tracks on charts and passage planning.

Table A-II/3 (masters and officers on ships of less than 500 GT engage in near coastal voyages) of the STCW Code is not considered as there were no ships grounded of this category.

18.5.1 Adequacy of training on position fixing and assessing the situation

Column 2 of the Table A-II/1 of the STCW Code states that among other things, the officers shall have KUP in;

a) *Ability to use celestial bodies to determine the ship's position*
b) *Ability to determine the ship's position by use of:*
   .1 landmarks
   .2 aids to navigation, including lighthouses, beacons and buoys
   .3 dead reckoning, taking into account winds, tides, currents and estimated speed

c) *Ability to determine the ship's position by use of electronic navigational aids*

At the same time, in achieving the above KUP, Column 4 of the same Table states that when evaluating the competence, *the information obtained from nautical charts and publications is relevant, interpreted correctly and properly applied. All potential navigational hazards are accurately identified.*

Therefore, training requirements for officers on ships of 500 GT or more can be considered sufficient for position fixing and assessing the situation when considering the above requirements.

Column 2 of the Table A-II/2 of the STCW code states that the chief officers and masters shall have gained the following KUPs:
Position determination in all conditions:
.1 by celestial observations

.2 by terrestrial observations, including the ability to use appropriate charts, notices to mariners and other publications to assess the accuracy of the resulting position fix

.3 using modern electronic navigational aids, with specific knowledge of their operating principles, limitations, sources of error, detection of misrepresentation of information and methods of correction to obtain accurate position fixing

Therefore, training requirements for mates and masters on ships of 500 GT or more can be considered sufficient for position fixing and assessing the situation when considering the above requirements.

In the case of using ECDIS, the Column 2 of the above Table A-II/1 states that the officers in charge of a navigation watch on ships of 500 GT or more shall have KUP in;

a) *Proficiency in operation, interpretation, and analysis of information obtained from ECDIS, including*:

.1 use of functions that are integrated with other navigation systems in various installations, including proper functioning and adjustment to desired settings

.2 safe monitoring and adjustment of information, including own position, sea area display, mode and orientation, chart data displayed, route monitoring, user-created information layers, contacts (when interfaced with AIS and/or radar tracking) and radar overlay functions (when interfaced)

.3 confirmation of vessel position by alternative means

.4 efficient use of settings to ensure conformance to operational procedures, including alarm parameters for anti-grounding, proximity to contacts and special areas, completeness of chart data and chart update status, and backup arrangements

.5 adjustment of settings and values to suit the present conditions

.6 situational awareness while using ECDIS including safe water and proximity of hazards, set and drift, chart data and scale selection, suitability of route, contact detection and management, and integrity of sensors

With regards to ECDIS, column 4 of the above Table states that when evaluating the competence, candidates shall be able to *Monitor information on ECDIS in a manner that contributes to safe navigation*.

When considering all the above facts, position fixing and assessing the situation can be considered sufficiently addressed for officers, mates and masters on ships of 500 GT or more in the STCW Code for ECDIS users and paper chart users both.

18.5.2 Adequacy of training on plotting ocean tracks

18.5.2.1 Plotting ocean tracks on paper charts

Column 1 of the Table A-II/1 of the STCW Code requires the navigational officers to be competent in '*Plan and conduct a passage and determine position*'. But column 2 of the Table addresses KUP in position fixing, knowledge on use of charts, publications, operation of echosounders, magnetic compass, steering control systems etc. But, silent on plotting ocean tracks on charts.

Column 2 of the Table A-II/2 of the STCW Code states that mates and masters shall have KUP in;

a) *Voyage planning and navigation for all conditions by acceptable methods of plotting ocean tracks, taking into account*, e.g.:
   .1 restricted waters
   .2 meteorological conditions
   .3 ice
   .4 restricted visibility
   .5 traffic separation schemes
   .6 vessel traffic service (VTS) areas
   .7 areas of extensive tidal effects

To ensure the above KUP is gained, column 4 of the same Table above requires to adhere to the following criteria for evaluation of the competence;

- *The equipment, charts and nautical publications required for the voyage are enumerated and appropriate to the safe conduct of the voyage*
- *The reasons for the planned route are supported by facts and statistical data obtained from relevant sources and publications*
- *Positions, courses, distances and time calculations are correct within accepted accuracy standards for navigational equipment*
- *All potential navigational hazards are accurately identified*

Not only the competency on plotting ocean tracks on charts but competency in voyage planning is appropriately and sufficiently addressed in order to avoid groundings in the STCW Code with regards to masters and mates. But this is not sufficiently addressed in training the junior officers with regards to plotting ocean tracks.

As mentioned earlier, it is a customary practice for the 2nd officer to plot ocean tracks on charts and approve by the master and now most of the companies have made it compulsory through the SMS. Therefore, they shall be given a good KUP in plotting ocean tracks on charts at the

‘Operational Level’. Even though the IMO model course [39] addresses the passage planning for operational level officers and most of the Administrations engage in maritime training has already included plotting ocean tracks in their curriculums of navigating officer training programmes, the STCW Code is silent on this matter. Therefore, IMO should consider of including the following in the column 2 of the Table A-II/1 of the STCW Code under the competency of *Plan and conduct a passage and determine position*.

- Plotting ocean tracks in restricted areas by considering;
    - Distances to navigational dangers
    - Areas to be avoided
    - Margins of safety
    - Depth, squat and under keel clearance
- Plotting ocean tracks for restricted visibility with the aid of parallel indexing
- Plotting passages within traffic separation schemes (TSS)
- Plotting tracks within vessel traffic service (VTS) areas

18.5.2.2 Plotting ocean tracks with ECDIS

The principles applied in plotting ocean tracks are similar in case of paper charts and ECDIS, but the officers must be trained on the safe and correct method of operating ECDIS. Table A-II/1 of the STCW Code states that the navigating officers shall have KUP in:

a) *Knowledge of the capability and limitations of ECDIS operations, including:*
   .1 a thorough understanding of Electronic Navigational Chart (ENC) data, data accuracy, presentation rules, display options and other chart data formats
   .2 the dangers of over-reliance
   .3 familiarity with the functions of ECDIS required by performance standards in force

b) *Proficiency in operation, interpretation, and analysis of information obtained from ECDIS, including:*
   .1 use of functions that are integrated with other navigation systems in various installations, including proper functioning and adjustment to desired settings
   .2 safe monitoring and adjustment of information, including own position, sea area display, mode and orientation, chart data displayed, route monitoring, user-created information layers, contacts (when interfaced with AIS and/or radar tracking) and radar overlay functions (when interfaced)
   .3 confirmation of vessel position by alternative means
   .4 efficient use of settings to ensure conformance to operational procedures, including alarm parameters for anti-grounding, proximity to contacts and special areas, completeness of chart data and chart update status, and backup arrangements
   .5 adjustment of settings and values to suit the present conditions

.6 situational awareness while using ECDIS including safe water and proximity of hazards, set and drift, chart data and scale selection, suitability of route, contact detection and management, and integrity of sensors

Same as the paper charts, Table A-II/1 of the STCW Code is silent on plotting ocean tracks by means of ECDIS with regards to junior officers.

With regards to masters and mates, the STCW Code states that they shall have KUP in;

a) *Management of operational procedures, system files and data, including:*
   - *.1 manage procurement, licensing and updating of chart data and system software to conform to established procedures*
   - *.2 system and information updating, including the ability to update ECDIS system version in accordance with vendor's product development*
   - *.3 create and maintain system configuration and backup files*
   - *.4 create and maintain log files in accordance with established procedures*
   - *.5 create and maintain route plan files in accordance with established procedures*
   - *.6 use ECDIS log-book and track history functions for inspection of system functions, alarm settings and user responses*

b) *Use ECDIS playback functionality for passage review, route planning and review of system functions*

Route planning which includes plotting ocean tracks is addressed for mates and masters. It is not very clear the reason for not requiring the competency in plotting ocean tracks for junior officers by the STCW Code. Even in accident investigation reports considered in this research, the 2nd officer had planned the ocean passages on board ships with a master and three or more navigating officers.

But practically when it comes to ECDIS this is not a major issue as most of the ship owners require a training certificate covering both Tables (Table A-II/1 and Table A-II/2) for junior officers and senior officers both. Therefore, it can be concluded that the ship operators have successfully handled the problem.

Still IMO should consider of amending the Table A-II/1 of the STCW Code to include KUP in plotting ocean tracks in order to make sure that the necessary basic knowledge is passed to the junior officers.

18.6 Sharing of casualty investigation reports with seafarers

Marine accident investigations are conducted with the objective of preventing marine casualties and marine incidents in the future [40]. In order to proactively use them for the prevention of accidents in future, the accident investigation reports shall be circulated among the stakeholders of the industry which includes the staff onboard. Usually, companies circulate summaries of accident investigation reports among the ships within the fleet when an accident is occurred onboard one of their ships. Mostly this may be forgotten by the seafarers before that long as it is a summary.

Even though publishing an accident investigation report may take some time, seafarers can study the accident in detail if the whole accident investigation report can be circulated among them. In fact, IMO provides summary of incidents occurred as lessons learned [41]. But, on one hand, there are no legal obligations for the shipowners and managers to circulate these lessons learned with seafarers. On the other hand, it is a just a summary, where experienced seafarers who considers that "I know everything" and seafarers who are complacent may not refer these summary reports even they receive it onboard.

The use of case studies can be a very effective classroom technique. Case studies have long been used in business schools, law schools, medical schools and the social sciences, but they can be used in any discipline [42]. IMO's approach to share at least a summary of casualty investigation reports is admirable. But it will be easy to remember, seafarers will find it interesting to read and discuss with the colleagues onboard if the full report is available for them to read.

Photography is a universal tool to communicate [43] which means photographs are also important tools to learn. A casualty investigation reports contain photographs of the actual accident. This will attract the attention of the seafarers, feel the incident, remember the incident and finally take proactive measures to avoid future similar occurrences, at least for few months or few years.

With the vast number of various casualties occurring around the world, no seafarer will be able to read the full casualty investigation reports issued by all the flag states around the world because of their workload onboard. Therefore, companies shall at least consider of sharing the casualty investigation reports issued by the flag State among the ships registered under that flag. At the same time, companies shall make it compulsory to keep a printout of the full casualty investigation reports in a common place onboard for all the seafarers to read and it shall be discussed during the next available safety committee meeting. Finally, the companies shall consider circulating the electronic copies of the full casualty investigation reports with the navigating officers and masters on vacation.

18.7 Substandard ships

Ship groundings, collisions, occupational accidents cannot be avoided by the seafarers alone. They need a good proactive support from the ship owners and managers in order to enhance the safety onboard. These supports include but not limited to;

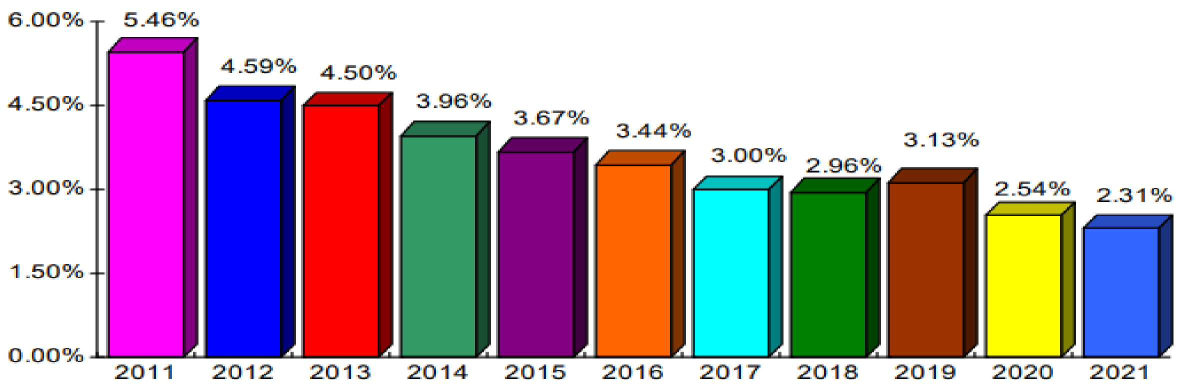
- Adopt and maintain SMS proactively
- Select competent staff for onboard duties and man the vessels sufficiently
- Comply with international regulations and standard practices
- Provide spare parts in time
- Maintain a good coordination with the ships
- Motivation of staff onboard
- Proactively identify and introduce new methodologies to eliminate accidents
- Training of onboard staff

All these comes at a cost to ship owners and management companies. That is why some shipowners are ill-treating their own ships. Number of such ill-treatments by some ship owners and managers were also identified during this research as well. This is one of the reasons for the substandard ships to exist.

A vessel may become substandard due to the actions of seafarers working onboard as well if the onboard staff is not competent or do not conduct their duties with a responsible and professional manner.

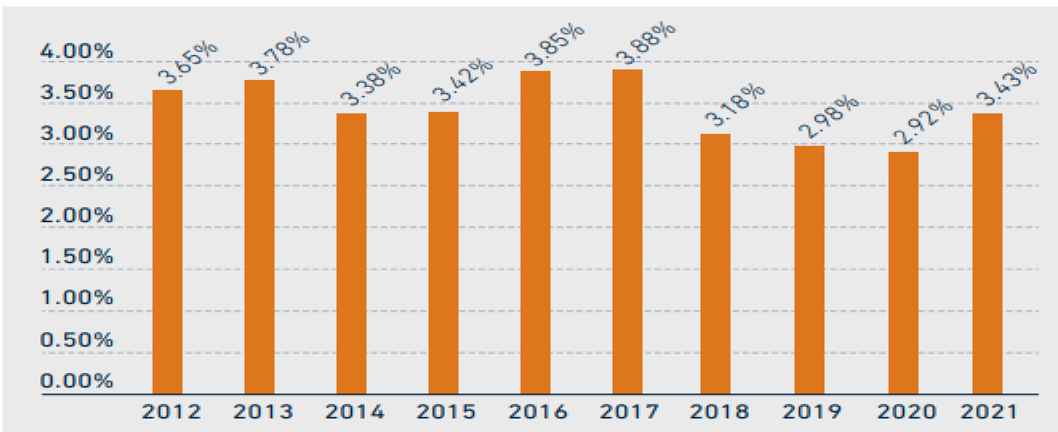
Port State Control (PSC) was introduced to eliminate substandard ships. PSC is the inspection of foreign ships in national ports to verify that the condition of the ship and its equipment comply with the requirements of international regulations and that the ship is manned and operated in compliance with the rules [44]. PSC may detain vessels if any major deficiencies are found which will immediately threaten the people onboard or the ship or the marine environment. If any non-major deficiencies are found, master need to rectify it within a given time frame.

Regional agreements on port State control, i.e., Memoranda of Understanding (MoU) were adopted between the countries within various regions of the world to establish effective port state control regimes and to harmonize their activities. Following two graphs are from annual reports for the year 2021 of Tokyo MoU and Paris MoU which shows the detention percentages calculated against the number of inspections conducted for the last few years.



Detention percentages by number of inspections Tokyo MoU (2021) [45]

*Graph – 27**



Detention percentages by number of inspections Paris MoU (2021) [46]

*Graph – 28**

*** Note** - The number of inspections conducted in year 2020 and 2021 were comparatively less than the number of inspections carried out in previous years due to the impacts of Covid – 19.

When considering the above two graphs, it looks like that there is a reduction in ship detentions. This is a good indication of improvement of the ship's standards.

Port State Control inspections have proven to be an effective tool for eliminating substandard vessels that may be in operation [47]. But, in some parts of the world, this is not happening in the same manner due to poverty and corruption. Port States with higher perceived corruption are less likely to detain vessels and more likely to have very serious incidents as the operating environment might facilitate substandard shipping and weaker enforcement of international conventions [48]. The stakeholders of the industry need to consider this matter seriously and identify solutions to control underperforming port states, because even though the PSC inspections have reduced the number of substandard ships, these ships may exist in certain parts of the world.

Flag States have a higher responsibility in making their vessels seaworthy. PSC inspections were introduced since this does not work properly. Of course, there are good flag States that look after their vessels. But again, the repercussions of poverty and corruption does exist. The flag States or ship owners located in countries associated with higher perceived corruption are more likely to have very serious incidents as the operating environment might facilitate substandard shipping and weaker enforcement of international conventions [48]. That could be the reason for some flag States are listed in the 'Blacklist' by the Tokyo and Paris MoU, which are considered as underperforming flag States. Flag States have more control over the ship owners who are ill-treating ships than the port states.

IMO Member State Audit Scheme (IMSAS) is conducted every seven years with the objective of determining to what extent Member States have implemented and enforced the applicable IMO instruments [49]. Flag States and Port States both are required to face this audit. Probably, rather than the port States that are corrupted, IMO may have a better control over the underperforming flag States. IMO can conduct additional IMSAS audits if a member flag State is blacklisted by a MoU. This may force the underperforming flag States to improve. IMO itself can maintain a blacklist of flag States and whatever the flags not improving after the 'additional IMSAS audits' can be included in the IMO blacklist. This may further force the underperforming flags to improve.

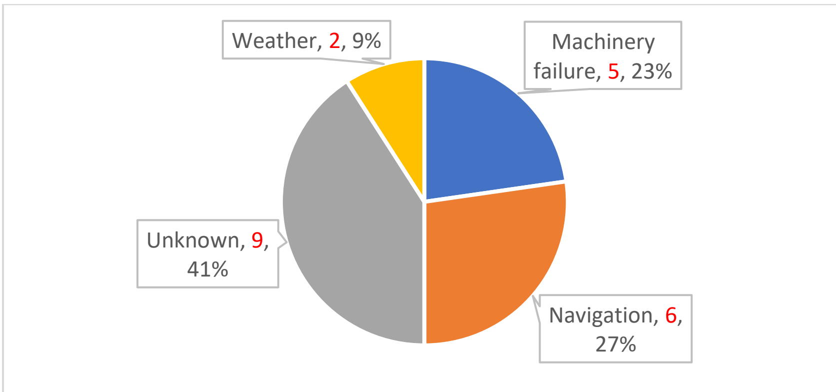
18.8 Use of mobile phones during watchkeeping hours

During the period considered there were only two groundings that had taken place while the duty officer was engaged in activities with mobile phones. But West of England P & I Club states that, there have been a number of navigational incidents, mostly groundings, which have occurred due to bridge team members becoming distracted while using mobile phones [53]. Out of the said two incidents, on one occasion the original passage of the vessel was amended to proceed closer to the land to receive signals for mobile phones. Even though not accounted in this research as the accident investigation report is not available, a similar incident took place in 2020 in the Mauritius coast [54].

Therefore, IMO should consider of prohibiting the use of personal mobile phones or other similar devices for personal matters which may distract safe watchkeeping and navigating ships close to the shore or shallows with the intension of receiving network signals.

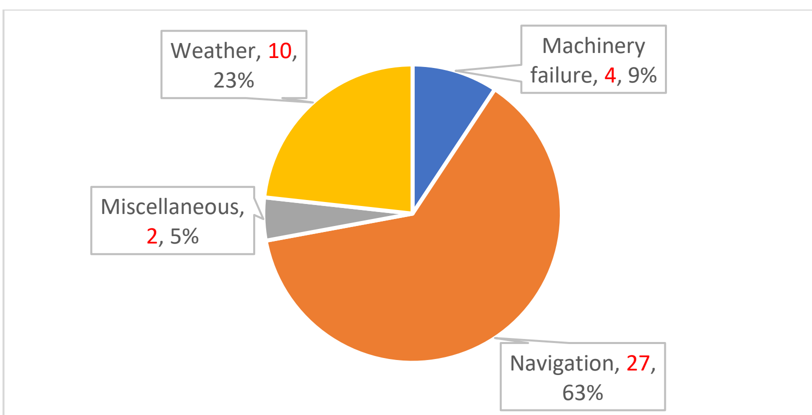
18.9 Higher rate of bulk carrier groundings

INTERCARGO [50] (International Association of Dry Cargo Shipowners) states that between 2008 and 2017 the most common reported causes of bulk carrier losses have been Grounding, totalling 22 losses or 41.5 % of total losses of bulk carriers. According to the INTERCARGO figures, reasons for the bulk carrier groundings can be illustrated as below.



Reasons for bulk carrier grounding as per INTERCARGO
Graph – 29

Figures will be as below if the same categorization is used for this research with regards to the bulk carrier groundings:



Reasons for bulk carrier groundings
Graph – 30

In the above graph miscellaneous include one incident due to an error made by a tug and one accident due to a conflict on board.

Out of the 10 groundings that had taken place during extreme weather conditions, 09 accidents could have been avoided if the onboard staff had taken proactive measures beforehand. At the same time, 07 accidents during heavy weather had happened while the vessel was in ballast condition. It is not clear, whether the heavy weather ballast was onboard in 06 groundings out of these 07. Ship operators must insist the bulk carrier masters to take heavy weather ballast if expecting extreme weather conditions during the passage.

Both researches indicate that there is a serious lack of safe navigational practices onboard bulk carriers. Reasons for these navigational malpractices are discussed in above chapters of this research paper in common to all the types of ships.

Machinery failures are also addressed in a above chapter in common to all the ships.

No research articles could be found on reasons for the higher rate of bulk carrier groundings but below arguments and suggestions are based on the information noticed on accident investigation reports and 10 years of sailing experience of the author of this research paper on board different types of ships including bulk carriers, container ships, car carriers and crude oil tankers.

18.9.1 Lack of safety precautions by ship owners, managers and seafarers on bulk carriers

Between 2015 and 2019 most of the cargo related accidents also had occurred onboard bulk carriers [18]. At the same time, most of the groundings also had taken place by bulk carriers. This may have a connection with the number of bulk carriers in the world but at the same time there could be a lack of safety consciousness by ship owners, managers and seafarers.

Probably, there is a misconception that the bulk carriers are 'less risk ships' among the seafaring community working on bulk carriers, ship operators and port operators. A risk has two elements, the likelihood that harm or damage may occur and the potential severity of the harm or damage [51]. Therefore:

Risk = Likelihood x Consequences

Which means, the risks will be high when:

- the number of groundings are high; or
- the consequences after grounding are high

The consequences are high in case of grounding a tanker. Therefore, risk of grounding of tankers are high. Because of that, tanker operators have taken extensive measures to eliminate tanker groundings. At the same time, seafarers onboard tankers are also safety conscious as the risk is high. That may be the reason for the tanker groundings are comparatively lesser than the other types of ship groundings. When it comes to bulk carriers, one may argue that the consequences are not high as the pollution risk is less (when comparing with tankers), but since the number of groundings are high, the risk is high. Therefore, bulk industry should take preventive measures by making the bulk ship operators and seafarers aware of the present risk and by strict implementation of a proactive SMS onboard similar to the tanker industry.

18.9.2 Lack of safety precautions by port operators

In case of 25 bulk carrier groundings port authorities were also involved in assisting and monitoring the vessel's navigation. Probably, most of these groundings could have been avoided if the port authority also actively involved in providing assistance for safe navigation. At the same time, it is important to note that when considering the total groundings with pilot/s onboard, 44% were bulk carriers. Therefore, pilots engaged in piloting bulk carriers must also be aware of the exiting risks.

Ports and terminals that entertain tankers have taken various measures to enhance the navigational safety of the ships, such as;

- monitoring the ships passage by Radars, AIS (Automatic Identification Systems) and through VHF (Very High Frequency) communications
- adopting safer routes with the aid of various navigational aids and strict compliance
- continuous training of the pilots, VTS (Vessel Traffic Service) operators and tug operators
- maintenance of safe passages etc.

Probably because of the under estimation of the risk by the port authorities, when it comes to bulk ports in some parts of the world;

- there are no VTS monitoring
- no proper navigational aids for safe navigation
- sometimes there are navigational aids and safe routes but no strict compliance
- no proper information on safe navigation to be found
- no sufficient emergency handling mechanisms such as sufficient number of tugs and manpower
- weather warning facilities are not available

These may lead the master to take own judgements without much knowledge of the local area which may end up with a disastrous situation. Therefore, bulk carrier ports shall consider of establishing safe procedures similar to the tanker terminals. At the same time, the bulk carrier ports shall consider of providing continuous training to their pilots, tug masters and VTS operators, as appropriate, on;

- Safe navigation while considering local climatological conditions and navigational dangers
- Safe ship handling
- BRM
- Monitoring of vessel's navigation
- Proper communication
- Emergency handling
- Design limitations of anchors etc.

19. Summary of suggestions

IMO should consider of;

- developing guidelines to eliminate complacency.
- adopting regulations to conduct trainings/discussions on fatigue, complacency and situational awareness regularly onboard.
- amending the STCW Code to include 'knowledge on design limitations of anchors, cables and windless' to the Table A - II/2 of the STCW Code as a KUP that the mates and masters should have.
- amending the Table A-II/1 of the STCW Code to include KUP in plotting ocean tracks on charts.
- conducting 'additional IMSAS audits' for flag States blacklisted by MOUs after port State inspections and maintain a blacklist of flag States.
- prohibiting the use of personal mobile phones or other similar devices for personal matters which may distract the safe watchkeeping and navigating ships close to the shore or shallows with the intension of receiving network signals.

Ship operators should consider taking further measures to;

- Improve bridge resource management practices onboard.
- Ensure that the SMS is proactively implemented onboard and proactively reviewed periodically.
- Motivate crew by conducting motivational and safety programmes over video conferencing facilities.
- Motivate crew by organizing events between other ships in the fleet through video conferencing facilities.
- Select crews those who are compatible to work and live with.
- Make onboard training/discussion compulsory on fatigue, complacency and situational awareness.
- Conduct awareness programmes to further educate the ship masters and navigating officers with regards to design limitations of anchors, cables and windless.

- Encourage and educate their masters on the importance of using the second anchor underfoot or lowering further cable to restrict dragging if the engines available and sufficient sea room is available.
- Amend SMS to include training on all the available steering systems and steering modes during emergency steering drills for the navigating officers and deck ratings.
- Share the casualty investigation reports issued by the flag State among the ships registered under that flag.
- Circulate the electronic copies of the above casualty investigation reports among the masters and officers on vacation.
- Make sure that their masters are strictly complying with the requirements regarding the use of BNWAS and assigning of dedicated lookout men during dark hours.
- Educate the masters and officers on the risks involved with bulk carriers.

Bulk ports and terminals shall consider of;

- Adopting striker regulations and preventive measures to improve navigational safety similar to the measures adhered by tanker terminals and ports.
- Providing continuous training to their pilots, tug masters and VTS operators.

20. Conclusion

The ISM Code, technology and the seafarer training has contributed to the reduction in maritime accidents by mitigating human errors by seafarers. But still, ship losses and damages due to ship groundings is a serious threat to the shipping industry. Still the main reason seems to be human errors of the seafarers.

Most common reasons for these human errors are poor BRM practices, noncompliance with the SMS and possibly due to complacency and autonomy/boredom. Even though neither training nor advanced technological equipment, nor even academic studies, will completely eradicate these accidents [52], maximum possible measures shall be taken to reduce the accidents to a lowest level.

Even though there is not much connection between ship grounding and type of cargo carried onboard, bulk carriers are the high-risk vessels for stranding among the flag States considered and at the same time, frequency of ship groundings is still considerably high when all the types of ship are considered.

Number of suggestions are made to IMO, ship operators, seafarers, port authorities and other stake holders of the industry to enhance the safety against ship strandings based on the findings of this study, most importantly, ship operators should make sure the onboard staff are complying with the instructions and procedures provided through SMS.

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