CHIRP Maritime

Perception, Decision Making and Fatigue at Sea

by ***CHIRP*** Maritime with
University College London

CHIRP Maritime

The Maritime Confidential Hazardous Incident Reporting Programme

Introduction

As seafarers, we are all used to working under pressure in adverse conditions. Our training reflects this and our experience teaches us how to think and react to situations. From the engine room to the bridge, we all work hard as individuals and as a crew to keep our ships running smoothly.

There are always new hurdles to overcome because nothing we do is commonplace. The challenges can be hidden in the way we see, scan, plan, decide and communicate. To be the best seafarer one can be means finding ways to recognise and deal with these issues.

Our ability to perceive the world around us and to make decisions, both individually and as a crew, is crucial for us to carry out our jobs and to avoid or respond to emergency situations. It is in how we see and how we decide that hidden factors, or factors we may know but take for granted, may ambush us.

Knowing about and understanding these issues and knowing how to avoid them is the route to first class and ever-improving seamanship. These guidelines highlight key issues in the areas of Perception and Decision Making, with makes recommendations on how we can combat them together, helping to make our ships more efficient and keeping our seas safe.

This paper is a summary of findings and recommendations in collaboration with the Arts & Sciences, and Neuroscience Departments at University College London.

Understanding how we see

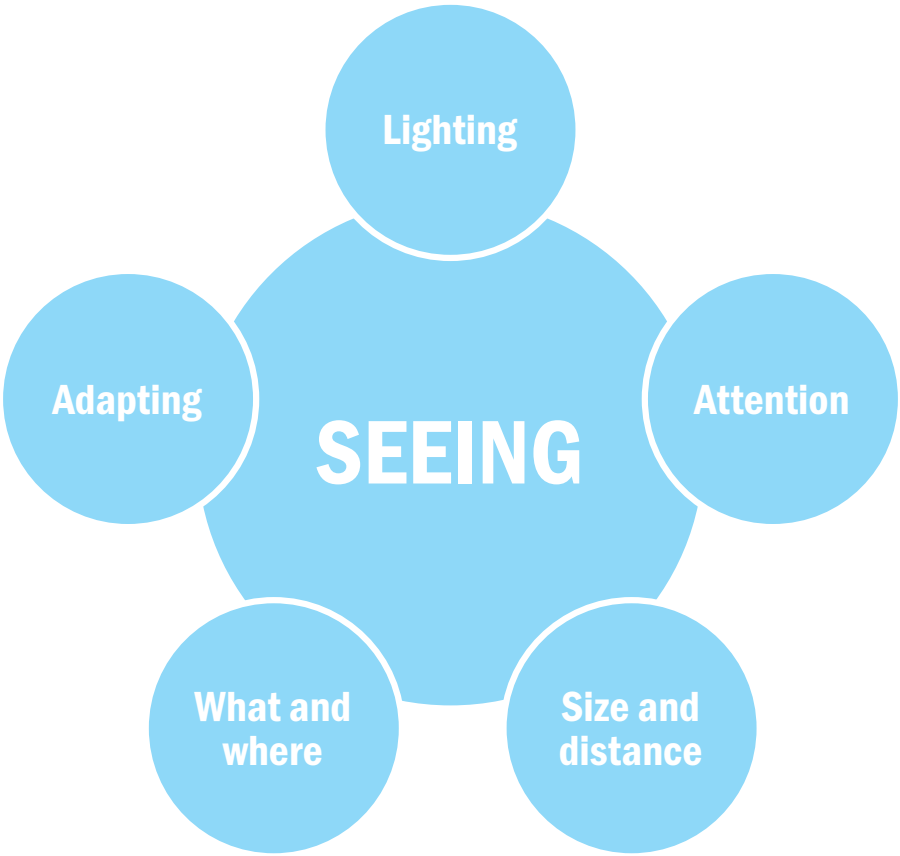
Seeing is something easily taken for granted. The eye is not a camera and the visual brain is easily fooled. Here are 5 things to consider which may help you understand how you see.

Attention

There are limits to what we can see, set by our eyes, brains, experiences and expectations. We often only see the things that we choose to focus on or are expecting to see. When fixated on certain tasks or objects, even the most experienced among us are in danger of missing what is happening under our noses or in our peripheral vision. On a bridge or in machinery control rooms, it is already hard enough to maintain our perspective on the totality of relevant visual information, a task which is complicated by the challenges of paying attention to several things at once while holding information from the last few minutes.

There is a limit to the amount of information we can hold in our memory at any one time. We think that we can track several items at once, but research has shown that this limit is only about four. With so many things to pay attention to and remember, we are working at our brains' limits much of the time. Without even taking into account how tiring it is for our eyes to stay focused for prolonged periods and for our brains to keep track of previously reported contacts, whether it's fixes to take, flashing alarms to respond to or moving contacts, maintaining our attention – i.e. the choice of what to focus on - is demanding.

The need to switch between modes of focus, such as near (to read and use the ECDIS and radar) and far (to spot a contact on the horizon), coupled with the challenge



of maintaining distance focus when looking out to sea, makes watchkeeping a more complex task than we think. To the seafarer it may be something we do every day; but to the seafarer's brain, it is an on-the-limit workout. The eye takes time to refocus between near and far modes, and loses focus within about a minute of not having something to focus on, especially with distant objects. We must be constantly aware of the limitations of glancing between screens and out of windows, or simply scanning the horizon for an extended period of time, because there is a cost to both switching and staying focused.

So, what does catch our attention? Two types of events dominate attention; things that are surprising (loud, bright, big, fast) or

unexpected, and things we strongly predict. As a result, we risk becoming too focused or desensitised to important events that all look and sound the same because we've seen it all before, or not responsive enough to unexpected events. This emphasises the need for good local knowledge to know when something is out of place. However, our expectations tend to influence our focus. When the radar presents a contact, we naturally look for the ship corresponding to that contact, and may miss others that have not been scanned. Similarly, with local knowledge, being on the lookout for the familiar may reduce our chances of spotting small, but potentially critical changes.

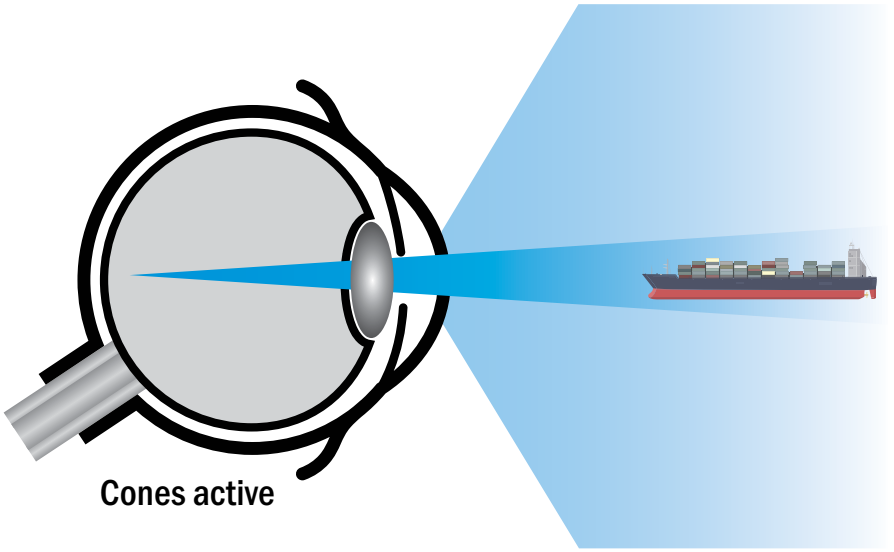
The challenges are not only set by the sea. Designers of ships and equipment need to remember that approximately 8% of males have some form of red/green colour blindness. Staff need to be capable of correctly recognizing colour coding on cables, pipes and display screens where incorrect judgement can be safety critical

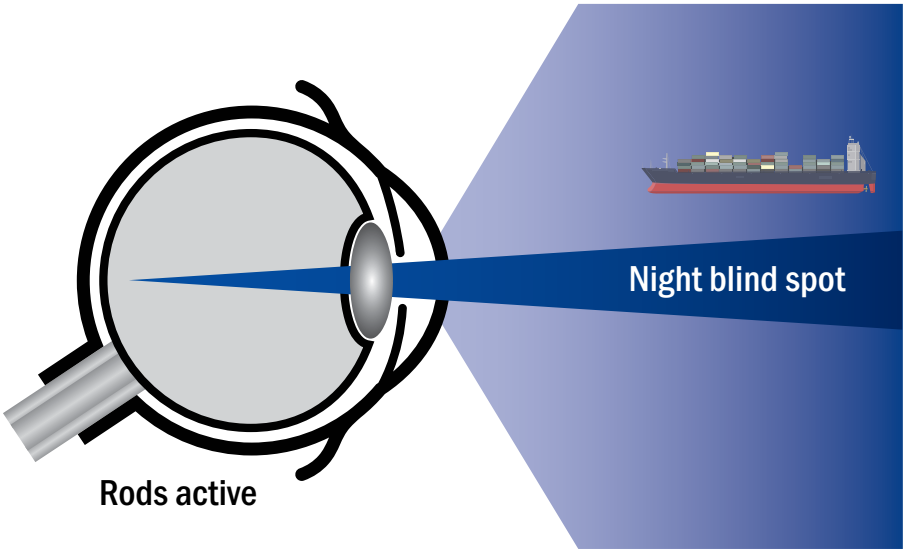
Working in night lighting conditions

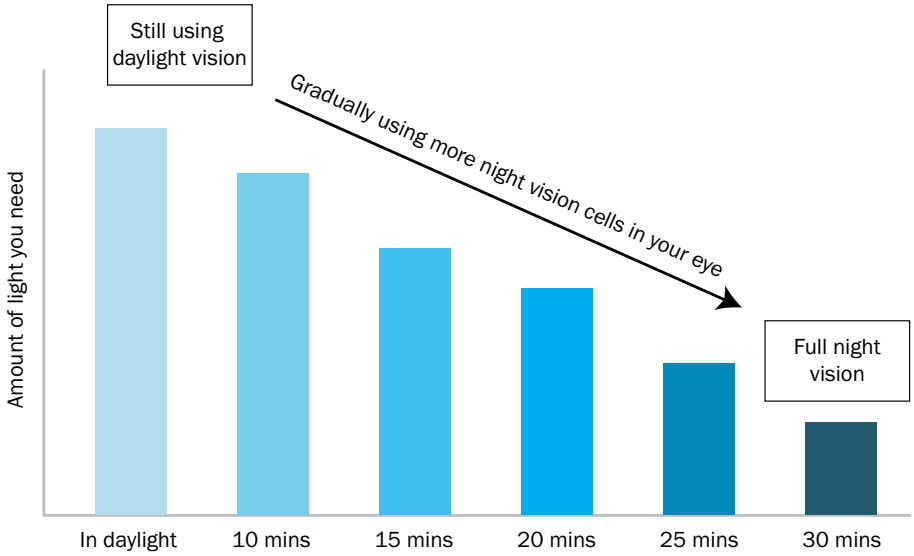
Human vision operates in several 'modes' depending on the level of light in our surroundings, and it takes time for the eye and brain to transition between the stages. Our eyes are made of two kinds of cells. Rod cells are for black & white vision, light sensitivity in darkness, and detection of movement in the periphery. Cone cells are for colour vision and seeing fine details. This is why you can't read out of the corner of your eye and screens flicker less when you look at them directly. It's useful to think of having two types of vision: one for fast movement and low lighting conditions, and another for detailed vision in high lighting conditions. Our special challenge is that in 24/7 sailing we need both systems under all conditions.

According to our review of IMO data on incident severity, more 'severe' and 'very severe' maritime incidents occur at night than during the day. This is partly linked to how our eyes adapt to perceive things at night. For example we have a night blind spot when looking directly at something for several seconds. This night blind spot is in the centre of our vision, which we depend on in daylight. If you hold out your fist at arm's length, this is about the area of relative blindness in dark conditions. It is why, to see a flickering star, you need to look slightly to the side of it. Unfortunately, we were unable to analyse the full extent of night incidents because, with very few exceptions, the Maritime industry does not collect information on types, timing, severity or near misses in a consistent manner. This is an important missed opportunity to improve our safety.

It takes time for our eyes to adapt when moving between bright and dimly lit sources and environments, such as ports, flashlights or screens that are not sufficiently dimmed. The time to adapt increases with age, and the resulting night vision abilities are less good in older people. Understandably, we can rarely afford the whole half hour required for our eyes to fully adapt and rid us of these problems, but that is not necessarily required so long as the light environment we are in prior to taking over a shift is not too bright, and conditions on the bridge itself are not too


Cones active


Night blind spot
Rods active



Dark adaptation line. This figure shows that our eyes are fully adapted to the night vision only after 30 minutes in the dark.

dim. To assist the eye in adapting to working in low levels of light, it is a good idea to spend some time in an environment illuminated by reddish light, because the rods - the eye cells that do the work at night – are most sensitive at longer wavelengths. This is also why we detect red moving objects quickest at night.

Lighting

Sufficient lighting is a key factor in a safe and productive workplace. However, our vision does not only depend on the lighting, but also on our own 'ability to see'. Age plays a key role here because as we age our need for light increase – older people need more light to read than younger people do and find a range of visual tasks more difficult, for example, motion detection, speed of motion, detection of the unexpected, and they are also less able to work with dim displays. We need to see objects under adverse lighting conditions, low contrast, glare and light scatter, mist and fog, this is why we have to be aware of lighting conditions with respect to each individual making allowance for wearing spectacles.

Light is not only about seeing. It controls our biological clocks that in turn regulate our hormones, appetite, body temperature and alertness. This makes thinking about light a broader issue. Rap-

idly switching between daylight or bright artificial light and dim, dark adapted conditions, will confuse the body's clock systems and reduce our alertness on night duty and recovery from shift work. Thinking about lighting is important in the now – we need the best conditions for observation – and in the longer term because our clocks need regularity.

Apart from these health and wellbeing advantages of good lighting, it can also lead to better and faster work performance, fewer errors and accidents and greater safety.

What and Where

One of our tasks at sea is to identify what we are seeing and where it is going. There are two different systems in our brains for this, and they are called the "what" and "where" visual systems. The "What" system relies on the centre of your eye for detail and colour and needs bright light to work at its best. The "Where" system relies on peripheral vision, is better in dim light and can detect transient events such as moving objects or flashing lights. These two different kinds of information use different areas of the brain and eye. This means that we can never optimize the two systems at the same time.

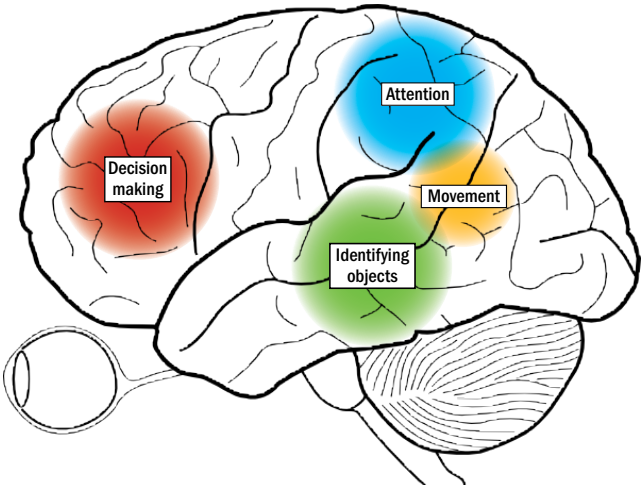
How we use our eyes also makes a difference. We look slightly downwards to read, sew, draw, look at our screens and anything that requires accuracy. We do this because our lower visual field is more sensitive than our upper visual field. So if we are looking down at our instruments and then glance upwards to look out to sea, we are not using our best field of vision.

The difficulties for locating and identifying also depend on external factors. For example, while the position and brightness of lights on larger vessels may be sufficient for us to detect, locate and identify, this will often not be the case on smaller craft.

Visual Size and Distance

In the world around us, we categorize each object that we see by its size, shape and location. This experience of the world is called visual space. However, visual space is not the same as the actual physical space, it is a distorted version. Because of this, visually perceived size and distance and true size and distance often vary. If we get either size or distance wrong, we get both wrong. If an object's size is underestimated, we will overestimate its distance and vice versa. Moreover, more errors in size-judgment appear with increasing distance i.e. the further the object is, the more likely we are to perceive its size falsely. The size, distance and the sense of space can change in different sea conditions or in different deck conditions, for example in misty conditions, when we are tired or when the light in the room is changing.

Seeing size and distance relies on our "Where" system for distance and both the "What" and "Where" systems for size. This makes it a very difficult task and it is important to use as many clues as possible. We can question each other and ask questions such as, "would something that far away be moving so fast?" or "if it's so close, shouldn't we be able to see its shape (or another aspect of the vessel)".



Understanding how we make decisions

The cliché "two heads are better than one" is based in truth. Our collective perception is much better than our individual perception. When as a group we are asked to estimate the size and distance of an object, we always produce more accurate results than any single individual. Within a group, we tend to communicate and reach a compromise, which is more accurate than our own separate estimates. This is at the root of good crew decision making.

Communication & Culture

The culture of communication between the crew onboard a vessel is one of the most, if not the most important aspects for keeping a vessel running effectively and avoiding emergency situations. The culture and communication on a vessel can vary from ship to ship, crew to crew or even shift to shift. Every ship develops its own culture, and we may be speaking a second language in that culture. It is important to go the extra mile to ensure clarity of communication by using closed loop communication in which we provide clear answers and feedback at every stage of the process.

Crews that don't promote questioning of actions and clear communication between their members can fall into the trap of

allowing events to unfold even when they know them to be dangerous. This can happen when other crew members being around discourages an individual from intervening in an emergency situation. This is known to happen in particular when people are fearful of communicating with their superior officers or have low confidence because of tiredness, politeness or fear of embarrassment or reprimand.

This is exemplified by the 1999 Korean Air Cargo Flight 8509 which crashed shortly after take-off. The black-box revealed that the crew present in the cockpit did not question their captain on his course of action, which was directly counter to what he was told by ground control, and also did not inform or challenge him on any information being given by the numerous alarms and gauges. The crash killed all onboard and is an extreme example where the failure to communicate coupled with a strict and closed culture, at the time the norm for the airline, can have devastating consequences.

Trust

The interface between man and machine is part of the human element of everyday operations and there is a need to recognize the value of human-centred design of safety-critical equipment. At sea we perform a balancing act between trusting each other, our eyes, instincts, experience, and the electronic equipment, which is vital for making quality decisions. Experience and expertise are two hard-earned elements essential to trusting yourself. They will give us the effectiveness to make quality decisions rapidly. Indeed, it is important for a skilful seafarer to be confident with his expertise rather than relying solely on electronic instruments. When the pressure is on and stress is high, the ability to trust your experience makes all the difference. In fact, in emergency situations, knowing your strengths and limits will lower your stress levels and helps to avoid taking risky and dangerous decisions.

There are, of course, dangers to overconfidence. We've all sailed with that crew member. It is important for us to distinguish expertise from familiarity. Poor decision-making and failure to follow protocols can lead to bad habits which become ingrained in our experience. This can lead even the most experienced seafarer to forget to focus or disregard important information. For example, a seafarer's experience helps to develop rules of thumb or habits, such as prioritising information from screens over eyes or vice versa. Sometimes our rules and habits are exactly right for the way we work as individuals, but we need to recognise and challenge them to stay sharp and to develop another habit - the habit of always being a better seafarer than yesterday. We can learn something new every day: the sea is never the same and neither are our individual habits and ways of seeing, deciding and sailing. By knowing our habits, trusting ourselves, respecting the experience of others, even when they see a situation differently, we can prevent incidents and collisions.

Group Decisions

Human error continues to be the main cause of most maritime casualties. Unfor-

tunately, some level of human error is a factor in any industry that involves human labour. We all make mistakes. But there are effective ways of limiting these errors, and one of them is by favouring group decisions over individual ones.

Many collisions are due to crew members making decisions on their own and avoiding discussions with others. You may even have experienced a situation in which you know you should have said something - but didn't. As individuals, we all have different biases and succumb to different forms of illusions. By involving two or more crew members in the decision-making process, we are less reliant on individual biases and lessen the chances of a mistake. Asking others, "what do you think of this?" is never a mistake. The lessons learned from Bridge Resource Management and Engine Room Control Management training promote an appreciation of the need for challenge, intervention, teamwork and effective closed loop communications

By making group decisions we are able to catch each other's errors earlier, preventing them from leading to a mistaken course of action. In addition, when navigating, we

are all exposed to different inputs, and we don't have access to the same information. Focusing on one specific element makes us ignore other elements and factors. This can lead us to make decisions based purely on our own perceptions, which can be misleading. This is why is it important to communicate information clearly with our crewmates - it gives us a broader view on events and helps us come up with more relevant and useful solutions.

Understanding Fatigue

Fatigue is known to anyone who has worked at sea for any length of time, but it takes many forms and has more causes than we might think. It also has consequences that we understand – severe incidents at night.

For example, we can suffer from what is known as visual fatigue. Four moving objects is the maximum number of objects that our brains can pay attention to and perceive properly at any time. When we are looking at radars, ECDIS or machinery space screens, there are a number of things we need to focus on and as a result, we are constantly at our own limits of perception as well as decision-making. This constant pressure on our perception can lead to omitting some information, that our brain is no longer capable of perceiving. This can then in turn result in worsened decision-making.

Shift work is known for its disruptive effects on our normal body clocks as well as one's social life. Rotating shift work has been associated with a decrease in cognitive ability and this association becomes stronger over time, especially when we exceed 10 years of chronic fatigue. Moreover, the effects can be lasting. Even after leaving any form of shift work, the recovery of cognitive functioning can take 5 years or longer. This means that managing fatigue is important for life at sea, on shore, and even in retirement.

When working shifts, days can pass without workers seeing daylight – if we work during the day, we are usually in a room with artificial lighting and if we work night shifts, we sleep during the day. This is another cause of fatigue as well as insomnia. The result is a decreased ability to make decisions and to understand what is going on around us. Shift workers are more likely to have vitamin D deficiency as their exposure to the sun is minimal, and this has also been linked to damaged cognitive functioning as well as to low mood and depression.

The same goes for stress and pressure. Short term stresses can make us more likely to take risks, but long term stress and prolonged exposure to stress hormones can make us risk averse. In either case we need to be aware of ourselves and others, to make sure that our decisions don't suffer from either of these problems.

Regardless of the length of voyage, research indicates 61% of seafarers feel more tired at the end of the voyage than at its beginning. Combining all these factors - shift work, lack of daylight, stress and pressure - fatigue may negatively impact health as well as how we carry out our jobs.

Recommendations

Now that we understand the problems, here are a few ***CHIRP*** recommendations to help us optimize our perceptual and decision making behaviour. These are important for seafarers to be aware of and for managers and Maritime regulators when considering the human element in ship design and when writing operating procedures.

Improving how we see

Attention, What and Where

- Discourage operations where individuals are working alone on safety critical activities.
- We can only track a maximum of 4 moving objects, so working with our crewmates is necessary to assist our attention.
- Be aware of our attention limitations, actively change focus between areas.
- We can never optimize the What and the Where system at the same time, so our best option for using our vision at sea is to check with a mate and have one person lead on each element.
- Lift your head when scanning the horizon. Our awareness of near and far space when we lift our heads instead of glancing up is improved as it ensures that the most appropriate part of the eye is being used.

Lighting

- Make sure that you are exposed to at least some daylight during your day to help your body clocks adjust.
- Always ensure that you're working in appropriate lighting.
- Be conscious of adjusting for clutter (e.g. sea, rain) to minimise distractions on equipment screens.

Visual Size and Distance

- When possible, check the size and distance of an object with a colleague, rather than relying on the perception of one individual.
- Use multiple clues to judge size, distance and motion.

Dark Adaptation

- Use red light for adaptation. Use a red light zone before entering the bridge on all ships at night and wear red lensed glasses before taking over shift.
- The industry needs to set recommendations for luminance levels of workstations.
- Adapt for as long as possible, preferable 30 minutes before commencing night work.
- Be aware that even brief exposure to bright screens compromises your night vision.
- Regulate your use of torches and aim for better light discipline by crew.
- Be conscious of changing displays to night mode or dimming them at night.
- Improving how we make decisions

Communication & Culture

- Have a culture on board that promotes questioning of decisions, including those of senior crew members by lower ranked members. This will help to counteract the errors caused by individual decision making.
- An explicit layout of the hierarchy on board will favour effective and successful decision making, where every mem-

ber of crew knows who to report to, and upon whom the final call lies.
- Closed-loop decision making will help improve safety. At each stage of decision making - identifying the question, gauging evidence, proposing and implementing solutions - question and agree an outcome and evaluate the decision.
- Have procedures in place and available for easy reference to ensure that in emergency situations that crew members are able to respond ASAP. Practice these drills.

Trust

- Relying solely on electronic instruments or only on experience isn't good enough. A balance must be struck where both are used.
- Strike a balance between relying on your experience and using your crewmates for help.
- Remain calm, trust your expertise and the ships protocols to make balanced and considered decisions in emergency situations.

Group Decisions

- Two heads are always better than one and decisions should be made by groups instead of by individuals whenever and wherever possible.
- Be aware that stress can lead to risky decision making in emergency situations so try to work with your crew mates to decrease risky decision making.
- Double checking the data with another member of crew will increase the likelihood of it being unbiased and reliable. Ensuring that inputs are the same for all members of crew is essential for successful decision making.
- Be conscious of the negative effects of being a bystander and encourage all crew members to be participant.

Fighting/Managing Fatigue

- Those who have remained in shift work for over 10 years should take a proper care of their health, both mental and physical, and regularly see a doctor.
- It is important to remember that physical as well as mental wellbeing is crucial for our functioning and safety of everyone on the ship.
- Consider taking Vitamin D supplement if you are not exposed to the daylight for a prolonged period time.

Act now .....

Take a moment to consider the bullet points listed above. Think: eye, brain, group, health

- We can improve our seeing by being aware of the limits of the eye and implementing good adaptation behaviours. Commit to these.
- The quality of information received by the brain is largely influenced by what we see. Look after your eyes but also appreciate the limitation of eyesight and the impact that improper lighting may have on perception and your decision making.
- Be aware that the brain has limits and was not designed for life at sea.
- Physical and mental well-being are important to performance as a seafarer. Fatigue will harm both. In addition to your mandatory seafarer medical, it may be beneficial to see your doctor for a check up.

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CHIRP Maritime

We aim to improve the safety of all individuals employed in or associated with maritime operations.

We manage an independent confidential reporting programme for the reception and handling of human factors and hazardous safety-related issues associated with the international maritime communities.

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