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Improving operational safety during icebreaker operations

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Abstract

The study presented in this paper aims at investigating what safety measures that can be taken to improve the operational safety during icebreaker operations in the Baltic Sea. During icebreaker operations, the icebreaker and the assisted vessel operate in close proximity to each other, a distance which can be even smaller if weather and ice conditions are severe. This poses a severe threat to the operation, since the extremely short distance between the vessels leaves no room for error.

The results, which are based on data collected through individual interviews and questionnaires, indicate several possible improvements. Firstly, on a regulatory level, the introduction of an ice navigation certificate for deck officers would set a minimal level of formal competency. Secondly, on a knowledge level, more ice navigation training and better language skills work in favour for the safety. Thirdly, on a technical level, having an electronic chart with target tracking capability increases the efficiency and safety of the passage through ice. In addition to these results, this study shows a need to further research the communication and language situation during icebreaker operations.

Keywords

Icebreaker, Icebreaking, Ice navigation, Communication, SMCP, Safety

1 Introduction

In the Baltic Sea, the shipping lanes are maintained and kept open all-year round. In winter time, this service is maintained by the Swedish and Finnish icebreaker services. Open shipping lanes are crucial for the national economy of Sweden in general, and for the industries in northern Sweden in particular. These key industries depend heavily on the export of goods (Layton 1981), thus requiring a well-functioning infrastructure. Governmental efforts to facilitate shipping during periods of ice are considered to have developed and modernized the economy of the northern region (Eriksson 2006). Today it is more than 40 years since any of the northern ports in Sweden was forced to cancel loading or discharging operations due to unmanageable ice conditions (Malmberg 2000).

Icebreaking assistance, the operation where an icebreaker assists a merchant vessel through ice, can be performed either as indirect assistance, e.g. by directing a vessel towards lighter ice conditions with the use of waypoints, or as direct assistance. Direct assistance can be further divided into pre-break escort where the assisted vessel follows an icebreaker, either alone or as part of a convoy; towing, which is the option when pre-break escort is not possible due to tough ice conditions; or break-out assistance (Buysse 2007). The latter is done when the assisted vessel has become beset in the ice and is unable to move any further under the present ice and weather conditions. As a consequence, the icebreaker needs to break the vessel loose by passing it very closely, thus releasing the pressure that the ice exerts on the beset vessel. This procedure is one of the features that distinguish icebreaking assistance from most other types of shipping operations – the inherent necessity of extreme proximity between the vessels. Two vessels passing each other in open sea might do so at a distance of a few miles, and in a heavily trafficked Traffic Separation Scheme (TSS) the passing distance might be reduced to a few cable lengths. However, during direct icebreaking assistance, the vessels can be as close to each other as ten meters or even less. It is not the short distance itself that poses a threat, but the extremely short time period the crews have at their disposal to act, if the operation does not advance according to plan. Ten meters at a speed of five knots gives the officer on watch (OOW) less

than four seconds to first perceive and interpret any sensory information that something is about to happen, make an appropriate decision, and finally to act. After this short period of time, the vessels could collide if e.g. the icebreaker would suddenly change course towards the assisted vessel while passing it alongside, due to weak ice around the stern of that vessel.

Navigation in ice adds a number of inherently precarious aspects compared to most other types of shipping. The vessel can be subjected to extremely low temperatures, severe weather conditions, ice crushing pressure on the hull (Kujala and Arughadhoss 2012), and icing. Icing is the build-up of ice on superstructure, caused by sea spray, which severely can affect the vessel's stability due to its high centre of gravity. Even though there is less risk of sea spray when operating in ice, icing can still be caused by precipitation or fog (Snider 2012). Being under direct icebreaker assistance includes all of these dangers. In addition, the close distances kept between the vessels significantly increase the risk of collision. The ice pressure affected by wind and current is an impact that influences the vessel's ability to proceed through ice. During icebreaker escort, a higher ice pressure will close the ice track behind the icebreaker much quicker than if the ice pressure is more moderate. As a consequence, the distance between an icebreaker and the assisted vessel has to be decreased when the ice pressure is high, if the vessels are to be able to proceed, and the same applies to the distance between two or more merchant vessels in a convoy. This, in turn, increases the risk of collision if the icebreaker were to get stuck in the ice (House et al. 2010). During icebreaking operations, continuous assessments are made by the officer in charge on board the icebreaker, where the level of calculated risk is weighted against the possible advancement of the voyage. If the risk is deemed to be too high, it might be advisable to stop the vessel and proceed at a later time.

Any vessel can enter the Baltic Sea during winter, but to be eligible to state icebreaker assistance, the vessel has to comply with the icebreaking service ordinance (SFS 2000:1149). This statute prescribes that 'vessels suitable for winter navigation may obtain icebreaker assistance in Swedish coastal waters and in sea-routes to Sweden between open sea and waters which are sheltered from sea-ice, drift-ice, pack-ice or similar ice obstacles' (SMA 2014). There are two aspects of this statute that deserve further attention. Firstly, the state icebreaker service provides no assistance in ports or sheltered areas; in these areas the responsibility rests on the local municipality or the port authority. Secondly, it has to be noted that only vessels *suitable for winter navigation* can expect assistance. Consequently, a vessel must meet the traffic restrictions imposed by the Swedish Maritime Administration (SMA) at any given time, which state the minimum deadweight and ice class required to receive assistance (SMA 2014). However, the SMA further lists a number of criteria necessary for a vessel to be deemed suitable for winter navigation. One of these requires that the crew should be suitable for, and in such condition, that a voyage through ice does not compromise the safety of the ship (SJÖFS 2011:1). With the composition of the merchant fleet of today, with international crewing, it is safe to say that the experience and knowledge of ice navigation will vary greatly among the crews that enter the Baltic Sea, and this poses a challenge for the operational safety during ice operations

2 Study aim and limitation

The study presented in this paper aims at investigating what safety measures could be taken to improve the operational safety during icebreaking assistance in the Baltic Sea. The geographical limitation of the study is the Gulf of Bothnia, the area generally covered by the Finnish and Swedish icebreakers.

3 Safety in icebreaker operations

To the extent that preceding maritime safety research activities have at all concerned icebreaker operations, the focus has primarily been on ice and weather conditions (e.g. Haapala and Leppäranta 1997; Leppäranta and Hakala 1992; Valdez Banda et al. 2015), and technical aspects and engineering principles (e.g. Cho and Lee 2015; Juva and Riska 2002). Research on human and organizational aspects contributing to safe and efficient icebreaker operations is however sparse.

Based on experiences from the masters and crews of the icebreakers, and through internal documentation of incidents, the SMA as the supervisor of sea icebreaking assistance in Swedish waters made an effort in 1994 to classify the five most common types of incidents (Stenberg 1994).

- Collision in an ice channel: This is by far the most common accident and occurs when an icebreaker comes to a sudden stop and the escorted vessel is not able to reduce the speed in due time. Such an accident generally results in minor damage on the icebreaker, while the escorted merchant vessel might become severely damaged and require extensive repair. The SMA further identified that this type of accident usually involve one or several of the following: misjudgement of the icebreaker's ability to penetrate heavy ice, misjudgement of the assisted vessel's ability to stop, inattentiveness when observing changes of distance between vessels and the lack of briefing nearby vessels about increased ice resistance.
- Weak ice around the stern: When a beset vessel tries to manoeuvre by itself, the movement of the propeller keeps the wake around the stern of the vessel open. When the movement stops, the ice freezes but is still extremely weak. If an icebreaker were to pass close by, chances are that the icebreaker would involuntarily steer towards this patch of light ice, following the rule of least resistance, thus hitting the stern of the beset vessel.
- Jack-knifing: During closed-coupled towing there is a risk of jack-knifing, especially at high speed and in uneven ice. Closed-coupled towing is an operation where the bow of the assisted vessel is placed in the stern-notch of the icebreaker, so that the vessels are in direct contact with each other. In addition, a towing wire can be used to firmly hold the vessels together. Closed-coupled towing may be necessary in tough ice conditions, but includes the intrinsic risk of jack-knifing. This phenomenon can occur when the speed of one of the vessels suddenly changes, e.g. if the icebreaker hits a patch of heavy ice. The momentum of the tow can cause the vessels to fold at the weakest point which is where the bow and stern are in contact, which poses a great safety risk.
- Low freeboard in combination with ice crushing pressure: Tankers with small freeboard in laden condition are especially at risk if beset in ice. If the ice pressure increases, there is a risk that ice is built up along the sides and on deck, resulting in damaged deck equipment and decreased stability.
- Integrated bridges and new technological equipment: New innovations can pose a safety risk if the user is not fully aware of how they are used. There is also always a possibility of technical malfunction.

The SMA has not carried out any new analysis of occurred incidents or accidents since 1994, but in a recent study, Valdez Banda et al. (2015) performed an integrated risk analysis of winter navigation, including a hazard identification analysis, an accident data review, as well as an expert evaluation of winter navigation operations. The results of this study correspond well with the findings made by their Swedish counterparts in 1994, in terms of complexity of operations, hazardous scenarios and contributing factors leading to incidents and accidents. Based on the expert evaluation, ice and weather conditions, but also lack of experience in winter navigation are stated as the main factors that compromise safety in icebreaking operations (Valdez Banda et al. 2015, pp. 114-115).

Providing ice assistance has many similarities with piloting a vessel from shore; they both involve guiding someone from a distance through the use of radio communication, e.g. Very High Frequency (VHF), and in both cases there are at least two parties involved, one of them being dependent of the other. Bruno and Lützhöft (2010) studied human aspects of shore-based ship assistance. The result indicated that for Vessel Traffic Service (VTS) and pilot duty, the Standard Marine Communication Phrases (SMCP) contained phrases for most feasible situations, but, however, it was important that operators were allowed to deviate from the standard communication protocol when deemed necessary. One example was the use of greeting phrases which, even though a deviation from the SMCP, were used as a means of establishing trust. Finally, it was observed that the intake procedure i.e. when an operator asks general questions about a vessel's particulars and present voyage, was used to get a feeling of what the crew was like, whether they could be trusted or not.

Traditionally, maritime safety has been largely reactive, focusing on legislation, quantitative risk mitigation, automatization, and training of operators to cope with increasingly complex systems

(Schröder-Hinrichs et al. 2013). Focus in this approach has mainly been the *causality credo* where accidents are seemed to be caused by mechanisms, or chain of events, that once they have been identified can be eliminated and prevented (Hollnagel 2014a; Schröder-Hinrichs et al. 2012). Solutions in this approach are mainly placed on *designing errors* (and to some extent humans with increased automation) out of the systems. The challenge for this kind of approach is that with a low number of adverse outcomes there is a lack of information about the overall safety of the system.

In what Hollnagel (2014b) calls the Safety II-perspective, focus is shifted towards successful, or at least acceptable, performance; what are normal operations and how can safety be promoted on board? This shift in safety approach is not meant to replace, but rather serve as a complement, when defining, measuring, monitoring and improving system safety in maritime operations. The basic assumption is that everyday performance is variable, thus functional resonance may occur. Safety can be seen as a dynamic non-event (cf. Weick 2011) that is continuously re-accomplished when the system successfully adjusts to the contextual demands of the environment and situation.

To complement the studies made on why things go wrong in icebreaking operations, more knowledge is needed that focus on situations where nothing goes wrong – where there is safety. It is necessary to understand what safe practices in icebreaking operations are, and identify the needs and prerequisites of the icebreaking crew as individuals and as a working team to safely and efficiently perform their everyday work. Finally, it is necessary to understand formal and informal ways of interaction between the icebreaker and the assisted vessels.

4 Research design

A qualitative approach was employed to get a thorough understanding of the problem. Furthermore, since there are at least two parties involved in an icebreaker operation, the beset merchant vessel (or vessels) and the icebreaker that is to assist, it was important to obtain the view of both of them. As a result, the collection of data was conducted in two separate ways, by individual interviews and questionnaires.

As described in the following sub-sections, the focus of this study has been on Swedish icebreakers and vessels calling Swedish ports, even though the area of operation for the icebreakers is the northern Baltic and thus geographically includes Finland as well as Sweden. However, the absence of interviews with Finnish icebreaker officers and questionnaires obtained from vessels in Finnish ports has not posed any problem, as the authors have never intended to paint a thick description, i.e. no quantifications were expected to be made. All things together, the research design has been deemed suitable to meet the exploratory goal of the study.

4.1 Individual interviews

The information from the officers on board Swedish icebreakers was obtained through personal interviews. These were conducted during fall of 2012. This was the off-season for Swedish icebreaking, which made it easy to reach the officers. The interviews were semi-structured to ensure that a number of themes were discussed, while at the same time allowing the interviewer and interviewee to explore new areas as the interview progressed. A template was used for the interviews to make sure that all premeditated areas were covered. Prior to the interviews the template was constructed, evaluated and improved by personnel familiar with the methodology of interviews, as well as shipping in general and icebreaking in particular. The final template covered nine main themes, each with a number of mostly open-ended questions. The purpose of having prepared questions in the template was to aid the interviewer, facilitate a steady progress through the interview and allow the interviewer to focus on the conversation at hand, rather than on how to progress the interview.

To give an account of the content of the interviews, Table 1 offers a brief explanation of the themes. However, observe that the following is just a sample of the queries discussed and not a complete account. The initial two themes covered *personal background* of the interviewee and *vessel specific information* respectively, such as age, nationality, training and qualifications, and experience of ice, as well as vessel dead weight and ice class, approximate number of days in ice service on a yearly basis,

the bridge watch rotation scheme and how that was perceived by the interviewer. The next two themes concerned the *means of communication* that were used when communicating with other vessels and icebreakers, and how the communication differed during *convoy operations*. Another three themes focused on language use: how *communication from other vessels* was perceived, e.g. trouble hearing or understanding voice communication and the use of closed-loop communication, *effective language use*, e.g. what measures that can be taken to increase the likelihood of successful communication, and the *SMCP*. A major theme covered *safety during icebreaker operations*, a theme for which the interviewee was encouraged to think outside the box and discuss anything that he or she felt could influence the safety. In the final theme, the interviewee was asked to *summarise any concern or major area of improvement* regarding the operations, and to add any additional information.

Table 1 Interview themes

Theme	Example of queries
Personal background	Sex, age, nationality, experience, training
Vessel specific information	Vessel type, dead weight, ice class, bridge watch rotation scheme, working language
Means of communication	Means of communication with merchant vessels/ icebreakers, and how the communication works
Convoy operations	Difficulties arising from convoy operations
Communication from other vessels	Hearing and understanding, closed-loop communication
Effective language use	Means to facilitate effective communication, e.g. brief and simple language, choice of language
SMCP	Proficiency in SMCP and to which degree it is being used
Safety during icebreaker operations	Factors that could affect safety, e.g. training, regulations, communication
Major concern or improvement	Any major concern or area of improvement with regard to ice navigation and/or icebreaker operation

A total of seven interviews were conducted, with the length spanning approximately 30-45 minutes each. They were conducted in Swedish since all interviewees had Swedish as their first language, and took place on board their respective icebreakers. Furthermore, all participants were at the beginning of the interview briefed about the aim of the study, that participation was voluntary and that no answers would be retraceable to any individual. During the data collection, one important object was to influence the respondents as little as possible, so that the view of the interviewer would not be reflected in the answers. At the interviews, this was achieved by first letting the respondent talk freely about safety. That way, many aspects were covered without the interviewer explicitly asking for them. The remaining aspects were then brought up by the interviewer, so that all respondents would have discussed the same topics.

4.2 Questionnaire

The information from the officers on board merchant vessels was obtained through a questionnaire. It was considered necessary to obtain information from not just any merchant vessel, but vessels that called ports in northern Sweden, since this would increase the likelihood that the officers on board those vessels would have experience from receiving icebreaker assistance. The northern part of Sweden was defined as any port north of, and including, the Swedish city of Gävle. This included all parts of the Bay of Bothnia and Gulf of Bothnia, areas that are ice covered during a normal winter (SMHI 2014). The ship agents along that coast were contacted, and nine of them agreed to present the vessels with a questionnaire during their port calls. The questionnaire covered the same themes as the

interview template and was written in English since it was expected that the participants on board the merchant vessels would have different first languages. Most questions were closed-ended to minimize the risk of misunderstandings; however, a few open-ended questions were included so that the respondents would have the opportunity to address issues not brought up in the questionnaire.

A total of 22 questionnaires were returned. This meant that the result could neither be subjected to statistical analysis, nor to be seen as representative for all the vessels in the Baltic Sea, but should be viewed as individual opinions used to shed light upon the problems associated with icebreaker operations. Interestingly, there were an equal number of questionnaires returned from Swedish and Finnish respondents respectively, which mitigates the fact that the data collection was focused to only Swedish ports.

4.3 Data analysis

The interviews were recorded, transcribed, and then paraphrased, except for when exact quotations were deemed necessary. To analyse the data, a method of content analysis, or textual analysis, was used. Krippendorff (2004, p. 18) defines content analysis as 'a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use'. This method both simplifies and enriches qualitative data (Jacobsen et al. 2012). The analytic process followed the following steps:

1. Thematization: Themes within the data were identified. A theme is a piece of data that deals with a limited and defined idea, e.g. risks associated with closed-coupled towing.
2. Categorization, grouping of themes: Themes were collected into broader categories with the aim of structuring the text. The theme mentioned in step one could be categorized as safety.
3. Filling the categories with content: Pieces of data and quotes from the text were used to exemplify and explain the categories.
4. Comparing data: The data were examined with the aim of identifying differences and similarities, and to see whether opinions diverge or converge.
5. Seeking explanations to the differences: These explanations were sought for in the transcription and quotes from the interviewees.

Since both an interview template and a set questionnaire were used for data collection, most of the categories were distinguished in advance during the construction of the template and the questionnaire.

5 Results

Many aspects of safety during icebreaker operations were discussed during the interviews, and covered by the questionnaires as well. The safety aspects were categorized into three groups, and are presented below. The results include both the data from the individual interviews and the questionnaires.

5.1 Technical development

The use of Automatic Identification System (AIS) during icebreaker operations is a valuable device according to many respondents on board the icebreakers. Today, apart from showing the location of a vessel, it can supply valuable information to the icebreakers; a vessel that is being monitored can be deemed beset if the speed indicated by the AIS is zero, eliminating the need of verbally requesting speed information from that vessel. Similarly, the ship's heading derived from the AIS is valuable when deciding the most favourable method for freeing a beset vessel. Furthermore, acquiring the speed and heading information electronically not only saves time, but also eliminates the risk of mishearing the information due to weak VHF-reception or language difficulties, which was summarised by one of the respondents.

The AIS has helped a great deal for us. We can see if the vessel is stuck even if there are language difficulties.

Another valuable tool, which already is in use on the icebreakers, is having an Electronic Chart Display and Information System (ECDIS) with track keeping capability; that is, an ECDIS that shows not only the present location of AIS targets with their current speed and course, but also their track history with the speed history of the target. The speed history can e.g. be colour coded to indicate vessel speed over time. It was understood during the interviews that from an icebreaker perspective, this allows easy monitoring of a vessel which has been given waypoints to follow through ice, and the speed history can be used to evaluate how tough the ice conditions are. Furthermore, the AIS track helps greatly when trying to follow an ice lead or to find the entrance to one, especially during darkness or periods of restricted visibility. One of the interviewed icebreaker officers even suggested that this functionality could be part of the vessel's ice class.

5.2 Training and experience

Training and experience is a vital part to icebreaker operations, and it was mentioned as a concern by several respondents both from the icebreakers and the merchant vessels. A person can be very experienced within a field, without having any formal training, e.g. a master with numerous years on board vessels sailing in ice conditions. The opposite is also possible, i.e. fulfilling the formal training requirements and taking on a position as deck officer with a newly acquired deck officer license, without any previous experience.

To work on board a Swedish icebreaker, all deck officers need to fulfil the training requirements, which currently include both theoretical and simulator training. The experience is then gained on board icebreakers over time, where a junior deck officer holds a watch together with a more experienced officer; on Swedish icebreakers, there are always at least two nautical officers on watch during icebreaker operations. This on-board training was regarded by several respondents as a suitable way of obtaining the indispensable experience that is a necessity for advanced icebreaker operations. On the merchant vessels, there is no similar structured way to secure that everyone on the bridge obtains experience over time. The lack of experience was noted by respondents from both sides, but mainly from the icebreaker officers, and as the following quote illustrates, there seems to be a geographical difference.

There is a big difference, the vessels that call the most northern ports where there is ice, they are good, they know what it's all about. However, during a normal winter with ice further down in the Bay of Bothnia, you get a vessel with proper ice class, that should have a trained crew, but we experience problems that they don't follow what we say, [...] maybe they don't understand the importance of what we say, they want to manage on their own.

However, on the merchant vessels, the problem applied not only to experience, but also to training. Several icebreaker officers viewed this as a serious problem, and noticed a lack of knowledge regarding ice navigation, e.g. the use of radar in ice and VHF usage during assistance, as well as what to expect during icebreaker assistance. A lot of this is covered by the publication *Winter Navigation*, and therefore it was suggested that a reasonable start would be to raise the awareness about it.

To stress that the crews read Winter Navigation, so that it doesn't just end up on the ship agent's desk. Sometimes the agent might bring it to the ship, but then the vessel receives it only for the outbound voyage, not on the way in. Send it to the shipping company so it can be distributed early.

The majority of the respondents identified training as a vital component for increasing the safety during icebreaking operations. All icebreaker officers, and approximately 80% of the officers on board the merchant vessels, responded positively to the notion that more ice training at the master mariner program would promote safety. The content of this additional training would not necessarily need to be very extensive. Key areas to be included, as mentioned by respondents, include a general introduction to ice navigation and the kind of operations one can encounter when being assisted by icebreaker, basically an ice operations familiarisation. Furthermore, the ability to correctly interpret the radar image when under way through or near ice, and the correct handling of the VHF, i.e. how to

speak on the radio, were mentioned as important factors for increasing the safety. Since these two abilities are mainly practical, the ice training was suggested to include at least some elements of simulator training, to consolidate the theoretical knowledge acquired.

Yes, it [more training] would increase safety and speed up communication.

However, if a more thorough training would be implemented only on a national level, or on a joint Finnish-Swedish level, it is hard to estimate the effects of more extensive training. Two respondents highlighted that the problem has to be addressed on an international level.

More ice navigation training is always good, but since the merchant fleet composition is as it is the focus is not that much on the Swedish maritime training, we have relatively few vessels. The problem is that the foreign academies should have more ice training.

An overall theme, to which many respondents returned repeatedly, was that of sub-standard language skills. When asked what, if anything, made the communication between icebreaker and assisted vessel problematic, lacking English skills was by far the most common answer, compared to other issues, e.g. long distance between vessels, antenna placement and weak radio equipment. Poor English skills could be further divided into different issues. Firstly, some seafarers simply have very limited knowledge of the English language, i.e. they lack vocabulary and simple sentence structure. This, of course, makes it difficult for them not only to speak to others, but also to understand given instructions. Secondly, other seafarers know English, but have an accent which is uncommon for the area, thus making it more difficult to comprehend. One respondent had experienced that the general English skills of seafarers had deteriorated over time, something that was contributed to a change in vessel tonnage in the area. Lastly, another respondent mentioned the absence of specific icebreaker phrases as a problem, such as the SMCP, and that more phrases like that would help to facilitate a better communication.

5.3 Requirements

All respondents were asked their standpoint regarding the introduction of an ice navigation certificate and the effect that would have on safety of ice navigation and ice operations. Once again, the officers on board the icebreakers were unanimously positive to this statement. An ice navigation certificate would guarantee a lowest level of competence on a personal level, and in addition to the vessel's ice class, it should ensure that the vessel and crew are suitable for ice navigation, in accordance with the ice-breaker service ordinance. One respondent noted that ice navigation is a very special field of navigation compared to open-sea navigation; other special fields require a certificate of competency for officers with special responsibilities, e.g. Dynamic Positioning (DP), Crowd and Crisis Management (CCM) and the handling of dangerous goods, so the idea of a certificate for a special competence is not new. Two other respondents were concerned that there is much emphasis on the vessel's ice class, but very little on the individual knowledge of ship handling in ice.

A vessel's ice class accounts for 50%, and the other 50% is the crew who operate the vessel, whether or not they are suitable for ice.

Today you can operate a vessel in any way, as long as the vessel is ice classed.

Even though the icebreaker officers agreed that a mandatory ice certificate would improve the safety, several respondents did mention that shipping companies might be less than happy about the introduction of a certificate, due to the additional cost of obtaining it. This view could clearly be observed from the respondents from the merchant vessels; even though almost two thirds of those respondents were either positive or neutral toward the introduction of an ice certificate, almost one third were negative. The cost and the additional workload to require it were the main arguments, as expressed by two respondents from merchant vessels.

Enough! No additional courses!

Training ok, one extra certificate no. You already need too many certificates.

If such a certificate were to be introduced, it was suggested that not all deck officers would need the ice certificate; it might be enough for the master of the vessel to have it. Another respondent suggested the introduction of an ice pilot, a certified deck officer employed by the shipping company directly that could rotate among several vessels, and only be on board when required, or an external pilot that is hired for a specific voyage, or part of voyage, similar to a conventional navigation pilot.

6 Discussion

It should be noted that the result is based on the opinion of the respondents, and should therefore be viewed as such, individual opinions rather than a statistical representation of all shipping activities in the Baltic Sea. Nevertheless, since the respondents, representing both icebreakers and merchant vessels, play important parts during icebreaker operations, and some of them have accumulated more than 20 years of experience, their views must be considered highly valuable.

With regard to utilising technology, the AIS is a valuable tool for determining the progress of vessels in ice. However, current regulations already demand that all vessels that can be expected to sail in the Gulf of Bothnia during winter conditions, with a few exceptions, are equipped with AIS (IMO 1974). The vessels exempted from this requirement are generally small vessels, which anyhow would not fulfil the minimum requirements imposed by the Finnish and Swedish icebreakers, thus being excluded from icebreaker assistance nonetheless. As a consequence, the introduction of any additional AIS-requirement for a vessel to be eligible for ice assistance would be fruitless. Therefore, if one wants to achieve safer and more efficient operations by technical means, promoting an ECDIS with target tracking capability would better work towards that goal. However, if more use is to be made of the ECDIS in combination with AIS, care has to be taken not to over-rely on this modern technology. Out-of-the-loop unfamiliarity, automation induced errors and over-reliance on technical equipment have a long history of causing accidents (Kaber and Endsley 1997; Lützhöft and Dekker 2002; Stanton et al. 2010). Complacency and loss of skills are common problems associated with the introduction of new technology. AIS data is invaluable, but it should not be the sole source of information when making anti-collision decisions; Harati-Mokhtari et al. (2007) reported that it is not uncommon for the data provided by AIS to be unreliable, e.g. a vessel displaying incorrect position or manual data not being entered correctly by the user. Also, the UK Marine Accident Investigation Branch found over-reliance on AIS to be one contributing factor to the 2014 collision between MV Rickmers Dubai and the barge Walcon Wizard which was under tow by the tug Kingston (MAIB 2014).

Unsurprisingly, the general view among most of the respondents was that more training in ice navigation, within reasonable limits, would work towards greater safety and more efficient voyages in winter conditions. However, since shipping is an international business and the vessels trafficking the Baltic Sea have a great variety of flags and nationalities on board, it is evident that additional ice navigation training on a national level might neither be feasible, nor enough to increase the safety during icebreaker operations, a problem that was acknowledged by several respondents. Furthermore, even if the training issue would be addressed internationally, the results indicated that training alone is not enough; vessels that less frequently encountered icy conditions were seen as more problematic by icebreaker officers, compared to vessels that spent more time in the ice. With this in mind, a solution similar to the one on board the icebreakers, where junior navigation officers are allowed to practice together with a more experienced officer on the bridge, would be a step towards broadening the experience of ice navigation among the merchant vessels. Naturally, this would not generate any experience itself; officers who spend little time in the ice would only gain a limited experience, but the experience gained would at least be maximised under the supervision of a more experienced officer.

An alternative to educate and train a crew to better meet the difficulties with ice navigation could be the introduction of an ice pilot, as suggested by one of the interviewees. This could be a feasible solution for a shipping company with vessels which only occasionally encounter ice and winter navigation. The cost for training all deck officers and/or obtaining ice certificates would overturn the usefulness of the crew having a competence that is rarely used; hence, taking aboard an ice pilot when

needed and accepting an extra occasional cost would probably be wise. It could also be argued that the cost of an ice pilot would be negligible in relation to the time, fuel and money saved by a more efficient voyage through the ice. However, it is difficult to draw any conclusions from this argument before a requirement for formal ice navigation training exists. The advent of the Polar Code, which is expected to enter into force in 2017 (IMO 2014), will include elements of such training, which may spark a discussion for future similar requirements in the Baltic Sea.

The SMCP was designed to provide a simple and unambiguous way to enable ship-to-ship, ship-to-shore and intra-ship communication. Key elements of SMCP include a simplified grammar, a glossary with technical and nautical terms and a large number of standard phrases covering various situations and conditions at sea (IMO 2001). Furthermore, since people have varying knowledge of English prior to learning SMCP depending on e.g. their background, the SMCP is also meant to bridge that language gap. Consequently, the responsibility to facilitate safe communication does not solely rest on those with limited English skills; just as they have to learn and use SMCP, it is equally important for those with a good command of the English language to learn SMCP and reduce their eloquent language to the simpler SMCP. That way, two people can meet at a common language level, which increases the likelihood of successful communication (Bocanegra-Valle 2011; Trenkner 2010). Good intentions aside, ever since the first standard phrases were introduced, there have been complaints about bad adherence to the phrases, and Bocanegra-Valle (2011) proposes that the deviation between SMCP and actual communication needs to be researched further. Similarly, in a cross-domain study of VTS and ATC (Air Traffic Control), Praetorius et al. (2012) argue that VTS operations could benefit from more standardisation.

The results of this study indicate a perceived limited knowledge of the presence of standard communication phrases related to ice navigation and icebreaking. Nevertheless, to some extent, the SMCP does cover ice operations and includes three sections on that topic: *ice-breaker request*, *ice-breaker assistance for convoy* and *ice-breaker assistance in closed-coupled towing* (IMO 2001). In total, there are roughly 30 pre-set phrases relating to icebreaker operations, and an additional note that states that 'it is important to maintain a continuous listening watch on the appropriate VHF Channel and to maintain a proper lookout for sound and visual signals' (IMO 2001). Whether or not this body of phrases is adequate could be an area of future investigation. However, within a similar area of maritime operations, that of pilotage and tug assistance, Čulić-Viskota (2014) proposes the SMCP to be extended and further developed:

... whenever Maritime English tools, such as SMCP, are felt not to support appropriately the team work by allowing full grasp of the situation (situational awareness), i.e. in case they are felt as deficient in providing appropriate coverage of the activities taking place, such as the case with pilotage and tug assistance, the need is felt to elaborate on and extend the body of phrases.

As the international convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) states that all watch keeping officers should be able 'to communicate with other ships, coast stations and VTS centres and to perform the officer's duties also with a multilingual crew, including the ability to use and understand the IMO Standard Marine Communication Phrases' (IMO 2001), the problem cannot be said to be the unwillingness by the IMO to address the importance of communication. The core problem is more likely to be the non-compliance with the SMCP, and the large quantity of vocabulary and phrases contained in the SMCP; it is hard for any one individual to have good knowledge of the complete content of the SMCP, let alone to know a great deal of it by heart. As officers might be unaware of the presence of appropriate communication phrases, a solution would be to highlight these during ice navigation training, both within the master mariner program and at external ice navigation training courses. Furthermore, general communication protocols and information about the SMCP should be forwarded to vessels bound for icy waters, through existing channels of communication. One example in the Baltic Sea area is the publication Winter Navigation which is available for all vessels that enter the Baltic Sea during winter conditions.

7 Conclusions

The result of this study, as it was designed, shows that there are several ways that the operational safety during icebreaker operations can be improved. Even though the study has focused on Swedish icebreaker operations, it is fair to assume that the findings would be applicable to Finnish icebreaker operations as well. However, as a suggestion for future research, the area of interest could be extended to include Finnish icebreakers as well.

- Since ice navigation largely differs from open-sea navigation in many ways, it would not be unreasonable to require an ice navigation certificate for a person in charge of a navigational watch in ice, similar to e.g. a DP certificate. Presently, there are construction requirements for the vessel, but none for the crew.
- A majority of the respondents held a positive attitude towards ice navigation training, and believed that more training would increase the operational safety during icebreaker operations. However, from an icebreaker perspective, it was also noted that experience of ice navigation varied greatly among the merchant vessels. This, in combination with the multitude of nationalities on board vessels, makes it difficult to get to the appropriate target group. Increased ice navigation training within Sweden and Finland will only have a limited effect.
- Language plays an imperative part in the operational safety of icebreaker operations. Raising the awareness of SMCP phrases can help facilitate a better communication and as a result safer icebreaker operations.
- An ECDIS with target tracking capability can be a valuable tool for both icebreakers and merchant vessels during ice navigation and ice operations. The past tracks of merchant vessels indicate with which speed the vessels have been able to progress through ice, thus indicating to other merchant vessels whether or not that route is favourable. The same information can help icebreakers to assess whether or not a vessel is beset in ice and in need of icebreaker assistance.

In addition to the aforementioned improvements, this study reveals two areas that deserve further attention and continued research. Firstly, as adequate language skills are considered by the respondents to be an important prerequisite for safe icebreaker operations, it is desirable to further investigate that area. Aspects of language to be examined could include e.g. the role of SMCP, effective turn-taking and intercultural communication. Secondly, no objective analysis of the effectiveness of the suggested improvements presented in this paper has been carried out, which is something future research should attempt.

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