EFFECTS OF SIMULATOR TRAINING ON NOVICE OPERATOR PERFORMANCE IN SIMULATED ICE COVERED WATERS

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Effects of Simulator Training on Novice Operator Performance in Simulated Ice Covered Waters

By

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Abstract

Operations in ice-covered waters are increasing as Arctic environments become more accessible. With this move, there is an increased need for better equipment, procedures, regulations and training to operate in cold, harsh environments. No mandatory training exists for lifeboat coxswains charged with navigating lifeboats in ice-covered water during emergency evacuation situations. This study sets out to examine simulator training in comparison with traditional coxswain training to observe performance in a simulated ice field. Novice participants completed one of three training regimes before performing a standardized protocol of lifeboat maneuvers within a simulated ice-field. Performance measurements and psychometric measurements were collected. Simulator trained participants were 3.35 times more likely to correctly navigate through the course compared to those who received standard training. As well, simulator trained participants perceived a higher level of confidence and proficiency towards their past and future performance. Future work in this area should further examine the effect simulator training could have in real ice environments.

Key Terms: Simulation training, Standard Training, Certification, and Watchkeeping (STCW), Escape, Evacuation, and Rescue (EER), Ice-Covered waters, Arctic.

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List of Abbreviations

AMSA ....Arctic Marine Shipping Assessment
ANOVA...Analysis of Variance
ARPA...Automatic Radar Plotting Aid
BST...Basic Survival Training
CAPP ....Canadian Association of Petroleum Producers
CIS...Canadian Ice Services
DGPS...Differential Global Positioning System
DNV...Det Norske Veritas
EER...Escape, Evacuation, and Rescue
EN...East to North
ES ....East to South
GT...Gross Tonnage
HMD..Head Mounted Display
HSE ....Health and Safety Executive
HUET.. Helicopter Underwater Escape Training
ILAMA................... International Lifesaving Appliance Manufacturer's Association
IMLA...International Maritime Lecturer's Association
IMO..International Maritime Organization
ISO...International Organization for Standardization
LCD..Liquid Crystal Display
LSA ....Life Saving Appliance
MOUs.. Mobile Offshore Units
MSC ....Marine Safety Committee
NS ....North to South
NWSE..Northwest to Southeast
OIM..Offshore Installation Manager
PAR-Q...Physical Activity Readiness -Questionnaire
RNLI..Royal National Lifeboat Institution
SA..Situational Awareness

SOLAS..Safety of Life at Sea
SENW...Southeast to Northwest
SN...South to North
STCW.................................. Standard of Training, Certification, and Watchkeeping
TEMPSC ....Totally Enclosed Motor Propelled Survival Craft
USCG...United States Coast Guard
US...United States
UK..United Kingdom
VMT...Virtual Marine Technologies
WMU...World Maritime University

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Chapter 1 : Introduction

1.1:Background

Each year as researchers observe and study the changing environments of northern and arctic geographies, a common theme is emerging: northern navigation for shipping, industry, and tourism is becoming more accessible throughout the year (Arctic Marine Shipping Assessment (AMSA), 2009). As shipping in the north increases, stakeholders have to address the changes needed to modify and develop safety standards that are at similar levels as those required in southern waters. From regulators and classification societies to oil companies, shipping conglomerates and workers, changing environmental conditions will require addressing pertinent safety requirements.

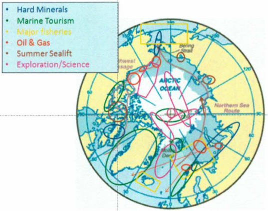


Figure 1-1: Arctic marine use (Adapted from L. Brigham, 2008)

Data collected over the last decade (Figure 1-1) has shown that the likelihood of Arctic waters becoming less ice-covered for longer periods during the year could become a reality. This would result in an increase in industry and tourism traffic (Steward & Draper, 2006). Yet, others urge caution in making this speculation because as first year ice becomes less abundant, multi-year ice could move into the resulting open spaces and potentially cause structural damage to vessels (Steward & Draper, 2006). Either way, it is clear that the environment in Arctic and northern waters is changing and social, economic, and environmental factors must be taken into consideration (Jensen, 2007). From research to shipping, oil and gas, military interests, and tourism, the north is becoming a place of high interest to a number of different interest groups.

Also important to recognize is the impact this growing interest has on search and rescue capabilities of countries with northern and Arctic jurisdictions. Increased rescue time and higher risk of environmental interference affect the ability to access and successfully perform a rescue if an accident were to occur (Jensen, 2007). If an emergency situation was to take place on a large ferry (Figure 1-2), the results could be disastrous if proper arctic Escape, Evacuation, and Rescue (EER) procedures are not in place.

Figure 1-2: Blanc Salon to St. Barbe Ferry, NL (R. Acton-Bond, Personal communications, 2011)

Judson (2010) points out that, although Canadian Arctic vessel traffic has increased over the last twenty years, incidents have actually decreased. Although the improved safety climate in shipping and oil and gas industries has likely contributed to this decrease, it must be taken into account that fewer reported accidents alone are not sufficient grounds for overlooking the current state of search and rescue resources and related training regimes.

Northern and Arctic waters are predicted to become more open (Figure 1-3) for longer periods of the year (Anderson, 2007). Ho (2010) reports that the AMSA predictions of opening passages for Arctic navigation may actually be conservative, and suggests that there are certain, previously impassable, waterways that will be opened as early as 2013. He urges, however, that increases in Arctic movement through northern waters should occur with caution and preparation, as there are many issues such as navigation, operating technologies, search and rescue capabilities, government relations and many others that must be dealt with for successful operations (Ho, 2010).

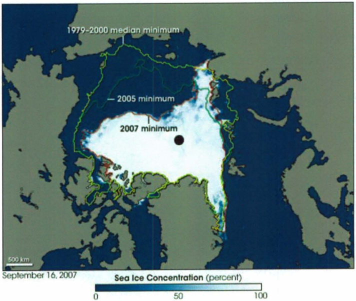


Figure 1-3: Lessening sea ice coverage (Anderson, 2007)

1.2:Overview of Lifeboats

The Royal National Lifeboat Institution (RNLI) reports that lifeboats have been in use since at least the 18th century, with the earliest patented use of a lifeboat (Figure 1.4) in 1785 by Lional Lukin (RNLI, 2011). The founding of the RLNI occurred in 1824, highlighting an important landmark in the history of lifeboats.

Figure 1-4: Historical depiction of one the first lifeboats (RNLI, 2011)

Today, lifeboats are categorized as life-saving appliances (LSAs) and are governed internationally in Chapter III of the Safety of Life at Sea (SOLAS) Convention, a governing document from the International Maritime Organization (IMO). The technical aspects of LSAs are regulated by the LSA Code. The IMO also governs certain aspects of lifeboat operations through the Maritime Safety Committee (MSC). There are a number of stakeholders, such as the International Life-saving Appliance Manufacturers' Association (ILAMA), interest groups such as the cruise ship industry, IMO member states, IMO committees, and classification societies that contribute to the advances in technology and regulations surrounding LSAs.

Various evacuation craft have been designed for arctic and northern use; however, this technology is expensive and largely limited in their use (Poplin & Bercha, 2010). While pertinent maritime technologies have evolved rapidly in recent years, there have been relatively few adaptations that are specific to lifeboats during this time period. In fact, the speed at which various environmental changes are redefining areas where maritime operations take place is outpacing the safety requirements of lifeboat training (Veitch et al., 2008a).

1.3:Regulatory Regime

Currently, the international maritime and offshore training certification required for those charged with navigating lifeboats does not include any materials on navigation through ice-covered waters. The IMO's Standards of Training, Certification and Watchkeeping (STCW) Convention has yet to provide any guidance for the safe and successful operation of a lifeboat in ice fields. Recently, the IMO has moved to amend the Convention to formally recognize the wider utility of simulation training as a surrogate for physical training, and through this recognition of importance, opportunities to develop simulator-based training in harsh arctic environments could follow these amendments. These changes will come into practice in 2012 (IMO, June 2010)

Those tasked with filling the coxswain position for a Totally Enclosed Motor Propelled Survival Craft (TEMPSC) are responsible for ensuring the safety of those aboard (Canadian Association of Petroleum Producers (CAPP), 2010-0028). TEMPSCs are employed on a variety of maritime structures, from shipping and tourism vessels to offshore oil and gas installations and can be located in both cold and warm environments. Challenges with providing adequate training are two-fold since they exist at both the regulatory level and at the more practical training level. Training poses risks, due to many factors ranging from poorly maintained equipment to human error (Hill, Dobbin, & Myers, 2009). The Canadian Ice Service (CIS, 2011) reports that ice-covered waters can cause ship navigators a variety of issues, including vessel damage, fuel overuse, navigation difficulties, and slowing speed.

The CAPP guide (2010-0017) highlights the fact that performance standards are created to take into account the importance of considering various circumstances specific to an installation and its operation. Recognizing that operational limits are the same for lifeboats on installations both in northern and arctic waters and those on installations in places like the Gulf of Mexico, there are gaps in terms of differences in environmental exposure. Moreover, when one considers the environment off the east coast of Canada and in waters farther north, it is also vital to examine the difference between the installations in these regions and those in places like the Gulf of Mexico. It is also important to note that the training standards for coxswains of evacuation craft do not address geographical difference. Poplin and Bercha (2010) report on International Organization for Standardization (ISO) 19906, an international standard that addresses Arctic Offshore Structures, and was developed based on the input of a variety of stakeholders with interests in Arctic operations. Of particular relevance from this paper are the EER considerations for ISO 19906, which are focused on performance-based standards rather than prescriptive-based standards. The change in philosophy has come from the need to speak to the relatively small amount of research addressing operations in waters that experience sea ice-coverage. Prior to ISO 19906, very little literature existed for EER in terms of performance standards. Performance standards, as defined by Bercha and Poplin (2010), are those that work towards a performance goal, set by the designer/operator that can be measured by a variety of means and also validated by regulatory bodies (p.2). Inherent in performance standards is the idea that they must work towards overall safety goals and adapt to the changing needs of any technology, program or environment. In attempting to address these performance standards there is a need to focus on training, and in particular TEMPSC lifeboat training.

Researchers in the marine field suggest that simulation training be part of a holistic teaching method, including traditional and other emerging methods (Barber, 1996). As Poplin &Bercha (2010) have pointed out, emerging technologies will be very important to EER in Arctic environments, and developments in simulation training in the maritime field will certainly be a part of this.

1.4:Statement of the Problem

Many of the guidelines concerning vessels and installations operating in ice-covered waters are recommendations, rather than mandated standards, which IMO member states must follow (Simões Ré, Veitch, & Spencer, 2010). As well, these guidelines are rarely framed in a performance-based manner. There is a movement to change international guidelines, as many member states of the IMO have moved to create their own performance-based standards in different fields. As the STCW Convention begins to shift toward incorporating simulator training into recommended guidelines, there is anticipation that the greater maritime world will consider simulator training as a viable, safe, and effective replacement or addition to STCW physical coxswain training.

Patterson et al. (2011) highlight in their work that life-saving craft are used for scenarios that are generally characterized by rapidly escalating situations and adverse weather conditions (p.1). Simulation training, which is currently employed in a wide variety of industries such as aviation and medicine, could provide training for such situations. It has been proposed that simulation must be presented to a trainee in a realistic manner in order to be accepted as an appropriate replacement for physical training (MacKinnon, Evely, & Antle, 2009).

The purpose of this research is to assess whether performance outcomes and experiences of novice lifeboat coxswains are enhanced through the use of simulation training technologies. This work will examine simulator training for ice-covered waters as a viable alternative to physical training that normally cannot be undertaken due to risk to personnel and assets. This will contribute to the growing body of knowledge regarding the need for increased specialized training for those working in harsh, cold maritime environments.

1.5:Hypotheses

The following hypotheses are addressed in this study:

1. Simulator trained participants perform better when navigating through a simulated ice-field, taking a longer path and time through the field, incurring fewer and less severe impacts, and making more steering maneuvers than participants trained in the standard manner.
2. Novice operators who partake in simulator training experience an increased level of confidence in their ability to navigate a lifeboat through an ice field compared to those who do not undergo simulator training.

Chapter 2 : Review of Literature

2.1:Overview of the Regulatory Environment

The International Maritime Organization (IMO) is an international body that provides support and guidance, as well as defines international regulations and recommendations for member states on areas such as marine safety, security, and environmental preservation. The IMO is a special United Nations Agency that was formed in 1948 to protect the lives of those who work at sea. Since then, many IMO technical committees have been formed to address more specific issues through conventions and committee reports. These technical committees are primarily charged with creating, updating and amending the standards, rules, and regulations employed to prescribe minimum standardized requirements in a number of areas, including mariner training. This international collaboration involves the participation of representatives from member states working toward developing an international culture of safety surrounding maritime industries around the globe (IMO, 2011).

The technical committees are made up of jurisdictional members such as Transport Canada (the Canadian regulatory body) and similar organizations of other member states, and interest groups like the Cruise Line International Association (CLIA) and the International Life-Saving Appliance Manufacturer's Association (ILAMA), cruise ship operators, oil companies, and others. Stakeholders from these groups make up the membership of the committees that create and revise the many different IMO regulations, including those outlined by the Safety of Life at Sea (SOLAS) convention. Of particular importance to the work of the IMO with regard to safety at sea is the Marine Safety Committee (MSC). Notably, this body has contributed a great deal of work aimed at standardizing regulations and recommendations for lifeboat operation and training.

An examination of the various standards and regulations regarding lifesaving equipment and training processes highlights the lack of requirements for weather-related conditions within training, testing, and drills. Ironically, the IMO Guidelines for Arctic Shipping recommends that each vessel of 500 gross tonnage (GT) or more, engaged in international voyages, has a person on board who is familiar with ice navigation and is certified under the Standards of Training, Certification, and Watchkeeping for Seafarers (STCW) Convention (IMO, 1978). For example, Transport Canada sponsored the development of a course in international ice navigation to support and produce safe and effective training for those charged with navigating vessels through ice-covered waters (Tucker et al., 2006). Other member states also offer ice navigation courses, such as Norway, Latvia, and Russia. Unfortunately, this ice navigation training is limited to standard vessel operations and does not extend to lifeboats and other evacuation systems.

The STCW Convention guides member states, holding them accountable for maintaining and ensuring that training, certification, and any other procedures related to the convention undergo quality assurance processes (Drown, 1996). As Patterson (2007) highlights, the STCW Convention sets out initial and refresher training for seafarers, while the SOLAS Convention is the body that governs regulations for safety drills onboard vessels. The IMO recommendations for offshore oil and gas platform regulations are covered in the Assembly Resolution A. 891 (21) "Recommendations on Training of Personnel on Mobile Offshore Unites (MOUs)". Patterson (2007) provides a detailed description of the STCW Convention and the training standards that the IMO has set. It is up to individual member states of the IMO to adhere to these standards and to meet the regulations through their own state agencies. For states with operations in northern and Arctic waters, providing practical training for all weather conditions is very difficult and comes with a high level of risk.

Maintaining compliance with the STCW Convention (1978, 1995) and The Guidelines for Ships Operating in Polar Waters (2002a) has become increasingly difficult due to the risks associated with performing training and drills in rough seas, wind conditions and/or in ice-covered waters. While the MSC/Circ 1056 identifies the need to adequately address environmental issues unique to operations in Arctic and northern waters, such as ice recognition, navigation, and changes to standard operations due to ice-covered waters, it does not provide technical direction as to how this should be done. Although it is only a guideline, and does not mandate members to follow the given recommendations, there is speculation that it will become incorporated into new polar environment operating guidelines (Simões Ré, Veitch, & Spencer, 2010). This, along with forthcoming changes to allow for simulator training within the STCW Convention, should work toward improving the skills of coxswains operating lifeboats in ice-covered waters.

As Simões Ré et al. (2010) point out; the IMO/SOLAS standards do not include any information or guidance pertaining to ice-covered environments lifesaving appliances (LSAs), thereby providing a real operational challenge for vessels and installations operating in northern and Arctic waters. More specifically, this gap affects crews when they are training for EER in harsh environments (Veitch, Billard, & Patterson, 2008a). Providing practice and skill building in adverse conditions is challenging as it poses danger for individuals involved (Simões Ré et al., 2010). The STCW Convention was revised in 1995, and changes were made to a number of regulations and recommendations, including possible inclusion of simulator-based training within the curriculum. Prior to 1995, little was published about the utility of maritime simulators for skill acquisition and trainee assessment. This changed when the United States (U.S.) and the United Kingdom (U.K.) brought position papers to the IMO for the purpose of information sharing (Drown, 1996). Most recently, the IMO has introduced the 2012 Manila Amendments to the STCW Convention. These amendments contain improved guidelines on modern educational methods, such as distance and web-based learning. As well, there is improved training guidance for those who are working on ships operating in polar waters (IMO, June 2010).

2.1.1:Escape, Evacuation, and Rescue training standards and guidelines

An examination of the various standards and regulations for the use of lifesaving equipment reveals a lack of requirement for training, testing and drills for adverse weather-related conditions. Totally Enclosed Motor Propelled Survival Craft (TEMPSC) has been designed as a temporary safe haven in the EER process. It is expected that many of the emergency evacuation situations in northern and Arctic environments will likely occur in harsh weather and ice-covered water conditions. Research has shown that TEMPSC operations can be negatively affected by environmental conditions (Robson, 2007), yet these findings have not necessarily been considered when describing the craft's operational limits. Exposure to wind and wave conditions, along with launching and navigating away from the vessel or installation through ice or debris, is generally absent from international training standards.

The Atlantic Canada Offshore Petroleum Agency (2010) defines the Survival Craft Coxswain course objectives as the following: "To provide designated personnel with theoretical and practical training that will enable them to take command of rigid and inflatable survival craft during abandonment" (p. 3-42). Inherent in this objective is the idea that once trainees have experienced the practical training and passed the certification standards they are able to manage an evacuation craft. However, this does not include any training in adverse environmental conditions, as this poses risks to both trainers and trainees. Hill, Dobbins, and Myers (2009) describe the coxswain as the person responsible for determining the operational limits of a lifesaving craft, such as a TEMPSC, along with the safety and security of those aboard. The coxswain is also in charge of route planning, taking into account sea and weather conditions. Given these responsibilities, this should further underscore the need for adding a form of training that exposes coxswains to a variety of environmental situations.

International stakeholders, through conventions such as SOLAS, recognize the dangers associated with practical drills for lifeboats that have resulted in injuries and fatalities to personnel involved (Oil Companies International Marine Forum 1994, Marine Accident Investigations Branch Safety Study 1/2001). In light of this, regulations have been redefined for these processes, and, through amendments to SOLAS, the requirement for launching full complement lifeboats has been removed for participant and asset risk reasons (IMO, 2006b). The responsibility of whether or not to perform lifeboat drills now lies with the Vessel Master or Offshore Installation Manager (OIM), depending on the environmental conditions (Patterson, 2007). This, along with the drastically decreased confidence of crews in the safety and practicability of lifeboat drills, has contributed to a culture of fear and unease surrounding them (Ross, 2006).

Currently training for TEMPSC operators is undertaken in harbors and sheltered ports under relatively benign conditions, because conditions more representative of extreme maritime environments (e.g. wind, waves, and ice) may pose unnecessary risk to trainers, students, and assets (Veitch, Billard, & Patterson, 2008b). The Health and Safety Executive (HSE) of the U.K. has highlighted the problem presented by employing testing requirements based in calm conditions from the perspective of those required to operate a vessel in all weather conditions. However, despite the fact that the IMO has made revisions to facilitate safe and effective operations of TEMPSC, the changes have not covered training procedures for the types of volatile situations that are common in northern and Arctic environments (Robson, 2007; Bercha, 2003).

2.1.2: Training Regimes for Coxswains

The STCW Proficiency in Survival Craft course for coxswain certification offered in Canada generally takes 5-12 students at a time to ensure everyone has adequate time to become acquainted with the craft. It is possible that the smaller class sizes provide each student with more time to practice their skills if needed (G. Small, personal communications, 2011). In both cases, the variability in course delivery may instill confidence in participants if they are able to easily and quickly demonstrate the necessary competence immediately, with very little repetition and practice. Without directed guidelines from regulatory bodies regarding the process necessary to achieve the desired competencies, the sense of confidence may be misguided. This highlights the need for more specific direction for how to facilitate training, especially as simulator training becomes more popular. It is imperative for EER situations that training be as close to the real environment as possible (A. Simões Ré, personal communications, 2010). Emergency response training, like many other critical areas where simulation training plays an important part of skill acquisition, prepares trainees for life or death situations. Choosing the wrong action sequence could have disastrous consequences. Failure to provide a realistic environment and adequate practice could result in trainees having less confidence in their abilities; as well, it could lead to longer times for completing the procedures associated with emergency situations. Research has demonstrated that the realism of a practice situation can help improve behavior patterns for the EER sequence (Hytten, 1989).

Robson (2007), for the HSE has determined that current prescriptive lifesaving craft standards should evolve to performance-based regulations, which they define as "relating to the purpose of the system, item of equipment, procedure etc. which they describe. They may be described in terms of functionality, survivability, reliability and availability. They should be measurable and auditable" (p. 22). This change in approach towards regulation adherence is more in accordance with the shift from theoretical knowledge to practical knowledge and proven competence reported in the ISO 19906 standards towards EER. Simulator training could be effective in filling the gap regarding training in harsh and dangerous conditions, complementing the theoretical and physical training participants already receive with current coxswain training (Muirhead, 2006; Patterson, 2007; Rose, 2000). Barber (1996) notes that there is very little recent research examining the transfer of simulator training into real life in the maritime field.

2.2:Current Uses and Mediums of Simulator Training

Saus, Johnson, and Eid (2010) suggest that simulation training could be used as a means of improving maritime health and safety. Their research demonstrated that situational awareness (SA) could be improved through simulator training, especially in novice operators. As poor SA contributes to stress levels in both low and high work load situations, Saus et al. (2010) advocate for the design of training to facilitate improving SA, since this could lead to greater prevention of human error. This supports their idea that simulation training can contribute to an enriched work environment. Muirhead reported in 1996 that there were 810 maritime simulators being used worldwide for maritime training purposes (1996). It may be suggested that improvements in technologies, decreasing costs, and changes to the regulatory regime are likely responsible for this growth.

Simulation training platforms can range from personal computer-based interfaces to full mission, immersive simulators. Simulator training can take the form of devices such as driving units (Jannick, et al., 2008), head mounted display (HMD) systems (Richardson &Waller, 2007), or medical based simulation-training devices, such as the Procedius Abdomen for simulating laparoscopic surgery (Strom et al., 2006).

2.2.1:Maritime Simulator Applications

Through Section A of the STCW Convention, the IMO has made simulator training mandatory for Radar/Automatic Radar Plotting Aids (ARPA) training. Any other form of simulation training is only recognized through general recommendations, under guidelines in Section B. It is believed that this is mainly due to the fact that many member states do not possess the facilities or capabilities for simulation training (Drown, 1996; Muirhead, 1996), possibly due to the lack of physical and financial infrastructure within training institutions. As discussed earlier, broader recognition of various forms of simulator training may be more widely recognized by the IMO as amendments to the STCW Convention occur in 2012. Code A, which is the mandatory part of the STCW Convention directed towards simulator training, points out (Table A/II, Muirhead, 2006) that those who navigate ships of 500 GT or more must be able to handle the vessel in all weather conditions, yet they only need to possess the theoretical knowledge.

2.2.2:Simulation Instruction Issues

When examining skill acquisition for a particular skill set, course design must consider skill development from many different perspectives. Gallagher et al., (2005) discuss the fact that a prescriptive approach is favored in simulator training in the medical field. This approach allows for trainees to perform a given task a predetermined number of times in order to fulfill requirements, instead of carrying out assessments using a performance-based standard. However, their research cautions that this approach could be very detrimental to skill development. Thus, it is something that maritime educators, classification societies, and regulators must be aware of as simulator training becomes more widely accepted. Given the Manila amendments coming into place in January 2012, the risk of settling for skill acquisition through meeting prescriptive milestones could become a reality.

Since the 1980s, Gynter et al. (1982), along with other researchers in the maritime field, have indicated that the role of the instructor is the most important contributor to the success of simulation training outcomes. Various institutions around the world offer courses for instructor training, such as the IMO (Model Course 6.09), World Maritime

University (Sweden), Integrated Simulation Centre (Singapore), and the Regional Maritime Academy (Ghana). While these courses exist, and further partnerships have been developed between institutions through bodies such as the International Maritime Lecturers Association (IMLA), very little reference material exists for those who are charged with instruction and assessment in maritime simulation training courses (Drown, 1996; Ali, 2007).

Ali (2007), Muirhead (1996, 2006), Barber (1996), and Drown (1996) agree about the pedagogical elements that must be met to maintain the integrity and success of simulation training. Ali (2007) reviews the amendments to the 1995 STCW Convention and the move by various institutions to create courses to prepare instructors for simulation training. Muirhead (2006) shares the course outline for a Professional Development Course held at the World Maritime University (WMU). The course (Table 2-1) was designed to approach the vague terms set out by the STCW Convention regarding instructor and assessor qualifications and experience. Other institutions have since followed suit, such as the "Train the Trainer" course developed at the Integrated Simulation Centre in Singapore (Ali, 2001).

Table 2.1:WMU's Simulator Instructor Course (Muirhead, 2006)

Syllabus for Simulator Instructor Course
STCW95 and use of simulators
Competency based training
Training process
The role if instructor
Course design
Exercise development
Pre-briefing techniques
Simulator familiarization
Monitoring and recording activity
De-briefing techniques/feedback
Assessment process
The role of assessor
Feedback/performance evaluation
Validation

Barber (1996) echoes Muirhead's suggestions on certain aspects that should be developed by all instructors carrying out simulator training and assessment. Notably, the debriefing and provision of feedback could be seen as the most important part of this process (Barber 1996; Muirhead, 2006), as it enables trainees to reflect on how they can improve in the future. Drown adds to this discussion through an identification of the characteristics an instructor should possess, consisting of knowledge of simulator technology and its application, training capabilities, and objectives delivered through the simulator (1996). In addition, he suggests that these characteristics should be coupled with professional experience with simulation, ideally with the specific simulator, as well as educational and psychological training (p.251). Recognizing the role of the instructor in contributing to the success of simulator training can aid in the development of high-level simulator course material.

2.3:Reported Costs, Benefits, and Future Uses of Simulator Training

The IMO's MSC Circular. 1136 (2004) identifies the unacceptably high level of risk associated with lifeboat drills, while still recognizing the importance of drills to gain experience in lifesaving system evacuation. In particular, this document distinguishes the benefit of simulation training in providing a realistic and safe environment for free-fall lifeboat training. Through this submission of the usefulness of simulator training, opportunities could arise for the training realm, ushering in the possible acceptance of onboard desktop simulation.

In the last 50 years, simulation training has emerged in a number of different vocations as a potentially safe and effective alternative to traditional physical training. It may be proposed that simulation training can provide obvious training benefits. Also, such an environment can be used to assess other learning aspects such as the capacity for developing and measuring situational awareness (Saus et al., 2010), visual-spatial ability (Kewman et al., 1985), and time-performance gains (Aggarwal al., 2006). Ultimately, the level of skill transfer to real environments is critical in examining the effectiveness of simulation training (Seymour et al., 2002). Rose et al. examined learning and performance between virtual and real-time training, and results from this research show that those who completed virtual task training were less likely to be affected by unexpected interruptions than those who completed real task training (2000).

Current technology has developed beyond desktop and partial task simulators to include fully immersive simulators. Using this medium of training would allow crew members to demonstrate and practice their knowledge of managing situations occurring in adverse weather and ice-covered waters in safe conditions. In other words, simulation training eliminates risks that would normally be associated with attempting drills in adverse environmental conditions (Patterson et al., 2011). Additionally, increasing crew knowledge and competence toward the handling of lifesaving appliances in a variety of conditions could serve to increase their confidence, like studies in medicine have shown (Sedlack et al., 2004).

2.3.1:Importance of Developing Knowledge Regarding Simulator Training

Gallagher et al. (2005) reported a lack of empirical evidence of the training effect virtual reality has on surgery skill acquisition. This study also looked at the void in knowledge regarding the most effective manner of using simulation training. These researchers suggested that possible factors that contributed to the lack of technology development for simulation training in the past were due to this lack of knowledge, and an absence of effective application. Strum and colleagues (2008) also support the notion that the existing body of scientific knowledge regarding simulation training for medicine, in particular, must be expanded to reinforce the proof for including and incorporating simulation training into surgical programs. It is noteworthy that the aviation industry paved the way for many other industries to accept simulation training as an effective medium for skill acquisition (Gallagher et al., 2005). Maritime industries could learn from the experiences, and eventual success that the field of medicine has had in integrating simulation training into education curriculum, realizing the benefit it can provide for both the skill building and safety of trainees.

Many experts in the field of maritime education believe that simulation training can replace in-service training for seafarer certifications (Ali, 2007), with one month of sea service being replaced by one week (40 hours) of simulator time (Drown, 1996). Yet, there are those who believe simulator training can never replace the real experience of physical training (Muirhead, 1996), or that it can only enhance physical training (Drown, 1996). Muirhead reports (1996) that many watch keepers and senior maritime officers do not have the chance to acquire key skills, due to both safety and operational factors (p. 259). He believes that simulators may be able to aid in bridging this training gap. These researchers believe that there is an opportunity to fill this gap through simulator training, and thereby effectively allow maritime workers to acquire and maintain skills in a safe manner.

2.3.2:The Importance of Skill Development through Simulator Training

Signorini (As cited in Drown, 1996) defines competence as "a carefully thought-out quality approach to ensure personnel have knowledge, skill, experience and personal qualities" (p. 249). In 1995, the STCW Convention amendments moved from knowledge milestones for training certifications to the need for proven competence in a specific skill set for certification purposes (Drown, 1996). Questions arise to the extent of which simulators can be used for measuring competency, for both effectiveness (USCG, 1993) and evaluation quality (Drown 1996). Although maritime simulators may not be able to evoke the complete psychological and physical response that a real emergency situation would, when properly designed, simulators can create an environment that can illicit pertinent mental and physical responses (Drown, 1996; Saus et al., 2010).

It is important that when competency and continued proficiency are desired results from simulator training, as prescribed in the STCW Code A, that the simulators in question are appropriately validated for system performance, student performance (Muirhead, 1996), and instructor assessment (Barber, 1996; Drown, 1996; Ali, 2007). Muirhead (1996) suggests that outcomes must be based upon real world shipboard operations through criterion-based goals (p. 263). Experts in the field of maritime simulator education agree that having a trained instructor and assessor is very important to the delivery and validity of simulator instruction (Barber, 1996; Drown, 1996). In fact, Muirhead (1996) takes this a step further in proposing that those who are in this position should have formal simulator training certification themselves. Member states, through institutions such as World Maritime University (Sweden), United States Coast Guard (U.S.), and Transport Canada (Canada) have been leaders in the development of instructor courses for simulation training (Ali, 2007; Patterson, 2007).

Another important consideration for the benefits of simulation training is the ability to provide refresher or continuance training on board vessels and installations, so that students are able to continually practice the skills they have gained (O'Hara, 1990). Simulator training is able to assist in the development of behavior patterns that students can use as a basis if they are in an emergency situation (Hytten, 1989). Muirhead (1996) defines "skill" in the simulator context as "the combining of mental and physical dexterity in the face of audio and visual cues to perform tasks to meet specific objectives" (p.259). The idea behind skill acquisition in a simulator is that the skill set and behavior developed would translate into real life situations. The possibility of maintaining skill development and acquisition through at-sea training could give trainees an opportunity to have more frequent and recurrent training. Research suggests that continued skill development past the first successful demonstration of a skill set can lead to a better grasp of the desired tasks (Taber, 2010).

2.3.3:Fidelity in Simulator Training

Simulating emergency situations, whether through physical simulation such as the Helicopter Underwater Emergency Training (HUET) for offshore workers or conventional lifeboat training and free-fall simulator lifeboat training for coxswains, can contribute to confidence in performance and survival (Hytten et al., 1989). Although researchers disagree on the level of fidelity required for a simulator to deliver expected learning or skill acquisition outcomes (Dahlstrom et al., 2008), using a simulator to train for dangerous and emergency situations has been shown to give trainees an increased sense of confidence and level of competence towards future performance (Chopra et al., 1994). Simulator training offers the benefit of delivering immediate performance feedback, and also allows for repetitive exposure to stimulus (Scalese et al., 2007). Gallagher and colleagues (2005) highlight the importance of simulator training for error feedback, as a participant will know the results of their actions immediately and experience realistic consequences associated with their choices without any real harm experienced.

Studies in medicine, specifically in the field of surgery, suggest that higher fidelity virtual reality demonstrates better transfer of skills for surgery than lower fidelity systems (Gallagher et al., 2005). Dahlstrom and colleagues (2008) disagree, stating that the fidelity of the virtual reality does not correlate with the skill transfer. Both studies would agree, however, that low-cost simulators could be very effective in providing an environment for skill transfer. Ultimately, training can only go so far in preparing trainees for future situations they may face. Simulation training can advance the capabilities of personnel when faced with emergency situations through practicing various scenarios, developing a generic skill set that will help prepare them for demanding situations in the future (Dahlstrom et al., 2008). Research also suggests that resilience could be learned through simulator training, allowing for crews to use the skills they have gained in training for slightly different situations effectively and efficiently. It is important to address the fidelity debate, which has divided researchers along the lines of high fidelity versus low fidelity. On one hand, Dahlstrom et al. report that the reaction the simulator provides to a student's behavior is more important than the realism of the environment (Heeter, 1992, as found in Dahlstrom et al., 2008). On the other hand, Dahlstrom et al. also suggest that the more realistic the environment, the better the learning transfer (2008).

2.3.4:Maritime Simulator Training Certification

Industry, as opposed to regulatory bodies, has moved regulation, specification, and classification of simulators ahead in the last 10-15 years. Classification societies (e.g. DNV) have taken it upon themselves to publish standards for simulators (Standard for Certification No. 214 for Maritime Simulator Systems, 2011) as one way to fulfill the requirements set out by the STCW code (Muirhead, 2006, DNV, 2011). Kongsberg, a Norwegian company, has begun a project from a user-directed perspective that will examine simulation from a human factors point of view. As reported in Safety at Sea International, the company believes that aspects of human factors in simulation training are very important when examining and assessing the effectiveness of the training (January, 2011).

The U.S. Navy recently released a plan for training extending into 2015, through the National Training and Simulation Association. This document highlights the reduced costs that could be associated with simulator training as a complement to traditional training. In fact, they estimate that the cost of simulation training is substantially less than real-life training, with estimates predicting that it could be as low as 10% of the cost of traditional approaches (Navy: Training 2015, p.17, 2010). However, is it important that costs do not become the main driver for simulator training. The focus should remain on efficiency and ability of simulators to train and prepare people for future situations.

2.4:Summary

Many experts in the field of maritime safety acknowledge the benefits of simulator training, yet few studies have examined the skill acquisition and performance outcomes of such training (Saus et al., 2010, Barber, 1996). Research has determined that both high and low fidelity simulators can contribute to positive learning outcomes (Dahlstrom et al., 2008; Saus et al., 2010). Desktop simulators are currently used in a variety of fields (Raby, 2000), and accompanied with new and emerging technologies mentioned above, with significant research and development from various partners, a range of learning styles could be easily met. As technology for simulation training improves, it is integral that research moves at the same pace, examining the educational and real-life effects and outcomes of simulator training.

Chapter 3 : Methodology

This research employs an experimental method to examine outcome participant performance and experience during navigation of a lifeboat through a simulated ice field. Three groups of novice coxswains underwent various training regimes to prepare them for these tasks.

3.1:Subject Recruitment

Nineteen participants were recruited (Appendix A) to participate in this study and ranged in age from 19-35 years. Participants were required to have no previous experience operating small marine crafts. They had to meet the following experimental pre-requisites:

1) Not current holders of STCW lifeboat training certification
2) Little sensitivity to cold and motion sickness
3) No health conditions that could be aggravated by increased anxiety
4) Lack of pre-existing heart or lung conditions that impair physical activity
5) Lack of pre-existing muscle or skeletal conditions that limit mobility
6) Ability to swim
7) Comfortable over water
8) No fear of enclosed spaces

All subjects completed the Physical Activity Readiness Questionnaire (PAR-Q) (Appendix B) and gave written consent (Appendix C) to participate in the study. The Human Investigations Committee at Memorial University of Newfoundland and the National Research Council Research Ethics Board granted ethical approval for this study.

3.2:Training

3.2.1:Pleasure Craft Operator's Course

In accordance with Transport Canada regulations, subjects were required to successfully complete the Pleasure Craft Operator's Course prior to any lifeboat training and operation. The course outlines basic safety at sea procedures for those operating a pleasure craft outfitted with a motor and used for recreational purposes. An approved training provider delivered training and all participants were issued official certifications upon successfully completing the course.

3.2.2:Group assignment

Each participant was randomly assigned to one of the three groups (Table 3-1). Training took place over a two-day period.

Table 3.1: Group Assignment

	Group 1	**Group 2**	**Group 3**
Training	STCW	STCW + ice briefing	Ice briefing + Simulation training
Number of Participants	6	7	6

3.2.3:Standard Training

Group 1 and Group 2 were trained based on the STCW convention from the IMO. An instructor, from the Marine Institute's Offshore Safety and Survival Centre in St. John's, Newfoundland, delivered curriculum on the STCW components of lifeboat navigation and maneuvering (Appendix D). This was a three-hour classroom session, complemented with a three-hour session in a Schat Harding lifeboat, giving each participant practical experience with the lifeboat, in calm, open water conditions in St. John's Harbour. This lifeboat contained a coxswain station quiet similar to the one used for the test program.

3.2.4:Classroom Briefing on the Theory of Navigation in Ice Fields

The two-hour classroom briefing on the theory of navigation in ice fields was conceived and delivered by a STCW trained research collaborator. This curriculum was based on information from the Canadian Ice Services, along with the instructor's personal and professional experience in ice navigation. Notes were provided to students for their reference (Appendix E). This information was provided to Group 2 and Group 3.

3.2.5:Simulation Training

An instructor from Virtual Marine Technologies (VMT) provided a three-hour simulator training session for participants in Group 3 after their classroom briefing on ice navigation. Each participant spent approximately 30-minutes navigating the simulator. This was approximately the same amount of time Groups 1 and 2 navigated the lifeboat within the Harbour. The davit launch lifeboat simulator (Figure 3-1) is a full mission class "S" training simulator, approved by DNV and fulfills the STCW Chapter 2 requirements for compliance and competency.

Figure 3-1: VMT "S" Class Simulator

The simulator measures 1.98 m high x 1.82 m long x 1.55 m wide (Appendix F), representing a generic davit launch lifeboat with all the operating controls to launch and maneuver a lifeboat, including an ignition switch, battery switch, steering wheel, compass, and radio. The instructor's station gives the instructor the ability to apply a number of different variables to the training scenario including time of day, visibility, weather, seas state, location, and ice-coverage. For the purpose of this study, the ice-coverage was set at 1/10ths coverage. In the simulator used for this study, when a participant committed an error that would result in significant "virtual" damage to the vessel, the simulation program ended. At this time there is no physical response incorporated into the simulator to react to crashing into an object, whether an ice flow or the side of a rescue vessel. However, a visual response shows the participant they encountered a situation that could possibly cause harm to the lifeboat.

The visuals for the simulator were presented to the user through four 82 cm liquid crystal display (LCD) screens, consisting of four different views: port, starboard, bow and stern (Figure 3-2). The visual angles measure greater than 45 degrees. The sound system was a 5.1 Dolby Digital surround sound system. The simulator was set up with an instructor station that enabled the instructor both to monitor what the participant sees and control the simulation scenario (Figure 3-3).

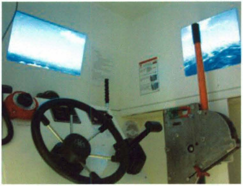


Figure 3-2: Inside the simulator, bow and starboard view

Figure 3-3: Simulator Classroom

3.3:Testing

3.3.1:Test Field

North Arm Bay, Holyrood, NL, (Figure 3-4) was chosen as the testing location for the simulated ice field. This location was selected for the medium depth of the water (between 8-20 metres) for securing the obstacles to the seabed, the protection from exposure to the elements to attempt to provide some control in the environmental variability, and the availability of wharves for setting up test equipment.

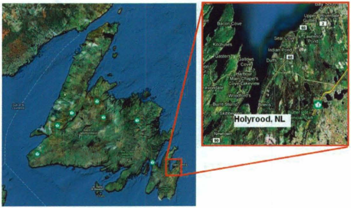


Figure 3-4: Map of Newfoundland with Holyrood highlighted

Research team members designed the ice-field for the test program (Figure 3-5).The test field (Figure 3-6) was set-up to simulate an ice field with a 1/10ths concentration (i.e. 10% of the water surface was populated).

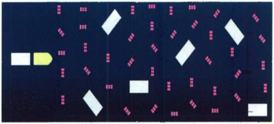


Figure 3-5: Concept drawing of 1/10ths ice-field

Figure 3-6: Actual test field in Holyrood, NL

This concentration was chosen because of the visibility experienced from the point of view of the coxswain (Figure 3-7), which is seen as denser than the aerial view of the field (Figure 3-5).

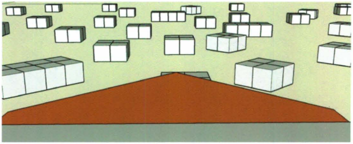


Figure 3-7: Google Sketch-Up drawing of ice-field between 1/10ths and 2/10ths ice-cover from coxswain's view.

The test field was created using plastic barrels (Greif, Belleville, Ontario) and wooden docks (JetFloat, Guelph, Ontario), anchored to the sea bottom. The smaller artificial ice pieces (Figure 3-8) were created using three 190 L barrels strapped to a yoke and ballasted with seawater to one third of their total volume.

Figure 3-8: Smaller ice pieces created from barrels

The larger artificial ice pieces were created using custom made aluminum platforms attached to small floating docks (Figure 3-9).

Figure 3-9: Larger artificial ice pieces built of docks and platforms

3.3.2:TEMPSC – Lifeboat

The TEMPSC lifeboat (Figure 3-10) used in the field trials was manufactured by Beihai Shipyard, China. It was purchased as an IMO-SOLAS survival craft rated for 20 occupants but has since been retrofitted as a research craft and no longer holds type approval.

Figure 3-10: NRC-IOT TEMPSC during Field Trial preparation

The dimensions of the lifeboat are: 5.28 m (length), 2.20m (width), 2.7 m (height) and 1.10 m (molded depth to the gunwale). For a more detailed description of the engineering capabilities of the lifeboat, the reader should refer to Kennedy, Simões Ré & Veitch (2010). Throughout the data collection period there were two trained coxswains inside the lifeboat with the participant for safety purposes. The lifeboat was ballasted for full complement with three occupants and 40 sand bags, which corresponds to a mass of ≈3800 kg. The throttle was set at an idling speed for all runs, but speed varied slightly over the duration of the test period due to changes in wind, waves, and current speed. During trials, the hatches of the lifeboat remained closed in order to maintain an environment for navigation that would be similar to one that may be faced in a real life evacuation situation.

3.3.3:Instrumentation

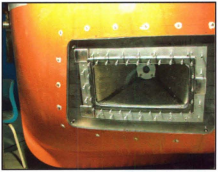
Data collection was monitored remotely from the shore (Figure 3-11).

Figure 3-11: The shore set-up for data collection

Measurements collected during this study included lifeboat parameters described in Table 3-2. Through conversion of the differential global positioning system (DGPS) data into Northing and Easting measurements, the course over ground could be determined for each run. Eight cameras were secured inside (two) and outside (six) of the lifeboat (Figure 3-2) to get a complete view of the lifeboat surroundings, the course, and the collisions the lifeboat made during each run.

Figure 3-12: Bow view from the TEMPSC video system

Two of the cameras were placed within the cabin, to view the impacts the lifeboat made. This was done from a camera mounted behind an impact panel located in a sea chest on the port side near the bow (Figure 3-13). The other camera focused on the participant driving the lifeboat (Figure 3-14).



3-13: View of the impact panel, where a camera is located in the lifeboat interior.

Figure 3-14: Camera view of participant inside TEMPSC

The outside cameras were positioned to look at the bow and stern (Figure 3-12). Two were positioned to look at the port and starboard bow, and two were at the port and starboard quarters. The other two cameras were mounted on the coxswain's tower, one positioned to look forward and one to look aft.

3.3.4:Measurements

This experiment set out to examine whether simulation based training can be adopted as a valid supplement for standard physical lifeboat training. Two different measures were used for testing parameters: navigation performance factors and questionnaires assessing subject perceptions.

3.3.4.1: Performance Measures

Table 3-2 details the measurements obtained through a data acquisition system in the lifeboat and used to calculate the variables indicated.

Table 3.2: Measurements of TEMPSC performance during field trials

Performance Measure	Derived Variables	Description
Position and Heading	Path Length, Pass & Fail Rate	Latitude and longitude in the X and Y Cartesian planes (degrees).
Time	Time through course	Measured in s.
Craft accelerations and rates	Number and Severity of Impacts	Measured in $m \cdot s^{-2}$ in the X(longitudinal), Y(vertical), and Z(transverse) directions converted to g.
Craft global loads	Number and Severity of Impacts	Derived from force = mass · acceleration (f=m·a).
Craft local loads	Number and Severity of Impacts	Measured with impact panel, X and Y accelerations ($m \cdot s^{-2}$) and forces (N).
Steering	Steering Nozzle Executions	Through steering nozzle executions (degrees).
Course over ground	Path Length, Pass & Fail Rates	Measured by differential G.P.S. ($m \cdot s^{-1}$ and m).
External lifeboat video	Number and Type of Impacts	Head on and glancing impacts.

3.3.4.2: Data Analysis of Performance Measures

Path Length and Pass & Fail Rates were collected from calibration of the position and heading measurements, along with the calculation of course over ground, and then organized into run direction and group assignment. Each run was plotted and visually examined for the correct execution of entry and exit points (Figure 3-15).

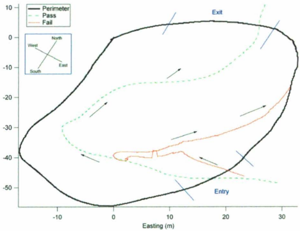


Figure 3-15: Pass/Fail plot

From the impact panel and motion pack installed in the lifeboat, local forces were measured at the bow to determine the impacts loads, which were given in units of g, where 1 g=acceleration due to gravity. The impacts were verified through three different methods. First the impacts were computed (Figure 3-16), filtered at a low pass level of accelerations over 0.10 g, to ensure that impacts registered were with obstacles. The impact indicated in Figure 3-15 is shown to be 0.12 g, as an example. Then the X (red) and Y (black) accelerations were examined to verify the time and magnitude of the impact (Figure 3-17). Impacts were examined for both frequency and intensity to see if this influenced performance during testing.

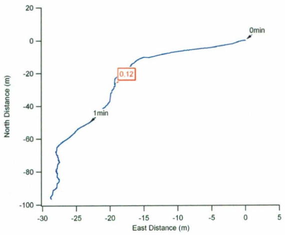


Figure 3-16: Impact Plot

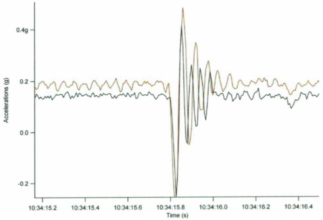


Figure 3-17: Impact verification via graphing X (red) and Y (black) accelerations (g) over time (s)

For real-time observational analysis, the cameras fixed to the outside of the lifeboat provided video recordings for verification. The videos for each run were examined visually (Figure 3-18 and 3-19).

Figure 3-18: Observational analysis for impact verification (Bow Video)

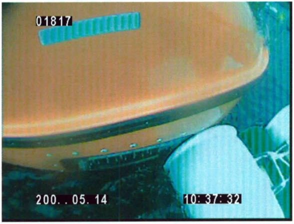


Figure 3-19: Portside Camera view for impact verification

For analysis of the steering data, a procedure using zero crossing analysis was used to calculate the steering nozzle period. An execution was defined as an oscillation between port and starboard. Both the count and time between executions were calculated for each participant for each run, to establish how these measures reflected performance.

3.3.4.3: Psychometric Measurement

The psychometric questionnaires employed in this study were a modified version of the NASA Task Load Index (Perry et al., 2008) and sought to obtain the subjective experience of participants through the testing and training periods, examining their confidence and perceived proficiency of ice-covered water navigation. In total, two questionnaires were administered – one after the participant completed his /her training and the other after testing. Group 1 received general questions regarding lifeboat navigation and maneuvering (Appendix G, Part IA), and for Groups 2, these questions, along with questions regarding specific information on ice navigation (Appendix H, Part IB). Group 3 received both the Group 1 and 2 questions and additionally questions specific to ice navigation and simulator training (Appendix I, Part II). The post-testing questionnaire was the same for all participants, regardless of group assignment, and contained both scale and open-ended questions, in respect to participant's experience during the testing period. Each subject identified a scale score between 1-10, with 1 representing low proficiency or confidence and 10 representing high proficiency or confidence on each question presented (Appendix J). For the open-ended questions in the post-testing questionnaire, the responses were analyzed using classic content analysis (Hsieh & Shannon, 2008). This method examined word frequencies in the responses.

The first questionnaire was given to participants upon completion of their training, and examined their experience with the training they received. The second questionnaire was administered once the participants had completed the full set of runs through the test field. The responses showed how participants perceived confidence and proficiency in what they had done.

3.4: Procedure

Training for participants was provided on May 8^{th} and 9^{th}, 2010. Field trials took place over a five-day period from May 14^{th} -17^{th}, 2010. The maximum possible delayed between training and testing was ten days. For field trails, all participants were provided with transportation to and from the test site. Once they arrived at the test site, they were asked to remain in a room that did not have a window facing the test field, in order to reduce the opportunities for the subject to view the ice-field before their test. They were provided with a laptop computer for movies, as well as snacks and beverages while they waited for their test period to begin. Once it was time for a participant to complete the test program, they were escorted to a trailer where they donned an immersion suit (White's Marine, Victoria, British Columbia) (Figure 3-20).

Figure 3-20: Marine Abandonment Immersion Suit worn by participants

Subjects were then escorted to the lifeboat and given instructions by a member of the research team on how to prepare to enter the simulated ice field. Each participant performed six runs (Table 3-3). The order of the runs was randomized for each participant. Participants were instructed to enter and exit the test field at specified locations (Figure 3-21).

Table 3.3: Directional runs through test field

Run Number	Direction
1	North to South (NS)
2	South to North (SN)
3	East to South (ES)
4	East to North (EN)
5	Northwest to Southeast (NWSE)
6	Southeast to Northwest (SENW)

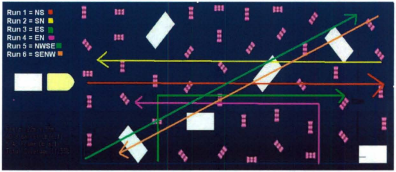


Figure 3-21: Visual representation of runs through test field

3.5:Statistical Analyses

A repeated one-way analysis of variance (ANOVA) was carried out in order to establish if group assignment influenced performance in each directional run. Comparisons included path length, time through course, number of impacts, mean maximum impact severity, and steering nozzle executions between the different group training conditions. Fisher Least Significant Difference tests were used as post-hoc test to determine if any significance existed. For the psychometric and questionnaire data, a Spearman's Rho (rs) correlation was chosen because of the lack of homogeneity of variance within and between subjects.

Chapter 4 : Results

Due to the challenges posed by field work and the costs associated with undertaking such research, statistical interpretations will be liberal. *P* values <0.05 will be considered to identify statistical significance and *p*< 0.10 will be considered to approach statistical significance and interpretations of these data are undertaken.

4.1:Performance Data

A qualitative, graphical analysis was utilized to examine the path through the course, relative to the pre-described entry and exit points (Figure 3-15). Depending on the course navigated, each participant was given a pass or fail for each of their six runs (Table 4-1).

Table 4.1: Pass/Fail Rates by Group Assignment

Group	1	2	3
Total runs	36	42	36
Fails (%)	28	29	11
Passes (%)	72	71	89

There was a significant association between the type of training and whether or not the participants successfully completed the trial (Appendix K, $\chi 2$ (1) = 13.95, p=0.001). The raw data can be found in Appendix L. These data suggest that the chance of participants having a passing attempt was 3.35 times higher if they were trained using a simulator rather than undertaking the standard STWC or STWC and theoretical ice navigation training.

The runs were examined from both a directional (Table 4-2) and order of execution perspective (Table 4-2) to examine if there was a learning effect. This examination showed that there did not seem to be a learning effect throughout each participant's test period.

Table 4.2: Number of Failed Runs by Direction

	Run					
Group	NS	SN	ES	EN	NWSE	SENW
1	1	3	2	1	2	1
2	1	3	4	2	0	2
3	0	1	0	1	1	1
Total:	2	7	6	4	3	4

Table 4.3: Number of Failed Runs by Order of Attempt

	Run					
Group	1	2	3	4	5	6
1	0	1	3	2	3	1
2	0	2	2	5	2	1
3	0	1	0	2	1	0
Total:	0	4	5	9	6	2

4.1.1:Path Length

The path taken through the course, derived from position, heading, and course over ground information, was examined in two different ways. First, the mean path length per group per run was calculated (Table 4-4).

Table 4.4: Mean (SD) Path Length (m) through the course

	Path through course (m)		
Run	**Group 1**	**Group 2**	**Group 3**
NS (p=.036)	64.55(1.74)	64.97(1.39)	69.66(5.72)
SN (p=.088)	57.44(13.14)	65.55(3.83)	68.24(5.06)
ES	61.10(3.52)	63.76(8.94)	60.93(7.47)
EN	64.85(8.29)	65.71(10.05)	68.88(9.21)
NWSE	64.81(4.50)	66.65(5.06)	64.93(4.73)
SENW	63.23(6.57)	61.73(9.38)	66.30(9.53)

An ANOVA (Appendix M) was performed and revealed that the path length taken by Group 3 trained participants (p=.036) was significantly longer than the other groups. Post-hoc analysis showed that Group 3 trained participants showed a longer path length than those in Group 1 training (p= 0.021) and Group 2(p=0.027) for the NS run. For the SN run, the ANOVA showed that Group 3 showed a significantly longer path through the course (p=0.088). Post hoc analysis (Appendix M) showed that it is significant compared to Group 1 training (p=0.037).

4.1.2:Time in Course

Since the vessel speed was governed throughout the trial, only the time taken to complete the course was assessed. The mean time through each trial is presented in Table 4-5. A one-way analysis of variance was performed on the data, but no statistically significant differences were found.

Table 4.5: Mean (SD) of Time in the course (s)

	Time in course (s): Mean (SD)		
Run	**Group 1**	**Group 2**	**Group 3**
NS	63.07(7.13)	71.43(7.60)	71.38(17.73)
SN	69.34(34.62)	68.93(13.92)	73.12(11.65)
ES	64.99(8.74)	74.39(20.05)	70.20(18.12)
EN	93.18(47.27)	81.20(28.26)	77.84(13.48)
NWSE	67.78(5.90)	71.09(14.34)	69.24(9.36)
SENW	63.73(10.09)	69.19(21.73)	70.83(10.94)

4.1.3:Impact Data

Table 4-6 shows the mean and standard deviation values for the number of impacts for each group through all 6 runs. These values were derived from the craft accelerations and the impact loads on the craft.

Table 4.6: Mean (SD) of Number of Impacts (g) through the course

	# of Impacts: Mean (SD)		
Run	**Group 1**	**Group 2**	**Group 3**
NS	1.5(0.84)	3.14(2.12)	3.00(1.90)
SN (p=0.104)	4.00(1.55)	2.43(1.51)	2.17(1.47)
ES	3.33(1.86)	3.71(1.89)	3.50(2.17)
EN	4.17(2.48)	4.29(1.80)	4.50(1.05)
NWSE	4.33(1.21)	3.00(2.58)	2.00(1.10)
SENW	3.83(2.48)	2.71(1.38)	2.17(2.04)

Group 3 participants tended to have fewer impacts than Group 1 participants. The ANOVA revealed no significant differences for the impact severities that occurred during the test period (Table 4-7).

Table 4.7: Mean (SD) of Maximum Impact Severity (g)

	Mean (SD) Maximum Impact Severity		
Run	**Group 1**	**Group 2**	**Group 3**
NS	0.26(0.13)	0.29(0.08)	0.19(0.08)
SN	0.26(0.08)	0.23(0.15)	0.16(0.09)
ES	0.19(0.05)	0.26(0.11)	0.27(0.11)
EN	0.31(0.08)	0.27(0.12)	0.27(0.06)
NWSE	0.25(0.07)	0.27(0.18)	0.31(0.17)
SENW	0.17(0.05)	0.21(0.08)	0.17(0.12)

4.1.4:Steering Nozzle Executions

Steering nozzle executions were used to examine the number of times the participant turned the wheel towards port or starboard (Table 4-8). The ANOVA (Appendix M) for steering nozzle executions demonstrated that for the SN Run (p=0.072), Group 3 participants tended to perform more rudder executions.

Table 4.8: Mean (SD) of Number of Steering Nozzle Executions Performed

	Number of Steering Nozzle Executions/Run: Mean (SD)		
Run	**Group 1**	**Group 2**	**Group 3**
NS	10.31(1.97)	11.71(3.40)	11.50(2.35)
SN (p=0.072)	10.50(1.05)	10.57(2.23)	13.33(3.08)
ES	11.50(3.78)	12.71(2.81)	11.83(3.66)
EN	9.50(2.95)	11.29(6.34)	13.00(1.79)
NWSE	11.17(3.87)	12.14(4.30)	12.00(2.45)
SENW	9.83(2.48)	10.71(3.59)	12.00(4.10)

4.2:Psychometric Data

4.2.1:Post-training questionnaire results

The following questions were examined for the participants' responses on predicted performance based on training. The scale asked participants to report a score between 1-10, with 1 representing low proficiency or confidence and 10 representing high proficiency or confidence on each question presented. Questions 4, 6 and 9 (Table 4-9) addressed the participants' responses to the training they received in terms of lifeboat handling, the effects of weather on navigation and their perceived proficiency in navigating through ice. Questions 10, 11, and 12 (Table 4-10) were for the participants in Groups 2 and 3 who received the ice classroom briefing session.

Table 4.9: Mean Scores from Post-Training General Questions

Question	Group 1	Group 2	Group 3
4: How confident are you in understanding the purpose and effect of a lifeboat's maneuvering controls?	9.2	8.3	6.5
6: How confident are you in understanding the effect waves and wind have on lifeboat maneuvering?	8.5	6.9	6.5
9: How proficient do you feel that if demanded, you could navigate a lifeboat within an ice field?	8	4.9	6.2

Table 4.10: Mean Scores from Post Training Ice-Specific Questions

Question	Group 2	Group 3
10: How well do you think you will be able to navigate through ice?	5.1	6.2
11: Do you feel you would likely sustain damage to the lifeboat in an ice field?	7	6
12: At what maximum concentration of ice do you think you are able to navigate through?	4.3	3.8

Part II of the Post-Training Questionnaire focused on the fidelity of the simulator training participants in Group 3 received. Questions 1-14 (Table 4-11) examined contextual, mathematical and behavioral fidelity.

Table 4.11: Scores from Post Training Simulator Specific Questions

Question	Group 3
1: How responsive was the simulated environment to actions that you initiated (or performed)?	8
2: How natural did your interactions with the simulated environment seem	7.2
3: How completely were all of your senses engaged?	7
4: How much did the visual aspects of the simulated environment involve you?	8.2
5: How much did the auditory aspects of the simulated environment involve you	6.8
6: How natural was the mechanisms that controlled movement through the simulated environment?	7.3
7: How inconsistent or disconnected was the information coming from your various senses?	6
8: How much did your experiences in the simulated environment seem consistent with your real-world experiences?	6.2
9: Were you able to anticipate what would happen next in the simulated environment in response to the actions that you performed?	6.3
10: How involved were you in the simulated environment experience?	7.7
11: How much delay did you experience between your actions and expected outcomes?	4
12: How quickly did you adjust to the simulated environment experience?	6.2
13: How proficient in moving and interacting with the simulated environment did you feel at the end of the experience?	7
14: Did you learn new techniques that enabled you to improve your performance	8.7

4.2.2:Post-Testing questionnaire results

The post-test questionnaire included open-ended questions regarding the lifeboat experience. It included specific questions examining confidence and perceived proficiency.

4.2.2.1: Post-Test Open-ended Questions and Responses

Table 4.12: Responses to Question 1: What were the challenges you faced during testing?

Categorized Responses	Frequency of Response
Visibility Issues	16
Steering related issues	13
Environmental conditions	12
Ergonomic issues	8
Internal environment issues	3
Instruction issues	2

Table 4.13: Responses to Question 2: What would better prepare you to face these challenges?

Categorized Responses	Frequency of Response
More time spent training / practicing	24
Steering and handling ability	5
Visibility	4
Ergonomic issues	3

Table 4.14: Responses to Question 3: What would help prepare you better for the ice trials?

Categorized Responses	Frequency of Response
Training and practice	16
Simulator training	9
More/better knowledge and experience with ice-covered waters	6

4.2.2.2: Post-Test Specific Questions and Responses

Responses from the Post-Test questionnaire (Appendix N) were examined (Table 4-15). The full data set can be found in Appendix M. A Spearman's Rho (rs)analyses of the post-test questionnaire mean responses (Appendix O) determined that Question 4 (training effectiveness) was correlated to perceived competency in Question 5 (rs =.620) and future perceived ability (proficiency) in Question 6 (rs =0.785) at a significance level of p =.01. The maximum concentration that participants perceived they were able to navigate through did not show to correlate to training type, ranging from an average of 3/10ths from Group 2, to an average of almost 5/10ths for Group 1.

Table 4.15: Mean (SD) of Post-Test Specific Question Responses by Group Assignment

Group Average	**Q4***	**Q5***	**Q6***	**Q7***
1	5.5(2.81)	5.17(2.79)	4.67(2.58)	4.83 (2.14)
2	6.29(2.83)	5.86(2.48)	5.86(1.46)	3(1.00)
3	7.6(0.52)	6.2(1.37)	6.6(1.17)	4.2(2.25)

Q 4: How effective did you find the training?

Q 5: How well do you think you navigated the ice field during the testing?

Q 6: How well do you feel you can navigate through ice in the future?

Q 7: At what maximum concentration of ice do you think you are able to navigate through in the future?

Chapter 5 : Discussion

5.1:Introduction

Current STCW training requires that certain competencies be achieved in both classroom and practical settings. This training, however, is limited with respect to the broad array of environmental conditions likely to challenge coxswains in real-life emergency situations. Training opportunities in harsh maritime environments are limited due to the inherent risks to the student, instructor, and training assets. There is no regulatory standard in place where ship masters have to demonstrate their competence in all-weather navigation. Technology has facilitated advances in training, such as the development of bridge simulator training as means to prove one's competence for large vessel navigation in ice-covered waters (Patterson et al., 2011).These developments are promising for the field of maritime simulation training, as simulator training becomes more widely accepted as a suitable platform for skill acquisition. In terms of lifesaving appliances, however, coxswains do not have to demonstrate any competency of how to navigate in debris ridden or ice-covered waters. These are concerns that could be addressed by small craft simulator training, as a means to achieve competency through skills developed beyond the classroom setting. Beyond specific skill building, simulation training can provide opportunities for building communication and teamwork, preparing for varied environmental conditions, and dealing with emergency situations in which lifeboat evacuation can occur. Companies working toward innovation in maritime training have developed simulators capable of providing this training.

This study set out to examine whether simulation training would better prepare novice TEMPSC operators undertaking ice navigation compared to those who underwent conventional STCW training. It was hypothesized that those in the control groups (Groups 1 and 2) would perform worse during their attempts at navigating through simulated ice-covered waters, while those who completed simulator training in ice would perform better.

The research completed in this study demonstrated that simulator trained participants (Group 3) performed better overall in the test period than those who received standard training (Group 1). It also pointed out that through participant experience, those who were in the simulator group felt more confident regarding their ice navigation abilities compared to the other participants. This allowed researchers to accept the two hypotheses proposed.

5.1.1:Simulator Training versus Traditional Training

Current practices surrounding STCW Coxswain training allow for participants to have between 30-72 minutes of hands-on physical training in the coxswain position in a lifeboat in order to demonstrate operational competencies, including launching, maneuvering, recovering and transferring casualties, and steering by compass navigation (G. Small, personal communications, June 10, 2011). Other competencies include operational aptitude in a group setting including prelaunch checks, launch, towing, pacing, casualty approach and recovery, recovery of the lifeboat, and full abandonment. Contrasting this to the simulator training delivered in this study, over a 30 minute period, participants were able to get acquainted with the simulator, fulfill the prelaunch and launch procedures, and complete a number of trials through varying wind and weather conditions, including ice navigation. The simulator training provided the advantage of placing participants in challenging scenarios that would not likely be experienced during typical training opportunities. Additionally, the training provided to Group 3 delivered realistic interactions and immediate feedback, and according to Veitch, Billard, and Patterson (2008a), simulator training offers trainees the opportunity to improve SA, while Taber (2010) believes that having the chance to practice a skill in a realistic situation better enables the trainee to recall that skill in real life.

The Canadian Transport Safety Board Report (A09A0016, 2009) of the March 2009 Cougar Helicopter Incident indicates that those who undergo Basic Survival Training (BST) must complete up to 40 hours of training. The time spent in the Helicopter Underwater Escape Training (HUET) simulator is reported to be dependent upon the rate at which trainees acquire the necessary evacuation skills, and their need for explanation and practice. Early success may translate into reduced practice time in the HUET. It is possible that this is similar to the training experience of the STCW coxswain course. There are experts in the maritime field that believe a competency gap exists (Veitch, Billard & Patterson, 2008b) between the theoretical and physical training for those who complete STCW training. Taber (2010) in the Offshore Helicopter Safety Report brings forward the point that while certified under the same body; the institution delivering a particular training program could require that trainees demonstrate very different task requirements for HUET training. Where simulator training is officially recognized for STCW coxswain training, standardized, performance based programs must be developed that would aid in alleviating issues such as these. Standardizing lifeboat navigation training could be better addressed using simulation-based technologies.

It is possible that simulator training could be easier to coordinate and deliver than standard training (Taber, 2010), especially if the simulator is located onboard a vessel or oil installation. Canadian coxswains must renew their certification every three years, while the IMO requires seafarers to maintain competency for survival craft every five years (Patterson et al., 2011). Studies have shown that the longer the period between skill acquisition and use, the less likely the skill will be retained (O'Hara, 1990; Taber, 2010). Given the state of how training drills are performed at sea, implementing refresher training through simulation or virtual reality could prevent or minimize skill and knowledge loss. This study demonstrated that simulator training could provide an advantage in this respect, showing that novice operators that have received simulator training are more likely to successfully navigate through an obstacle field, with higher confidence and perceived proficiency compared to those who have received standard training.

5.2:Limitations

The field trials had limitations that influenced the ecological validity of the experimental design and the statistical analyses of these data. A small sample size (n=19) resulted in weak power for statistical analysis. Other factors that may have influenced statistical analysis include the relatively short trial period during which data were collected, the density of the simulated ice-floes used during the trials, and the day-to-day variability in weather conditions (Table 5-1) that influenced lifeboat speed and maneuverability.

Table 5.1: Weather conditions over Test Period

Day/Date	Temperature Range (°C)	Temperature (°C) with wind chill	Average Wind Speed (knots)	Maximum Wind Speed (knots)	Description
Day 1 / May 11th, 2010	4-8	4.2	5.4	7.0	Overcast
Day 2/ May 12th, 2010	4-8	5.0	9.4-12.4	22.0	Drizzle with cloud breaks
Day 3/ May 13th, 2010	6-12	3.4	2.4-13.5	19.4	Cloudy
Day 4/ May 14th, 2010	1-2	-4.7	8.3-14.1	15.9	Moderate snow and fog
Day 5/ May 17th, 2010	3-6	-1.2	8.2	9.8	Cloudy, fog and drizzle

For the time of each trial, there was generally 1-2 minutes of collected data. In a real-life emergency situation, it is likely that coxswains would spend much longer attempting to navigate around debris or ice. The density of the simulated ice floes was significantly less than what can be experienced with level and pack ice in seawaters in northern and arctic regions.

5.3:Performance Factors

5.3.1:Pass/Fails

Participants were instructed to enter and exit the ice-field at certain points and to avoid collisions with simulated ice obstacles while navigating through the course. Statistical evidence suggests that the rate of failure is lower for simulation trained participants, with participants from Group 3 being 3.35 times more likely to succeed in successfully completing the demands of the trial. This suggests that their level of competence for obstacle navigation is better than those who did not experience simulator training (Table 4-1). As Taber, Simões Ré, and Power (2011) report, it is likely that those who have not had the opportunity to navigate a lifeboat in more than benign environmental conditions will experience difficulty in more threatening situations, which agrees with the hypothesis posed in terms of failures on course. Studies in fields such as medicine have shown that simulators increase levels of competency and can be used over long-term periods to maintain and upgrade trainees' skill sets (Chopra et al., 1994). Research examining simulator training and rehabilitation for driving following a stroke has shown that those who experience simulator training are more likely to pass a driver's test than those who underwent solely cognitive skill training (Akinwuntan et al., 2005).

Since the simulation trained group experienced the challenges posed by obstacle navigation during their training, they may have been able to develop skills for adapting to the TEMPSC and the challenges they faced when maneuvering through the ice-field, compared to participants assigned to Groups 1 and 2.

The pass and fails were examined in both a direction based and order based manner to see if any trends emerged such as improvement as participants progressed through the six runs. No such trend was found. This could be due to the short number of runs conducted and the fact the weather conditions changed throughout the duration of the test period.

5.3.2:Performance Factor Comparisons

Strum and colleagues (2008) caution those in the field of simulation training not to examine performance-indicating factors in silos. Performance time, for example, has been used as a measurement for a variety of studies in the medical field, yet as a single measure it may not be able to confirm that a trainee has acquired an expert level of proficiency. It may contribute to expert performance but alone cannot measure the quality of the trainee's work. In order to gauge a participant's overall ability, it was necessary to undertake a more comprehensive or holistic evaluation of the participant's performance.

5.3.2.1: Path Length

Examining the mean path length across groups, Group 3 took the longest path through the course for four out of the six runs and showed significantly longer path lengths through the field for the NS run and the SN run (Table 4-4). It is possible that this indicates participants from Group 3 were more attentive and selective to the path they chose through the field, showing better recognition of the hazards of ice navigation compared to those in Groups 1 and 2. It is also possible, as seen in the specific Post-Test Questionnaire results (Table 4-15) that Group 3 participants had more confidence in their ability to maneuver through the ice-field.

When comparing various performance metrics, clusters seem to be present especially between Group 1 and Group 3. Generally, Group 2 falls somewhere in between. The majority of the Group 3 participants tended to take a longer path through the course (Figure 5-1), compared to the majority of those in Group 1. This could be indicative of navigation choices made through the field and attempts at obstacle avoidance.

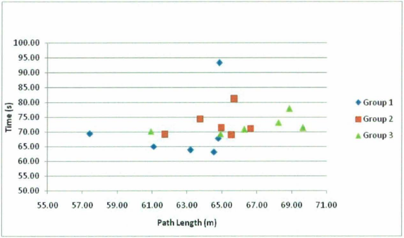


Figure 5-1: Path Length versus Time through course (with failed runs)

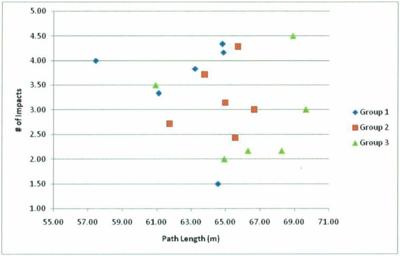


Figure 5-2: Path Length versus Number of Impacts (with failed runs)

This tendency for group means to cluster together seemed to occur for number of impacts over the path taken during the run. In line with the hypotheses that Group 3 participants would perform better than those in Groups 1 and 2, this comparison (Figure 5-2) suggests that overall simulator trained participants were able to better navigate through the field, colliding with fewer obstacles.

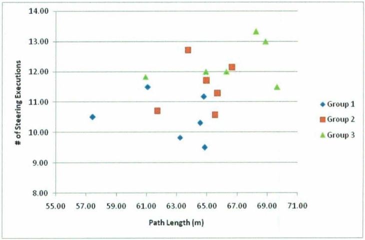


Figure 5-3: Path Length versus Steering Nozzle Execution (with failed runs)

When comparing the number of steering executions to the path taken through the course, the data seems to suggest that the number of steering nozzle executions performed by Group 3 participants were often more than Group 1 participants. It is possible that one reason for this is that they were able to better plan their path through the course, choosing a longer path, making more executions (Figure 5-3) in order to get to the exits compared to those in Group 1.

5.3.2.2: Time

The data reveals no statistical significance in regards to group assignment (Table 4-5) and trial time. While prevailing weather conditions could have had an effect on time between trials and groups, this consistency is likely due to the fact that the throttle was governed for the entirety of the trials. Differences in time on course are related to path length or the effects of a participant getting stuck on an obstacle. In reality, it is likely that this takes place often, if a coxswain was attempting to navigate through pack ice. As Igloliorteet.al (2008) demonstrated, even experienced coxswains had difficulty maneuvering through thick pack ice. Future studies must examine the effect of ungoverned speed on the performance of novice operators.

5.3.2.3: Impacts and Impact Severity

The number of impacts each group had was not statistically different (Table 4.6). Based upon video record analyses, it was found that more of the impacts made were head-on impacts compared to glancing impacts (Table 5-1).

Table 5.2: Number of Impacts by Group Assignment

	Group 1	Group 2	Group 3	Total
Glancing	74	56	48	178
Head-on	59	79	55	193

It is likely then, in reality that the type of impact made relates to the damage to the vessel and potential for occupant injury. Impact severity demonstrated no statistical significance across groups (Table 4-7). Although the mean maximum impact severities were small due to the low mass of the simulated ice obstacles, the data indicates that it is important in future research to examine the type of impact and the corresponding severity.

5.3.2.4: Steering Nozzle Executions

This metric is considered to be an indication of maneuvering and navigating ability. There was no statistical significance found (Table 4-8) in the data, however, this can in part be due to the fact that participants found the lifeboat's visibility of the field very limiting (Table 4-12). It is also possible that due to the speed limitations placed on the lifeboat, turning the vessel was slow and it took a period of time for the boat to respond to the wheel turn, adding to the difficulty of maneuvering around obstacles.

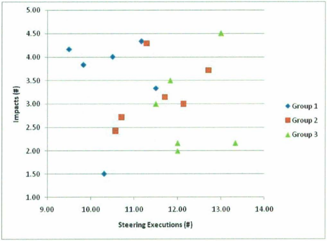


Figure 5-4: Steering Executions versus Number of Impacts (with failed runs)

Maneuvering ability and obstacle avoidance data tended to cluster by group. Group 3 participants demonstrated a better ability in navigating through the field with fewer collisions compared to those in Group 1 (Figure 5-4). In this study, all collisions were considered the same in terms of potential for damage to the vessel or injury to the occupants. Given the small decelerations due to gravity, the impact severity did not reach a level that could produce structural damage or musculoskeletal injury.

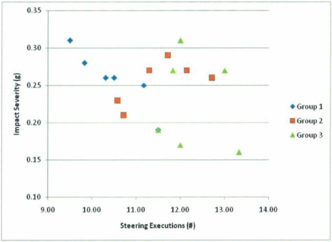


Figure 5-5: Steering Executions versus Impact Severity (with failed runs)

This trend continues when observing the steering executions against the mean maximum severity of impacts sustained. Simulator trained participants has a tendency to make more maneuvers and hit less obstacles (Figure 5-4) while maintaining impacts that were less severe (Figure 5-5). Given the larger inertial properties of ice, or other debris that might be in the water, avoiding large, head on impacts should lessen the likelihood of critical damage to the lifeboat or impact related injuries to the occupants.

5.4:Psychometric Factors

Collecting feedback can play an integral part in training, as it enables participants to focus on specific areas for improvement (Ali, 2007; Barber, 1996; Muirhead, 1996).It can also be useful in looking at the quality of training. In the instance of this study, the research team used the feedback to examine the effect training had on perceived performance.

5.4.1:Post-Training Questionnaires

5.4.1.1: General questions

The general questions reported that Group 1 participants (9.2) felt more confident (Table 4-9, Question 4 – Appendix G) than Group 2 (8.3) and Group 3 (6.5) participants regarding the need and response of the lifeboat's maneuvering controls. This could be attributed to the fact that Group 1 and 2 had hands-on training and experience in a TEMPSC, while Group 3 only spent time in the simulator before the actual testing period. Group 1 participants (8.5) felt more confident in their understanding of wind and waves on lifeboat maneuvering (Table 4-9, Question 6 – Appendix G), while Group 2 (6.9) and Group 3 (6.5) felt less confident with their understanding in this area. Interestingly, the reported mean responses for future proficiency (Table 4-9, Question 9 – Appendix G) of ice navigation ability, Group 1(8) felt the most proficient, while Group 3 (6.2) felt less proficient and Group 2 (4.9) felt the least proficient. It is possible that Group 2 participants felt this way because they spent their time training on calm waters and clear skies, and with the information on ice navigation through their classroom session they received, they may have felt that this training did not adequately prepare them to face ice-covered waters. It is also likely that training necessitates some exposure to the physical setting of the lifeboat, which could be why participants in Group 1 felt more proficient after training.

5.4.1.2: Ice-specific questions

In terms of ice related questions, Groups 2 and 3 were given the same classroom session, but received different types of lifeboat training. Mean scores (Table 4-10, Questions 10 & 11 – Appendix H) from Group 3 (6.2) indicated that participants felt they could navigate through ice better than their counterparts in Group 2(5.1). Additionally participants in Group 3(6) believed they would be less likely to sustain damage to the vessel than participants in Group 2(7). Regarding ice concentration (Table 4-10, Question 12 – Appendix H), participants in Group 3 answered that they felt they could navigate through a lesser concentration (3.8) compared to participants in Group 2 (4.9). This could be due to their experience with ice-covered waters in the simulator. When examining the responses from participants in Groups 2 and 3 after they completed the test program (Table 4-15), these rankings changed. Group 3 participants felt they could navigate through slightly higher concentrations (4.2) compared to participants from Group 2 (3).

5.4.1.3:Simulator specific questions

In the lifeboat simulator used in this study, sensory feedback from any impacts was immediate. The subject had audio and visual feedback related to the magnitude of the impact and the severity of damage to the craft, but no inertial feedback. Veitch, Billard and Patterson (2008a) state that the fidelity of a simulator depends on three components: contextual, mathematical, and behavioral. These must be considered in the design of the simulator and the training experiences. Contextual fidelity is defined as the "relevance of the training matter and environment from the perspective of the trainee" (Veitch, Billard and Patterson, 2008a, p. 407). Mathematical fidelity refers to the accuracy through modeling of the vessel's motions, wind and wave effects and the response of the navigation equipment. Finally, the authors define behavioral fidelity as depending on the subject and their perception and response to the simulated environment (Veitch, Billard& Patterson, 2008). Taber (2010) places high importance on physical fidelity for the transfer of procedural knowledge. He also indicates that the amount of practice a trainee receives in the simulated environment contributes to skill transfer. Based on participant response (Table 4-11), it was found that the Group 3 participants felt that the simulator had over 60% effectiveness for these measures of fidelity.

5.4.1.3.1: Contextual Fidelity

Simulator trained participants were posed five questions regarding the contextual fidelity of the simulator (Appendix I). Overall, participants reported that the environment felt natural (7.2), consistent with the real world (6.2), involved with the simulation (7.7)), proficient from their interaction with the simulator (7) and that they had learned new skills (8.7). This suggests that the simulator had a high degree of contextual fidelity.

5.4.1.3.2: Mathematical Fidelity

Six questions addressed the mathematical fidelity of the simulator. When asked about the visual aspects of the simulator, the mean response was 8.2 out of 10. This measure demonstrates that the programming used in the simulation training fulfilled the visual expectations and met high levels of mathematical fidelity. Other aspects surveyed included the responsiveness of the simulator (8), the auditory interaction (6.8), the natural movement control (7.3), the ability to predict the consequences of one's actions (6.3) and the delay experienced between actions and expected outcomes (4).

5.4.1.3.3: Behavioral Fidelity

Six questions were answered regarding behavioral fidelity. The questions examined participant engagement (7), inconsistency of the experience (6.3), ability to predict the consequences of one's actions (6.3), involvement (7.7), learning adjustment (6.2), and learned proficiency (7). Five out of the six responses demonstrate that the participants felt the behavioral realism presented in the simulator engaged them and presented realistic conditions in which they were able to learn. The only questions that reveal that the cueing of the operating system was not as good as the participants felt it could be was Question 7: "How inconsistent or disconnected was the information coming from your various senses?". Overall, participants felt that this was an issue they experienced during their training, with an average response of 6. This could be due to the lack of physical motion response when they made an error that would sustain damage to the lifeboat. Upon examining the question, it is possible that the wording was confusing for participants, as all the other responses show a positive recognition of the behavioral fidelity of the simulator.

5.4.1.4: Summary of Fidelity

It is essential that virtual environment training mediums yield learning outcomes equivalent to, or better than existing training methods, when being utilized for emergency training programs. A technical assessment of simulator training effectively defines how closely the simulated environment compares to the real environment. Examining simulator training from a regulatory point of view, three main technical attributes are utilized: physical realism (a measure of the functionality of the system); behavioral realism (a measure of the mathematical fidelity of the system); and the operating environment (a measure of the fidelity of the cuing system). The research completed in this study suggests that the simulator used to provide ice navigation training for lifeboat coxswains was effective in providing the appropriate fidelity to ensure a successful training experience.

Future work in the area of simulator training validity must pointedly measure the subjective experience of participants for a wide variety of factors relating to fidelity, as this will provide useful information on how to improve simulator-based training for survival craft operators.

5.4.2:Post-Testing Questionnaires

5.4.2.1: Open-ended questions

When examining the results of the Post-Test Questionnaire data, in regards to visibility and navigation of the lifeboat (Table 4-15), clear ergonomic issues emerged. This information ties into the design of many TEMPSC lifeboats that have placed the coxswain's position near the stern of the vessel. Igloliorte, Kendrick, Brown & Boone (2008) reported that the placement of the coxswain's seat poses significant difficulties for steering visibility, especially in ice-covered waters. They reported that it is likely that the less experience a coxswain has in TEMPSC navigation, the more challenges he/she will face in terms of dealing with visibility issues when attempting to navigate through ice-covered waters.

5.4.2.2: Specific Questions

Research has highlighted that the confidence participants place in simulator training, for both attaining knowledge and refreshing proficiencies, is important to examine (Dahlstrom et al., 2008; Hytten, 1989). Simulator trained participants seemed to feel more comfortable with ice navigation and had more confidence in the effectiveness of their training, as indicated by Question 1-3 on the Post Testing Questionnaire. Sedlack et al. (2004) demonstrated that medical residents perceived higher levels of confidence upon completion of simulator training compared to standard training. Since no participants had previous experiences with small craft navigation, it may be assumed that all participants, regardless of group assignment, had similar competencies at the start of the pre-collection training. Given that they were at a similar baseline skill-level entering into training, this could speak to the improvement seen in both the decreases in the failure rate and increased level of confidence experienced by the simulator group. Gallagher and colleagues (2005) reported that medical residents separated into two different training groups with similar baselines, demonstrated that those who experienced simulator training enhanced their initial level of knowledge more than those who did not.

5.5:Ergonomic Issues

As Taber, Simões Ré, and Power (2011) share, it is apparent that little or no consideration regarding evacuation into harsh environments, as they illustrated many of the issues encountered when navigating in ice-covered waters, is used in the design of TEMPSCs. Their paper considers a number of ergonomic and habitability issues that must be considered for lifeboat evacuation, but the ergonomic-related findings were of particular interest for this study (Table 4-12, 4-13). Taber (2010) examined the workspace for a coxswain faced with navigation through ice-covered waters and came to many of the same conclusions that participants in this study also made. Visibility was a major issue, along with temperature and inability to navigate around ice that was no longer visible due to the shape of the lifeboat. As suggested by some of the performance factors, poor design of the lifeboat could be the main reason why more significant differences were not found between the experimental groups. It is possible that those in Group 3 were better able to overcome the ergonomic challenges presented during the test period. This may be due to the opportunities they had to practice obstacle avoidance in the simulator. It is reasonable, then, to conclude that ergonomic considerations are an issue that must be further investigated as a means to provide grounds for performance based standards for lifesaving appliance approval.

5.6:Future Uses of Simulation Training in the Maritime Domain

More empirical evidence must be delivered by the maritime research community surrounding the effectiveness of skill transfer from simulator training into the real physical world (Barber, 1996). As Webb &Wooley (1996) have suggested, the use of differential global positioning system (DGPS) can be useful in comparing simulator performance with actual lifeboat performance.

As visibility emerged as one of the main issues of concern for participants in this study (Table 4-15), it may be reasonable to conclude that more simulator training could better prepare coxswains to deal with visibility issues in debris ridden and ice-covered waters. Lifeboat simulators possess the capacity to create situations with changing and degrading visibility (Veitch, Billard, & Patterson, 2008). The other alternative to improve visibility, which may improve collision avoidance performance, is to consider redesigning the craft such as putting the cockpit in the front of the vessel or using bow-mounted camera.

5.7:Summary

Overall, participants trained via simulator were more confident in their abilities and holistically demonstrated better performance. In future research in this area, a larger sample size and more ecological validity is necessary to improve upon the statistical power of the research. Investigating the challenges posed by ergonomic issues for lifeboat coxswain may also provide valuable information in terms of influence of ergonomics and training adaptability.

Chapter 6 : Conclusion

As technology advances, simulation training becomes increasingly relevant, and in the case of extreme environmental conditions, a safe and reliable complement to current training regimes. This research demonstrates that simulation training can offer a host of performance and psychometric skill building parameters that may be refined and developed further with additional research. Aviation, medicine, and military industries have consistently demonstrated that simulation training can play an integral role in situational training that would otherwise place personnel at risk.

The U.S. Navy (2010) has suggested that certain training approaches are able to allow cadets to continue to hone their skills while not at sea, using gaming and virtual reality. It may be possible that this training model can be translated into STCW training for lifeboat coxswains, during their time onshore, as well as during their time at sea, using either part-task or full mission simulators. This research provides preliminary evidence with which to lobby national and international bodies to formally include ice-navigation in course requirements for lifeboat coxswains. Simulator training would also be useful in filling the gap that often occurs between standard training and real world emergencies.

A clear message from the post-testing survey was the request for more training, with a focus on obstacle avoidance. More research is necessary in this area to determine what parameters should be benchmarks for performance improvements. The findings in this study relay to regulators that they should examine the current STCW coxswain training standards for inclusion of obstacle avoidance training as a surrogate for ice-covered water training. Environmental changes necessitate a closer look at how regulations surrounding training should evolve for the EER process. This evaluation is paramount for the safety of those onboard vessels and installations in northern and Arctic environments. Although the effect of simulation training on coxswain performance is not yet fully developed, this research allows parallels to be drawn with the long established success of medical simulation training. Many facets of medicine use simulation to educate students and to aid experts in maintaining and developing skills. Similarly, in terms of the maritime environment, simulation training could be a viable alternative or complement to current standard STCW training.

This study can be considered a proof of concept regarding the utility of simulation training within the STWC curriculum and experimental approaches to assessing simulation training efficacy. Expanding the training time may be recommended for future research in this area. It is expected that with longer training times for control and simulator groups, participants will have more time to become acquainted with the lifeboat and more accustomed to the feel and behavior of the vessel. This area should be further investigated.

These preliminary findings provide an opportunity for those with an interest in bringing international attention to the usefulness of simulators. It establishes a basis on which future research can be expanded upon. Training through the use of simulators may allow regulators, institutions, and companies the prospect of enhancing and supplementing current lifeboat coxswain training standards.

Bibliography

Aggarwal, R., Black, S. A., Hance, J. R., Darzi, A., & Cheshire, N. J. W. (2006). Virtual reality simulation training can improve inexperienced surgeons' endovascular skills. *Journal of Vascular and Endovascular Surgery, 31*, 588.

Ali, A. (2006). Simulator instructor - STCW requirements and reality. *Pomorstvo, 20*(2), 23.

Ali, A. (2007). *Role and importance of simulator instruction.* (Master's, World Maritime University). Retrieved from www.seaman.or.kr/mcboard/mn_etc.php%3Fact%3Ddown%26mnid%3Dcusm%26mncd%3Dcusm4%26code%3D1864+A

Allan, J. (2007). *Arctic sea ice for NASA* Retrieved from http://www.globalwarmingart.com/wiki/File:2007_Arctic_Sea_Ice_jpg

Atlantic Canada Offshore Petroleum Agency: Standard practice for the training and qualifications of personnel. (2010). (No. 2010-028).Canadian Association of Petroleum Producers. Retrieved from http://www.capp.ca/library/publications/

Atlantic Canada Offshore Petroleum Industry: Escape, Evacuation, and Rescue. (2010). No. 2010-017).Canadian Association of Petroleum Producers. Retrieved from http://www.capp.ca/library/publications/

Barber, P. (1996). The need for improved curriculum development in marine simulation training. In M. S. Chislett (Ed.), *Marine simulation and ship manoeuvrability* (pp. 77). Rotterdam, Netherlands: A.A. Balkema.

Bercha, F. G., Brooks, C. J., & Leafloor, F. (2003).*Human performance in arctic escape, evacuation, and rescue. International Offshore and Polar Engineering Conference,* Honolulu, Hawaii.

Brigham, L. (2008). *Update – arctic marine shipping assessment of the arctic council.* Paper presented at the *Conference of Arctic Parliamentarians,* Retrieved from http://arcticparl.org/files/files%20from%208th%20conference/080812LawsonBrigham1.pdf

Canadian Ice Services. *Sea Ice Symbols.* Retrieved, April, 2010, from http://ice-glaces.ec.gc.ca

Chopra, V., Gesink, B. J., DeJong, J., Bovill, J. G., & Brand, R. (1994). Does training on an anesthesia simulator lead to improvement in performance? *British Journal of Anesthesia, 73*, 293.

Dalhstrom, N., Dekker, S., vanWinsen, R., & Nyce, J. (2009). Fidelity and validity of simulator training. *Theoretical Issues in Ergonomics Science, 10*(4), 305.

Deering, S., Poggi, S., Macedonia, C., Gherman, R., & Satin, A. J. (2004).Improving residence competency in the management of shoulder dystocia with simulation training. *Obstetrics and Gynecology, 103*(6), 1224.

Det Norske Veritas. (2011). *Maritime simulator systems.* (Standard No. Standard for Certification No. 214).Det Norske Veritas.

Drown, D. (1996). Simulation and the revised 1978 STCW convention. In M. S. Chislett (Ed.), *Marine simulation and ship manoeuvrability* (pp. 245). Rotterdam, Netherlands: A.A. Balkema.

Gallagher, A. G., Ritter, E. M., Champion, H., Higgins, G., Fried, M. P., Moses, G., & Satava, R. M. (2005). Virtual reality simulation for the operating room. *Annals of Surgery, 214*(2), 364.

Guidelines for simulator-based training. (1993). (No. 2115-0111).United States Coast Guard.

Gynter, J. W., Hammell, T. J., Grasso, J. A., & Pittsley, V. M. (1982).*Simulators for marine training and licensing: Guidelines for deck officer training systems.*(Technical Report No. 50-8004-03).Computer-Assisted Operations Research Facility (CAORF).

Heeter, C. (1992). Being there: The subjective experience of presence. *Presence, 1*(2), 262.

Hill, J., Dobbin, T., & Myers, S. (2009). *Advanced high speed craft coxswain training. Royal Institution of Naval Architects Conference: SURV 7 – Surveillance, Search, and Rescue Craft,* Poole, United Kingdom.

Ho, J. (2010). The implications of arctic sea-ice decline on shipping. *Marine Policy, 34*(3), 713.

Hsieh, H. F., & Shannon, S. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research, 15*(9), 73.

Hytten, K. (1989). Helicopter crash in water: Effects of simulator escape training. *Acta Psychiatrica Scandinavica, 20*(73)

Igloliorte, G., Kendrick, A., Brown, R., & Boone, J. (2008).*Performance trials of a totally enclosed motor propelled survival craft. ICETECH 2008,* Banff, Alberta, Canada.

International Maritime Organization. (June, 2010). *Revised STCW convention and code adopted at the manila conference.* Retrieved, May, 2011, from http://www.imo.org

International Maritime Organization. (2011). *Human Element.* Retrieved September, 2011, from http://www.imo.org/OurWork/HumanElement/Pages/Default.aspx

Issenberg, S. B., & Scalese, R. J. (2007). Best evidence on high-fidelity simulation: What clinical teachers need to know. *The Clinical Teacher, 4*(2), 73.

Jannick, M. J. A., Erren-Wolters, V., de Kort, A. C., & van de Kooij, H. (2008). An electric scooter simulation program for training the driving skills of stroke patients with mobility problems: A pilot study. *Cyber Psychology and Behavior, 11*, 751.

Jensen, O. (2007). *The IMO guidelines for ships operating in arctic ice-covered waters: From voluntary to mandatory tool for navigation safety and environmental protection?* No. FNI-rapport 2/2007).Fridjof Nansen Institute. Retrieved from http://www.fni.no/doc&pdf/FNI-R0207.pdf

Judson, B. (2010). Traffic and casualty trends in Canadian arctic shipping. *ICETECH 2010,* Anchorage, Alaska, United States

Kennedy, A., Simões Ré, A., & Veitch, B. (2010). Operational Limitations of Conventional Lifeboats Operating in Sea Ice. ICETECH 2010. Anchorage, Alaska, United States.

Kewman, D. G., Seigerman, C., Kintner, H., Shu, S., Henson, D., & Reeder, C. (1985). Simulation training of psychomotor skills: Teaching the brain-injured to drive. *Rehabilitation Psychology, 30*, 11.

MacKinnon, S. N., Evely, K., &Antle, D. (2009).*Does mariner experience effect distance judgment of visual targets in virtual marine environments? Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC),* Orlando, Florida, United States.

Main Gearbox Malfunction/Collision with water. (2010). (No. A09A0016). Ottawa, Ontario, Canada: Transportation Safety Board of Canada.

Muirhead, P. M. (1996). The revised STCW convention and the new simulation performance standards: Some implications for simulator designers, operators, and instructors. In M. S. Chislett (Ed.), *Marine simulation and ship manoeuvrability* (pp. 257). Rotterdam, Netherlands: A.A. Balkema.

Muirhead, P. M. (2006). *STCW and assessment of competence by simulator: Ten years on: Why no global acceptance of the practice? International Conference on Marine Simulation and Ship Maneuvering,* Terschelling, Netherlands.

O'Hara, J. M. (1990). The retention of skills acquired through simulator-based training. *Ergonomics, 33*(9), 1143.

Patterson, A. (2007).*Lifeboat simulation – the safe alternative. Company of Master Mariners of Canada,* St. John's, Newfoundland and Labrador, Canada.

Patterson, A., McCarter, P., MacKinnon, S. N., Veitch, B., & Simões Ré, A. (2011). (White Paper).*Survival craft training using simulators.* Virtual Marine Technologies.

Perry, C. M., Sheik-Nainar, M. A., Segall, N., Ruidi, M., & Kaber, D. B. (2008).Effects of physical workload on cognitive task performance and situation awareness. *Theoretical Issues in Ergonomics Science, 9*, 95.

Poplin, J. M., & Bercha, F. G. (2010). Arctic offshore escape, evacuation, and rescue. *ICETECH 2010,* Anchorage, Alaska, United States.

Protection of the Arctic Marine Environment Working Group (PAME). (2009). *Arctic marine shipping assessment report.* Arctic Council. Retrieved from http://www.pame.is/amsa/amsa-2009-report.

Raby, M., Forsythe, A. M., McCallim, M. C., & Smith, M. W. (2000).*Methodology for evaluating A Simulator's capacity to support assessment of mariner proficiency. The Human Factors and Ergonomics Society 42Nd Annual Meeting,* San Diego, California.

Results of a survey into lifeboat safety. (1994). (Survey) Oil Companies International Marine Forum. Retrieved from http://www.ocimf.com

Review of lifeboat launching system accidents. (2001). (Safety Study No. 2001/01).Marine Accidents Investigations Branch. Retrieved from http:www.maib.gov.uk/publications/index.hfm

Richardson, A. R., & Waller, D. (2007). Interaction with an immersive virtual environment corrects users' distances estimates. *Human Factors, 49*, 507.

Robson, J. K. (2007). *Overview of TEMPSC performance standards.* (Research Report No.RR 599). London, United Kingdom: Health and Safety Executive. Retrieved from http://www.hse.gov.uk/RESEARCH/rrpdf/rr599.pdf

Rose, F. D., Attree, E. A., Brooks, B. M., Parslow, D. M., Penn, P. R., & Ambihaipathan, N. (2000). Training in virtual environments: Transfer to real world tasks and equivalence to real task training. *Ergonomics, 43*(4), 494.

Ross, T. W. (2006). *Ship's lifeboats: Analysis of accident cause and effect and its relationship to seafarers' hazard perception.* (Master's, Dalhousie University). Retrieved from http://www.msc1206.com/trevor_w_ross_report.pdf

Royal Naval Lifesaving Institution. Retrieved, March, 2011, from http://www.rnli.org.uk

Saus, E. R., Johnson, B. H., & Eid, J. (2011). Perceived learning outcome: The relationship between experience, realism, and situation awareness during simulator training. *International Maritime Health, 1*(4), 258.

Scalese, R. J., Obeso, V. T., & Issenberg, S. B. (2007).Simulation technology for skills training and competency assessment in medical education. *Journal of General Internal Medicine, 23*(Suppl. 1), 46.

Sedlack, R. E., Kolars, J. C., & Alexander, J. A. (2004). Computer simulation training enhances patient comfort during endoscopy. *Clinical Gastroenterology and Hepatology, 2*(4), 348.

Seymour, N. E., Gallagher, A. G., Roman, S. A., O'Brien, M. K., Bansal, V. K., Andersen, D. K., & Satava, R. M. (2002). Virtual reality training improves operating room performance. *Annals of Surgery, 236*(4), 458.

Simões Ré, A., Veitch, B., & Spencer, D. (2010).*Escape, evacuation and rescue for arctic and subarctic.*(No. EXX027-01). St. John's, Newfoundland and Labrador, Canada: Oceanic Consulting Corporation.

Simulation training is all set for change. (2011).*Safety at Sea, 45*, 503.

Steward, E. J., & Draper, D. L. (2006). Sustainable cruise tourism in arctic Canada: An integrated coastal management approach. *Tourism in Marine Environments, 3*(2), 77.

Strom, P., Hedman, L., Sarna, L., Kjelin, A., Wredmark, L., & Fellander-Tasi, L. (2006). Early exposure to haptic feedback enhances performance in surgical simulator training: A prospective randomized crossover study in surgical residents. *Surgical Endoscopy, 20*, 1383.

Strum, L. P., Windsor, J. A., Cosman, P. H., Cregan, P., Hewett, P. J., & Maddern, G. J. (2008). A systematic review of skills transfer after surgical simulation training. *Annals of Surgery, 248*, 166.

Taber, M. (2010).*Offshore Helicopter Safety Report.* (Safety Report Retrieved from http://www.oshsi.nl.ca

Taber, M. J., Simões Ré, A., & Power, J. (2011).A preliminary ergonomic assessment of piloting a lifeboat in ice. *Safety Science, 49*, 139.

Training 2015: Training and simulation industry market survey. (2010). (Survey) National Training and Simulation Association. Retrieved from http://www.traningsystems.org/publications/Tr2015.crm

Tucker, J., Patterson, A., Fiander, G., Harris, C., & Spencer, D. (2006).Simulation and modeling of navigating in ice. *The International Navigation Simulator Lecturers' Conference,* Genoa, Italy.

Veitch, B., Billard, R., & Patterson, A. (2008a).Emergency response training using simulators. *Offshore Technology Conference,* Houston, Texas.

Veitch, B., Billard, R., & Patterson, A. (2008b).Evacuation training using immersive simulators. *The International Society of Offshore and Polar Engineers Conference,* Vancouver, British Columbia, Canada.

Webb, D. W., & Wooley, R. T. (1996).Applying prototype ship transit data to simulator validation. In M. S. Chislett (Ed.), *Marine simulation and ship manoeuvrability* (pp. 225). Rotterdam, Netherlands: A.A. Balkema.

Appendix A: Recruitment Poster

RECRUITMENT FOR SCIENTIFIC RESEARCH PROJECT

"Validation and Accreditation of Small Craft Simulator Training"

NRC REB #:2009-73

The Institute For Ocean Technology (IOT), part of the National Research Council of Canada (NRC), is conducting a research program on the validation and accreditation of small craft simulator training. Currently, under international regulations, no requirements exist that indicate training must be completed by lifeboat coxswains for navigating through ice infested environments. The purpose of this study is to determine if simulated lifeboat training will provide participants with the ability to navigate through ice, while maintaining a safe training environment.

We are looking to recruit healthy individuals, 19 plus years of age to volunteer for this study. The study would consist of two certification sessions (Small Craft Operators Card) – **Mon. Apr. 26th & Wed. Apr. 28th: 1:00 –4:00 p.m.**, one training session of 8 hours **(between May 3rd and May 7th)** and one testing session of approximately 5 hours (**Between May 10th and May 14th**). The training session will take place at either the Marine Institute or Virtual Marine Technologies. The test session will take place in close vicinity to St. John's. Transportation will be provided for you. The training program will start in April 2010 and the testing will take place in the first two weeks of May 2010. You will be given $50.00 CAD for training and $50.00 for the testing.

If you have any of the following criteria, you will **NOT** be eligible for the study:

- Cannot currently hold STCW lifeboat training certification
- Sensitivity to the cold
- Large susceptibility to motion sickness
- Conditions that could be aggravated by increased anxiety
- Pre-existing heart or lung conditions that impair physical activity
- Pre-existing muscle or skeletal conditions that limit mobility
- Inability to swim
- Uncomfortable over water
- Fear of enclosed spaces

Recruitment will start January 4th, 2010 and will be ongoing.

If you are interested in volunteering for this project please contact **Stephanie Power** at the following numbers:

Monday – Friday, 08:30 – 17:00: (709) 772-3927

Anytime after 17:00: (709) 764-0201.

Appendix B:Physical Activity Readiness Questionnaire

PAR-Q & YOU

Physical Activity Readiness

Questionnaire - PAR-Q (revised 2002)

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES NO

___ ___ 1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?

___ ___ 2. Do you feel pain in your chest when you do physical activity?

___ ___ 3. In the past month, have you had chest pain when you were not doing physical activity?

___ ___ 4. Do you lose your balance because of dizziness or do you ever lose consciousness?

___ ___ 5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?

___ ___ 6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?

___ ___ 7. Do you know of any other reason why you should not do physical activity?

If you answered YES to one or more of these questions:

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

• You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.

• Find out which community programs are safe and helpful for you.

If you answered NO

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

• start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.

• take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME____

SIGNATURE____

DATE____

SIGNATURE OF PARENT or GUARDIAN (for participants under the age of majority)

____

WITNESS ____

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

Health Canada Santé Canada

Appendix C: Written Consent Form

Consent to Take Part in Research

TITLE:

Effect of simulated training upon the performance of ice field navigation in a lifeboat

INVESTIGATOR (S): Dr. Scott MacKinnon, Ms. Stephanie Power, Mr. Antonio Simões Ré, Mr. Jonathan Power, Capt. Philip McCarter

SPONSOR: **Transport Canada**

You have been invited to take part in a research study. It is up to you to decide whether to be in the study or not. Before you decide, you need to understand what the study is for, what risks you might take and what benefits you might receive. This consent form explains the study.

The researchers will:

- **discuss the study with you**
- **answer your questions**
- **keep confidential any information which could identify you personally**
- **be available during the study to deal with problems and answer questions**

1. **Introduction/Background:**
   Currently, under international regulations, no requirements exist that indicate training must be completed by lifeboat coxswains for navigating through ice infested environments. As many maritime operations move northwards, such as shipping and offshore oil & gas drilling, expectations for personnel to experience harsh environments, in particular, those infested with ice are increasing. There remains little opportunity to train in ice conditions and such training will add to the risk of harm to the participant. The National Research Council of Canada's Institute for Ocean Technology (NRC-IOT), Memorial University, and Virtual Marine Technology Inc. (VMT Inc.) are examining the effectiveness of using virtual lifeboat training through the use of simulator to help increase the safety of offshore personnel. By using a simulator to train operators in such harsh conditions training opportunities can be increased and risk to operators and instructors and damage to equipment can be reduced. It is still not known whether simulated ice navigation training is as effective as training in the actual environment.

2. **Purpose of study:**
The purpose of this study is to determine if simulated lifeboat training will provide participants with the ability to navigate through ice, while maintaining a safe training environment.

3. **Description of the study procedures and tests:**
If you choose to participate in this study, you will be required to complete one day of training, provided by experts in the area of lifeboat navigation. Depending on the group you are placed in, this training will either take place in a classroom or in the simulator. On the test day, you will be provided transportation to and from the test site. You will be required to wear warm clothing and footwear for that day. When you arrive on site, a testing order will be determined and as long as weather and equipment allows, you will complete a test, which will run for approximately 30 minutes through a simulated course of ice. During this test, you will be the one navigating the lifeboat. There will be two experienced crew members on board the lifeboat in case you should decide you are not comfortable in finishing the test. NRC-IOT's field trials coordinator will be responsible for ensuring all safety procedures are followed throughout the trials. As a result, the field trials coordinator may, at any time, stop the tests if they feel they have become unsafe. As well, the field trials coordinator may excuse any person from participating, or continuing, in the study if they feel that their safety could be at risk.

Current Transport Canada (TC) regulations require that anybody piloting a motorized boat will require a Pleasure Craft operator's license. In order to ensure that this study complies with TC regulations, the research team will hold a course at NRC-IOT to allow you the opportunity to obtain the license. The time commitment for this course will be two, two-hour sessions held on different nights. The research team is offering this course at no cost to you, and upon completing the course you will obtain a Pleasure Craft operator's license.

During the tests, you will be required to wear a floater suit, helmet, and ear protection while they are in the lifeboat, along with an Electro Cardiogram (ECG) monitoring system. The ECG will measure and record your heart rate throughout the trial. Once the testing is complete, you will be asked to fill out an exit questionnaire.

In order to be eligible to safely participate in this study, you must meet certain conditions. These conditions are:

1.) Cannot currently hold Standards, Training, Certification and Watchkeeping (STCW) certification – we require naïve people to participate in this experiment who have had no experience driving a lifeboat.
2.) No sensitivity to the cold – it is possible that the tests may occur during cold weather. If you have a sensitivity to, or not able to tolerate, cold temperatures, then you are not eligible to participate in the study.
3.) Not susceptible to motion sickness – the unstable environment may cause symptoms of motion. If you have a high susceptibility to motion sickness, you will not be able to participate in the study.
4.) No conditions that could be aggravated by anxiety – if you have a medical condition that is aggravated by anxiety, then you are not eligible to participate in this study.
5.) No pre-existing heart or lung conditions – if you currently have a heart or lung condition that impair your ability to perform physical activity, you will not be able to participate in this study.
6.) No pre-existing muscle or skeletal condition that limits your mobility – since there will be some physical activity required to enter and exit the lifeboat, you not be able to participate if you have limited mobility. If you are unable to climb a ladder by yourself, only able to enter/exit a car with great difficulty, or unable to crawl, then you will not be able to participate.
7.) Ability to swim – you must be able to swim in the water for short periods of time (less than 10 minutes) to be eligible to participate in this study.
8.) Comfortable over water – since these tests are being conducted in a lifeboat, you must be comfortable in being over water to be eligible to participate in this study.
9.) Not Claustrophobic – the interior of the lifeboat is small. You must not have a fear of enclosed spaces to be able to participate in this study.

4. Length of time:

You will be asked to participate in training sessions where you will have the opportunity to obtain your Pleasure Craft operator's license. The sessions will consist of two (2), two-hour (2) courses.

You will be required to come in for one day of training prior to the testing which will be one (1) eight (8) hour session. For the testing, you will be required to come for one (1) day for up to six (6) hours. Unless there is adverse weather, which delays testing or requires testing to be rescheduled, your total time commitment will be approximately 16-18 hours.

5. **Possible risks and discomforts:**

Risks:

1) There is potential that you may slip, trip or fall resulting in physical bruising or injury. Members of the research team have been trained in advanced first aid, and will be able to treat any minor injuries you may receive at the test location. If you fall into the water, you will be wearing a floater suit that will keep you afloat in the water while research team members retrieve you.
2) There is a very small risk of the safety of the lifeboat to be compromised, resulting in you having to abandon it into the FRC or into the water.
3) Risk of noise levels exceeding safety limits - you will be provided with hearing protection.
4) There is a possible risk that carbon dioxide and carbon monoxide build-up may exceed safe levels. Carbon dioxide and carbon monoxide levels are measured and monitored by sensors both in the lifeboat, and by research team members on shore. If these gas levels exceed safety limits, audio and visual warnings will activate in the lifeboat and the test will be stopped.

Discomforts:

1) Possibility of you becoming too hot or too cold throughout the trials. Since this study is not measuring the thermal responses of the participants, you will be encouraged to adjust your clothing state (i.e. opening a zipper, removing gloves) to a level of thermal comfort you find acceptable.

Inconveniences:

1) You will be provided transportation for travel of approximately 45 minutes to test site.
2) You could have interruption of normal daily schedules.
3) You may have to commit to early mornings or late evening, depending on testing.
4) You will be in an enclosed space while piloting the lifeboat.

6. **Benefits:**

You will receive a Pleasure Craft Operator's license as a result of participating in this experiment.

7. **Liability statement:**

Signing this form gives us your consent to be in this study. It tells us that you understand the information about the research study. When you sign this form, you do not give up your legal rights. Researchers or agencies involved in this research study still have their legal and professional responsibilities.

8. **What about my privacy and confidentiality?**

Protecting your privacy is an important part of this study. Every effort to protect your privacy will be made. However it cannot be guaranteed. For example we may be required by law to allow access to research records.

When you sign this consent form you give us permission to

- **Collect information from you**
- **Collect information from your health record**
- **Share information with the people conducting the study**
- **Share information with the people responsible for protecting your safety.**

Access to records

The members of the research team will see study records that identify you by name.

Other people may need to look at the study records that identify you by name. This might include the research ethics board. You may ask to see the list of these people. They can look at your records only when one of the research team is present.

Use of records

The research team will collect and use only the information they need for this research study.

This information will include your

- **date of birth**
- **sex**
- **mass**
- **height**
- **information from questionnaires**

Your name and contact information will be kept secure by the research team in Newfoundland and Labrador. It will not be shared with others without your permission. Your name will not appear in any report or article published as a result of this study.

Information collected for this study will kept for 5 years.

If you decide to withdraw from the study, the information collected up to that time will continue to be used by the research team. It may not be removed. This information will only be used for the purposes of this study

Information collected and used by the research team will be stored by Dr. Scott MacKinnon and he is the person responsible for keeping it secure.

Your access to records
You may ask the Dr. MacKinnon to see the information that has been collected about you.

9. Questions:

If you have any questions about taking part in this study, you can meet with the investigator who is in charge of the study at this institution. That person is: Dr. Scott MacKinnon.

Or you can talk to someone who is not involved with the study at all, but can advise you on your rights as a participant in a research study. This person can be reached through:
Office of the Human Investigation Committee (HIC) at 709-777-6974 or
Email: **hic@mun.ca**
After signing this consent you will be given a copy.

Signature Page

Study title:

Effect of simulated training upon the performance of ice field navigation in a lifeboat

Name of principal investigator:

Dr. Scott MacKinnon

To be filled out and signed by the participant:

Please check as appropriate:

I have read the consent Yes { } No { }

I have had the opportunity to ask questions/to discuss this study. Yes { } No { }

I have received satisfactory answers to all of my questions. Yes { } No { }

I have received enough information about the study. Yes { } No { }

I have spoken to Dr. MacKinnon and he has answered my questions Yes { } No { }

I understand that I am free to withdraw from the study Yes { } No { }

- at any time
- without having to give a reason

I understand that it is my choice to be in the study and that I may not benefit. Yes { } No { }

I agree to be video/audio taped Yes { } No { }

I agree to take part in this study. Yes { } No { }

____

Signature of participant Date

____

Signature of witness (if applicable) Date

To be signed by the investigator or person obtaining consent

I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the participant fully understands what is involved in being in the study, any potential risks of the study and that he or she has freely chosen to be in the study.

____ ________________________

Signature of investigator/person obtaining consent Date

Telephone number: ________________________

Appendix D: Notes from Group 1 Standard Training

Procedures for operational checks required before using the launching system and lowering the lifeboat in conditions where sea-ice is present

Preparations for Launching

1. Overside lighting is switched on and swung out, if required.
2. An observation of ice conditions in launch area to see if a safe launch is possible is conducted. May need to move to an alternate lifeboat if a safe launch is impossible. Inform bridge of ice conditions. Bridge informs rescue or supply vessel to use propeller wash to clear launch area of pack ice if available and ice conditions allow for it.
3. The responsible crewman brings the SART (Search and Rescue Radar Transponder) to the mustering area.
4. The helmsman or other designated person checks the operation of the portable VHF radio telephone and brings it to mustering area.
5. The helmsman and designated launching crew enter the boat and carry out the following tasks:
   i. Close bottom plug.
   ii. Switch batteries to operating position (if necessary).
   iii. Disconnect charging cable.
   iv. Check fuel and coolant levels.
   v. Hook Release Interlock checked to be "ON", in safety position.
6. Designated persons on the deck carry out the following tasks and checks:
   i. Remove snow and ice around launch station that could impede loading of personnel. There may be a need for ice anti-slip provisions (e.g. sand) around the embarkation deck if de-icing is not done in time.
   ii. Conduct an exterior inspection to ensure no snow, icing, or obstructions exist to hamper the launch or will affect the lifeboat once it enters the water.
   iii. Ensure that no outboard maintenance pendants are connected to the boat.
   iv. Additional equipment is passed to crewmen in the boat to be stowed.

v. Check launching area for obstructions such as ice and debris. If all clear, they contact bridge and report "ready for boarding". If not clear they wait for a suitable launch area or get a rescue or standby vessel to use propeller wash to clear launch area of pack ice.

vi. The bridge will give order to board the boat and launch.

vii. Remove harbour pins

viii. Release the boat from its lashings and clear these away.

Embarkation

1. Those who are able board the lifeboat on their own. All personnel must be mindful of slippery surfaces. Casualties on stretchers are passed inboard and secured. All passengers should put on seatbelts. Helmsman starts the engine.

2. The last person to board reconfirms that launching area is clear.

3. All doors and portholes are closed.

Launching the Boat

1. Make sure that all lifeboat lashings are removed before launching.

2. If possible have a rescue vessel, supply vessel or someone still onboard the ship or platform to monitor the launch area during launch.

3. Pull the control wire in top of the hatch. Pulling down on the control wire lifts the brake and starts the descent. Releasing it applies the brake and stops the descent.

4. The winch has a two-speed lowering system with a hydraulic speed controller. The low speed should be used during turn-out of the davit and the high speed should be used for the descent and is fixed by the hydraulic speed controller and cannot be adjusted by the remote control wire.

   During turn-out of the davit a gentle pull should be applied to the remote control wire and the winch will operate at low speed. When the lowering blocks/hook links leave the davit head, pull harder on the wire and the high speed mode will be activated.

5. The boat should be allowed to descend to the water at the automatically controlled speed and splash down. This frees the fall for easy release. Descent can be stopped if ice or debris enters the launch area.

Appendix E: Notes from Group 2 Classroom Tutorial on Ice Navigation

Lifeboat (TEMPSC) in Ice Tutorial

VAST Project

May 7th & 8th, 2010

1

Tutorial Outline

1 Sea-Ice [30 minutes]

2 Lifeboat Operation in Sea-ice - General Knowledge. [30 minutes]

3 Operations and Procedures to operate a lifeboat in Sea-ice. [30 minutes]

4 Hazards associated with operating a lifeboat in Sea-ice. [30 minutes]

2

1 - Sea-ice

1.1 Sea-ice types
- Identify different types of ice.

1.2 Sea-ice concentration
- Identify sea-ice concentrations from the 'ice-egg code'.
- Determine sea ice concentrations

1.3 Environmental factors
- Describe additional environmental factors that can effect operating a lifeboat in an ice field.

1.4 Perspective
- Assess sea-ice concentrations from a variety of perspectives.
- Assess sea-ice concentration from the perspective a launched lifeboat coxswain position

1.5 Sea-ice formation
- Explain how ice is formed

1.6 Effect of Pressure
- Demonstrate the effects of pressure on sea-ice and the resultant ability of a lifeboat to maneuver.

3

Sea Ice Cycle

- Formation
- Growth
- Deformation
- Disintegration

Fresh water freezes at a steady state of 0°C. However, the **freezing point of sea water** is not only **lower than 0°C**; it also varies depending on the **degree of salinity**. As salinity increases, the freezing point becomes lower.

4

Sea Ice Formation

- The first sign of freezing on the sea is an **oily appearance** of the water caused by the formation of **needle-like crystals**. These crystals are pure ice, free of salt. They increase in number until the sea is covered by a slush of a thick, soupy consistency.
- Ice will form first in shallow water, near the coast or over shoals or banks, and particularly in bays, inlets, and straits in which there are no currents, and in areas of low salinity (near the mouths of rivers, for instance).

5

Sea Ice Growth

- Once a sheet of ice has formed, it can **increase in thickness by the freezing of water on its lower surface**. This means that heat must be removed from the water.
- When the air above the ice is colder than the water below the ice, heat is removed by conduction through the ice from the water to the air above.

6

Sea Ice Deformation

- As the temperature of sea ice falls below its freezing point, the ice expands rapidly at first, and continues to expand but at a decreasing rate until a certain temperature is reached, after which it contracts slightly. The greater the salt content (salinity) of the ice, the greater the expansion with cooling.
- As a result of this thermal expansion, we have pressure ridges forming on the ice surface at first; later on, when temperatures are lower and the ice begins to contract, cracks will form. The cracks are narrow because the contraction is much less than the expansion.
- As the ice warms up, the ice first expands slightly, closing any cracks, then contracts again and at an ever-increasing rate as its melting point is reached. Thus, during a mild spell or after the beginning of the thawing period, wide cracks will be found in the ice.

7

Sea Ice Deformation

- Pressure ridges can be formed in two ways: from the pressure exerted on the ice by the force of wind or tide; or from thermal expansion.
- Pressure ridges occur mostly in newer ice. Since newer ice is the most salty and flexible of ice types, the pressure ridges are relatively weak in strength when newly formed. They are a navigational hazard because of their thickness, rather than their strength.

8

Sea Ice Deformation

- Hummocks are small hills of broken ice which has been forced upwards by pressure. They may be fresh or weathered. The weathering may occur when drifted snow piles up against a pressure ridge and is partially melted and compacted into a solid mass. Or, it may occur because of summer thawing and solar radiation.

9

Sea Ice Deformation

- Ice floes are formed by the cracking and breaking of a solid ice sheet.

10

Sea Ice Deformation

- Rafting occurs when two floes are pressed together in such a way that one over-ridges the other in a continuous manner. The thickness is obviously doubled where the rafting occurs but there is a minimum of fracturing of the floes. Rafting is most common in the thinner forms of ice where the vertical displacement required is low.

11

Sea Ice Deformation

- Cracks are formed where an ice sheet breaks and the floes separate. In low temperatures they refreeze quickly and may subsequently be forms of ridging.

12

Sea Ice Disintegration

- Disintegration of ice takes place **primarily through melting.** Melting occurs when the temperature of the ice is raised above its freezing point. The heat required to do this comes from two major sources:
  - the absorption of the sun's radiation by the ice, and
  - the conduction of heat from the surrounding air, water or land.

13

Sea Ice Dynamics

- There are two primary forces that affect the motion of pack ice:
  - wind stress (at the top surface of the ice), and
  - water stress (at the bottom of the ice).

14

Sea Ice Dynamics

- **Wind Stress**
  The wind exerts a force on the surface of the ice pack, causing it to move. Furthermore, ridges and hummocks in the pack present a sail area to the wind. This means that ice having an uneven ("rough") surface will move faster than smooth ice. In the absence of other forces, open pack ice will typically move at a speed equivalent to 2% of the wind speed.

15

Sea Ice Dynamics

- **Water Stress**
  If the pack ice is being blown across otherwise still water, the water will exert a drag on the bottom surface of the ice tending to slow it down. The rougher the bottom surface, the greater will be the drag. Similarly, if the water is in motion because of a current, it will drag the ice along with it.

16

Sea Ice Dynamics

- There are three main types of current:
  - **permanent currents**, such as the Labrador Current
  - **periodic currents**, such as tides
  - **temporary currents**, which are wind induced

- **It is essential to consider the presence of sea currents when estimating the ice drift.**

17

Sea Ice Types

- **New Ice**
  Recently formed ice composed of ice crystals that are only weakly frozen together (if at all) and have a definite form only while they are afloat.
- **Nilas**
  A thin elastic crust of ice (up to 10 cm in thickness), easily bending on waves and swell and under pressure growing in a pattern of interlocking "fingers" (finger rafting).
- **Young Ice**
  Ice in the transition stage between nilas and first-year ice, 10-30 cm in thickness.
- **First-year Ice**
  Sea ice of not more than one winter's growth, developing from young ice, with a thickness of 30 cm or greater.
- **Old Ice**
  Sea ice that has survived at least one summer's melt. Its topographic features generally are smoother than first-year ice.

18

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Sea Ice Forms

- **Pancake Ice**
  Circular pieces of ice 30 cm to 3 m in diameter, up to 10 cm in thickness, with raised rims due to the pieces striking against one another.
- **Brash Ice**
  Accumulation of floating ice made up of fragments not more than 2 m across, the wreckage of other forms of ice.
- **Ice Cake**
  Any relatively flat piece of ice less than 20 m across.
- **Floe**
  Any relatively flat piece of ice 20 m or more across.
- **Fast Ice**
  Ice which forms and remains fast along the coast. Fast ice higher than 2 m above sea level is called an ice shelf.

24

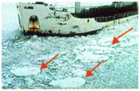
- **Pancake Ice**
  Predominantly circular pieces of ice 30 cm to 3 m in diameter, up to 10 cm in thickness, with raised rims due to the pieces striking against one another.

25

- **Brash Ice**
  Accumulation of floating ice made up of fragments not more than 2 m across, the wreckage of other forms of ice.

26

- **Ice Cake**
  Any relatively flat piece of ice less than 20 m across.



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- **Floe**
  Any relatively flat piece of ice 20 m or more across. Floes are subdivided according to horizontal extent as follows:

Small: 20-100 m across.
Medium: 100-500 m across.
Big: 500-2,000 m across.
Vast: 2-10 km across.
Giant: Greater than 10 km across.

28

Concentration

- The ratio expressed in tenths (/10) describing the area of the water surface covered by ice as a fraction of the whole area. Total concentration includes all stages of development that are present; partial concentration refers to the amount of a particular stage or of a particular form of ice and represents only a part of the total.

29

Concentration

- **Consolidated Ice:** Floating ice in which the concentration is 10/10 and the floes are frozen together.
- **Compact Ice:** Floating ice in which the concentration is 10/10 and no water is visible.
- **Very Close Pack/Drift:** Floating ice in which the concentration is 9/10 to less than 10/10.
- **Close Pack/Drift:** Floating ice in which the concentration is 7/10 to 8/10, composed of floes mostly in contact with one another.
- **Open Drift:** Floating ice in which the concentration is 4/10 to 6/10, with many leads and polynyas. Floes generally not in contact with one another.
- **Very Open Drift:** Ice in which the concentration is 1/10 to 3/10 and water dominates over ice.
- **Open Water:** A large area of freely navigable water in which ice is present in concentrations less than 1/10. No ice of land origin is present.
- **Bergy Water:** An area of freely navigable water in which ice of land origin is present. Other ice types may be present, although the total concentration of all other ice is less than 1/10.
- **Ice Free:** No ice present. If ice of any kind is present, this term shall not be used.

30

Ice Egg Code

- The Egg Code is organized in four sections that directly relate to each other. It is critical to understand that each of the sections provides a piece of coded information that is further refined by the next section. In this way, the Egg Code offers a complete picture of the ice condition for a given region.

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Ice Egg Code

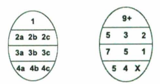
1. *Total Concentration:* the ice coverage of an area determined by its concentration and expressed in tenths.

2. *Partial Concentration:* the break-down of the total ice coverage expressed in tenths and graded by thickness (thickest-2a, medium-2b, thinnest-2c.) These grades directly relate to the type of ice described in Section 3.

3. *Stage of Development:* the type of ice in each of the grades, in sections 2a, 2b and 2c above, determined by its age- old ice or young ice- and expressed as a number.

4. *Floe Size:* the form of the ice determined by its floe size (any relatively flat piece of ice 20 m or more across) for each section and expressed as a code number.

32



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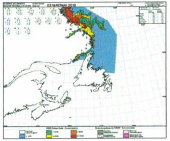

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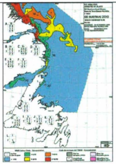

35

Summary of Sea-ice section

1.1 Sea-ice types
- Identify different types of ice.
1.2 Sea-ice concentration
- Identify sea-ice concentrations from the 'ice-egg code'.
- Determine sea ice concentrations
1.3 Environmental factors
- Describe additional environmental factors that can effect operating a lifeboat in an ice field.
1.4 Perspective
- Assess sea-ice concentrations from a variety of perspectives.
- Assess sea-ice concentration from the perspective a launched lifeboat coxswain position
1.5 Sea-ice formation
- Explain how ice is formed
1.6 Effect of Pressure
- Demonstrate the effects of pressure on sea-ice and the resultant ability of a lifeboat to maneuver.

36

2 - Lifeboat Operation in Sea-ice - General Knowledge

2.1 Engine and Propulsion Systems
- Identify engine pre-start procedures in cold conditions.
- Describe effects of cold water/ice operations on engine and propulsion systems.

2.2 Maneuvering System
- Describe effects of cold water/ice operations on maneuvering systems.

2.3 Launching System
- Describe operational checks required before using the launching system.
- Describe the procedures for lifeboat launching in adverse ice, weather and sea conditions.
- Describe effects of cold water/ice operations on launching systems.

2.4 Pre-Launch
- Describe pre-launch checks when in an ice field.
- Determine the compass heading to a safe area.

37

Starting the Engine

Lifeboats and their engines differ from manufacturer to manufacturer with starting instructions specific to each particular model. There are some generic checks that usually have to be completed before starting the engine no matter the model:

- Check fuel, coolant and lubrication levels;
- Ensure all valves are set in proper position;
- Inspect all belts and hoses;
- Place the gear/throttle lever in neutral;
- Set other controls to manufactures instructions;
- Start the engine and adjust the throttle;
- Check oil pressure gauge or light; and
- Check water temperature gauge or light.

Lifeboat engines are required to operate no less than 5 minutes after starting from cold with the lifeboat out of the water. It is advised to keep watch on the temperature indicator to help prevent overheating the engine when allowing the it to run for longer periods of time.

38

Engine and Propulsion Systems

- Regulations require that a lifeboat have a power starting system with two independent rechargeable energy sources or a manual starting system. Power systems are usually dual battery power with a selector switch and glow plugs or a hydraulic pump with two hydraulic accumulators and an ether system as a cold temperature starting aid. The hydraulic accumulators are pressurized when the engine is running or can be pressurized using a hand crank. Some lifeboats will also have a mechanical rewind starter as a backup to the electrical power system.

39

Engine and Propulsion Systems

- The diesel engine in a lifeboat may be air-cooled which may require opening dampers to facilitate airflow. Other engines may be fresh-water cooled using a keel cooler or may be seawater cooled using a keel cooler or may be seawater cooled requiring the opening of valves to allow water to be pumped through the cooling system.

40

Engine and Propulsion Systems

- Seawater cooled intake systems are easily clogged by slush and ice in pack ice conditions. Keel coolers are less likely to cause issues, although they may become damaged by ice moving underneath the craft creating leaks.

41

Water Spray System

- The sprinkler system, when activated, should keep the inside air temperature from rising more than 10°C.
- There are two things that coxswains need to be concerned with before using the deluge system in pack ice conditions. One, the water may quickly freeze after being sprayed, covering the windows, which will prevent visibility. Second, when the system is starts, suction can cause ice to clog the intake preventing the system from operating correctly. The coxswain should keep these in mind when choosing where to navigate the TEMPSC.

42

Launching Systems

- Excessive personnel payload
- Seawater cocks/jammed; plug cannot be shipped
- Access to craft blocked
- Craft 'takes control'
- Release pins (harbour pins) jammed
- Davit seizes
- Winch brake release mechanism seizes
- Falls/wires/shackles break

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Launching Systems

- Accidental on-load release of TEMPSC
- Wave impact on TEMPSC
- Craft rotates during descent
- TEMPSC lowered onto ice floe
- Movement of 'mother-vessel' whilst lowering

ENSURE ALL PERSONNEL ARE PROPERLY AND SECURELY STRAPPED INTO POSITION

44

Determine the compass heading to a safe area.

- Factors
  - Ice concentration
  - Wind
  - Current
  - Location of rescue assets
  - Wave action
  - Location distance
  - Hazards in the area (debris, atmospheric, fire etc.)

Magnetic

45

2 - Lifeboat Operation in Sea-ice - General Knowledge - Summary

- 2.1 Engine and Propulsion Systems

- Identify engine pre-start procedures in cold conditions.
- Describe effects of cold water/ice operations on engine and propulsion systems.

- 2.2 Maneuvering System

- Describe effects of cold water/ice operations on maneuvering systems.

- 2.3 Launching System

- Describe operational checks required before using the launching system.
- Describe the procedures for lifeboat launching in adverse ice, weather and sea conditions.
- Describe effects of cold water/ice operations on launching systems.

- 2.4 Pre-Launch

- Describe pre-launch checks when in an ice field.
- Determine the compass heading to a safe area.

46

Operations and Procedures to operate a lifeboat in Sea-ice.

- Demonstrate
  - Simulator
- Predict the outcome of a weather forecast on an ice field and the ability of the lifeboat to continue maneuvering.
  - Wind speed and direction
    - Effect on sea-ice
    - Effect on TEMPSC

47

3 - Operations and Procedures to operate a lifeboat in Sea-ice.

- Performance Limits
  - Increased power of a lifeboat has minimal affect on the vessel's ability to progress through pack ice.
  - In model tests, ice concentrations of about 6/10ths to 7/10ths were found to be limiting conditions. Larger floes were found to hinder performance more than smaller floes while increasing power did not significantly improve performance in ice.

48

4 -Hazards associated with operating a lifeboat in an ice-field

- Describe hazards associated with operating a life boat in ice fields of varying concentrations.
- **Wash back**
- **Coxswain does not steer a correct course**
- **Cork nozzle steering direction limited**
- **Side hatch door stays open**
- **Propulsion system fails**
- **Towing**
- **Stability of TEMPSC**

49

Hazards

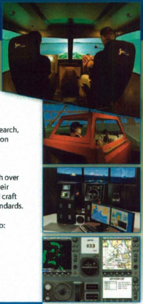
- **Air unable to enter air vent**
- **TEMPSC pushed up onto the ice**
- **TEMPSC crushed by ice**
- **TEMPSC hull damaged by ice**
- **Deterioration of health of crew and TEMPSC occupants**
- **Radio antenna covered by ice**
- **Rescue vessel unable to find TEMPSC**
- **TEMPSC hatch doors unable to be opened**

50

Appendix F: Virtual Marine Technologies Simulator Technology

VMT
virtual marine technology

Small Craft Training Simulators



Virtual Marine Technology (VMT) develops simulators for lifeboat, fast response craft and high speed electronic navigation training. VMT is partnered with Canada's leading maritime institutions to research, model and simulate small craft motion. Specific emphasis is placed on fast response craft when operating at speed and lifeboats when launched into waves.

Complementing VMT's simulation expertise is a team of mariners with over 70 years of Coast Guard, teaching and regulatory experience. It is their responsibility to ensure the company's training tools enhance small craft training programs and follow internationally recognized training standards.

By investing in VMT's small craft simulators, organizations are able to:

- Increase training frequency and focus
- Mitigate training and operational risk
- Reduce training costs

Visit www.vmtechnology.ca to:

- Watch videos of VMT's simulator visuals
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t. +1(709) 738-6306
f. info@vmtechnology.ca

Appendix G: Post-Train Questionnaire Part IA

GROUP 1 PART IA POST-TRAINING QUESTIONNAIRE

DESCRIPTION AND INSTRUCTIONS

This questionnaire is asking about your experiences with the training you had today. Please circle one response on each question that best suites the level of competence or confidence you feel for that statement.

Part I

1. How proficient do you feel in your abilities in the pre-start, start, stop and after-use procedures of the lifeboat engine?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Not at all proficient   Fully proficient

2. How confident do you feel in your abilities in the pre-start, start, stop and after-use procedures of the lifeboat engine?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Not at all confident   Fully confident

3. How proficient do you feel in your abilities to use the engine monitoring gauge function?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Not at all proficient   Fully proficient

4. How confident are you in understanding the purpose and effect of a lifeboat's manoeuvring controls?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Not at all confident   Fully confident

5. How confident are you in understanding the effect trim, list, and displacement have on lifeboat acceleration, speed and turning?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Not at all confident								Fully confident		

6. How confident are you in understanding the effect waves and wind have on lifeboat manoeuvring?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Not at all confident								Fully confident		

7. How confident are you in understanding the procedures for approaching stationary objects?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Not at all confident								Fully confident		

8. How proficient do you feel in your ability to calculate a "Safe Haven Heading"?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Not at all proficient								Fully proficient		

9. How proficient do you feel, that if demanded, you could navigate a lifeboat within an ice field?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Not at all proficient								Fully proficient		

Appendix H: Post-Train Questionnaire Part IB

GROUP 2 PART IB POST-TRAINING QUESTIONNAIRE

DESCRIPTION AND INSTRUCTIONS

This questionnaire is asking about your experiences with the training you had today. Please circle one response on each question that best suites the level of proficiency or confidence you feel for that statement.

Part I-B

10. How well do you think you will be able to navigate through ice?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Not at all — Very well

11. Do you feel you would likely sustain damage to the lifeboat in an ice field?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Not at all likely — Very likely

12. At what maximum concentration of ice do you think you are able to navigate through?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

$0/10^{th}$	$1/10^{t}$	$2/10^{th}$	$3/10^{th}$	$4/10^{th}$	$5/10^{th}$	$6/10^{th}$	$7/10^{th}$	$8/10^{th}$	$9/10^{th}$	$10/10^{th}$
s	h	s	s	s	s	s	s	s	s	s

Appendix I: Post-Train Questionnaire Part II

GROUP 3 PART II POST-TRAINING QUESTIONNAIRE

DESCRIPTION AND INSTRUCTIONS

This questionnaire is asking about your experiences with the training you had today. Please circle one response on each question that best suites the level of proficiency or confidence you feel for that statement.

Part II

1. How responsive was the simulated environment to actions that you initiated (or performed)?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Not at all responsive — Very responsive

2. How natural did your interactions with the simulated environment seem?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Not at all natural — **Very natural**

3. How completely were *all* of your senses engaged?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Not at all — Completely

4. How much did the visual aspects of the simulated environment involve you?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Not at all involved — Fully involved

5. How much did the auditory aspects of the simulated environment involve you?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Not at all involved Fully involved

6. How natural was the mechanisms that controlled movement through the simulated environment?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Not at all natural Very natural

7. How inconsistent or disconnected was the information coming from your various senses?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Very disconnected Not very disconnected

8. How much did your experiences in the simulated environment seem consistent with your real-world experiences?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Very inconsistent Very consistent

9. Were you able to anticipate what would happen next in the simulated environment in response to the actions that you performed?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Not very easy to anticipate Very easy to anticipate

10. How involved were you in the simulated environment experience?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Not very involved   Very involved

11. How much delay did you experience between your actions and expected outcomes?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Very little delay   A lot of delay

12. How quickly did you adjust to the simulated environment experience?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Not very quickly   Very quickly

13. How proficient in moving and interacting with the simulated environment did you feel at the end of the experience?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Not very proficient   Very proficient

14. Did you learn new techniques that enabled you to improve your performance?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

No techniques at all   Many new techniques

Appendix J: Post-Test Questionnaire

Post Testing Debriefing Questionnaire

DESCRIPTION AND INSTRUCTIONS

This questionnaire is asking about your experiences with the testing you had today. Please circle one response on each question that best suites the level of proficiency or confidence you feel for that statement.

1. What were the challenges you faced during testing?

2. What would better prepare you to face these challenges?

3. What would help prepare you better for the ice trials?

4. How effective did you find the training?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Not at all effective Fully effective

5. How well do you think you navigated the ice field during the testing?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Not very well Very well

6. How well do you feel you can navigate through ice in the future?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Not well at all Fully well

7. At what maximum concentration of ice do you think you are able to navigate through in the future?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

$0/10^{th}$s	$1/10^{t}$h	$2/10^{th}$s	$3/10^{th}$s	$4/10^{th}$s	$5/10^{th}$s	$6/10^{th}$s	$7/10^{th}$s	$8/10^{th}$s	$9/10^{th}$s	$10/10^{th}$s

Appendix K: Chi Squared Test

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	13.951[a]	2	.001
Likelihood Ratio	17.269	2	.000
Linear-by-Linear Association	2.658	1	.103
N of Valid Cases	114		

Directional Measures

			Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Nominal by Nominal	Lambda	Symmetric	.116	.031	3.311	.001
		Type of Training Dependent	.139	.041	3.311	.001
		Did they pass Dependent	.000	.000	.[c]	.[c]
	Goodman and Kruskal tau	Type of Training Dependent	.062	.022		.001[d]
		Did they pass Dependent	.122	.051		.001[d]

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Cannot be computed because the asymptotic standard error equals zero.

d. Based on chi-square approximation

Appendix L: Full Data Set – Pass/Fails and Performance Measurements

Pass/Fail Full Data Set

Participant	Group	Day	Time	NS	SN	ES	EN	NWSE	SENW	Totals
4	1	1	PM	P	P	P	P	F	P	
6	1	2	PM	P	P	F	P	P	P	
7	1	2	AM	P	F	F	P	F	F	
12	1	3	PM	P	F	P	F	P	P	
13	1	3	PM	P	P	P	P	P	P	
18	1	5	AM	F	F	P	P	P	P	
Fails				1	3	2	1	2	1	10
Passes				5	3	4	5	4	5	26
2	2	1	PM	P	P	P	F	P	F	
9	2	4	AM	P	P	F	P	P	P	
11	2	3	AM	P	P	P	P	P	F	
15	2	3	PM	P	F	P	F	P	P	
16	2	3	PM	P	F	F	P	P	P	
17	2	4	AM	P	P	F	P	P	P	
19	2	5	AM	F	F	F	P	P	P	
Fails				1	3	4	2	0	2	12
Passes				6	4	3	5	7	5	30
1	3	1	AM	P	P	P	F	F	P	
3	3	1	PM	P	P	P	P	P	P	
5	3	1	PM	P	P	P	P	P	P	
8	3	5	AM	P	F	P	P	P	P	
10	3	3	AM	P	P	P	P	P	F	
14	3	3	PM	P	P	P	P	P	P	
Fails				0	1	0	1	1	1	4
Passes				6	5	6	5	5	5	32

Group 1 Performance Measurements

PARTICIPANT	Path Length	Time through Course	Steering Nozzle Executions	# of Impacts	Max. Impact Severity
4					
NS	63.77	56.84	9.00	1	0.17
SN	66.26	77.04	11.00	3.00	0.32
ES	59.28	61.60	9.00	2.00	0.15
EN	77.95	161.62	12.00	3.00	0.42
NWSE	62.15	57.44	7.00	3.00	0.22
SENW	52.11	58.18	14.00	1.00	0.31
6					
NS	65.43	60.36	11.00	1.00	0.11
SN	68.92	81.46	10.00	6.00	0.26
ES	58.79	63.10	11.00	7.00	0.21
EN	56.77	63.86	8.00	2.00	0.16
NWSE	67.22	74.88	11.00	3.00	0.18
SENW	64.01	76.10	9.00	2.00	0.22
7					
NS	62.29	71.22	13.00	2.00	0.29
SN	36.16	26.24	9.00	5.00	0.25
ES	59.10	79.02	19.00	3.00	0.17
EN	71.45	144.72	9.00	4.00	0.31
NWSE	72.92	65.74	12.00	6.00	0.31
SENW	60.89	48.90	8.00	4.00	0.22
12					
NS	63.33	71.92	12.00	1.00	0.39
SN	59.25	126.78	12.00	5.00	0.37
ES	58.75	65.52	10.00	3.00	0.17
EN	58.16	61.04	6.00	3.00	0.30
NWSE	61.47	71.04	18.00	4.00	0.18
SENW	63.60	63.66	11.00	5.00	0.29
13					
NS	67.07	62.94	8.00	1.00	0.17
SN	66.95	56.96	11.00	3.00	0.17

ES	67.34	68.32	11.00	2.00	0.16
EN	60.65	74.64	14.00	4.00	0.34
NWSE	61.81	68.92	8.00	5.00	0.25
SENW	71.69	82.28	10.00	3.00	0.27
18					
NS	65.42	55.12	9.00	3.00	0.44
SN	47.07	47.54	10.00	2.00	0.18
ES	63.31	52.38	9.00	3.00	0.29
EN	64.11	53.22	8.00	9.00	0.31
NWSE	63.28	68.64	11.00	5.00	0.36
SENW	67.05	53.28	7.00	8.00	0.34

Group 2 Performance Measurements

PARTICIPANT	Path Length	Time through Course	Steering Nozzle Executions	# of Impacts	Max. Impact Severity
2					
NS	64.62	79.00	11.00	4.00	0.20
SN	67.54	70.32	9.00	3.00	0.11
ES	67.24	93.40	10.00	1.00	0.15
EN	52.27	60.96	3.00	2.00	0.20
NWSE	72.39	56.18	9.00	1.00	0.24
SENW	60.90	71.48	8.00	2.00	0.14
9					
NS	65.84	81.72	8.00	4.00	0.23
SN	67.70	85.16	13.00	2.00	0.37
ES	50.95	54.50	15.00	7.00	0.20
EN	80.18	127.04	17.00	6.00	0.20
NWSE	65.52	81.22	8.00	6.00	0.39
SENW	57.62	61.00	5.00	1.00	0.13
11					
NS	65.16	69.30	10.00	1.00	0.20
SN	69.70	64.64	8.00	2.00	0.34

ES	76.52	107.40	8.00	4.00	0.36
EN	74.56	103.18	4.00	4.00	0.53
NWSE	64.22	86.36	12.00	6.00	0.34
SENW	76.89	109.94	13.00	4.00	0.36
15					
NS	63.03	64.08	16.00	1.00	0.31
SN	64.35	59.32	8.00	5.00	0.35
ES	58.13	61.98	14.00	3.00	0.21
EN	59.92	50.56	13.00	6.00	0.18
NWSE	57.68	51.20	16.00	0.00	0.00
SENW	59.23	51.48	15.00	4.00	0.24
16					
NS	63.71	76.56	16.00	2.00	0.32
SN	58.21	48.64	11.00	0.00	0.00
ES	69.91	76.66	15.00	5.00	0.17
EN	57.30	53.48	9.00	4.00	0.28
NWSE	72.11	86.26	18.00	2.00	0.19
SENW	57.44	48.00	9.00	1.00	0.24
17					
NS	65.17	62.76	8.00	7.00	0.37
SN	63.80	88.12	12.00	2.00	0.14
ES	56.16	54.34	15.00	3.00	0.30
EN	64.37	90.66	20.00	6.00	0.24
NWSE	66.31	72.28	7.00	5.00	0.15
SENW	71.22	84.06	11.00	3.00	0.18
19					
NS	67.27	66.58	13.00	3.00	0.40
SN	67.55	66.32	13.00	3.00	0.31
ES	67.42	72.46	12.00	3.00	0.45
EN	71.35	82.50	13.00	2.00	0.28
NWSE	68.33	64.12	15.00	1.00	0.57
SENW	48.84	58.38	14.00	4.00	0.20

Group 3 Performance Measurements

PARTICIPANT	Path Length	Time through Course	Steering Nozzle Executions	# of Impacts	Max. Impact Severity
1					
NS	68.03	59.26	12.00	1.00	0.11
SN	73.66	77.80	17.00	0.00	0.00
ES	57.48	61.92	13.00	3.00	0.28
EN	64.70	66.42	15.00	5.00	0.18
NWSE	66.93	67.70	11.00	3.00	0.22
SENW	75.98	76.14	13.00	2.00	0.32
3					
NS	73.29	66.54	10.00	3.00	0.30
SN	71.97	84.11	8.00	3.00	0.22
ES	58.61	58.42	8.00	2.00	0.47
EN	62.01	74.16	10.00	6.00	0.27
NWSE	73.34	74.26	8.00	3.00	0.45
SENW	77.53	85.44	7.00	2.00	0.12
5					
NS	62.98	56.72	16.00	4.00	0.26
SN	62.96	61.96	15.00	2.00	0.24
ES	58.71	53.94	18.00	1.00	0.15
EN	70.52	67.48	14.00	5.00	0.25
NWSE	63.85	59.14	12.00	1.00	0.16
SENW	61.02	70.22	16.00	6.00	0.29
8					
NS	69.57	67.08	10.00	3.00	0.14
SN	62.02	65.26	14.00	4.00	0.15
ES	71.77	77.06	13.00	7.00	0.21
EN	66.08	78.60	12.00	4.00	0.30
NWSE	60.00	57.58	15.00	1.00	0.59
SENW	53.06	53.98	13.00	0.00	0.00
10					
NS	65.26	73.18	10.00	1.00	0.12
SN	72.20	87.90	14.00	3.00	0.22
ES	51.29	66.38	10.00	5.00	0.24

EN	86.69	103.44	14.00	4.00	0.32
NWSE	63.77	76.70	14.00	3.00	0.21
SENW	61.37	63.70	16.00	1.00	0.14
14					
NS	78.80	105.52	11.00	6.00	0.22
SN	66.65	61.66	12.00	1.00	0.11
ES	67.74	103.48	9.00	3.00	0.26
EN	63.27	76.96	13.00	3.00	0.33
NWSE	61.71	80.04	12.00	1.00	0.23
SENW	68.82	75.50	7.00	2.00	0.12

Appendix M: ANOVAs for Directional Based Runs

NS ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Number of impacts	Between Groups	10.274	2	5.137	1.700	.214
	Within Groups	48.357	16	3.022		
	Total	58.632	18			
Average impact severity	Between Groups	.004	2	.002	1.352	.287
	Within Groups	.026	16	.002		
	Total	.030	18			
Number of rudder executions	Between Groups	6.896	2	3.448	.475	.631
	Within Groups	116.262	16	7.266		
	Total	123.158	18			
Average time between rudder ex	Between Groups	15.930	2	7.965	1.136	.346
	Within Groups	112.202	16	7.013		
	Total	128.132	18			
Path length through course	Between Groups	98.226	2	49.113	4.135	.036
	Within Groups	190.047	16	11.878		
	Total	288.272	18			
Time through course	Between Groups	285.621	2	142.810	1.051	.372
	Within Groups	2173.383	16	135.836		
	Total	2459.004	18			

Post Hoc Test NS Multiple Comparisons

Path length through course	LSD	Standard STCW training	STCW + classroom	-.41976	1.91742	.829	-4.4845	3.6450
			Simulation training	-5.10333*	1.98980	.021	-9.3215	-.8851
		STCW + classroom	Standard STCW training	.41976	1.91742	.829	-3.6450	4.4845
			Simulation training	-4.68357*	1.91742	.027	-8.7483	-.6188
		Simulation training	Standard STCW training	5.10333*	1.98980	.021	.8851	9.3215
			STCW + classroom	4.68357*	1.91742	.027	.6188	8.7483
	Bonferroni	Standard STCW training	STCW + classroom	-.41976	1.91742	1.000	-5.5451	4.7056
			Simulation training	-5.10333	1.98980	.062	-10.4221	.2155
		STCW + classroom	Standard STCW training	.41976	1.91742	1.000	-4.7056	5.5451
			Simulation training	-4.68357	1.91742	.080	-9.8089	.4418
		Simulation training	Standard STCW training	5.10333	1.98980	.062	-.2155	10.4221
			STCW + classroom	4.68357	1.91742	.080	-.4418	9.8089

SN ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Number of impacts	Between Groups	11.979	2	5.989	2.622	.104
	Within Groups	36.548	16	2.284		
	Total	48.526	18			
Average impact severity	Between Groups	.004	2	.002	.508	.611
	Within Groups	.058	16	.004		
	Total	.061	18			
Number of rudder executions	Between Groups	32.084	2	16.042	3.109	.072
	Within Groups	82.548	16	5.159		
	Total	114.632	18			

Average time between rudder ex	Between Groups	38.926	2	19.463	2.328	.130
	Within Groups	133.773	16	8.361		
	Total	172.699	18			
Path length through course	Between Groups	382.949	2	191.474	2.837	.088
	Within Groups	1079.923	16	67.495		
	Total	1462.872	18			
Time through course	Between Groups	66.112	2	33.056	.068	.935
	Within Groups	7833.337	16	489.584		
	Total	7899.449	18			

Post Hoc Test SN Multiple Comparisons

Dependent Variable		(I) Group distinction	(J) Group distinction	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Number of impacts	LSD	Standard STCW training	STCW + classroom	1.571	.841	.080	-.21	3.35
			Simulation training	1.833	.873	.052	-.02	3.68
		STCW + classroom	Standard STCW training	-1.571	.841	.080	-3.35	.21
			Simulation training	.262	.841	.759	-1.52	2.04
		Simulation training	Standard STCW training	-1.833	.873	.052	-3.68	.02
			STCW + classroom	-.262	.841	.759	-2.04	1.52
	Bonferroni	Standard STCW training	STCW + classroom	1.571	.841	.240	-.68	3.82
			Simulation training	1.833	.873	.156	-.50	4.17
		STCW + classroom	Standard STCW training	-1.571	.841	.240	-3.82	.68
			Simulation training	.262	.841	1.000	-1.99	2.51
		Simulation training	Standard STCW training	-1.833	.873	.156	-4.17	.50
			STCW + classroom	-.262	.841	1.000	-2.51	1.99

Path length through course	LSD	Standard STCW training	STCW + classroom	-8.11500	4.57071	.095	-17.8045	1.5745
			Simulation training	-10.80833*	4.74325	.037	-20.8636	-.7531
		STCW + classroom	Standard STCW training	8.11500	4.57071	.095	-1.5745	17.8045
			Simulation training	-2.69333	4.57071	.564	-12.3828	6.9961
		Simulation training	Standard STCW training	10.80833*	4.74325	.037	.7531	20.8636
			STCW + classroom	2.69333	4.57071	.564	-6.9961	12.3828
	Bonferroni	Standard STCW training	STCW + classroom	-8.11500	4.57071	.285	-20.3326	4.1026
			Simulation training	-10.80833	4.74325	.110	-23.4872	1.8705
		STCW + classroom	Standard STCW training	8.11500	4.57071	.285	-4.1026	20.3326
			Simulation training	-2.69333	4.57071	1.000	-14.9110	9.5243
		Simulation training	Standard STCW training	10.80833	4.74325	.110	-1.8705	23.4872
			STCW + classroom	2.69333	4.57071	1.000	-9.5243	14.9110

ES ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Number of impacts	Between Groups	.475	2	.237	.061	.941
	Within Groups	62.262	16	3.891		
	Total	62.737	18			
Average impact severity	Between Groups	.002	2	.001	.847	.447
	Within Groups	.015	16	.001		
	Total	.016	18			
Number of rudder executions	Between Groups	5.185	2	2.593	.223	.802
	Within Groups	185.762	16	11.610		
	Total	190.947	18			
Average time between rudder ex	Between Groups	16.295	2	8.148	.761	.483
	Within Groups	171.316	16	10.707		
	Total	187.612	18			
Path length through course	Between Groups	33.446	2	16.723	.326	.726
	Within Groups	820.716	16	51.295		
	Total	854.162	18			
Time through course	Between Groups	285.647	2	142.824	.515	.607
	Within Groups	4434.752	16	277.172		
	Total	4720.400	18			

EN ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Number of impacts	Between Groups	.343	2	.172	.049	.952
	Within Groups	55.762	16	3.485		
	Total	56.105	18			
Average impact severity	Between Groups	.001	2	.000	.148	.864
	Within Groups	.028	16	.002		
	Total	.029	18			
Number of rudder executions	Between Groups	36.756	2	18.378	.977	.398
	Within Groups	300.929	16	18.808		
	Total	337.684	18			
Average time between rudder ex	Between Groups	78.462	2	39.231	1.115	.352
	Within Groups	562.924	16	35.183		
	Total	641.386	18			
Path length through course	Between Groups	54.633	2	27.316	.318	.732
	Within Groups	1373.462	16	85.841		
	Total	1428.094	18			
Time through course	Between Groups	788.309	2	394.154	.374	.694
	Within Groups	16874.054	16	1054.628		
	Total	17662.363	18			

NWSEANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Number of impacts	Between Groups	16.456	2	8.228	2.468	.116
	Within Groups	53.333	16	3.333		
	Total	69.789	18			
Average impact severity	Between Groups	.004	2	.002	.347	.712
	Within Groups	.081	16	.005		
	Total	.084	18			
Number of rudder executions	Between Groups	3.467	2	1.734	.129	.880
	Within Groups	215.690	16	13.481		
	Total	219.158	18			
Average time between rudder ex	Between Groups	2.639	2	1.320	.110	.896
	Within Groups	191.896	16	11.993		
	Total	194.535	18			
Path length through course	Between Groups	14.064	2	7.032	.307	.740
	Within Groups	366.406	16	22.900		
	Total	380.469	18			
Time through course	Between Groups	35.867	2	17.933	.155	.857
	Within Groups	1845.819	16	115.364		
	Total	1881.686	18			

SENW ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Number of impacts	Between Groups	8.694	2	4.347	1.102	.356
	Within Groups	63.095	16	3.943		
	Total	71.789	18			

Average impact severity	Between Groups	.013	2	.007	2.733	.095
	Within Groups	.039	16	.002		
	Total	.052	18			
Number of rudder executions	Between Groups	14.264	2	7.132	.594	.564
	Within Groups	192.262	16	12.016		
	Total	206.526	18			
Average time between rudder ex	Between Groups	5.886	2	2.943	.177	.840
	Within Groups	266.485	16	16.655		
	Total	272.370	18			
Path length through course	Between Groups	68.802	2	34.401	.459	.640
	Within Groups	1197.958	16	74.872		
	Total	1266.761	18			
Time through course	Between Groups	167.212	2	83.606	.312	.736
	Within Groups	4289.163	16	268.073		
	Total	4456.375	18			

Appendix N: Full Post-Test Data Set

Responses to Post-Test Questionnaire – General Questions

Question 1: What were the challenges you faced during testing?

Responses:

different boat
not hitting docks
wind, docks, entering at certain point
wind, docks, barrels
avoiding obstacles, wind, difficult to see front of boat
window too small, uncomfortable driver's seat, steering in wind and waves, suit was bulky
limited visibility, steering at slow speed, fear of getting propeller caught in lifeboat lines
wind, waves, steering difficulties, visibility
foggy windows, obstacles, wind, steering difficulties
steering difficulty due to throttle governed, visibility through windows and only one set of eyes to navigate through the field
visibility, steering
steering, visibility
uncomfortable driver's seat, confusion with direction to proceed through field
inability to see obstacles, visibility
Steering
wind, steering
visibility, steering in wind and waves
unclear directions, wind, visibility

view of field
wind, small space in lifeboat, heat from wearing immersion suit, uncomfortable driver's seat

Question 2: What would better prepare you to face these challenges?

Responses:

time in boat
more training
obstacle course before to ease into small ice field
practice, handling the boat
more awareness of course, direction was difficult to figure out, steering was difficult
training in wind and waves, virtual training, better fitting suit, more lifeboat driving
more time on water
more lifeboat driving to improve turning
maneuvering training at low speeds, more time and experience with boat with challenges present
more experience operating the lifeboat, rudder position indicator, training in simulator
more and bigger windows, more experience behind the wheel
more time driving lifeboat
better expected perception of field, training in tight maneuvering
more visibility, more training in the lifeboat
more training for steering accuracy
more training in both the real lifeboat and in the simulator
time in the real lifeboat to get acquainted

practice runs to get a handle of the lifeboat
better visibility
a bigger boat with a cooling system, more practice in wind conditions

Question 3: What would help prepare you better for ice trials?

Responses:

nothing
training
unsure
more time in boat
being away of the perimeter, having a destination instead of a direction
practice driving the lifeboat, simulation training
simulator
more obstacle avoidance training, training in open water gave false sense of what to expect because of nice weather and lack of wind and waves
maneuvering around obstacles, slow increase in degree of ice cover
more training in real life simulated ice fields and in a simulator, ice education focused on presenting possible routes based on what is visible from the cockpit
more knowledge about certain types of ice, learning how much contact with ice a vessel can experience, snowboarding experience
expecting different ice scenarios
better training for test conditions, in steering and visibility
more simulator training
more training and practice in ice in the simulator

more practice in the simulator with ice covered waters, adding wind to simulator effects
simulator training was good to prepare for maneuvering lifeboat through ice
more training in real lifeboat and simulator
more time in the simulator
reviewing what was taught in class, more time simulator

Responses to Post-Test Questionnaire – Specific Questions

Question 4: How effective did you find the training?

Question 5: How well do you think you navigated the ice field during the testing?

Question 6: How well do you feel you can navigate through ice in the future?

Question 7: At what maximum concentration of ice do you think you are able to navigate through in the future?

Group	Q1	Q2	Q3	Q4
1	4	6	4	3
1	8	9	8	7
1	10	6	7	6
1	4	6	5	7
1	4	1	1	2
1	3	3	3	4
Average	**5.50**	**5.17**	**4.67**	**4.83**
Standard Deviation	**2.81**	**2.79**	**2.58**	**2.14**
2	6	6	6	4
2	3	3	4	1
2	6	7	6	3
2	5	7	7	4
2	10	7	6	3
2	9	9	8	3
2	5	2	4	3
Average	**6.29**	**5.86**	**5.86**	**3.00**
Standard Deviation	**2.43**	**2.48**	**1.46**	**1.00**
3	7	6	5	1
3	7	6	6	5
3	8	5	7	6
3	8	7	8	3
3	8	7	7	6
3	8	9	8	7
Average	**7.60**	**6.20**	**6.60**	**4.20**
Standard Deviation	**0.52**	**1.37**	**1.17**	**2.25**

Appendix O: Spearman's Rho Test

Non-Parametric Test for Post-Test Questionnaire- Specific Question Data

Correlations

			How effective did you find the training?	How well do you think you navigated the ice field during the testing?	How well do you feel you can navigate through ice in the future?	At what maximum concentration of ice do you think you are able to navigate through in the future?
Spearman's rho	How effective did you find the training?	Correlation Coefficient	1.000	.629**	.784**	.303
		Sig. (2-tailed)	.	.004	.000	.208
		N	19	19	19	19
	How well do you think you navigated the ice field during the testing?	Correlation Coefficient	.629**	1.000	.828**	.349
		Sig. (2-tailed)	.004	.	.000	.144
		N	19	19	19	19
	How well do you feel you can navigate through ice in the future?	Correlation Coefficient	.784**	.828**	1.000	.500*
		Sig. (2-tailed)	.000	.000	.	.029
		N	19	19	19	19
	At what maximum concentration of ice do you think you are able to navigate through in the future?	Correlation Coefficient	.303	.349	.500*	1.000
		Sig. (2-tailed)	.208	.144	.029	.
		N	19	19	19	19

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).