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COMMUNICATIONS PROBLEMS IN MARINE CASUALTIES

FINAL REPORT
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16. Abstract

The present study developed casualty investigation procedures that focused on communications problems. These procedures were applied by U.S. Coast Guard (USCG) Investigating Officers in their investigation of 589 marine casualties over a seven-month period. Analysis of the resulting casualty reports determined that communications is a prevalent causal factor in marine casualties, being a factor in 18 percent of critical vessel casualties, 28 percent of critical personnel injuries, and contributing to 19 percent of critical marine casualties overall. The investigations procedures also identified characteristics and causes of communications problems. The single largest problem involved mariners who did not communicate when appropriate. Two types of faulty assumptions were usually the cause of this: they either misinterpreted the situation and did not perceive a threat, or they incorrectly assumed that others were aware of the problem and would take care of it. Training in developing team situation awareness is suggested to combat the first problem. Better crew resource management, specifically empowering crewmembers to speak up when a threat is perceived, would correct the second problem and potentially reduce communications-related casualties by 29 percent.

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We are most grateful to the Senior Investigating Officers and the Investigating Officers from the U.S. Coast Guard Marine Safety Offices at Portland, Oregon; New Orleans, Louisiana; Paducah, Kentucky; and New York, New York. These individuals provided useful comments regarding the investigation and reporting procedures, and substantial time and effort to investigate and report casualties.

Dr. Alice Barnes carefully reviewed and edited this report. Ms. Judy Panjeti prepared the final version of this report.

We are especially thankful to Ms. Susan Czarny, who provided her significant skills and good humor in preparing forms, instructions, training materials, and reports during earlier periods of this study.

EXECUTIVE SUMMARY

It is estimated that human error contributes to between 75 and 96 percent of marine casualties (U.S. Coast Guard, 1995A). In order to identify strategies to reduce the likelihood of casualties resulting from human error, we must first gain a better understanding of the nature and causes of these casualties. The U.S. Coast Guard (USCG) has historically investigated marine casualties for cause; however, procedures for investigating, reporting, and analyzing *human factors* causes is a more recent initiative. A recent study demonstrated the value of developing and implementing investigation and reporting procedures that focused on a single human factors topic (fatigue) for use by USCG investigators (McCallum, Raby, & Rothblum, 1996). The present study was conducted to investigate the suitability of this focused approach for investigating the role of inadequate communications in marine casualties. In addressing this goal, two study objectives were identified:

- Develop a method for the focused investigation and reporting of communications problems in marine casualties.
- Identify the characteristics and underlying causes of communications problems.

The topic of communications was selected based on an earlier study which showed it was an important contributor to marine casualties. Communications investigation and reporting procedures were developed, and USCG Investigating Officers (IOs) received initial training in the investigation and reporting procedures during August and October 1997. A total of 29 IOs from four Marine Safety Offices (MSOs) supported this study by investigating and reporting on 589 marine casualties during the seven-month period from September 1, 1997, through March 31, 1998. A final assessment of the investigation and reporting procedures was conducted with IOs from each participating MSO in May 1998.

The procedures for investigating communications-related casualties were based on a model of communications processes, problem areas, and contributing factors. The model divides communications into four processes (*Prepare and Send Message*, *Message Transmission*, *Receive and Interpret Message*, and *Act on Message*) and four corresponding communications problem areas. Sixteen individual communications problems were defined within these four problem areas. The model further identifies seven general contributing factor areas that can cause or contribute to a communications problem (*Knowledge or Experience*, *Procedures*, *Performance*, *Assumptions*, *Environment*, *Communication Equipment*, and *Management and Government Regulations*). Thirty-four individual contributing factors were defined within these seven areas.

The procedures for investigating and reporting communications problems in marine casualties included a general casualty screening form and separate forms for reporting on the nature of communications problems in each of five operational areas: vessel-vessel, bridge-pilot, vessel-shore authority, crew-crew, and vessel-shore worker. The procedures consisted of a progressive, three-step series of casualty review and screening: (1) casualty criticality screening (a screening method already used by MSOs to determine which casualties warrant a full investigation); (2) human factors contribution screening (to determine which of the critical casualties appear to have a direct human factors cause); and (3) communications operational area identification, investigation, and reporting. Feedback from IOs indicated that the procedures were useable and facilitated more accurate characterization of communications problems.

Overall, communications problems were associated with 18 percent of all critical vessel casualties and 28 percent of all critical personnel injuries (19 percent of critical casualties overall). The communications screening procedure was found to be quick and easy to use and effective: among the 50 critical casualties identified through the screening procedure as having a potential for communications, 38 cases (76 percent) were found to have a contributing communications problem.

The analysis of communications problems revealed striking similarities among the vessel and personnel injury cases. Among both types of casualties, the most prevalent communications process problem was *Prepare and Send Message*; problems in this area contributed to 87% of the communications-related casualties. This problem area was most frequently cited in crew-crew, vessel-vessel, and pilot-bridge communications. A failure to initiate needed communications was identified as the most common specific problem, and contributed to 68% of the communications-related casualties. Several contributing factors were cited as leading to problems in preparing and sending messages, with incorrect assumptions regarding the need to communicate as the most prevalent general factor among both critical vessel and critical personnel injury casualties. In this subset, the most frequently cited incorrect assumption was that there was no need to communicate. An incorrect interpretation of the situation and the incorrect assumption that someone else recognized the danger and would take action were two other frequent causes for not initiating communications.

A meta-analysis of the reasons behind these failures to communicate led to the conclusion that in almost all these situations, at least one mariner did not recognize that a dangerous situation was unfolding that required him to take action (communicate with others). Methods for improving crew situation awareness would help eliminate this problem. A second discovery was that in almost half of the "did not communicate" casualties, there was a different crew member who *did* recognize the threat, but who still *did not speak up*, generally because he thought (incorrectly) someone else was also aware of the problem. Training and implementation of crew resource management is highly recommended as a way to instill a responsible and participatory attitude among crewmembers and to empower them to speak up whenever a potential threat is perceived.

The set of communications screening procedures could be adopted as a tool for identification of cases that are likely to involve communications problems. The set of follow-up questions that is included in each communications operational area reporting form could be used by IOs in identifying specific communications problems and underlying causal factors. The revised and streamlined set of investigation procedures is provided in Appendix D. In addition, along with the present findings, the communications process model and contributing factors developed as part of this study could be incorporated into the Coast Guard's Investigating Officer course.

The current study identified the most prevalent communications problems and contributing factors in critical vessel casualties and personnel injuries. These findings can help in establishing a framework for ameliorative actions by industry. Specifically, the single most pervasive problem found was that of mariners who did not communicate important information. It would appear that actions to improve crew situation awareness and to facilitate the sharing of information are sorely needed. As a first step in making industry aware of these problems, the findings from this project were presented at the Maritime Human Factors Conference in March, 2000.

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LIST OF ACRONYMS

IO	Investigating Officer
GRT	Gross Tons
MINMOD	Marine Investigations Module
MSIS	Marine Safety Information System
MSO	Marine Safety Office
OP	Operational
PTP	Prevention Through People
QAT	Quality Action Team
SOP	Standard Operating Procedures
USCG	United States Coast Guard

1 INTRODUCTION

It is estimated that human error contributes to between 75 and 96 percent of marine casualties (U.S. Coast Guard, 1995A). In order to identify strategies to reduce the likelihood of casualties resulting from human error, we must first gain a better understanding of the nature and causes of these casualties. The U.S. Coast Guard (USCG) has historically investigated marine accidents for cause; however, procedures for investigating, reporting, and analyzing *human factors causes* is a more recent initiative. Two recent Coast Guard Headquarters initiatives, the Prevention Through People (PTP) Quality Action Team (QAT) study (U.S. Coast Guard, 1995A) and the Marine Safety Investigations QAT study (U.S. Coast Guard, 1995B), focused on improving the Coast Guard's ability to identify human-related causes of marine casualties. The USCG Office of Investigations and Analysis is implementing recommendations from these studies. Steps that have been taken include providing introductory human factors training to Investigating Officers (IOs), and reducing the investigation of minor casualties to provide more time for a fuller investigation of critical marine casualties.

In support of the Office of Investigation and Analysis, the USCG Research and Development Center is conducting studies to develop investigation procedures and job aids to help IOs identify specific types of human error contributing to a marine casualty. The first, which focused on mariner fatigue, provided significant insight into the nature of fatigue-related marine casualties, as well as specific guidance for future investigations of fatigue in marine casualties (McCallum, *et al.*, 1996).

The present study focused on the topic of mariner communications. Communications was chosen based on an evaluation of several human factors areas relevant to marine casualties (McCallum and Raby, 1995). Communications was known to be a prevalent cause of casualties and ranked near the top of the priority list in the evaluation[1]. This report documents the development and implementation of investigation and reporting procedures designed specifically to address the role of communications in marine casualties and our findings regarding communications problems in marine casualties.

1.1 Study Objectives

The current study had two objectives:

- Develop a method for the focused investigation and reporting of communications problems that contribute to marine casualties.
- Identify the characteristics and underlying causes of maritime communications problems.

[1] The top three topics were fatigue, communications, and knowledge. All three of these topics have now been investigated.

1.2 Study Approach

The basic study approach was to develop procedures for investigating and reporting communications problems, conduct a small-scale study for a limited period of time with a sample of Marine Safety Offices (MSOs), and then analyze the resulting casualty reports. Following the success of our earlier fatigue study, we employed the same basic strategy in developing and implementing the investigation and reporting procedures. This strategy included the following:

- Limiting IOs' investigation and reporting to well-defined issues.
- Training participating IOs on the selected human factors topic (communications) and in the use of the procedures.
- Employing stand-alone reporting forms that did not require the use of the CG's casualty database (Marine Investigations Module, MINMOD), thus keeping the research independent from the operational reporting of casualties.

In order to limit the scope of this study, we set several limits on the type and number of casualties to be investigated and analyzed. First, only cases involving vessel casualties or personnel injuries were included. Second, only "critical" casualties, i.e., those associated with significant risk to property or injury to individuals, were fully investigated and reported. Third, MSO participation was limited to four offices. Finally, based on our preliminary estimates of the prevalence of human factors and communications contributions to casualties, we determined that we would require approximately 500 cases to adequately assess the value of the casualty data in these investigation reports. This led to the collection of casualty data over a seven-month period.

2 TECHNICAL APPROACH

2.1 Overview

This study began with the development of the communications investigation and reporting procedures. Investigating Officers received initial training in the investigation and reporting procedures during August and October 1997. A total of 29 IOs from four MSOs supported this study by investigating and reporting marine casualties during the seven-month period from September 1, 1997, to March 31, 1998. A final assessment of the investigation and reporting procedures was conducted with each participating MSO in May 1998. The remainder of the *Technical Approach* section describes each of these activities.

2.2 Communications Investigation and Reporting Procedures

In developing the communications investigation and reporting procedures, we adopted the basic approach that had been successful in the earlier fatigue study (McCallum, Raby, & Rothblum, 1996). Investigating Officers first conducted an initial *Screening and Background* process to collect general casualty information and to identify cases that met established criteria for further investigation of communications issues. Then, if the criteria for further investigation were met, an in-depth investigation of communications problems and contributing factors was conducted.

Figure 1 depicts the logic of the *Screening and Background* process. After determining whether the casualty was reportable, *Casualty Criticality Screening* was conducted in order to identify those cases where there was a significant risk to property or personnel safety. Those cases not meeting the criticality screening criteria were excluded from further investigation for the purposes of this study. Next, if the criticality criteria were met, *Human Factors Screening* was conducted to identify those cases where an individual's action or inaction directly contributed to the casualty.[2] Finally, for the critical human factors cases, *Communications Operational Area Identification* was conducted to determine if one or more of the five operational areas pertained to the case. If a communications operational area was determined to be pertinent, the case was further investigated to determine if communications problems contributed to the casualty and, if so, to characterize the communications problems and contributing factors. If none of the communications operational areas was determined to be pertinent, only the screening form was completed and forwarded to the research team.

[2] This captured only about half of the true human error causes, since latent errors stemming from poor policies, procedures, or maintenance errors were not considered.

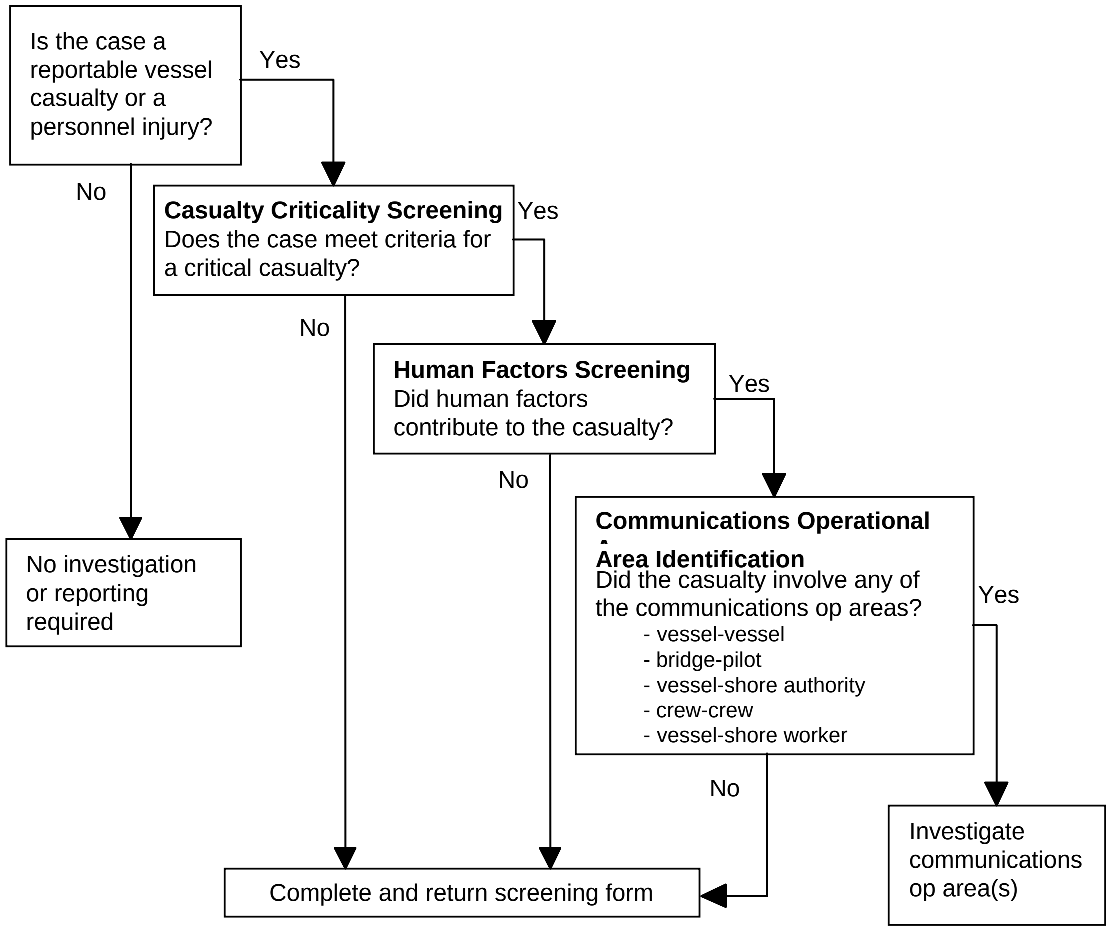

Figure 1. Summary of screening and background investigation process.

As noted above, five communications operational areas were defined, based on an analysis of marine operations communications. The five operational (op) areas were vessel-vessel communications, bridge-pilot communications, vessel-shore authority communications, crew-crew communications, and vessel-shore worker communications. The screening procedure used by IOs to determine the pertinence of each of these five op areas involved one screening question for each area. Each screening question asked whether the people who held the positions relevant to the operational area had any role in operations at the time of the casualty. For example, the sub-topic vessel-vessel communications was determined to be pertinent if the IO judged the following question to be true: *Were two or more vessels involved in the casualty?* Table 1 lists the five communications operational area screening questions.

Table 1. Communications operational areas and screening questions.

Communications Operational Area	Screening Question
Vessel-Vessel	Were two or more vessels involved in this casualty?
Bridge-Pilot	Was there a pilot, other than a member of the ship's crew, responsible for the navigation of the ship?
Vessel-Shore Authority Personnel	Was the vessel navigating in an area under the supervision of a VTS operator, a bridge tender, a lockmaster, or a light operator?
Crew-Crew	Were two or more crewmembers working together who were directly involved in the casualty, or could the casualty have been prevented if someone had shared additional information with another crewmember?
Vessel-Shore Worker	Did the casualty occur during coordination of activities between the ship and shore-based personnel (e.g., dockworker, crane operator, vessel agent)?

To help IOs better conceptualize the role of communications in marine casualties, a general model was developed. As shown in Figure 2, the model divides communications into four *communications processes* (*Prepare and Send Message*, *Message Transmission*, *Receive and Interpret Message*, and *Act on Message*) and four corresponding *communications problem areas* (problems preparing and sending messages, problems with message transmission, problems receiving and interpreting messages, and problems acting on messages). Sixteen individual problems were defined within these four problem areas. For example, the *Act on Message* problem area is comprised of two specific problems: *Took no action* and *Action was not in accordance with agreement*.

The model further identifies seven general *contributing factor areas* that can cause a communications problem (Knowledge or Experience, Procedures, Performance, Assumptions, Environment, Communication Equipment, and Management and Government Regulations). Thirty-four specific contributing factors were defined within these seven areas. For example, the area of environment (which can contribute to message transmission problems) is comprised of three specific factors: *Excessive ambient noise*, *Excessive electronic or atmospheric disruption of signal*, and *Excessive traffic on the assigned communications channel*.

Using the five reporting forms, IOs were asked to review the facts of each case where communications was a potential contributor and identify all communications problems that were evident in the casualty. They were also asked to identify between one and four factors that directly contributed to each communications problem. By determining which contributing factors were associated with individual communications problems, IOs were able to characterize the nature and likely cause of each problem. The revised reporting form in Appendix D lists the 16 communications problems and 34 contributing factors (see page D-5; note that "Other" is not considered as one of the 34 specific contributing factors).

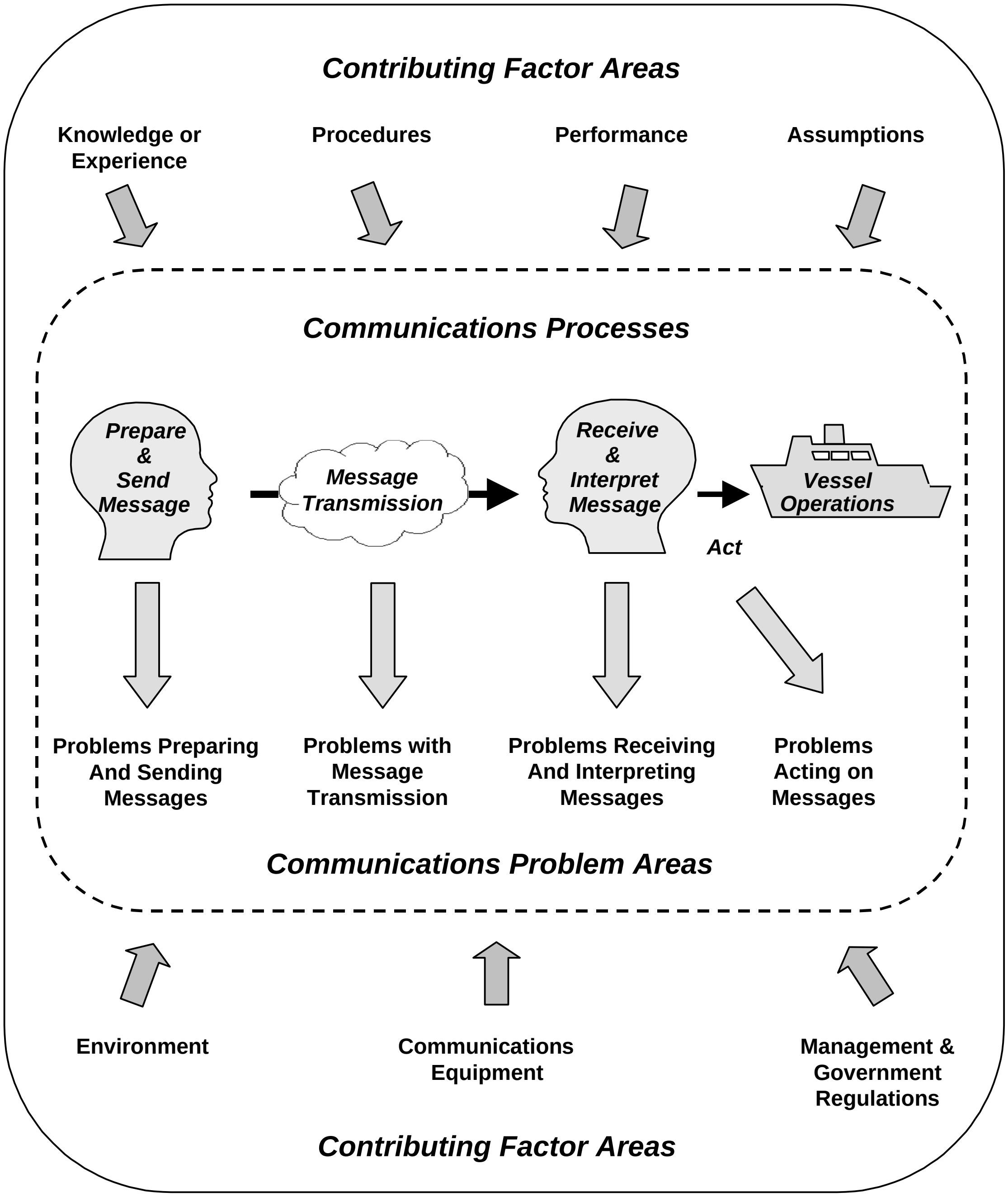

Figure 2. Model of communications processes, problem areas, and contributing factor areas.

2.3 Investigating Officer Training

Investigating Officers at each participating MSO received one day of initial training on the use of the investigation and reporting procedures and forms. The training had three main objectives:

- Introduce the purpose of this study and its objectives.
- Provide a general overview of some basic human factors and communications concepts.

- Familiarize IOs with the investigation and reporting procedures to be used in this study.

Given the short duration of training and the need to ensure IOs' proficiency with the investigation and reporting procedures, the amount of time spent on human factors concepts was limited. The majority of time was spent introducing the concepts of communications, communications processes, communications problems, contributing factors, and the investigation and reporting procedures and forms.

As part of the training, a series of practical demonstrations in using the forms was provided. Three case studies that involved marine casualties with different communications problems and contributing factors were presented. Each case was summarized, investigation requirements were identified, and sample completed reporting forms were presented and discussed. Each IO received copies of the training slides, communications forms, and the set of instructions. Appendix A contains the slides used during the training session.

2.4 Review of Reports by Research Staff

Investigating Officers at participating MSOs completed the applicable communications reporting forms for cases that occurred between September 1, 1997, and March 31, 1998. These forms and supporting materials (CG 2692 and selected portions of the MINMOD report) were sent to the research team for review and data entry. Two researchers independently reviewed the forms submitted with each case, providing independent judgments concerning the factors casualty criticality, human factors contribution, appropriate communications sub-topic to investigate, and conclusion regarding the contribution of the specific communications sub-topic to the casualty.

Following the completion of these independent reviews, the judgments of the two researchers were compared and any disagreements were identified and discussed until agreement regarding each of the above four factors was reached. If the researchers' decision differed from that of the IO, then the IO was contacted to resolve the difference of opinion and revise the form, as necessary.

Throughout the casualty investigation and reporting period, a summary of cases received, reviewer comments, and issues requiring clarification was maintained. These summary sheets were periodically sent to each participating MSO for the IOs to review and address outstanding issues. In addition, a newsletter was prepared and sent to participating MSOs twice during the investigation and reporting period to provide IOs with information regarding any procedural changes, the ongoing study schedule, and preliminary results.

2.5 Procedure Assessments

An initial assessment of the communications investigation and reporting procedures was completed approximately 60 days following initial training. Nineteen IOs participated in one-day assessment sessions that were conducted at the four participating MSOs. A group discussion addressing the adequacy of the investigation process and reporting forms took place in the morning, and individual meetings with IOs to review ongoing and completed cases were conducted in the afternoon. The group discussion addressed the investigation process, investigation strategies and difficulties, and problems encountered in completing the reporting forms. Minor modifications were made to the *Screening and Background Form* based on information gathered during the initial assessment.

Approximately six weeks after the end of the scheduled period for casualty investigation, two researchers visited each MSO for one day to obtain feedback about the study and discuss unresolved questions concerning specific cases. Fourteen IOs participated in these final reviews. During this visit, IOs were presented with a summary of preliminary findings and asked to complete a survey addressing the training sessions, support materials, casualty reporting forms, and the costs and benefits of study participation. Group discussions then addressed ways to improve the investigation, reporting, and research methods. Appendix B contains a copy of the final assessment survey, and results of selected survey questions.

2.5.1 Perceived Benefits of Study

One of the questions on the final survey addressed the potential benefits of this study to the IO and the USCG. With respect to benefits to the individual IOs, most respondents said the study gave them a heightened awareness of the potential contribution of communications to casualties. Several IOs also said the experience of participating in the study would prompt them to investigate communications more thoroughly in the future. With respect to communications issues and benefits to the USCG, IOs mentioned that the investigations for this study were more thorough than they would have been if communications had not been a focus.

2.5.2 Time Demands on Investigating Officers

As part of the reporting process, IOs were asked to indicate the time spent investigating potential communications problems and completing the reporting forms. Estimates of the additional time required for the procedures used in this study are based on the medians (50^{th} percentiles) of the IO estimates, shown in Figure 3. For the 482 cases in which communications was not investigated, the median investigation time was 10 minutes and the form completion time was 10 minutes. For the 107 cases in which communications was investigated, the median investigation time was 60 minutes and the form completion time was 30 minutes. Across all 589 cases, the median investigation time was 25 minutes and form completion time was 10 minutes. Thus, our best estimate of the additional time spent by IOs in meeting the investigation and reporting requirements associated with this study is 35 minutes per case (representing the sum of the medians of 25 minutes for additional investigation and 10 minutes for additional form completion).

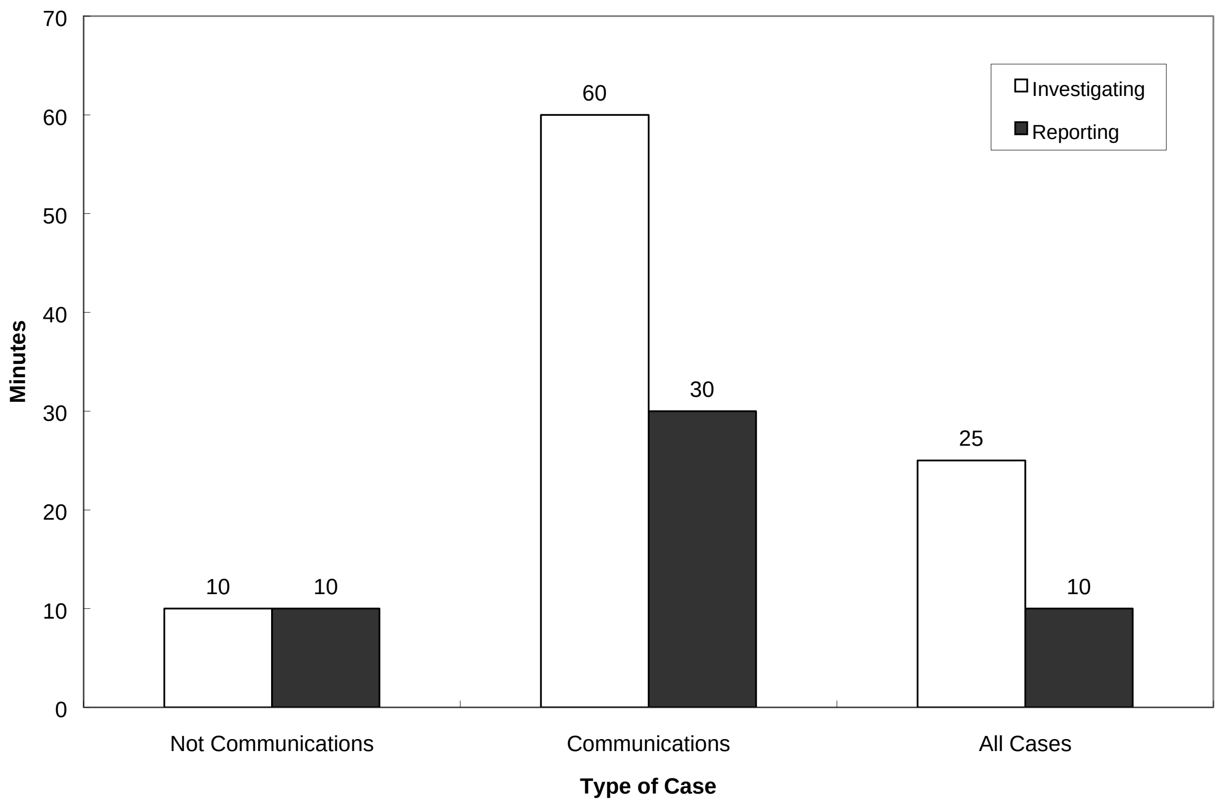

Figure 3. Median estimated time for casualty case investigation and reporting.

2.6 Revised Communications Problem Screening and Investigation Tools

One of the final activities for this study was to develop a simplified set of tools that IOs could use to investigate casualties resulting from communications problems. The first tool was to be a streamlined, one-page form that IOs could use to determine whether a given casualty appears to have a communications cause. The second tool was to be a more extensive form, or set of forms, that would aid IOs in collecting information that could be used to specify causal links explaining "why" the casualty occurred.

The result of the streamlining process was a two-page, front-to-back set of tools for communications screening and investigation. To create these tools, the five reporting forms used in the present study were condensed and revised. The tools have a checklist format, incorporating a set of screening questions and an in-depth review of communications problems and specific factors that contributed to a given casualty. A one-page set of instructions accompanies the tools. Appendix D outlines the development process we used and contains copies of the revised tools and instructions.

3 FINDINGS

This section presents the findings from our analyses of the casualty reports submitted by the Investigating Officers from the four participating Marine Safety Offices. The findings are divided into three major topics:

- General characteristics of the casualties in the study sample.
- Types of communications process problems contributing to marine casualties.
- Causes of communications process problems.

3.1 General Characteristics of the Casualties in the Study Sample

This section summarizes the characteristics of the casualties in this study. The four participating MSOs investigated and completed reports on 589 cases that occurred during the seven-month sampling period. Eighty percent (469) of these were vessel casualties, 17 percent (103) were personnel injuries, and another three percent (17) involved both a vessel casualty and a personnel injury. This trend was consistent with that found in a national sample of casualty cases at all MSOs over the same period (Eulitt, 1999). A second way to characterize the sample is to analyze the types of vessels involved in the casualties. Our sample departed from the national sample in terms of the relative number of towing vessel casualties: towing vessels were involved in 49 % of the cases in this study, whereas the national sample had towing vessels represented in only 26 % of the casualties. Our oversampling of towing vessels is probably due to the inclusion of MSO Paducah, for which towing vessel casualties made up 93 % of the cases at that MSO. Compared to the national sample, our study may underrepresent passenger vessel casualties (10 % of our sample, compared to 24 % of the national sample). Most other vessel types were fairly comparable between the two studies.

Investigating Officers screened (and the human factors researchers reviewed) each of the 589 cases to determine criticality and whether human factors directly contributed to the casualty. The breakdown of these cases is given in Figure 4. Non-critical casualties were those which caused so little damage that the CG would not routinely investigate them. Minor casualties were defined as those involving limited property damage with no risk to the loss of the vessel or personnel injury. Many of these involved a transient loss of steering or propulsion, but since the vessel and crew never appeared to be at risk, these minor casualties were considered “near misses” and not included in the detailed analyses (Appendix C provides some cursory analyses that include minor casualties). The focus of this study was on critical casualties, those involving significant damage to the vessel or property, or in which the safety of the crew was at risk. As shown in Figure 4, 200 cases met the criteria for critical casualties. Of these, 99 cases (49%) were determined to have a direct human factors contribution. A “direct” human factors contribution was defined as a decision, action, or inaction which directly contributed to the casualty (i.e., was a proximal cause). Thus, latent human errors (such as management policies, maintenance errors, etc.) were excluded because it was felt that such errors would not be readily apparent during a casualty investigation.

There was a marked difference in the percentages of vessel casualties vs. personnel injuries which had a direct human factors contribution. Sixty-three (40%) of the 157 critical vessel-only casualties had a direct human factors contribution, while 33 (85%) of the 39 critical injury-only casualties did so. Three of the four critical cases in which both a vessel casualty and a personnel injury occurred had a direct human factors contribution. Human factors contributions were found in all types of vessel casualties, particularly in collisions, allisions, and groundings, where they accounted for the vast majority of these cases. Direct human factors was also important in founderings and sinkings, contributing to about half of those cases. Almost every type of personnel injury was associated with a direct human factors contribution. Human factors-related casualties were also found for every vessel type.

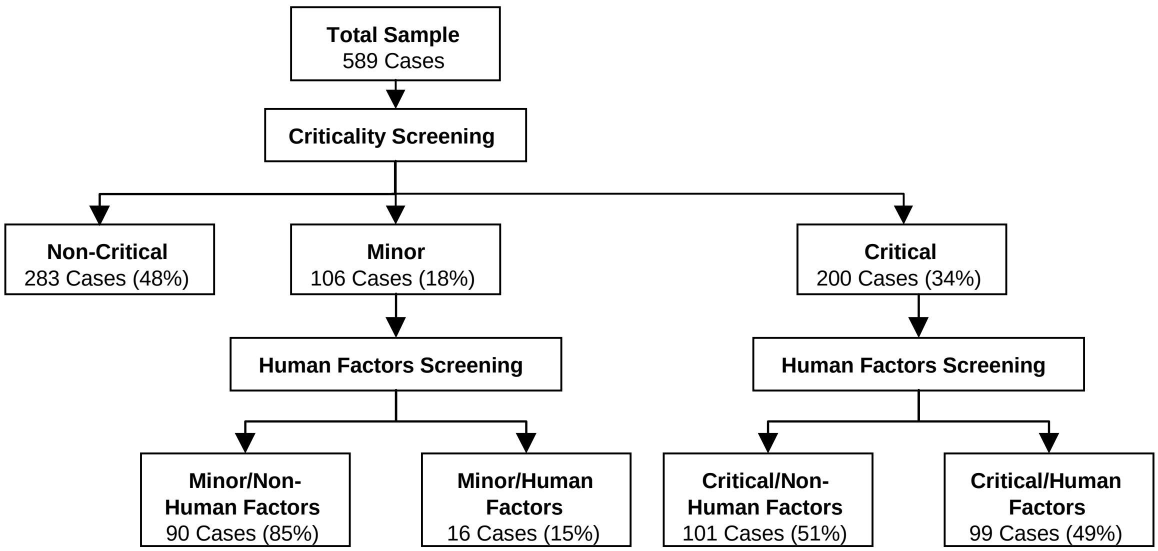

Figure 4. Summary of casualty criticality screening and human factors screening results.

3.2 Characteristics of Casualties with a Communications Contribution

This section addresses the prevalence of communications problems and the nature of those problems in vessel and personnel injury casualties.

3.2.1 Prevalence of Communications Problems

Investigating Officers screened all critical, human factors-related cases to determine if there was a potential for a communications problem. This was done using the five operational area (vessel-vessel, bridge-pilot, etc.) screening questions already described in Section 2.2. If the case had a potential for a communications problem, then a complete investigation was performed to determine whether communications contributed to the casualty.

Figure 5 summarizes the results of the screening for potential communications contribution and the final determination regarding the contribution of communications to each casualty. Of the 99 critical human factors cases, 50 cases were determined to have the potential for communications involvement. Of these 50 cases, 38 (76 percent) were determined to have one or more communications problems contributing to the casualty.

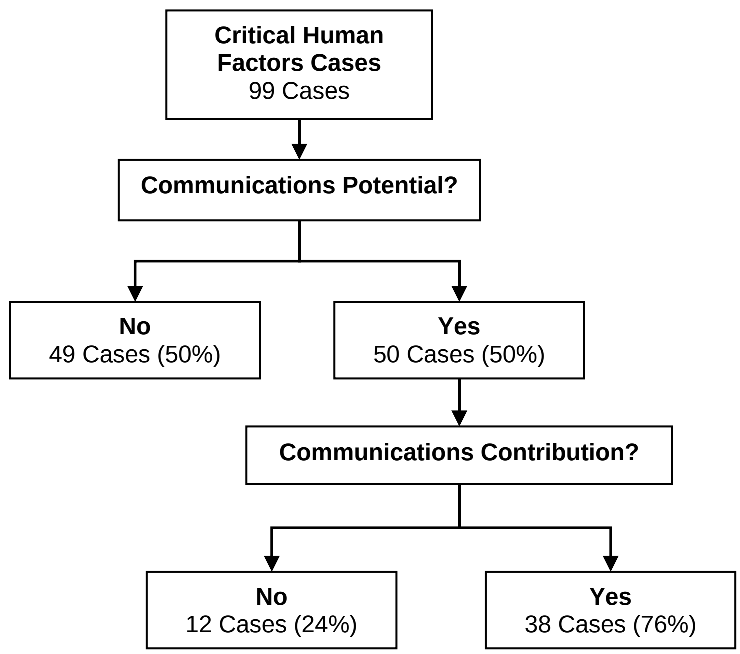

Figure 5. Summary of communications potential screening and communications investigation results.

As shown in Figure 6, the contribution of communications was comparable for vessel and personnel injury casualties. In vessel casualties with the potential for a communications contribution, communications problems contributed to 29 of the 37 cases (78 percent)[3]. In personnel injuries with the potential for a communications contribution, 12 of the 16 cases (75 percent)[4] were determined to have a communications problem. Overall, 19 percent of all critical casualties were determined to have a communications problem that contributed to the casualty. In critical vessel casualties and personnel injuries, the percentages of communications-related casualties were 18 percent and 28 percent, respectively.

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[3] Total vessel casualties include the "Vessel Only" and "Vessel and Personnel" casualties as shown in Fig. 14.

[4] Total personnel injuries include the "Personnel Only" and "Vessel and Personnel" casualties as shown in Fig. 14.

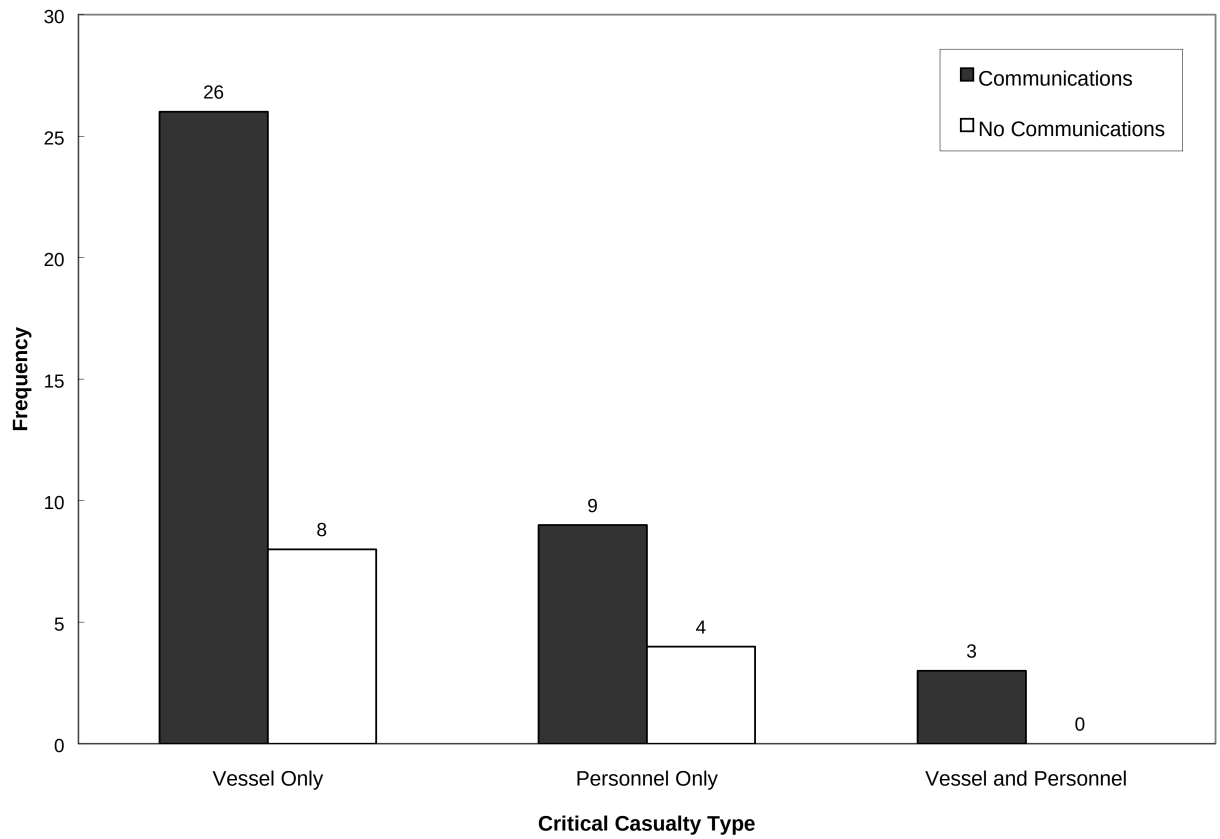

Figure 6. Frequency of critical casualty types with and without communications problems.

3.2.2 Types of Communications Problems in Marine Casualties

The following discussion addresses communications problems identified among 29 critical vessel casualties and 12 critical personnel injuries (including three cases that involved both a vessel casualty and personnel injury). Multiple communications problems were identified for most casualties. Because of this, the discussions on vessel and personnel injury casualties focus on the relative prevalence of different problems, rather than the percentage of cases in which different types of problems were cited. This is followed by a discussion on the important communications problems in marine casualties as a whole, showing the percentage of casualty cases with the different types of communications problems.

Communications problem areas in vessel casualties. Among the 29 critical vessel casualties in which communications problems were identified as a contributor, IOs identified 58 separate instances of problems. Figure 7 presents the distribution of these 58 problems across the five maritime operational areas (vessel-vessel, bridge-pilot, vessel-shore authority, crew-crew, and vessel-shore worker) and the four communications processes (*Prepare and Send Message, Message Transmission, Receive and Interpret Message,* and *Act on Message*). This figure depicts two findings worthy of note. First, there is a definite clustering of problems within communications processes. The *Prepare and Send Message* process has the majority of problems associated with it, with 33 (57 percent) of the total set of 58 cited problems. This process was the predominant source of communications problems in all five operational areas[5]. The *Receive and Interpret Message* process has 13 problems associated with it, or 22 percent of the total set of cited problems.

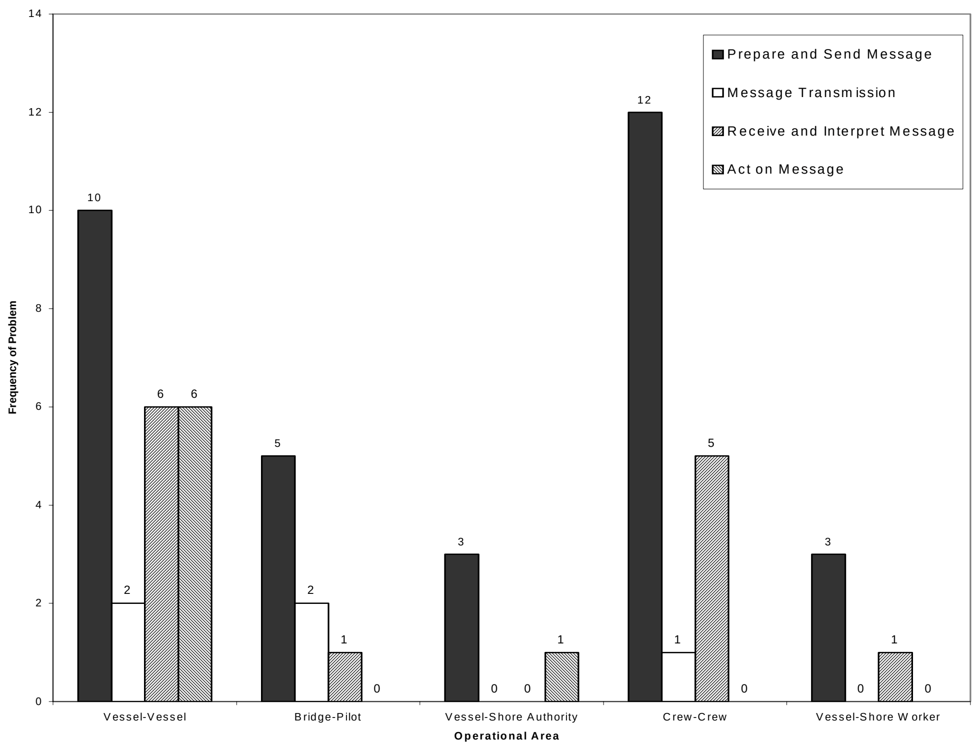

Figure 7. Critical vessel casualties – Communications process problems across five maritime operational areas.

[5] The five operational areas are shown to identify any differences in the types of communications problems which affect them. While the sample size in the present study (38 communications-related casualties) is too small to allow such an analysis, this type of analysis is recommended once a larger sample of casualties has been collected.

The second noteworthy characteristic of Figure 7 is that six combinations of communications process and operational area represent 44 (76 percent) of all cited problem areas. These six areas constitute potential opportunities for improving communications processes to reduce the risk of vessel casualties, and are explored further in the next section.

Specific communications problems in vessel casualties. Within each problem area (e.g., *Prepare and Send Message – Vessel-Vessel*) there were multiple specific communications problems. The 44 problem areas mentioned above gave rise to 56 specific communications problems, and these are presented in Table 2. In this table, the six operations-communications combinations are listed in order of their frequency, as are the specific problems listed under each area. Note that

Table 2. Critical vessel casualties – Most frequently identified communications problems within selected operational area-communications problem area combinations.

Operational Area – Communications Problem Area Specific Communications Problem		Frequency
Crew-Crew – Prepare and send message	**16**	
Did not communicate		10
Communicated ambiguous, incorrect, or incomplete information		3
Did not request information		3
Vessel-Vessel – Prepare and send message	**15**	
Did not communicate		4
Did not question other's actions or assert interpretation of situation		4
Did not request information		3
Communicated ambiguous, incorrect, or incomplete information		2
Did not send information in a timely manner		2
Vessel-Vessel – Receive and interpret message	**7**	
Did not monitor communications		5
Did not listen to complete message		1
Did not acknowledge information reception		1
Bridge-Pilot – Prepare and send message	**6**	
Did not communicate		3
Communicated ambiguous, incorrect, or incomplete information		2
Did not request information		1
Vessel-Vessel – Act on message	**6**	
Took no action		4
Action was not in accordance with agreement		2
Crew-Crew – Receive and interpret message	**6**	
Did not interpret the information correctly		3
Did not verify the validity or accuracy of the information		2
Did not acknowledge information reception		1

an IO could cite multiple communications problems within a casualty. A number of specific findings are apparent in reviewing Table 2. First, within the *Prepare and Send Message* area, *Did not communicate* was the most prevalent problem, especially among crewmembers on the same vessel. Second, a fairly broad range of specific problems in the *Prepare and Send Message* process were cited by IOs. Third, in the *Receive and Interpret Message* area, *Did not monitor communications* was the most prevalent problem. Finally, when *Act on Message* was cited as the general problem area, a general disregard for previous communications was indicated as the problem (*Took no action* and *Action was not in accordance with agreement*).

Communications problems in personnel injuries. Among the 12 personnel injury casualties in which communications problems were identified as a contributor, 26 specific problems associated with the four communications process areas were identified by IOs. Figure 8 presents the distribution of these 26 problems across four operational areas (vessel-vessel, vessel-shore authority, crew-crew, and vessel-shore worker) and the four communications process areas (*Prepare and Send Message*, *Message Transmission*, *Receive and Interpret Message*, and *Act on Message*). Review of this figure indicates that, as with critical vessel casualties, *Prepare and Send Message* was cited as the most frequent problem area, accounting for 18 (69 percent) of all cited process area problems. And again the *Prepare and Send Message* area was the predominant source of errors in each operational area. Further review of Figure 8 shows that the

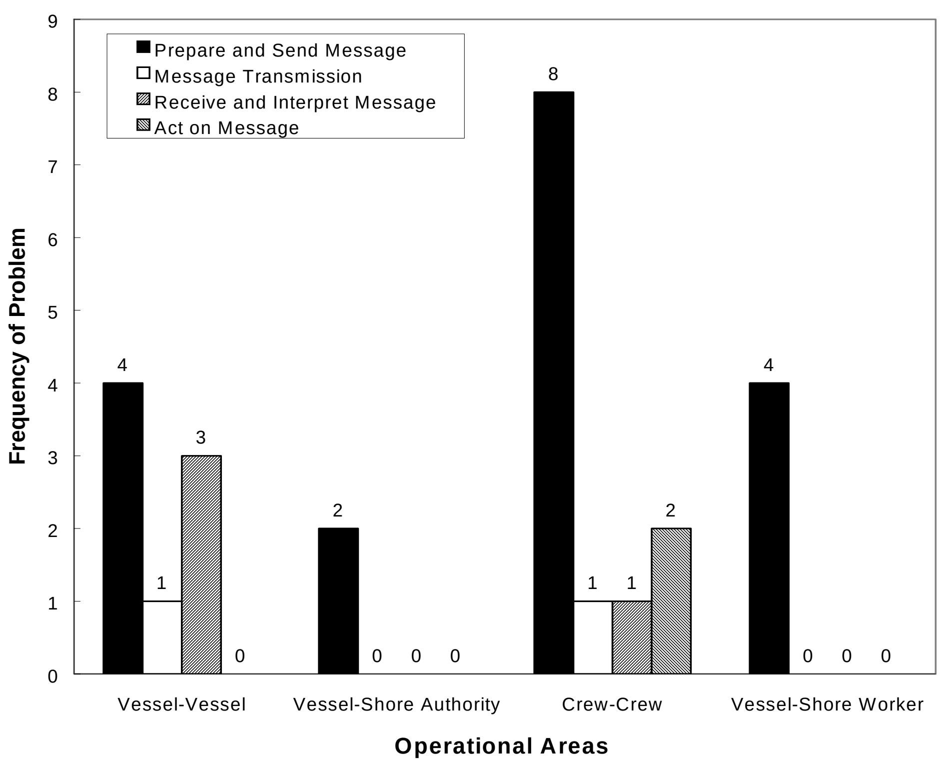

Figure 8. Critical personnel injuries – Communications problems across five maritime operational areas.

three most frequently cited combinations of operational areas and communications process areas account for 16 (62 percent) of the total 26 specific problems cited by IOs.

Most frequently identified communications problems in personnel injury casualties. The three operations-communications combinations in which specific communications problems were most frequently cited in personnel injuries are listed in Table 3, in order of their prevalence. Note that an IO could cite multiple problems within a casualty. These three combinations provide the greatest potential for improving communications processes and reducing the risk of personnel injuries resulting from similar communications problems. However, the low frequencies of problems and personnel injury cases provide limited insight into these problems. Again, there is a prevalence of the *Did not communicate* problem, accounting for 10 (63 percent) of the 16 specific problems identified among these three operational areas. Further generalizations from Table 3 are not warranted.

Table 3. Critical personnel injuries – Most frequently identified communications problems within selected operational area-communications process combinations.

Operational Area – Communications Process Specific Communications Problems	Frequency
Crew-Crew – Prepare and send message	**8**
Did not communicate	4
Communicated ambiguous, incorrect, or incomplete information	2
Did not send information in a timely manner	1
Did not request information	1
Vessel-Vessel – Prepare and send message	**4**
Did not communicate	3
Did not request information	1
Vessel-Shore worker – Prepare and send message	**4**
Did not communicate	3
Did not request information	1

Major communications process problems in marine casualties. The distribution of process problems over operational areas is quite similar for both vessel casualties and for personnel injuries. There is insufficient data to support any differences in communications problems by operational area. To get a clearer picture of the important process problems, the data were combined to show the frequency of problems in each of the four communications process areas for all casualties (Fig. 9).

Multiple communications problems were identified for most of the 38 communications-related casualties, resulting in a total of 76 communications process area problems (as shown in Fig. 9). Of these, 45 (59 percent) were *Prepare and Send Message* problems. The *Prepare and Send Message* category takes on even greater significance when we consider its frequency of

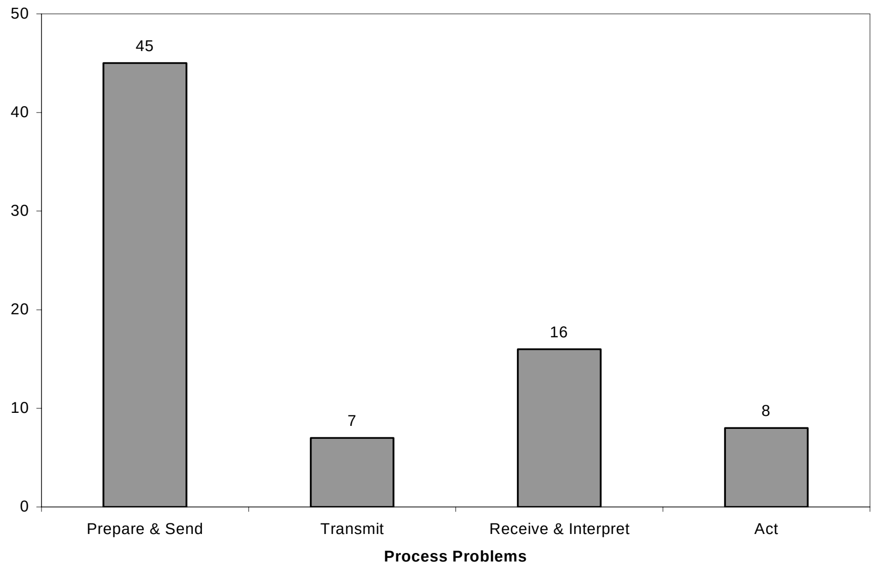

Figure 9. Frequency of communications process problems over all 38 marine casualties.

occurrence with respect to the number of casualty cases: 87 percent of the 38 communications-related casualties had at least one *Prepare and Send Message* process problem. The second most frequent process area problem was the *Receive and Interpret Message* area. This process area accounted for 16 (21 percent) of the 76 process area problems found. At least one instance of a *Receive and Interpret Message* problem was identified in 37 percent of the 38 communications-related casualties.

The most frequent specific communications problems within the *Prepare and Send Message* and *Receive and Interpret Message* process areas are shown in Table 4 (remember that most casualties had multiple communications problems). The biggest problem by far is *Did not communicate*, which contributed to 68 percent of the casualties. A related problem, that of not requesting information, was the second largest problem.

Table 4. Percentage of casualties containing selected communications process problems. (N=38 casualties)

Communications Process Area **Specific Communications Problems**	**Frequency**
Prepare and send message	**87%**
Did not communicate	68%
Did not request information	29%
Communicated ambiguous, incorrect, or incomplete information	18%
Receive and Interpret Problems	**37%**
Did not monitor communications	13%
Did not interpret information correctly	11%
Did not verify information validity or accuracy	8%

Following are some examples of how these communications problems contributed to casualties. Note that inadequate communication is not the only error which led to the casualty; but if the communication had been adequate, the casualty probably would have been prevented.

- A lighted buoy had been replaced by an unlighted one. The Vessel Traffic Service neglected to inform a vessel of the change (*Did not communicate)*. The vessel, which had transited this area often and was navigating by the buoys, hit the unlighted buoy.
- A Tankerman needed to remove the cam lock plug from the end of a diesel hose. He assumed the hose was not pressurized, but did not verify it (*Did not request information*). The hose was, indeed, pressurized, and the plug shot off into the Tankerman's knee.
- While the ship was transiting restricted waters, the Third Engineer noticed that the lube oil pressure was low, and shouted (across a noisy engine room) to a cadet to adjust the pressure. The cadet misunderstood (*Did not interpret information correctly*) and closed the valve, causing the engine to go to dead slow. (Note: the noisy engine room also constitutes a *Transmit Message* process problem.)

3.3 Contributing Factors to Communications-Related Casualties

In determining what caused the communications errors which contributed to a casualty, IOs were asked to choose from a list of 34 individual contributing factors, which were divided into seven areas (see, for example, the bottom of page B-9; the 34 factors do not include "Other"). The seven areas included: Knowledge or Experience in the proper technicques for marine communications (hand signals, standard maritime vocabulary, English skills); Procedures for communications (how to operate a radio); Performance issues regarding not communicating (high workload, forgetting, unwilling to communicate); Assumptions about the situation and one's responsibility to communicate; Environment (noise on the radio channel), Communications Equipment (was it available and in working order); and Management and Government Regulations in terms of whether communications was a "required" part of the job or operating procedure. Each of these areas consisted of several specific contributing factors. An analysis of the types of contributing factors which were found to be prevalent in communications-related vessel and injury casualties is described below.

Frequency of contributing factor areas to communications problems in vessel casualties. Investigating Officers identified 143 individual factors that contributed to specific communications problems among the 29 communications-related critical vessel casualties. Figure 10 presents the frequency with which IOs identified general contributing factor areas across the four communications processes for these critical vessel casualties. As the figure shows, 74 of the total 143 contributing factors identified (52 percent) are associated with the incorrect assumptions held by those communicating. In addition, 112 of the total 143 identified factors (78 percent) are clustered within five of the 28 possible combinations of contributing factor areas and communications processes.

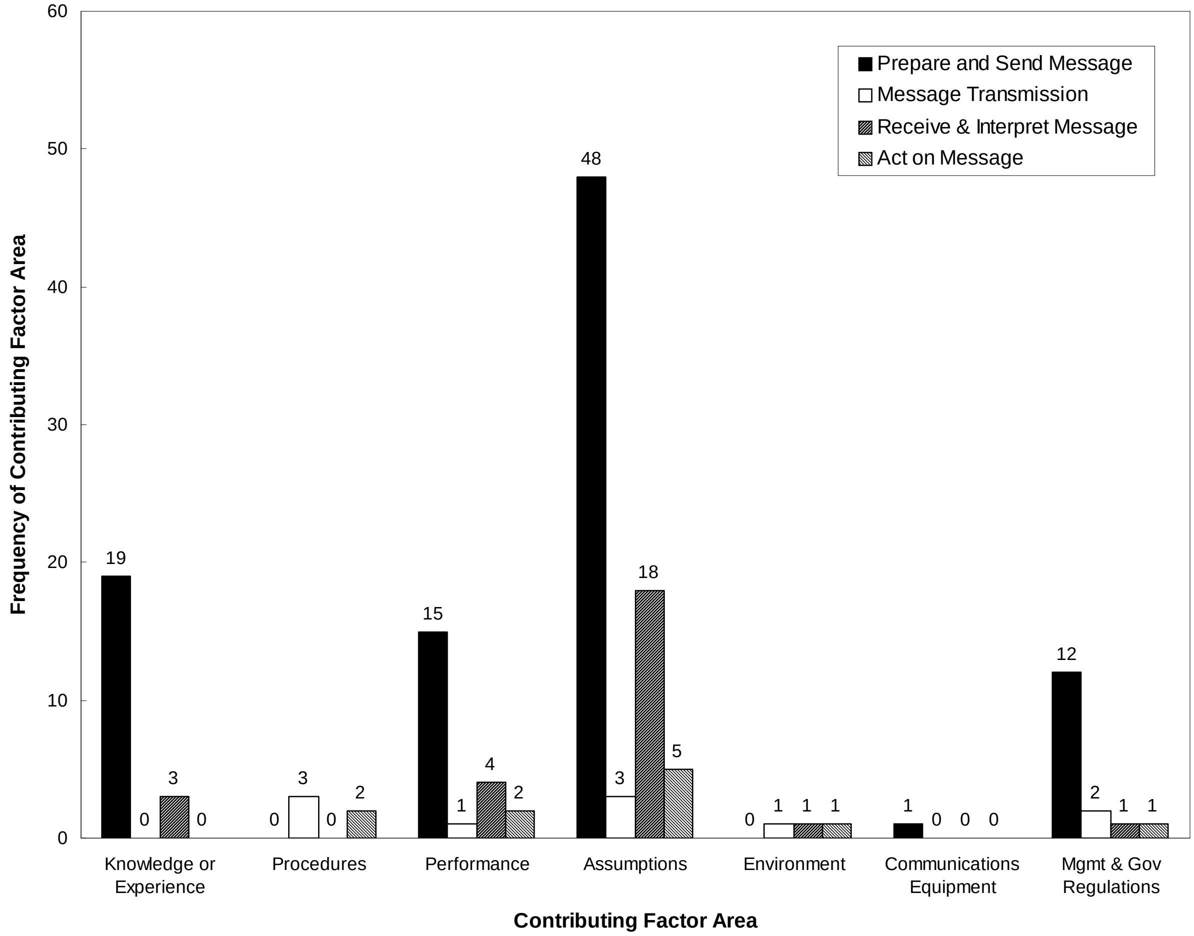

Figure 10. Critical vessel casualties – Frequency of contributing factor areas to communications problems.

Most frequently identified contributing factors to communications problems in vessel casualties. Table 5 lists the 112 specific contributing factors identified in the five most frequently cited factor areas. Review of this table provides a number of insights. First, many of the problems associated with Assumptions in *Prepare and Send Message* stem from the specific contributing factors *Assumed there was no need to communicate* (21 instances) and *Incorrect interpretation of the situation* (10 instances). Second, Performance factors contributing to problems in *Prepare and Send Message* involved both attitude (*Not willing to communicate*) and conflicting job requirements (*Distracted or interrupted by other tasks* and *Individual not at workstation*). Third, a lack of regulation and/or procedures were specific Management and Regulations contributing factors for problems in *Prepare and Send Message.* It should be noted that *Limited English skills* and *Lack of common language* are not as significant as might be thought from Table 5: there were only four casualties in which these problems were found, but multiple individuals contributed to the problem.

Table 5. Critical vessel casualties – Most frequently identified contributing factors within selected communications processes.

Communications Process – Contributing Factor Area / Specific Contributing Factor	Frequency
Prepare and send message – Assumptions	**48**
Assumed that there was no need to communicate	21
Incorrect interpretation of the situation	10
Assumed incorrectly that other party knew the information	6
Assumed individual in charge recognized the problem	6
Other	3
Assumed lack of response was silent confirmation	2
Prepare and send message – Knowledge or experience	**19**
Other	6
Limited English skills or knowledge	5
Lack of common language	3
Inadequate knowledge of correct communications protocol	2
Inadequate knowledge of regulatory requirements	1
Improper use of standard marine technical vocabulary	1
Inadequate knowledge of company procedures or policies	1
Receive and interpret message – Assumptions	**18**
Assumed there was no need to communicate	4
Assumed individual in charge recognized the problem	3
Assumed incorrectly that other party knew the information	3
Incorrect interpretation of the situation	3
Other	3
Assumed lack of response was silent confirmation	2
Prepare and send message – Performance	**15**
Not willing to communicate	6
Distracted or interrupted by other tasks	4
Other	2
Not willing to challenge authority	2
Individual not at work station	1
Prepare and send message – Management and regulations	**12**
No regulatory requirement to communicate	7
Inadequate Standard Operating Procedures	4
Other	1

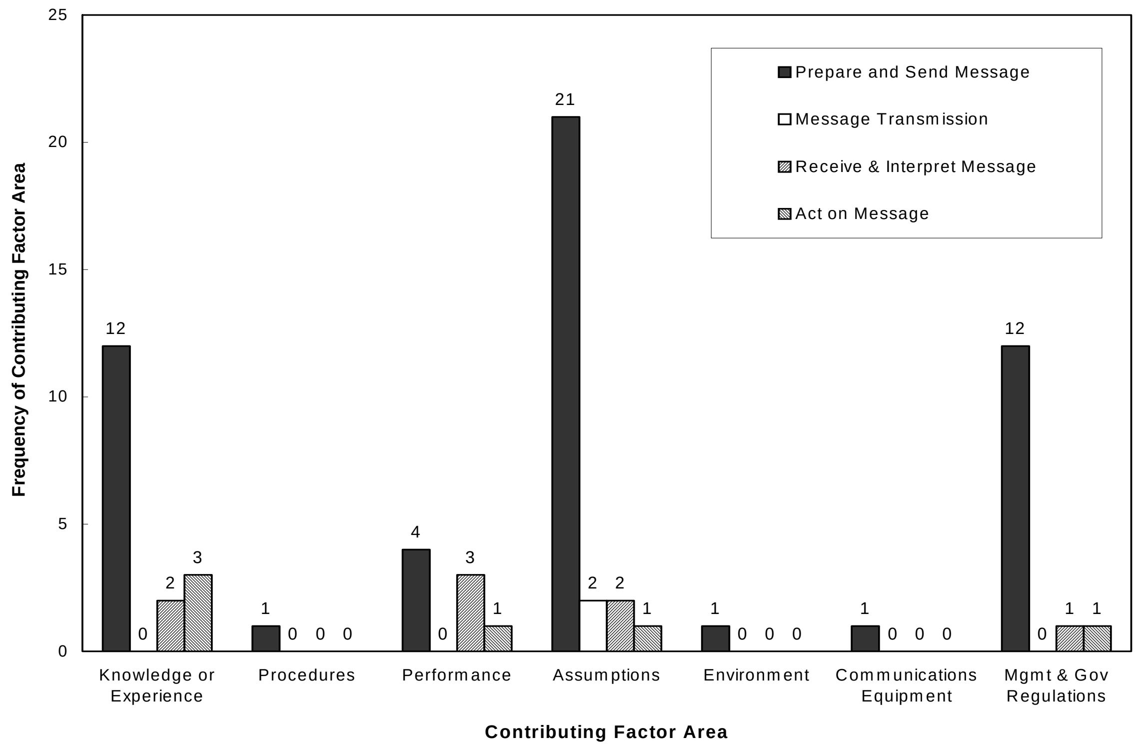

Figure 11. Critical personnel injuries – Frequency of contributing factor areas to communications problems across communications processes.

Frequency of contributing factor areas to communications problems in personnel injuries. Figure 11 presents the frequency with which IOs identified contributing factor areas across the four communications processes for the personnel injury cases. Note that the largest single area (26 of the total 68 contributing factor areas or 38 percent) concerns Assumptions on the part of those communicating. In addition, 45 of the total 68 identified factor areas (66 percent) are clustered within three of the 28 possible combinations of contributing factor areas and communications processes.

Most frequently identified contributing factors to communications problems in personnel injuries. Table 6 lists the specific contributing factors identified in each of the three most frequently cited areas in personnel injuries. Review of Table 6 provides several insights into the factors that contributed to these communications problems. First, *Assumed that there was no need to communicate* is the most prevalent factor contributing to Assumptions in the *Prepare and Send Message* process, and *Incorrect interpretation of the situation* is the second most prevalent in that area. Next, *Lack of common language* is the most frequent contributor to Knowledge or Experience problems in the *Prepare and Send Message* process area (but as mentioned previously, the eight instances of language/English problems occurred in only four casualties). Finally, IOs cited *No regulatory requirement to communicate* as a frequent contributor to Management and Regulation problems associated with the *Prepare and Send Message* process.

Table 6. Critical personnel injuries – Most frequently identified contributing factors within selected communications processes.

Communications Process – Contributing Factor Area / Specific Contributing Factor	Frequency
Prepare and send message – Assumptions	**21**
Assumed that there was no need to communicate	13
Incorrect interpretation of the situation	7
Assumed that individual in charge recognized the problem	1
Prepare and send message – Knowledge or experience	**12**
Lack of common language	5
Limited English skills or knowledge	3
Other	3
Inadequate knowledge of regulatory requirements	1
Prepare and send message – Management and regulations	**12**
No regulatory requirement to communicate	7
Not part of individual's job description or responsibilities	3
Inadequate Standard Operating Procedures	2

Table 7. Percentage of casualties with selected, specific contributing factors. (N=38. Note that a given casualty usually has multiple contributing factors.)

Communications Process – Contributing Factor Area / Specific Contributing Factor	Frequency
Prepare and send message – Assumptions	
Assumed that there was no need to communicate	50%
Incorrect interpretation of the situation	21%
Assumed other party knew information	8%
Assumed that person in charge (PIC) recognized the problem	5%
Prepare and send message – Management and regulations	
Not required to communicate—no regulation, SOP, or not part of job responsibilities	18%
Prepare and send message – Performance	
Not willing to communicate	16%
Distracted/interrupted by other tasks (high workload)	13%
Prepare and send message – Knowledge or experience	
Inadequate knowledge of procedures/policies	8%
Limited English / no common language	8%
Receive and interpret message – Assumptions	
Assumed there was no need to communicate	13%
Assumed other party / PIC knew information	11%
Incorrect interpretation of the situation	8%

Major communications contributing factors in marine casualties. The types of contributing factors which apply to vessel casualties are almost identical to those which contribute to personnel injuries. By collapsing the data over casualty type, it becomes more apparent what the major contributing factors are to communications-related casualties as a whole. Table 7 shows the major contributing factors in casualties having *Prepare and Send Message* and *Receive and Interpret Message* process problems.

The biggest contributing factor by far is the incorrect assumption that *there was no need to communicate*. Assuming there is no need to communicate often goes hand-in-hand with an *incorrect interpretation of the situation*. Consider the Tankerman example given earlier. The Tankerman had assumed that the hose was not pressurized. If the hose truly wasn't pressurized, then there would be no need to communicate (to ask about the status of the hose). In essence, the Tankerman's incorrect interpretation of the situation led him not to ask for verifying information, and caused him to uncap a pressurized hose and sustain a serious knee injury.

In other instances, failing to communicate appears to be due to not thinking about the "big picture." Here's an example. A barge was moored to a quarry loading facility by a pull cable that was controlled from the facility. A deckhand on the barge notices the pull cable is caught under a deck fitting, so he walks over to free it. Before he gets there, a dock worker starts the winch to take the slack out of the pull cable. The cable tightens, jumps off the fitting, and strikes the deckhand in the arm with such force that the muscles spasm and surgery is required. In this example, neither the deckhand nor the dock worker considered that they were part of a larger team, and that their actions needed to be communicated to, and coordinated with the actions of, other team members. Had the deckhand communicated to the dock worker the status of the pull cable and his intention to fix it, or if the dock worker had communicated to the deckhand his intention to tighten the cable, this accident would have been avoided.

Another *Assumption* that led to a lack of communications was the assumption that someone else recognized the problem and that they would take care of it. As an example, a pilot was docking a ship in rough weather. The Master was on the bridge, too, and noticed that the pier fenders were not positioned correctly for his ship, *but said nothing*. Why? He assumed that the pilot and the dock workers recognized the problem--but they didn't. The pilot lost control of the ship in the high winds, and the ship allided with the pier, sustaining significant damage (due to the mispositioned fenders).

Management and Regulations was the next most frequent contributing factor area to *Prepare and Send Message* errors. This category means that the mariner did not see communication as part of his responsibility: there was no regulation or standard operating procedures (SOP) that required him to communicate, or it wasn't considered part of his job description. This bears some similarity to the assumption that someone else (the person in charge) is responsible for communicating.

The contributing factor, *unwilling to communicate*, deserves a little explanation. In most cases where this was observed, an unlicensed crewmembers was the only person on the bridge when the casualty occurred. It may be that he did not use or respond to the radio for fear of being caught (or getting his captain in trouble).

The primary *Knowledge or Experience* contributing factors to a *Prepare and Send Message* error included mariners who did not have an adequate knowledge of the English language (English is the international standard for ship-to-ship communications), and crewmembers who could not communicate because they lacked a common language. While these two factors appear to represent a moderate-size problem, in fact, only four casualties make up this category: two of these casualties involved both types of contributing factors. While the industry often points to language problems as a serious contributor to casualties, this study (with its small sample size) failed to substantiate that claim.

If we consider *Receive and Interpret Message* process problems, we see some of the same *Assumptions* contributing to these casualties as was seen for *Prepare and Send Message* problems. The primary contributor is *assumed there was no need to communicate*. There were several instances in which no one was on the bridge to monitor communications. The captain left the bridge, believing that there was no other vessel in the area (and thus, no need to communicate). When another vessel eventually hailed his ship, he was not on the bridge to receive the message. A related reason for not monitoring communications was the belief that someone else was responsible for that. *Incorrect interpretation of the situation* caused *Receive and Interpret Message* errors and led to a few casualties. In a tragic example (in which there were several different communications errors), a roustabout was fatally pinned and crushed by a barge while attempting to tie off a mooring line. He was so focused on tying the line (cognitive tunnel vision) that he did not respond appropriately to the yelled warning from the deckhand on the barge. He apparently heard the deckhand, because he looked up briefly, but he neither communicated with the deckhand nor looked around to assess what had become a dangerous situation.

Why do mariners choose <u>not</u> to communicate? Two-thirds (68%) of these casualty cases involved someone who had information to communicate but *chose not to communicate*. In almost all (92%) of these "did not communicate" casualties, it appears that a mariner did not perceive that there was a threat. In some cases, an incorrect interpretation of the situation led to this belief: the mariner was unaware that a problem was unfolding, and thus, did not communicate information that could have helped avoid a casualty (like the Tankerman example). In other cases, the mariner was looking only at his small role in a larger, team-oriented task, and did not appear to realize that his actions (or inactions) could have a deleterious effect on another person (e.g., the barge pull cable). But in almost half (42%) of these "did not communicate" casualties, there was a second person on the scene who *did* perceive the threat, but still *did not communicate*. In these situations, the mariner appeared to believe that others saw the threat and would do something about it (e.g., the Master who watched his ship allide with the pier), or, similarly, that it wasn't his job responsibility to say anything. The first problem, that of not perceiving a threat, may be difficult to solve. It appears to get to the very crux of how people interpret bits of information and build a "mental model" of their situation (situation awareness). However, the second problem, that of perceiving a threat but deciding not to do anything about it, should be much easier to fix. This is the type of situation that "crew resource management" (originally developed as cockpit resource management in aviation) was designed to prevent. Mariners need to be trained to think of themselves as vital and participating parts of a team, and to feel empowered to speak up when a threat is recognized. This fairly simple intervention could have prevented 29% of the communications-related casualties in this study.

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4 CONCLUSIONS

The present study was conducted to facilitate the investigation and reporting of communications contributions to marine casualties. This study had two objectives:

- Develop a method for the focused investigation and reporting of communications problems.
- Identify the characteristics and underlying causes of the communications problems that lead to marine casualties.

The communications process model appears to be an effective tool for identifying specific communications errors and for determining the factors that contribute to those errors. The communications process model consists of four communications processes: *Prepare and Send Message, Message Transmission, Receive and Interpret Message,* and *Act on Message.* Investigating Officers were easily able to determine in which process area an error had occurred, and to identify specific communications problems. The model further incorporates seven contributing factor areas and 34 specific contributing factors, allowing IOs to provide structured and informative data on the causes of communications-related casualties.

The communications process model was successfully applied to 38 communications-related marine casualties. Some specific conclusions are given below.

4.1 Communications Investigation and Reporting Procedures

We developed the communications process model and implemented a logical and direct procedure for screening casualties to identify potential communications contributions. The procedure consisted of an initial screening for direct human factors contribution, followed by five questions regarding the potential need for communications during operations leading up to a casualty. Use of this procedure resulted in the selection of 50 cases from a set of 200 critical marine casualties. The screening procedure was so effective that of these 50 cases, 38 (76 percent) were subsequently judged by IOs to have a communications problem. We conclude that the set of screening questions used in this study are a useful tool in identifying cases where there is a high likelihood that a communication problem contributed to the casualty. Further, the follow-up questions allowed the IOs to identify specific communications process problems and their apparent causes. Such data will allow the CG to determine how to target future educational and regulatory initiatives in order to prevent similar marine casualties.

Feedback from IOs indicated that the procedures were valuable and increased the time spent on each case by only approximately 35 minutes. We have revised and streamlined the procedures somewhat, and feel they are ready to be deployed by all the MSOs. The revised procedures are included as Appendix D.

Our analysis of the communications data provided a number of insights into the nature and underlying causes of communications problems that contribute to marine casualties, demonstrating the value of the method. In the present study, communications were cited as contributing to 18 percent of all critical vessel casualties, 28 percent of critical personnel injuries, and 19 percent of all 200 critical casualties. These levels are sufficiently high to warrant further attention.

4.2 Characteristics and Underlying Causes of Communications Problems

Our analysis of the nature and causes of the communications problems in the 38 communications-related casualties provided valuable insights into the investigated casualties. The results provided specific findings that could serve as a point of reference for future comparisons and ameliorative actions. The primary process problems occurred in the *Prepare and Send Message* process, and were found in 87% of these casualties. They were primarily caused by flawed assumptions, in particular the assumption that there is no need to communicate or by an incorrect interpretation of the situation. The second most common set of process problems occurred in the *Receive and Interpret Message* process. These errors were also predicated on flawed assumptions, particularly the belief that there is no need to communicate or that another person is responsible for communications.

The single largest communications problem (found in 68% of the casualties) involved mariners who did not initiate communications when it would have been appropriate. There were two different types of causes for not communicating. In almost every casualty where this occurred, at least one mariner did not appear to perceive that a dangerous situation was developing, and thus, did not communicate information because he did not realize the need. This problem conveys the need to improve mariner situation awareness, both as it applies to his own tasks and as it applies to the larger team of which he is a part. The second reason that some mariners did not communicate is that, while they were aware that a dangerous situation was unfolding, they incorrectly assumed that others also saw the danger and would take action. This is the type of situation that “crew resource management” was designed to prevent. Based on this study, training crewmembers to speak up when a threat is noticed would be predicted to prevent 29% of communications-related casualties. As a first step in making the industry aware of these problems, the results of this study were presented at the Maritime Human Factors Conference in March, 2000.

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Appendix A

Training Materials

This appendix provides most of the 93 slides presented in the one-day Investigating Officer training conducted at participating Marine Safety Offices. The slides showing completed forms are omitted.

APPENDICES A-D ARE PROVIDED IN SEPARATE FILES.