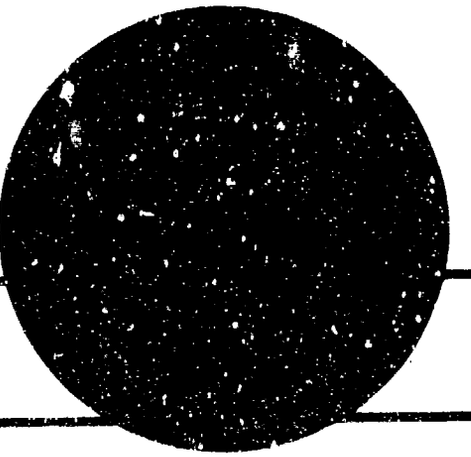
Human Error in Merchant Marine Safety



Maritime Transportation Research Board

Commission on Sociotechnical Systems

HUMAN ERROR IN MERCHANT MARINE SAFETY

Prepared by the
Panel on Human Error
in Merchant Marine Safety
Maritime Transportation Research Board
Commission on Sociotechnical Systems

National Academy of Sciences
Washington, D. C.

June 1976

NOTICE

The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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ABSTRACT

This report examines the problem of human error in merchant marine safety. It is organized into two parts, with Part I treating the conclusions and recommendations and Part II the supportive information and analytic techniques.

The study employs a literature review, a data base evaluation, job descriptions, casualty flow diagrams, and an in-depth survey in its overall analysis.

The recommendations are aimed at developing countermeasures against human acts of commission or omission that lead to merchant marine casualties. Recommendations are made in 21 specific areas.

FOREWORD

The Maritime Transportation Research Board (MTRB) has a continuing program in merchant marine safety. This report on human error completes a study started in 1971 in which industry, government, and labor have cooperated. However, the greatest contribution to the study was that of the seamen who had the interest and took the time to respond to the questionnaires and interviews of the study team.

There is no final solution to the quest for safety in the U.S. merchant fleet. Continuous evaluation is necessary to meet the challenges of an ever-changing technology. The problems of merchant marine safety cannot be treated unilaterally by the United States. International action is necessary for effective accident prevention.

This study suggests actions for a foundation to a continuing safety program for the U.S. merchant fleet. The MTRB hopes that this program will eventually become international.

The members of the Panel on Human Error in Merchant Marine Safety are to be congratulated for an excellent study. I also wish to express my appreciation to the staff and the review committees for their fine work on the report. I am particularly grateful to the Chairman of the Panel, Mr. Barry D. Margetts, for his long and dedicated service.

R. J. Pfeiffer
Chairman
Maritime Transportation
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June 1976

PREFACE

Marine casualties and their effects, including loss of life as well as ecological and cost considerations, are far more serious than is realized; this is especially disturbing since at least 80% of casualties are related to human error. With increasing numbers of large vessels being built -- very large crude carriers (VLCCs) and liquefied natural gas carriers (LNGs), etc.-- early action is required to avoid the potentially catastrophic results if present casualty trends continue. For example, a VLCC loss off the U.S. coast could cost in the order of $100,000,000, excluding environmental damage, while effective countermeasures to significantly reduce casualties related to human error can be developed and implemented at a fraction of this cost.

The Panel recognized that in some cases recommendations similar to our own have already been made and in fact implementation may already be under way. In those cases, it is the Panel's intent to reinforce that work to ensure its prompt and effective completion.

The Panel's recommendations are directed to the U.S. maritime community with the hope that the United States will take a position of leadership by adopting them and striving for similar early international action.

I sincerely appreciate the conscientious contribution made to this study by all panel members; without their active participation the issues concerned could not have been adequately addressed.

The level and scope of marine experience collectively represented by the Panel was impressive; in fact both psychologists, Drs. Bartlett and Hulbert, had the opportunity to make voyages aboard ships to observe marine operations first-hand. I am also particularly grateful to the liaison members for their knowledge and helpfulness.

We were extremely fortunate to have a Project Manager who diligently kept the objective in mind and ensured that everything necessary was completed with a high level of competence.

To participate in a study so vital to the maritime community has been rewarding and I sincerely hope that the Panel's efforts will contribute to improving safety at sea.

B. D. Margetts

Barry D. Margetts
Chairman
Panel on Human Error in
Merchant Marine Safety

June 1976

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PART I

CHAPTER 1

INTRODUCTION

Problem

A Washington Post article on August 7, 1972, said that ships of the world's merchant marine were sinking at the rate of a ship a day. This rather alarming statement was confirmed in Lloyd's Register of Shipping, Statistical Tables for 1972, which showed that 377 ships of 100 gross tons and over were lost through casualties in 1971. Although the number of vessels lost has declined slightly, according to Lloyd's Statistics (371 in 1972 and 363 in 1973), losses still average approximately one per day.

In fiscal year 1974, the U.S. Coast Guard (USCG) reported 199 deaths and 3,388 merchant marine casualties involving 5,413 vessels under its jurisdiction. Since 1972, the USCG has recorded a 31% increase in the number of vessels involved in merchant marine casualties.

The total cost of merchant marine casualties, excluding human lives lost, has been estimated to exceed $300,000,000 per year for the U.S. ocean-going merchant fleet alone. This cost is small, however, compared to the potential for destruction. For instance, in December 1917, the merchant ships IMO and Mont Blanc collided in Halifax Harbor. Their hazardous cargoes exploded and eventually claimed the lives of 1,600 people, completely devastating the city of Halifax. By comparison, the San Francisco earthquake claimed 452 lives.

The prospects for safe merchant marine operations in the future are not promising. Projections of trends show that over 75,000 merchant vessels totaling over 400,000,000 gross tons may be plying the world's trade routes by 1980. If current tonnage loss ratios continue (0.35%), some 1,400,000 gross tons of shipping will be lost in 1980.

Perhaps even more disturbing is the fact that vessels in hazardous cargo carriage (tankers, chemical carriers, liquefied natural gas carriers, etc.) are the fastest growing segment of the world's merchant marine. Tankers constitute 42% of all steamships and motorships. Large tankers, with their reduced maneuverability and greater cost associated with their casualties, are rapidly becoming a larger percentage of world total tonnage. In 1974, there were 419 vessels of 200,000 DWT and over as compared with 293 in 1973. At the same time, some of the merchant fleets that are growing most rapidly are those with the least regulation and the poorest safety performance. For instance, Liberia, with the world's largest and fastest growing merchant fleet, lost 281,931 gross tons in 1973, representing 0.56% of its active tonnage. This was the poorest performance of the major maritime nations.

Merchant marine casualties often result from a number of factors involving a series or combination of events and circumstances. However, in

most cases, human error or personnel fault is a contributing, if not fundamental, factor. According to Lloyd's Register of Casualty Returns for 1973, the greatest number of vessel losses can be traced to groundings, collisions, fires, and founderings, all of which invariably involve human judgment. In 1972, the chairman of the American Hull Insurance Syndicate revealed that 85% of the Syndicate's claims payments were for human-error casualties. USCG figures for fiscal year 1974 show that only 15% of vessels involved in casualties cited material or mechanical failure as the primary cause. These and other data point to the overriding importance of human performance in the operation of our merchant fleets.

Concern for public safety, the preservation of our environment, and the high cost of vessel casualties make safe merchant marine operations an important matter.

Background

The Maritime Transportation Research Board (MTRB) has a continuing interest in merchant marine safety because of the growing national and international concern over merchant marine casualties.

In December 1970, a panel of the MTRB published a report entitled *Merchant Marine Safety*.[46] Among the conclusions drawn by the panel was one citing personnel fault as the most frequent cause of merchant marine casualties. Accordingly, the 1970 study recommended that more research be undertaken to define and understand human error.

In October 1971, the MTRB authorized further research into the causes of casualties resulting from human error. In early 1972, the Board formed the Panel on Human Error in Merchant Marine Safety.

The first meeting of the Panel was held in Washington, D.C., in June 1972. The Panel was directed by the Board to develop a program of research and training countermeasures to reduce the incidence of merchant marine casualties caused by human error. The Panel broadened this charge to read: "providing recommendations that will lead to the development of countermeasures against human acts of commission or omission that lead to merchant marine casualties".

The Panel concentrated on seafarers in the oceangoing merchant marine; stevedoring was excluded. Its initial work included data base surveys, literature reviews, development of casualty flow diagrams, and construction of job descriptions.

Early in its deliberations, the Panel concluded that it needed a more appropriate data base on which to conduct its analysis. The Panel reviewed available information on human error and decided that existing data were not detailed enough. For the most part, existing merchant marine casualty data were by-products of adjudication and did not deal consistently with the basic causes of human error. In fact, in many cases, the term "human error" or "personnel fault" was the most detailed information available. Furthermore,

the Panel was convinced that full disclosure of the events leading to casualties was seldom possible in a regulatory or judicial forum.

The Panel concluded that a major data collection program was needed, not only to set priorities for research but also as a basis for the research itself. Accordingly, the Panel submitted an interim report recommending a comprehensive survey as a means of developing primary human-error data. The interim report was directed to the U.S. Maritime Administration for action in June 1973.

The Panel meanwhile began trials of interview and questionnaire techniques on experienced licensed officers attending refresher courses at two union schools. The results of these surveys provided valuable background and were helpful in preparing advice for the National Maritime Research Center (NMRC) on the in-depth survey.

The Maritime Administration acted on the Panel's recommendations in March 1974, sponsoring an in-depth survey through the NMRC at Kings Point, New York. The survey is discussed in detail in Chapter 8.

The Panel assisted the NMRC in evaluating proposals submitted in response to a request for proposal. The NMRC selected Lakeview Research of Peekskill, New York, to undertake the project. The contract was awarded in May 1974. The Panel continued to assist the NMRC by monitoring Lakeview's progress through July 1975, when the survey was completed.

In developing its conclusions and recommendations, the Panel relied heavily on the collective experience and judgment of its members, literature review, job descriptions, existing and newly developed data, and analyses. Figure 1 shows the process followed by the Panel in conducting its analysis and in developing its recommendations.

Since the in-depth survey was an important if not major part of the supporting information, the Panel calls attention to the following limitations of that survey:

1. The questionnaire was a self-reporting type. Self-reporting questionnaires are subject to the biases of the respondent. Bias due to ambiguity of behavioral language (e.g., terms such as fatigue or panic) is also a possibility.

2. Since only 25.6% of the questionnaires were returned, the response does not represent the entire population of seafarers. Rather, it is a sample of 359 persons who voluntarily returned the questionnaire. It has a higher percentage of younger, better educated, personnel with higher ratings than the overall group of merchant seamen. Although this could be regarded as a limitation, these respondents, because of their education and ratings, may be more knowledgeable and better equipped to observe casualties than the typical merchant seaman.

The Statistical Package for the Social Sciences, developed by the National Opinion Research Center, University of Iowa, was used for testing the

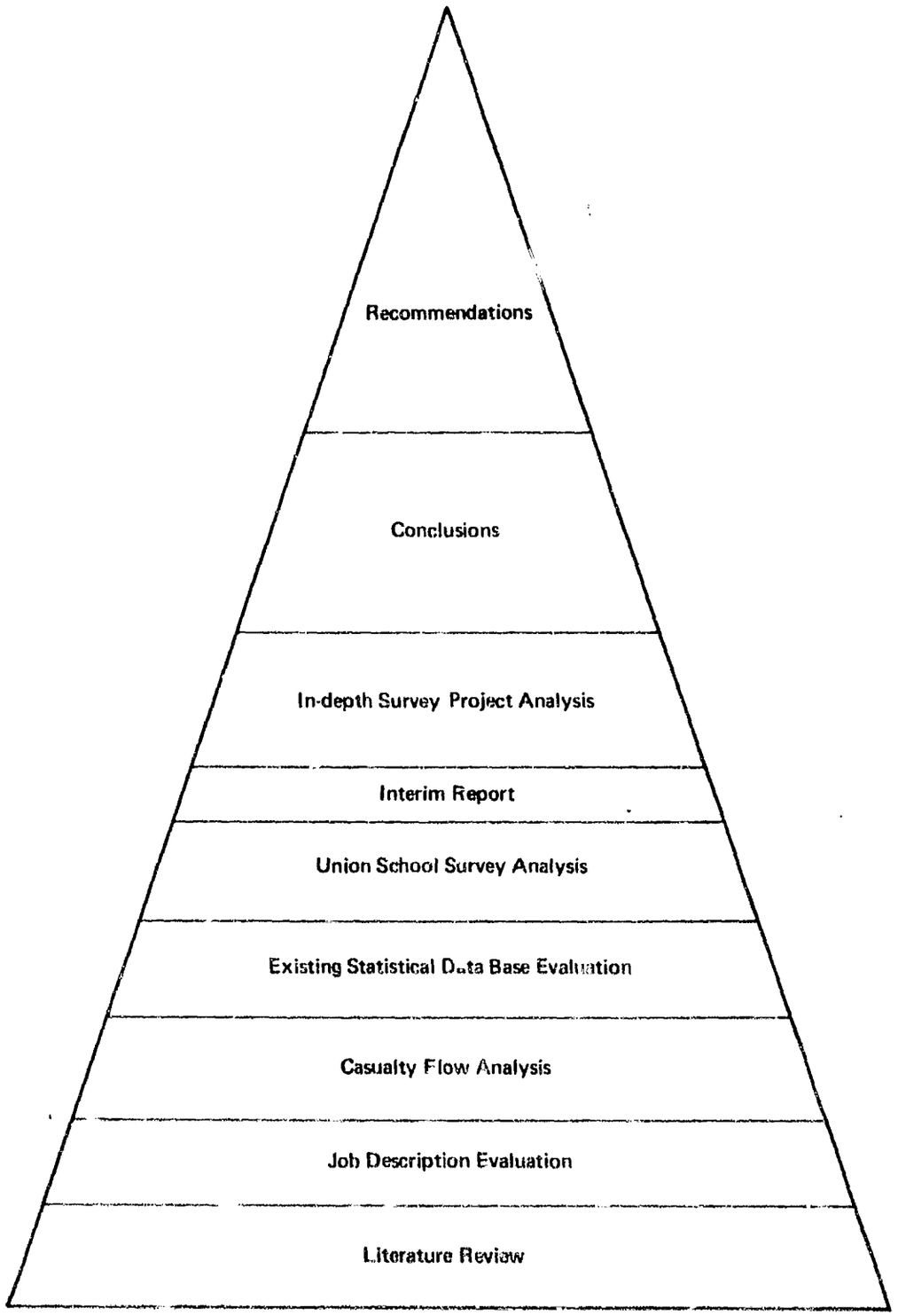


FIGURE 1

STUDY INTEGRATION DIAGRAM

data. For the reader who is interested, every reasonable statistic for each variable has been computed and can be found in Volume II of the Lakeview Research Study "Human Causal Factors in Maritime Casualty and Near Casualty in the United States Merchant Marine".[22]

This study has been organized into two parts to separate the conclusions and recommendations from the more detailed treatment of the supportive information and analyses. The purpose of this separation is to improve the readability and accessibility of the recommendations. Part I contains the introduction to the study and the conclusions and recommendations, in Chapters 1 through 3. Part II contains the literature review, data base survey, job description, casualty flow techniques, and the in-depth survey, in Chapters 4 through 8. The school surveys are covered in Chapter 8 as a part of the in-depth survey.

CHAPTER 2

CONCLUSIONS

The objective of the study was to determine the underlying causes of casualties resulting from human error in the U.S. merchant marine.

The Panel has relied heavily on the literature review and the in-depth survey to arrive at its conclusions. Although they are not cited in the narrative for the conclusions, the casualty flow diagrams and the job descriptions helped greatly to clarify the relationship between human error and casualty and were the major tools for developing the conclusions and recommendations.

For the purposes of this study, the Panel has defined human error as "the commission or omission of acts by maritime personnel that cause or contribute to merchant marine casualties or near-casualties".

In general, the Panel concluded that the tolerance for human error has decreased greatly with the introduction of large, fast, and highly sophisticated ships and the consequences of human error have become greater. While the probability and consequences of casualties have increased dramatically, the means for countering human error in vessel operations have not kept pace.

The Panel has concluded that 14 factors are either major or potential causes of casualties or near-casualties. These factors are listed below and defined with a short narrative to support the inclusion of each as a contributor to human-error casualties.

1. Inattention

Inattention is a lack of full vigilance to the duties or responsibility assigned. It may be related to a condition or situation that results in a crew member being distracted from his primary or necessary duty or responsibility. Inattention was found to be particularly serious in watchkeeping.

Inattention was cited either directly or indirectly in many of the reports reviewed. A Dunlap Associates study[9] found that slowness in reacting to early signs of danger suggests that coming officers would benefit from practice in meeting emergency situations presented on a simulator or a trainer. Mara[35] has suggested changing operational procedures to free the mate on watch to perform the collision-avoidance task during periods of heavy workload. He also suggests that in limited visibility one operator is required solely for collision avoidance and a second for position fixing.

In commenting on the collision of the S. S. African Neptune with the Lanier Bridge in Brunswick, Georgia, the U.S. Coast Guard held that the third mate was not remiss because at the time of the incorrect rudder application he was entering an engine order in the bell book.

Respondents to the in-depth survey ranked inattention first among 13 identified causes of human error.

2. Ambiguous Pilot-Master Relationship

This refers to the confusion in authority and responsibility that often results when a pilot assumes control of a vessel in a harbor or coastal situation.

Several references to this problem were found in the literature. For instance, Madsen, Nicastro and Schumacher[33] suggested that a checklist of information be exchanged between the pilot and master immediately after the pilot has boarded the vessel. They also suggested that a qualified pilot-master should assume control of long-haul vessels that are in congested pilotage waters. This new position would replace the conventional ship's master position as the pinnacle of a mariner's career.

Confusion concerning the status of the watch officer while a pilot is aboard is of such importance that it receives special emphasis in the Intergovernmental Maritime Consultative Organization Operational Guidance for Navigational Watchkeeping[76] which notes that despite the duties and obligations of a pilot his presence on board does not relieve the officer on watch from his duties and obligations for safety of the ship.

The in-depth survey contained numerous responses pointing out ambiguities in the responsibilities of the pilot and captain in pilotage waters. When asked if a dangerous incident had ever resulted from a conflict between the captain and the pilot, 40% of those responding to the question answered "yes". The interviews provided numerous incidents of confusion or contradictory orders from the pilot and master that resulted in casualties or near-casualties.

3 Inefficient Bridge Design

This refers to the generally poor instrumentation and overall design of ship's control stations (bridges). Although there has been some progress in centralizing bridge control consoles, overall bridge design has not kept pace with the increased control requirements for modern vessels. Efforts to standardize on modern bridge designs have been hampered by tradition and by strong personal preferences of the owner and owner's representatives.

The literature review produced numerous citations of requirements for improved bridge design and/or navigation equipment. For instance, Mara[36] found that, during the docking and undocking operation, it is essential that information be available to the captain of a ship in a format that can be quickly evaluated (i.e., not scattered throughout the wheelhouse, chart room, and bridge wings). Mara also suggests that equipment displays and work space

required by the mate be designed around the radar display. Volume V of the same study[5] concludes that a centralized console on the bridge controlled by a single, seated operator increased the effectiveness of deck officers compared with more conventional bridge layouts. In Volume IV of the same study[34] completed in 1969, Mara indicated that the location of controls on a ship's bridge is critical. Twenty percent or more of a deck officer's time can be spent obtaining information or implementing action through controls.

4. Poor Operational Procedures

This refers to the failure of many deck and engine watchstanders to observe consistent professional operating standards in the conduct of their duties.

There were several references found throughout the literature on operational procedures. Barrow[2] stated that bridge organization for conditions encountered was extremely informal, with duties imprecisely stated or not stated at all. He also noted that failure to plot targets has repeatedly been a factor in casualties between vessels equipped with radar.

In its review of the collision of the S. S. African Neptune with the Lanier Bridge, Brunswick, Georgia, the National Transportation Safety Board recommended that a conference be held before sailing prior to maneuvering through high-risk areas.

A review of casualties in a foreign flag fleet showed that ships' officers were apparently failing to make effective use of all operational equipment provided for safe navigation and piloting.

The in-depth survey cited a number of instances where operational procedures were not followed or were followed improperly. When asked if a casualty had ever resulted from a failure to follow operational procedures, 26% of those answering the question said "yes". When asked why the procedure was not followed, 32% of those answering indicated that the seaman performing the duty "did not want to bother".

5. Poor Physical Fitness

This refers to the lack of standards for physical fitness for key personnel in operating positions aboard ship. High standards are necessary because of the strenuous requirements of some positions and because medical attention usually is not immediately available. It is obvious that in key operating positions in both the deck and engine departments a high level of physical fitness is required to ensure alertness in watchkeeping.

Job descriptions tend to confirm the existence of long periods of continuous work, some of which require a high level of physical stamina and endurance.

The average age for operating personnel in the United States Merchant Marine is approaching 50 and the range extends into age 70.

In the in-depth survey, 14% of those responding to the question indicated that a casualty or near-casualty had resulted from a sudden illness of someone aboard ship. Of those responding, 31% identified the helmsman as the person taken ill. Of those responding to a question concerning excessive height and weight, 14% indicated that those factors had contributed to emergency situations. In one interview, a captain stated that he felt many current officers cannot move with sufficient agility to climb ladders and adequately inspect hatches and hulls.

6. Poor Eyesight

Although closely associated with physical fitness, poor eyesight merits individual emphasis. Obviously, in key seagoing positions where eyesight is essential to safe and efficient operation, crew members should be required to pass visual acuity tests periodically as a requirement for continued employment.

Twenty-three percent of those responding to the question in the survey indicated that impaired eyesight of someone on the bridge had been related to an emergency condition. Of those responding to that question, 33% identified the pilot and 25% identified the master as the individual experiencing the impaired eyesight.

7. Excessive Fatigue

Excessive fatigue has been defined as drowsiness or loss of vigilance due to long work periods and/or lack of sleep. The job descriptions show that some positions aboard ship require unusually long hours, particularly for those having both watchstanding and loading and discharging responsibilities.

The literature review contains many references to the problems associated with fatigue. Lockheed Georgia[16], in a 1964 study, concluded from its experiments that periods of sleep loss degrade performance. Its experiments showed that the performance of subjects working a 16-hour day, 4 on, 2 off, was depressed more by an extended period of sleep loss than that of subjects working on a 4 on, 4 off schedule.

The Oceanographic Institute of Washington[54] concluded that Washington state pilots should have specified rest periods and should be examined physically each year.

In the in-depth survey, when seamen were asked if excessive fatigue had contributed to a near-casualty or casualty, 31% of those responding to the question answered "yes". Particular concern was expressed for the long periods that captains and chief mates are continuously on duty while docking and undocking, transiting canals, etc. In one interview, it was said the chief mate suffers from chronic fatigue, "he is up when they bring the ship in, he will work all day and will be on the anchor in the evening when the ship goes out".

8. Excessive Alcohol Use

This refers to the apparent high incidence of intoxication by crew members in watchstanding or duty status.

More than half of those responding to the questionnaire indicated that drunkenness of a crew member, officer, or pilot was a factor in a casualty or near-casualty. Also, there were numerous descriptive comments in the questionnaire and in the interviews that referred to excessive use of alcohol aboard ship. The seriousness of the problem is perhaps best summarized by the response of one master who said, "it is a part of the code of the sea to protect drunk officers. Some day I may be in the same situation".

9. Excessive Personnel Turnover

Personnel turnover has been defined as the movement of crew members among various vessels. This is particularly common among licensed deck officers. Excessive turnover leads to many instances in which crewmen may operate vessels with which they have had little or no experience. In the Panel's judgment this leads to an incompatibility in the man-machine relationship and increases the probability for human error.

There were numerous citations in the literature relating to personnel turnover. Madsen, Nicastro and Schumacher [33] suggested that some type of written and performance examination be required of crew members to demonstrate proficiency in the class and size of vessel involved. They also recommended periodic proficiency checks to maintain licenses.

In the survey, 78% of those responding to the question felt that there was a relationship between personnel turnover and casualties. In several interviews, rotary shipping and high personnel turnover were identified as problems. One interviewee summarized the problem: "At one time there were very similar ships and very similar cargoes; men could take what they learned from one ship to another ship. Handling characteristics, engine room, and routines were all similar. Today, however, the fleets and cargoes are heterogeneous. A mate from a 500-foot ship can bid and get a job on a 900-foot ship".

10. High Level of Calculated Risk

Calculated risk is defined for this report as knowing acceptance of risk in operational situations to meet personal or corporate priorities. The acceptance of risk was found by the Panel to be a significant causal factor in merchant marine casualties.

A number of instances were found in the literature in which operating personnel were willing to base decisions on incomplete information. Dunlap Associates [9] found that 67% of the conning officers of large vessels and 42% of the conning officers of small vessels made their decisions to maneuver on the basis of incomplete information, either about the status of their own vessel or the status and intention of other vessels.

Barrow[2] indicated that many collisions occurring in low visibility are caused by a combination of excessive speed and a failure to plot radar targets in the vicinity.

The in-depth survey provided several instances where risk taking contributed to a casualty or a near-casualty. For instance, when asked to select among 12 criteria used by companies for grading a captain's performance, 40% of those responding to the question indicated that making schedules was the prime criterion. When asked how companies feel about meeting schedules in poor conditions, 50% of those responding said that there was strong pressure to meet schedules. Almost all of those responding reported sailing on a ship that they personally knew to be unseaworthy.

Perhaps the most revealing disclosure from the interviews was that of a company that in 1969 dropped a safety program that offered a good bonus to tugs and crews with the least accident claims, because the program resulted in decreased productivity and a slowdown in task completion.

11. Inadequate Lights and Markers

Lights and markers are defined as vessel navigation lights and channel lights and markers used for navigation purposes. The Panel determined that inadequacies of these aids were significant contributors to merchant marine casualties. It was also the Panel's contention that the state of the art of maritime lights and markers is not consistent with our technological capabilities. Conclusions on channel markers came primarily from the in-depth interviews. Of those responding to the question, 55% said they found that shore lights camouflage running lights of other vessels on clear nights. Respondents listed range lights, channel markers, radio communications, and channel lights, in that order as the navigation aids needing most improvement. Better and stronger lights, radar reflectors, and more and better ranges were recommended for the buoy beacon and light tower system along the coast of the United States. Of those responding to the question, 29% said they had experienced a casualty or near-casualty because a channel light in a harbor was confusing or misleading.

12. Misuse of Radar

Misuse of radar is defined here as a misinterpretation or improper operation of radar aids. The paradox of the radar-assisted collision is well known and is a persistent problem.

In addition to personal experience of the Panel members concerning the misuse of radar, there were several relevant citations in the literature review. A Link Division, Singer General Precision, Inc., study[26] published in 1969 concluded that the introduction of new radar hardware has not reduced accidents. It also concluded that there was evidence that the lack of proper training has prevented the effective use of radar.

Mara[36] suggested that a cause of collisions might be that radar contacts can exceed the operator's processing capability. He also noted that investigation of collision risk based on the time required to detect a

collision course showed an 89% probability of detecting a single collision course when only one collision course was presented among other targets. However, there is only a 38% probability that the operator will detect the third of three simultaneous collision courses.

A proprietary study of casualties for a foreign flag fleet indicated that radar equipment was not being properly maintained.

It is apparent from the in-depth interviews that the techniques for using radar and the types of equipment used are not consistent throughout the U.S. merchant marine. When asked what kind of radar display they preferred, 55% of those responding indicated relative motion, ship's head up; 23% indicated relative motion, north up; and 23% indicated true motion, stabilized. Fifty-seven percent of those responding said they had difficulty dividing their attention between the radar and other bridge duties. One of the difficulties in using radar is summarized in this response by a master: "In my experience as a port captain, I found that radar caused more accidents than it eliminated. Men rely too heavily on radar and fail to keep a good lookout."

13. Uncertain Use of Sound Signals

Uncertain use of sound signals is defined for this study as the general failure to employ sound signals as required by the rules of the road. Much of the difficulty is in the ambivalence that the crews feel for the value of such signals and in the customary avoidance of sound signals in all but emergency situations.

The following examples were found in the literature. Dunlap Associates[8] said that many conning officers of vessels in the sample studies appeared reluctant to change the status of their ships or to sound danger signals at a time when such actions could have been effective. Mara[35] noted that the operator is unreliable in determining the azimuth of a given sound.

The in-depth survey confirmed the seriousness of the problem. Thirty-two percent of those responding to the question indicated that failure to use sound signals contributed to a casualty or near-casualty. In addition, crews are ambivalent about the value of sound signals, since the majority, 69%, feel that they are of limited usefulness. The seaman's opinion of the usefulness of sound signals can best be summarized by this quotation by a master responding to the question: "VHF is better. Sound signals are O.K. as a last resort and/or for legal protection."

14. Inadequacies of the Rules of the Road

Rules of the road are considered to be inadequate when rules are a source of, rather than a countermeasure to, human-error casualties. The Panel noted that, because U.S. rules have been revised and are now being considered at the international level, conclusions on this subject would be premature.

The in-depth survey showed that there is considerable dissatisfaction with the rules of the road. Of those responding to the question, 29% said that they had been in a situation where strict obedience to the rules of the

road was a contributing factor to a marine casualty or near-casualty. Almost half of those in the sample feel justified in departing from the rules to meet normal expectations and operations. One of the chief complaints concerning the rules of the road can perhaps best be summarized by this quotation from a deck officer: "Over and over again you have the right-of-way, you know it's a collision course, you must hang on until the next to the last moment."

Inadequate Data Base

The Panel concluded that the merchant marine casualty data maintained by the U.S. Coast Guard and other government regulatory agencies are inadequate for casualty analysis.

This conclusion came from the Panel's efforts to develop the necessary data on which to base its analysis, conclusions, and recommendations.

A Maritime Transportation Research Board report completed in 1973, entitled *Merchant Marine Casualty Data*[45], contained recommendations for a program to improve the collection and use of merchant marine casualty information. It suggested that a national merchant marine casualty data system be established by consolidating existing data collections and systems. The system should create a formal relationship between all organizations collecting merchant marine casualty data and should be designed to make the most efficient use of available resources. The U.S. Coast Guard would be given the responsibility to form and manage this system.

The Panel noted that as of this date no action has been taken on this highly desirable and necessary function.

CHAPTER 3

RECOMMENDATIONS

The Panel's recommendations are based directly on the conclusions drawn in Chapter 2. In general, they are directed to the government agencies the Panel thought most appropriate for the action required. Specific research is recommended where knowledge is incomplete or where criteria and standards for increased regulation have not been adequately developed. In some instances, direct action is suggested where the Panel felt that enough information is available on which to make decisions and further study would be of limited use.

The recommendations are listed in priority order by categories. The recommendation categories are listed in priority order as assigned by a subpanel (a detailed explanation of the priority assignment is given in Appendix II):

Categories

Vigilance
Pilot-master relationship
Bridge design
Operating standards
Physical qualifications
Vessel familiarization
Boredom and job satisfaction
Fatigue
Calculated risk
Alcohol use
Radar
Sound signals
Lights and markers
Rules of the road
Data base (not rated)

The 21 study recommendations are given in the following under the assigned priority headings.

Vigilance

1. The U.S. Coast Guard should take immediate action to require that anti-collision devices be installed aboard oceangoing merchant vessels to reduce human-error casualties stemming from lack of vigilance.

Pilot-Master Relationship

2. The U.S. Coast Guard should propose changes in legislation and regulations to resolve the ambiguity in the authority and responsibility of pilots and masters.

Bridge Design

3. Experimental programs should be started by the Maritime Administration to improve the instrumentation and design of vessel bridges. For example, cockpit-type control bridges should be developed and tested on simulators. Designs with potential for increasing safety should be installed for operational testing on selected ships being built under subsidy.

Operating Standards

4. The Maritime Administration should develop programs to use its simulator facilities at Kings Point, New York, for experiments to develop optimal bridge manning and bridge operating procedures, by vessel type, for typical high-risk navigational situations. The purpose of the experiments would be to standardize operational procedures in the U.S. merchant marine.

5. The U.S. Coast Guard should formalize bridge and engineering operating procedures for ships in the U.S. merchant marine and take action to enforce use of these procedures.

6. The U.S. Coast Guard should develop criteria and standards that would include operational proficiency checks for bridge and engineering watchstanders, either aboard ship or with simulators, for issuing and renewal of licenses.

7. The Maritime Administration should be continuously aware of the development and evaluation of U.S. Coast Guard criteria and standards for licenses to develop proper education, training, and retraining programs.

Physical Qualifications

8. The U.S. Coast Guard should develop comprehensive physical requirements, including visual acuity, by job description and vessel type to establish physical examination criteria. The criteria should be operationally tested before adoption. Entry of women into the seagoing work force should be considered in establishing physical examination criteria.

9. The U.S. Coast Guard should establish a program requiring annual physical examinations for active seafarers as soon as physical examination criteria are established.

Vessel Familiarization

10. The Maritime Administration should develop a system for qualifying crew members by vessel type. The program should consist of (a) needs assessment by vessel type and job classification; (b) development of training requirements; (c) evaluation of effectiveness; and (d) a plan for assigning crew members to ships for which they are qualified. This program should include a pilot project covering a wide variety of vessel types and result in recommendations, to the U.S. Coast Guard, for regulations on crew qualification by vessel type and job classification. This is an immediate need that should be met as soon as possible.

11. The U.S. Coast Guard should be aware of Maritime Administration research in vessel familiarization and follow through by establishing a program for qualification of key crew members by vessel type.

Boredom and Job Satisfaction

12. The Maritime Administration should pursue a comprehensive program of research to increase job satisfaction, reduce boredom, and improve on-duty performance as a means of increasing vigilance aboard ship and as a way to attract and retain high-caliber seafarers in the merchant marine. Research might include such concepts as job enrichment, minimizing effects of family separation, and family acceptance of job.

Fatigue

13. The Maritime Administration should conduct research into fatigue, to include effects of duty cycles for specific tasks, physiological day-night cycles, and chronic or long-term fatigue.

Calculated Risk

14. Calculated risk results from unrealistic performance requirements, inaccurate perception of operating conditions, or a combination of both. In any case, where there is a gap between required and actual behavior, research should be undertaken to reduce this gap. Such research should have two purposes. First, a program is needed to examine the effects that performance requirements such as rigid adherence to schedules have on safety. Performance expectations may have to be revised in the interest of safety. A second program should examine ways to improve compliance with safety regulations, to increase awareness of general principles of safe operation, and to imbue the crews with a commitment to safety.

Alcohol Use

15. The Maritime Administration, together with the National Institute on Alcohol Abuse and Alcoholism, should undertake research to determine the causes of, and effective countermeasures against, alcohol and drug abuse aboard ships of the U.S. merchant marine.

16. U.S. operating companies and U.S. unions should increase their efforts to control alcohol abuse by establishing procedures and enforcing existing rules to discourage crew members from performing duties while under the influence of alcohol.

Radar

17. The Maritime Administration should establish standards for performance, maintenance, and use of radar to facilitate the transfer of skills from ship to ship. This should be done in consultation with the Radio Technical Commission on Marine Services concerning ongoing research in this area.

Sound Signals

18. The U.S. Coast Guard should consider taking action internationally to relegate sound signals to use in emergency situations only.

Lights and Markers

19. The Maritime Administration and the U.S. Coast Guard jointly should sponsor research and experiments to improve navigation aids and markers, including navigation lights on vessels. The objective should be to develop a new generation of navigation aids and improvements to vessel navigation lights that can be recommended for international implementation.

Rules of the Road

20. The U.S. Coast Guard should continuously review the rules of the road to compare with current practice. A semiannual report of the results of the review should be made by the U.S. Coast Guard relating the rules to casualty experience. The report should set forth recommendations for appropriate revisions or enforcement.

Data Base

21. The U.S. Coast Guard should move immediately on the recommendation of the Maritime Transportation Research Board report on *Merchant Marine Casualty Data* to develop a national merchant marine casualty data system. The data from actual operations should be supplemented with simulation data. Accidents should be programmed into simulators as a means of establishing underlying causes.

PART II

CHAPTER 4

LITERATURE REVIEW

The Panel's first step in evaluating human error as a cause of merchant marine casualties was to review currently available literature. Material was screened for facts, conclusions, and recommendations with direct bearing on human error in merchant marine safety.

The literature review covered material available through mid-1975, including newspaper and professional journal articles where appropriate. The material is discussed here chronologically.

Some of the articles reviewed refer to "large" and "small" vessels. Not all authors used the same basis for this distinction, and in some cases no definition of "large" or "small" was offered.

Literature dealing exclusively with statistics on merchant marine casualties, such as Lloyd's Register of Shipping Statistical Tables, is treated in Chapter 5 under Existing Statistical Data Base.

A summary of the in-depth survey conducted by Lakeview Research entitled "Human Causal Factors in Maritime Casualty and Near Casualty in the U.S. Merchant Marine", Volumes I, II, and III, is discussed in Chapter 8.

Human Engineering Operations Research Personnel Planning, Dunlap and Associates, Inc., 1959. [8]

This study was done to assess the value of marine casualty records as a source of data, based on a small sample of collision records. The following significant points are abstracted from the study.

Fifty-eight percent of the 26 officers in the sample who were conning their vessels by radar interpreted the relative motion situation correctly.

Communications performance of the vessels in the study is poor. Only 30% of the transmissions by large vessels in the sample and only 26% of the transmissions by the small vessels were received and understood.

All major collision-avoidance actions of the sampled vessels occurred within two miles of a target vessel and not earlier.

Under conditions where initial detection was made by radar, the vessels of the sample made as many course changes in the direction of the target as away from it.

In 90% of the cases sampled, a passing agreement was not established.

Sixty-seven percent of the conning officers of the large vessels and 42% of the conning officers of the small vessels made their decisions to maneuver on the basis of incomplete information, either about the status of their own vessel or the status and intentions of the other vessel.

Many conning officers in the sample appeared reluctant to change the status of their ship or to sound danger signals at a time when such actions could have been effective.

Slowness in reacting to early signs of danger suggests that conning officers should practice meeting emergency situations in a simulator or a trainer.

Combined Effects of Sleep Loss and Demanding Work-Rest Schedules on Crew Performance, Human Factors Research Laboratory, Lockheed Georgia Co., June 1964. [16]

This report describes experiments on sleep and crew performance. The following points are abstracted from its conclusions.

Subjects working a 12-hour day (4 on, 4 off) are able to maintain their performance at a higher level when subjected to an extended period of sleep loss than subjects working 16 hours per day on a 4 on, 2 off schedule. The imposition of a period of sleep loss degrades performance. If a period is anticipated in which emergencies are more likely, the 4 on, 2 off schedule should be used only with extreme caution.

Human Factors in Ship Control, Volume I, Analysis of Ship Operations, Operator Capabilities, and Recommended Bridge Arrangements, Mara, Thomas D., General Dynamics Corporation, January 1968. [35]

This report was made to develop human factor guidelines for merchant marine bridge design. The following significant points are abstracted from the report.

It is essential that information be available to the captain of a ship in a format that can be quickly evaluated (i.e., not scattered throughout the wheelhouse, chart room, and bridge wings). Information that should be available in the wheelhouse and both wings includes ship speed, rudder angle, distance from pier, pilot order, and helm response; adequate communication facilities to all deck officers and the helm are also required.

In a docking maneuver the mate spends much of his time logging speed changes. At night this is particularly troublesome because the task requires a light source that can affect the dark adaptation of all persons in the wheelhouse. The report recommends that pilot requests for speed changes be recorded on data logging equipment. The task could also be simplified by tape recording the requests for speed changes.

Some steering commands might not be heard when given by the pilot from the wing. An intercom system between the wings and the wheelhouse is recommended to eliminate this problem.

The design of a station or operator position that contains all pertinent information on ship location and status is desirable.

Information that is needed but not now available includes water depths several thousand feet in front of the ship, the intentions of other vessels, particularly in a multi-ship crossing situation, and passing distances of vessels when they are hidden from the ship's bow.

Coastal piloting may impose a heavy workload on the mate. Position fixing plus maneuvering in traffic constitutes an exceptionally heavy workload. Changes in operational procedures should be made to free the mate on watch from heavy workloads in restricted waters for collision-avoidance duties. During periods of limited visibility, two mates or a mate and the captain should be on the bridge at all times. One officer is required solely for collision avoidance and the second for position fixing.

Other equipment, displays, and work space required by the mate must be designed around the radar scope. Collision statistics on radar-equipped ships indicate that decisions are not always effective in the current system, suggesting a need for review of radar navigation practices.

Relative and true motion displays are quite different in presentation form, yet each is recommended by experienced personnel as the better display for the same situation.

Vigilance is probably lower on the open sea than in restricted waters.

Very little is known about the visual requirements for deck officers. A further study of these capabilities is necessary.

Research into sound locating capabilities has found that human beings have limited ability to determine the azimuth of a given sound.

The optimal bridge design from a human factors point of view would be a structure like an aircraft control tower with a 360-degree view. Within the bridge, the mate and the helmsman would be seated at a console.

The following equipment would be located at the mate's console in the optimally designed bridge:

1. Computer-aided radar;
2. Forward-searching sonar;
3. RPM control;
4. Automatic speed and course entry devices;
5. Communications;
6. Navigation system and latitude/longitude read-out;
7. Television monitors;
8. Digital display unit;
9. Whistle controls;

10. Speakers;
11. Ship's alarm and light panel;
12. Collapsible manual steering wheel;
13. Remote-control windows;
14. Log microphone; and
15. Speedometer.

Human Factors in Ship Control, Volume V, Radar Utilization Capabilities, Cooper, Richard B., Carey, B. G., and Mara, T. D., General Dynamics Corporation, 1968. [5]

The objective of this research is to maximize the degree of ship control that can be exercised from the bridge. Abstracts of the major points made by the study are as follows.

A centralized console bridge, controlled by a single, seated operator, improves deck officer performance.

Subjects free from operational bias (no previous radar experience except for training) controlled the ship more effectively when they used the true-motion radar presentation.

Use of computer-generated target true course and speed vectors significantly increases radar effectiveness for collision avoidance and conning. Electronically displayed target labels on the radar improved conning performance by providing continuous target identification.

During conditions of heavy workload on watch, a reduction in ship speed from 25 to 15 knots led to improved detection of target threats only when true-motion radar was used. When observers of relative-motion radar were overburdened, a comparable reduction in ship speed did not result in improved target-handling capabilities. Targets that emerge as high-risk threats verify that small angles of approach off the bow or stern are the most difficult to handle.

Deck officers trained in true-motion radar should be encouraged to use the true-motion display. Operators should be permitted to select either true or relative motion, north-stabilized,or ship's-head-up presentations.

Human Factors in Ship Control, Volume IV, Simulation Tests, Mara, Thomas D., and Cooper, Richard B., General Dynamics Corporation, April 1969. [34]

This report describes the results of a simulation program to study bridge equipment and arrangements. The following are some major points of the study.

The design and arrangement of equipment on the bridge significantly affect control in restricted waters and in landfall. Centralizing displays and controls in a single operator position is proposed to improve operator control. Position track display systems and integrated track collision-avoidance systems will help to control the accident rate.

Location of controls on a ship's bridge is critical; 20% or more of a deck officer's time can be spent obtaining information and acting on it through controls.

Collision-avoidance and positioning requirements can each demand the complete attention of one man in restricted waters. The conning officer is so busy in restricted waters that the bridge must be laid out to avoid time loss.

The equipment priorities derived from the "at sea" study and the simulation are as follows:

1. A central operator control station with secondary stations for additional operators that provide a clear view of the surroundings.
2. Automatic position plotters.
3. Repeating information displays for the wings.
4. A method of reading bearing to target and navigation markers at the prime operator's station.
5. A second radar on the bridge.
6. A tape recorder log with inscribed time line to replace the handwritten one.
7. An open-loop communication system for instant communication between bow and bridge and wings and wheelhouse.
8. Ship phones and ship-to-shore phones at all deck officers' stations.
9. Ship's speed and course change controls located at the wheelhouse and chart room stations.

The advanced bridge concept is shown in Figures 2, 3, and 4.

Programs for Analyzing and Reducing the Influence of Personnel Failure on Marine Casualties, Paper presented at 14th Annual Tanker Conference, American Petroleum Institute, Barrow, Winfred W., Capt., May 1969. [2]

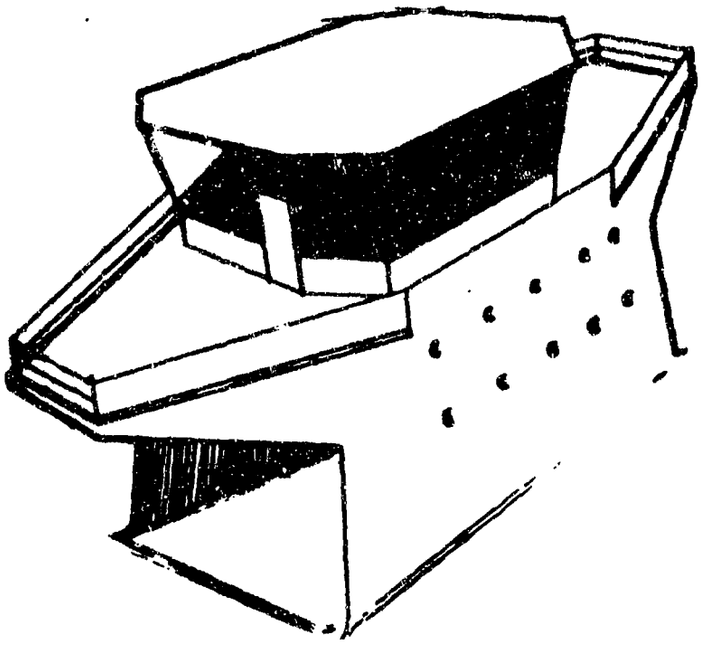
This paper discusses the following points about personnel failure in merchant marine casualties.

Collisions occurring in low visibility are caused by a combination of excessive speed and a failure to plot other ships in the vicinity.

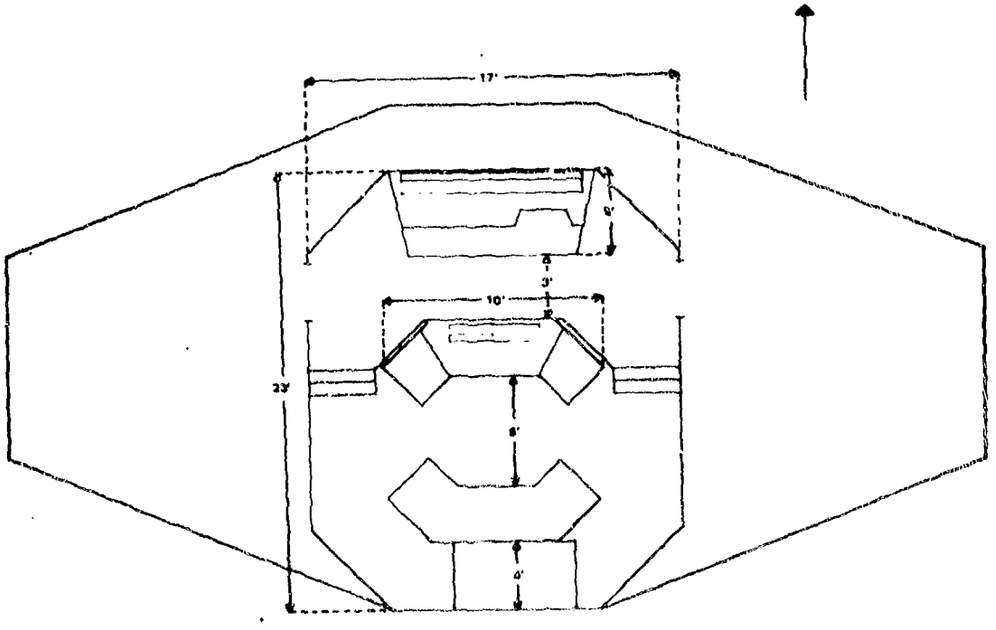
Bridge organization for conditions encountered was extremely informal, with duties imprecisely stated or not stated at all.

Failure to plot targets has repeatedly resulted in casualties between vessels equipped with radar.

There is a higher stability of operating personnel on tankers, especially in the coastal trade, than on dry cargo vessels. This is attributed to such factors as employee benefits, company image, and loyalty.

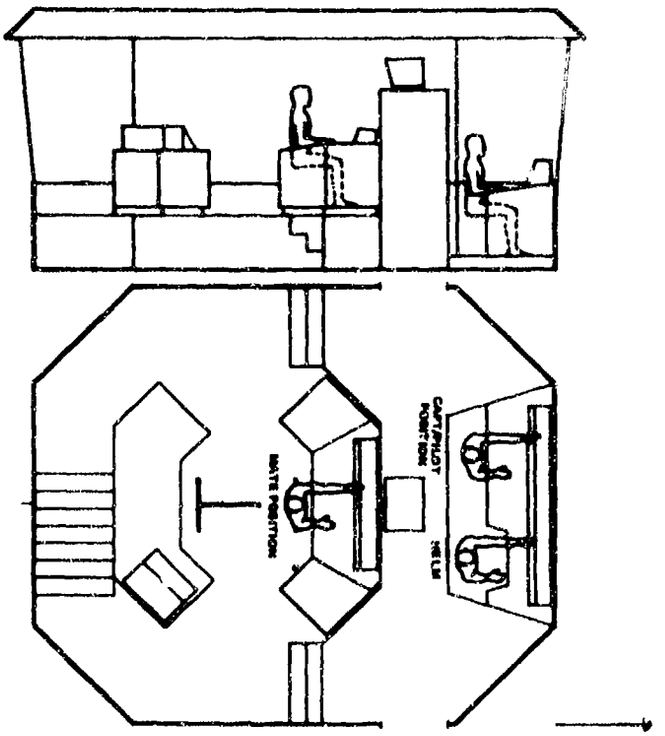


Glass Enclosed Control Tower Type of Bridge Structure for Future Merchant Ships

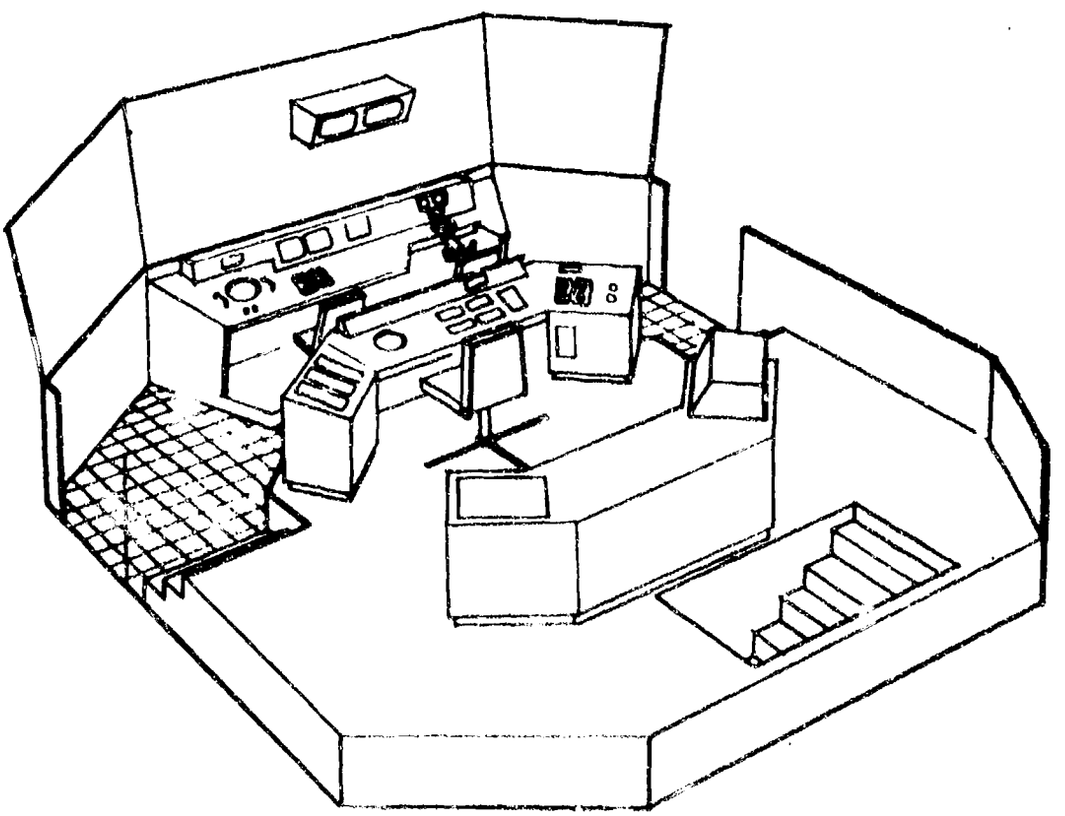


General Arrangement of Wheelhouse and Wings.

FIGURE 2

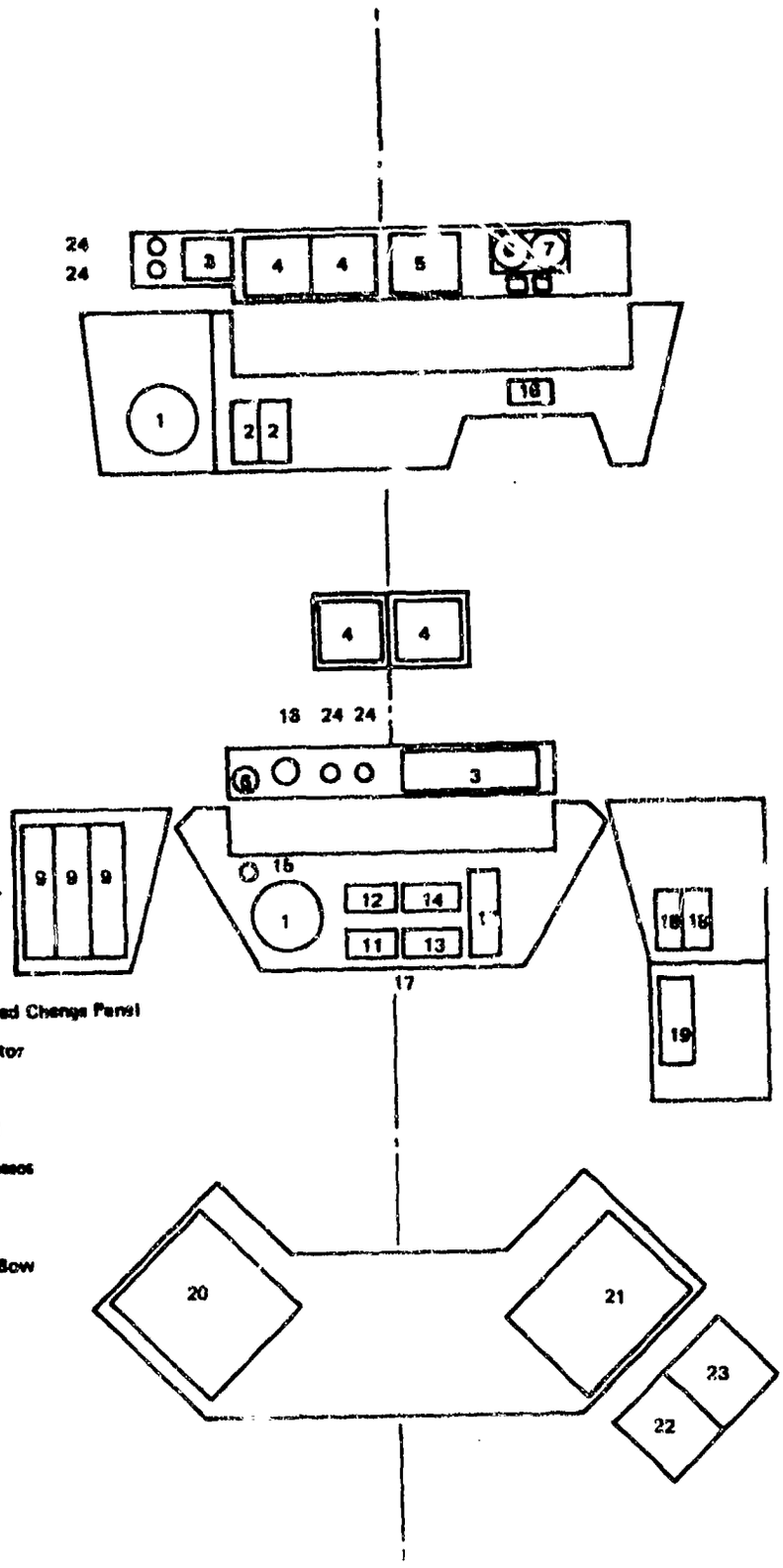


Primary Operator Stations



Arrangement of Equipment at Operator Stations.

FIGURE 3



List of Equipment

1. Radar
2. Communications
3. Digital Readout
4. T.V. Monitors
5. Digital Status Board
6. Gyro Indicator
7. Rudder Angle Indicator
8. Rudder Direction Indicator
9. Ship Status Panels
   (a) Alarm Panel
   (b) Navigation Lights
   (c) Etc.
10. Throttle
11. Automatic Course and Speed Change Panel
12. Whistles
13. Latitude/Longitude Indicator
14. Log Microphone
15. Clock
16. Magnetic Course Indicator
17. Collapsible Steering Wheel
18. Communications
19. Remote Control of Windlasses
20. Weather Facsimile
21. Prime Navigation System
22. Decca Navigator
23. Loran
24. Speakers from Wings and Bow

FIGURE 4

LIST OF EQUIPMENT AT OPERATOR STATION

Evidence of this stability also appears in statistics prepared by the Marine Index Bureau, which show that injury and illness frequency rates for tanker personnel are measurably lower than those for dry cargo vessels.

Changing Shipboard Duties and Recommendations for Training Modern Ships' Deck Officers, Link Division of Singer General Precision, Inc., June 1969. [26]

This study was conducted to develop recommendations for training and training support to prepare for the changing duties and licensing concepts for modern ships' deck officers. The following points were made in the report.

New radar hardware has not reduced accidents.

There is evidence that lack of proper training has prevented effective use of radar. There is a requirement for training in true motion as well as relative motion presentations and the plotting of proper target ship position, vector diagrams, and relative plots.

Radical differences among duties and responsibilities of ships' deck officers make traditional on-the-job training uncontrollable and outmoded.

Use of simulators is the best way to train deck officers.

Deck officers receive insufficient refresher training, training for professional advancement, and training for state of the art familiarization with new equipment and procedures.

Merchant Marine Safety--A Study of the United States Merchant Marine Regulatory System, Ship Safety Panel, Maritime Transportation Research Board, December 1970. [46]

Merchant Marine Safety is an analysis of the effectiveness of the U.S. Merchant Marine Safety Regulatory System, in which an examination is made of duplication of rules, regulations, inspections, and approvals within the multi-agency system. The study also compares U.S. safety standards and performance with those of other maritime nations. The following is a summary of the conclusions and recommendations of the study.

There are at least five government agencies involved in varying degrees in the regulation of safe design, construction, and operation of the U.S. merchant fleet. Each of these agencies is situated in a different department or independent agency of the federal government. They share no common executive authority other than that of the President of the United States. Administration of U.S. merchant marine safety regulations could be made more efficient by eliminating unnecessary duplication in regulation and enforcement procedures among the several government and nongovernment regulatory bodies.

Among the fleets of four countries studied, the U.S. subsidized fleet is constructed and operated under the highest degree of safety regulation, followed by the U.S. unsubsidized fleet and the fleets of the United Kingdom, Italy, and Liberia, in that order. Each of the four countries studied places some degree of reliance on classification societies to act on

behalf of the government in administering and enforcing portions of its safety rules and regulations. Of these, the United States places the least reliance on classification societies and Liberia and Italy place the most.

A comparison of 7 years of partially edited ship loss records in Lloyd's Register of Shipping showed that, of vessels of 1,000 gross tons or over, the United Kingdom lost fewer ships as a percentage of its active fleet than the other three nations studied. The United States, Italy, and Liberia followed in that order.

USCG casualty data for U.S. vessels of over 1,000 gross tons show that of 14 categories of primary cause, the most frequently occurring are errors of licensed or certified personnel and equipment failures due to normal wear. When all primary causes of casualties to U.S. commercial vessels over 1,000 gross tons were separated into three categories (personnel fault, equipment failure, and other), personnel fault was the most frequently occurring cause.

The Panel recommended that the Public Health Service, the Maritime Administration, the Federal Communications Commission, and the Department of Labor delegate their maritime safety authority to the USCG and that all activities relating to maritime safety come under the direct authority of the USCG Commandant. In addition to authorizations already delegated, such as load line certification authority, the Panel recommended that the U.S. Coast Guard delegate to the American Bureau of Shipping the authority to perform all regulatory functions associated with ship structure and machinery, including design approval, detail plan approval, inspection survey, and certification. The Panel also recommended that the Coast Guard retain responsibility and authority for all of the safety regulatory functions such as life saving, fire control, stability in subdivision, dangerous cargoes, casualty investigations, and licensing, certification, and discipline of seagoing personnel.

It recommended that the USCG intensify its marine safety activities with respect to testing, certifying, and licensing personnel with the objective of reducing human error. It also recommended that the Maritime Administration support appropriate research in the areas of personnel training, vessel operation, and ship design, with the specific objective of reducing human error as a cause of vessel casualties.

The Panel recommended that immediate steps be taken to institute a uniform international data collection and analysis system with respect to casualty, loss, death, and injury statistics. The United States should take the initiative in this regard and develop a proposed system.

Quotes from Risk Analysis of Oil Transportation Study, Oceanographic Institute of Washington, Pacific Northwest Sea, Volume 5, No. 4, 1972. [55]

The article summarizes the conclusions of the report on oil transportation and handling by the Oceanographic Institute of Washington.

Historical accident data show that human error as the basic cause or contributor to an accident with man-machine systems universally varies from 35% to 80%. There are volumes of regulations and rules relating to a mariner's qualifications and certification, yet there is no requirement to demonstrate proficiency, either initially or periodically.

One of the consistent findings of the post facto investigations of accidents by the National Transportation Safety Board is that there is no single cause of a transportation accident of any kind.

For the Puget Sound Vessel Traffic System to be truly effective, participation must be mandatory.

In view of the technological advances of our time, it is hard to accept that the rules of the road are concerned with proper execution of whistles.

According to court decisions, 99% of all collisions are caused by failure to obey the rules of the road, and no one, not even an admiralty lawyer, fully understands the rules and their various legal interpretations. The legal interpretations could not possibly be understood by a master or watch officer who may have only seconds to decide which rule should be applied to a given set of circumstances.

Oil Recommendations to State Legislature, Oceanographic Institute of Washington, Pacific Northwest Sea, Volume 5, No. 4, 1972. [54]

This article summarizes the recommendations of the Oceanographic Institute of Washington concerning the reduction of risk in oil transporting systems. It recommends that Washington state pilots have specified rest periods and will be examined physically each year. Training courses for pilots should include radar training and courses in maneuvering bulk carriers, such as those conducted at Grenoble and Wageningen.

Aviation/Marine--A Study of Contrasts, Paper presented to the 17th Annual Tanker Conference of the American Petroleum Institute, Madsen, Nicastro, and Schumacher, May 1972. [33]

The purpose of this paper was to contrast marine and aviation procedures in such areas as licensing, discipline, and testing. An abstract of the major points follows.

It appears desirable to stiffen international maritime licensing requirements to include:

1. Performance testing of some sort under both normal and stress conditions prior to issuing a license;
2. Periodic proficiency checks to maintain a license; and
3. Some restriction as to size and class of ship the individual is licensed to operate, i.e., some type of written and performance examination to demonstrate proficiency and competence in handling the size and class vessel involved.

Some type of formal training should be required before an officer can advance in grade. For example, this should take the form of simulator, navigation, or collision-avoidance training. Some form of periodic recurrent training should be required to validate licenses. This should take the form

of simulator training or perhaps at-sea shipboard training experiences in maneuvering and even collision-avoidance via video tape.

Some specific operational recommendations made in the paper include:

1. Radars must be turned on in pilotage waters.
2. Position fixes must be taken and recorded at intervals not greater than one half the time it would take to cover the distance to the nearest shore.
3. Fathometers must be turned on in pilotage waters.
4. Early and continuous contact must be made with harbor radar advisory services.
5. Harbor and radar advisory services must be advised if it is necessary to change frequencies at any time.
6. The master must check the bearing and range accuracy of his radar in every port, as well as the accuracy of his Loran/Decca.

This paper also included these more general operational recommendations:

1. Establish mandatory traffic separation lanes in heavily traveled international waterways.
2. Establish English as the universal maritime language. All communications between pilot and master, pilot and local advisory services, and pilot and tug should be carried out in English. Radio/voice communication should be clearly audible to the pilot and the master.
3. Prepare preplanned route information for frequently traveled trade routes.
4. Encourage national governments to place coded radar transponders in fixed key positions as an aid to navigation in pilotage waters.
5. Encourage the development of a checklist of information to be exchanged between the pilot and master immediately after the pilot has boarded the vessel.

Because the officers and crew of vessels in long-haul service sail in congested waters infrequently, perhaps a specifically trained and qualified pilot-master should assume command of long-haul vessels entering congested pilotage waters. This new position would replace the conventional ships' master position as the pinnacle of the mariner's career.

Collisions within the Navigable Waters of the United States--Consideration of Alternative, Preventive Measures, Proceedings of the Marine Safety Council, Department of Transportation, U.S. Coast Guard, Volume 29, No. 8, August 1972. [75]

This article is a summary of a special study undertaken by the National Transportation Safety Board to provide an overview of the problem of collisions. The following points were discussed.

Personnel error is the most frequently cited as the probable cause of collisions. However, the underlying reasons for the error are of greater importance when considering preventive action. There is a need for tools to assist the mariner in coping with increasingly complex decisions.

A complete collision-avoidance system provides position determination, vessel identification, surveillance, rapid data processing, communications, and decision making. An effective vessel identification system is required. The use of transponders in developing an accurate and economically feasible vessel identification system should be pursued.

The rules of the road are in need of revision.

The Radio Technical Commission for Marine Services, Committee 65, is developing general standards for shipboard collision-avoidance systems.

Navigation in Navigable Waters, Vessel Bridge-to-Bridge Radio Telephone Regulations, Proceedings of the Marine Safety Council, Department of Transportation, U.S. Coast Guard, Volume 29, No. 8, August 1972, p. 161. [75]

This article reviews amendments to the vessel bridge-to-bridge radio regulations. The following requirements are set forth in the amendments.

1. These regulations require the use of vessel bridge-to-bridge radio telephones.
2. Vessels subject to the Act will be equipped with at least one single channel transceiver capable of transmitting and receiving.
3. Vessels with multi-channel equipment will be required to guard the bridge-to-bridge radio telephone frequency as well as the VHF national distress calling frequency required by the Federal Communications Commission.
4. The regulations become effective on January 1, 1973.

Analysis of Pilot-Error Related Aircraft Accidents, Kowalsky, Nestor B., October 1972. [20]

This was a preliminary study analyzing the causes of aircraft accidents from which the following conclusions are abstracted.

Of the air carrier accidents analyzed, the largest number were classified under man, followed by environment and machine in that order. Under the classification man, crew coordination was the most frequently occurring element, followed by experience, fatigue, and training in that order.

Merchant Marine Casualty Data--A Recommended Program for Improving the Collection and Use of Merchant Marine Casualty Information, Panel on Merchant Marine Casualty Data, Maritime Transportation Research Board, 1973. [45]

This is a survey of existing collections of merchant marine casualty data and their associated systems. The study panel considered the need for

casualty data and the capabilities, costs, and benefits associated with its proper collection and dissemination. The report's conclusions and recommendations are directed toward collecting valid data and organizing existing public and private data collections into a national federated system. The following points were emphasized in the report.

It is difficult to collect valid information regarding a casualty because witnesses and parties to the investigation are concerned with their personal or employer's liability. There is no well-defined plan for coordinating collection, processing, or analysis of merchant marine casualty statistics within the government.

Most of the elements necessary for a comprehensive casualty data system are available. The U.S. Coast Guard data base should be expanded to include various indicators of personnel and equipment exposure time and a greater level of detail on causes of personnel fault. An improved casualty data system is an immediate need that cannot wait on the prolonged period of confusion that would be attendant on a major shift in responsibility from one group to another. Many persons and organizations object to the concept of having both the casualty-investigation and data-collection functions in the U.S. Coast Guard. However, the alternative agencies appear to be less than enthusiastic about assuming investigation, collection, and analysis responsibilities. The National Transportation Safety Board's role as an overseer of Coast Guard investigations is a reasonable safeguard against parochial interests that might impede full and objective casualty investigation and analysis, at least for the time being.

A national merchant marine casualty data system should be established by forming a federation of existing data collections and systems. The system should create formal relationships among all organizations collecting merchant marine casualty data and should make the most efficient use of available resources. The Coast Guard should be given the responsibility to form and manage the system.

The Coast Guard, as manager of the system, should approach government and private collectors of merchant marine casualty data to determine the extent and basis of their participation and to develop compatible means of communication. In addition to its role as manager of the system, the Coast Guard should continue to be the primary government agency for investigating merchant marine casualties and for collecting merchant marine casualty data. In addition, it should be the clearinghouse and distribution center for the system. Casualty data acquired by the USCG as well as trend and pattern analyses should be transmitted to the National Maritime Research Center (NMRC) on a periodic basis. The NMRC should periodically disseminate its research findings to the maritime community.

Upon establishing a national system, the U.S. Coast Guard should work in the Intergovernmental Maritime Consultative Organization (IMCO) for an international system that corresponds to the level of detail of the U.S. system.

Basic Principles and Operational Guidance for Navigational Watchkeeping, Proceedings of the Marine Safety Council, Department of Transportation, U.S. Coast Guard, Volume 31, No. 9, September 1974, p. 176.[76]

This article describes IMCO's efforts to strengthen and improve standards of training and professional qualifications of mariners.

The Maritime Safety Committee of IMCO established a Subcommittee on Standards of Training and Watchkeeping in 1971. Annex A to the Subcommittee's report is entitled "Basic Principles to be Observed in Keeping a Navigational Watch" and contains the Subcommittee's recommendations on this subject. The recommendations are advisory in nature and may become the subject of an international conference tentatively scheduled for 1977.

A basic principle of Annex A is that a master is bound to ensure that watchkeeping arrangements are adequate. It recommends that the watch system provide sufficient rest for the watchstanders to avoid fatigue.

Navigation and look-out standards are also included in the Annex.

A Study of Tanker Total Losses, 1964-1973, McKenzie, Arthur, Tanker Advisory Center, October 1974.[42]

This survey of tanker losses makes the following points:

Human factors appear to be the dominant cause of strandings, collisions, and fires in the cargo tanks. Masters of tankers should be required by law to conduct drills at least monthly for officers and crew on the causes and prevention of fires in cargo tanks and engine rooms. Courses of instruction in these subjects suitable for shipboard use should be issued to each tanker by the appropriate regulatory agency.

Every officer and crew of a tanker should be required by law to attend a government-approved fire-fighting safety training course to learn the correct use of each piece of shipboard fire-fighting equipment.

Thirteen Minutes, Proceedings of the Marine Safety Council, Department of Transportation, U.S. Coast Guard, Volume 31, No. 10, October 1974.[76]

This article reviews collision of the S. S. African Neptune with the Lanier Bridge in Brunswick, Georgia. The article makes the following points:

The investigators found the cause to be the helmsman's error in applying right rudder to a "left rudder" order. The lapse in time between the incorrect application of rudder and the time it was detected was a contributing cause. Evidence of negligence in the helmsman's actions was found.

The third mate was not held remiss because at the time of the incorrect rudder application he was entering an engine order in the bell book.

The National Transportation Safety Board noted that the wheelhouse arrangement prevented effective monitoring of the helm.

The NTSB recommended that a pre-sail conference be held prior to maneuvering through high-risk areas.

Status Report on Merchant Marine Licensing Examination Program, Proceedings of the Marine Safety Council, Department of Transportation, U.S. Coast Guard, Volume 31, No. 10, October 1974.[76]

This article summarizes the Coast Guard's experience in introducing a new type of licensing examination for second and third mates and second and third assistant engineers. Some highlights of the article are:

The Coast Guard recently changed its testing procedure from an essay-type examination to a multiple-choice test. Examinations for master, chief mate, and chief and first assistant engineer are also under revision. The new test items were written by licensed officers.

During the phase-in period, the candidate had the option to be reexamined with the superseded essay-type examination if he failed on his first attempt with the new multiple-choice test. Early results indicated that approximately 50% of those tested with the multiple-choice examination attained passing scores. Another 25% of the total candidates have received licenses as a result of exercising the option to be retested with an essay-type examination. The passing rate on previous examinations was around 75%.

Future developments in the maritime industry, as well as research concerned with human error presently under way, may well dictate the need for including proficiency demonstrations as a prerequisite for certain licenses.

Operational Guidance for Navigational Watchkeeping, Proceedings of the Marine Safety Council, Department of Transportation, U.S. Coast Guard, Volume 31, No. 10, October 1974.[76]

This article reviews IMCO's progress in establishing new standards of watchkeeping and training. Some of the report highlights are the following:

In early 1970, an IMCO working group urged that steps be taken to strengthen and improve standards of training and professional qualifications for mariners. A Subcommittee was established in October 1971. The recommendations are advisory but may be the subject of a conference tentatively scheduled for 1977. Annex B to the report of the Subcommittee on Standards of Training and Watchkeeping provides operational guidance for officers in charge of a navigation watch.

Guidance covers taking over the watch; periodic checks of navigational equipment, automatic pilot, electronic navigational aids, echo sounders, and navigational records; radar navigation in coastal waters, clear weather, and restricted visibility; calling the master; navigation with pilot aboard; watchkeeping personnel; and ship at anchor.

The section concerning navigation with the pilot aboard states that despite the duties and obligations of a pilot, his presence on board does not relieve the officer of the watch from his duties.

IMCO Recommendations for Vessel Personnel Handling Hazardous Materials in Bulk, Proceedings of the Marine Safety Council, Department of Transportation, U.S. Coast Guard, Volume 32, No. 2, February 1975, p. 29. [77]

This article reviews IMCO's progress toward improving standards of training and professional qualifications for handling hazardous materials and noxious chemicals in bulk. The article makes the following points:

In early 1970, an IMCO working group urged action to strengthen and improve standards of training and professional qualifications of mariners. This recommendation was prompted by the rise in maritime casualties and pollution. The Maritime Safety Committee of IMCO has made recommendations on training and qualifications of personnel handling hazardous chemicals in bulk. An international conference on the subject is tentatively scheduled for 1977. The public will be given an opportunity to express its views before these recommendations will be implemented in the United States.

IMCO's document recommends that administrations require officers and ratings to undergo special training and complete minimum periods of service on suitable ships to qualify in cargo operations. It also recommends training in elementary physics, chemistry, and toxicity, as well as in the hazards associated with handling volatile and toxic materials.

Amendment to Regulations (Maneuvering Characteristics), Proceedings of the Marine Safety Council, Department of Transportation, U.S. Coast Guard, Volume 32, No. 3, March 1975. [77]

This article announces amendments to federal regulations concerning maneuvering characteristics, setting forth the following requirements.

Maneuvering information must be displayed in the pilothouse on ocean and coastwise tank ships of 16,000 gross tons or over. Information must be displayed on full and half speed, turning circle diagrams to both port and starboard, time and distance to stop from half and full speeds, speeds at which auxiliary devices such as bow thrusters are effective, and other information. Maneuvering information must be provided for normal and ballast conditions for various combinations of weather, current, and hull conditions.

IMCO Urges Trial Use of Standard Marine Navigational Vocabulary, Proceedings of the Marine Safety Council, Department of Transportation, U.S. Coast Guard, Volume 32, No. 3 to No. 5, March, April, and May 1975. [77]

This is an article on difficulties in international marine communications. It makes the following comments.

The International Telecommunications Union, in 1974, designated Channel 16 as the VHF-FM International Distress Safety and Calling Frequency. In U.S. inland waters, the Bridge-to-Bridge Radio Telephone Act of 1975 requires ships to be capable of transmitting and receiving on Channel 13, also.

The last major obstacle to effective ship-to-ship communication is the language barrier between ship's crews of differing nationalities. The

Maritime Safety Committee of the Intergovernmental Maritime Consultative Organization (IMCO) has developed a standard marine navigational vocabulary for use on a trial basis. After concluding that the English language is the closest to a universal tongue among the world's mariners, the working group of IMCO has drafted a glossary of standard nautical terms and phrases in English to be used in all ship-to-ship communications. A standard vocabulary will also allow non-English-speaking watchstanders to communicate phonetically. IMCO has asked all member governments to conduct trials of the vocabulary and the U.S. Coast Guard has asked that the vocabulary be placed in handy reference for use on U.S. ships. The use of the vocabulary is not mandatory.

Use of Merchant Marine Radar by Deck Officers, Mara, Thomas D., Paper presented to the Federal Communications Commission and the Radio Technical Commission for Marine Services, March 29, 1968. [36]

In this paper, Mara discusses the use of radar by deck officers in operating merchant vessels. Mara concludes that a cause of collisions might be that the number of radar contacts has exceeded the operator's processing capabilities. Investigation of collision risk based on time required to detect collision courses showed an 89% probability of detecting a single collision course when only one collision course was presented among other targets. However, the probability of the operator's detecting the third of three simultaneous collision courses is only 38%.

Casualty Review of Foreign Flag Fleet (because of the proprietary nature of this study, neither the sponsor nor author can be revealed nor can the nationality of the fleet be identified).

Some 75 casualties were analyzed from the year 1970, with the following conclusions.

Most collisions and groundings occur during twilight hours, with a high incidence of collisions and groundings during the chief or first mate watches.

When analyzed by nationality of the officer on watch, officers of one national extraction showed a high incidence of collisions, while those from another showed a high incidence of groundings.

Excessive reliance is being placed on local pilots.

Ships' officers are apparently not making effective use of all operational navigation and piloting equipment provided. Radar equipment is not being properly maintained.

CHAPTER 5

EXISTING STATISTICAL DATA BASE

Previous MTRB reports have discussed the statistical data base for merchant marine casualties in some depth. A 1970 report entitled *Merchant Marine Safety*[46] and a 1973 report entitled *Merchant Marine Casualty Data*[45] cited numerous deficiencies in data with particular emphasis on lack of usable personnel-related information.

The 1973 report recommended that a National Merchant Marine Casualty Data System be established by forming a federation of existing data collections and systems. It further recommended that the systems, which would be under USCG management, include indicators of personnel and equipment exposure time and a greater level of detail on the causes of personnel fault.

To date no significant action has been taken to improve the data base at the federal level. The primary sources of casualty information are still fragmented and incomplete. For purposes of this study, four data collections are reviewed: Lloyd's Statistical Tables, the U.S. Coast Guard Annual Statistics of Casualties, the Marine Index Bureau's Statistical Analyses, and the U.S. Department of Commerce Seamen's Employment Analysis.

Lloyd's Register of Shipping Statistical Tables constitute the major source of international casualty statistics. Lloyd's provides no personnel statistics, however. For purposes of this study, they have been useful only in evaluating the overall safety performance of the U.S. merchant fleet.

According to Lloyd's 1974 Statistical Tables, the U.S. merchant marine lost 21 vessels (100 gross tons or over) for a total of 30,940 gross tons during 1973.* This loss is 0.21% of the total U.S. merchant fleet tonnage. U.S. safety performance ranked behind that of 14 other countries listed by Lloyd's. Among the traditional maritime powers, the United States ranked behind Great Britain, France, Germany, Japan, Netherlands, Norway, USSR, and Sweden. Of the major maritime powers, Liberia, Greece, Italy, and Panama showed poorer performance.

U.S. merchant marine safety performance can be seen in perspective in Figure 5, which shows the percentage of tonnage lost by the seven largest maritime powers (Liberia, Japan, Great Britain, Norway, Greece, USSR and U.S.) from 1967 to 1973. The performance varies from year to year, with the United States registering a good performance in 1970. The U.S. performance, with peaks in 1969 and 1971 and valleys in 1970 and 1972, closely resembles that of Liberia, Norway, and Greece; Japan and the United Kingdom register somewhat of a counter-trend.

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*Lloyd's Register of Shipping, Statistical Tables 1974, November 1974, p. 71. 1973 is the last year recorded in the 1974 tables.

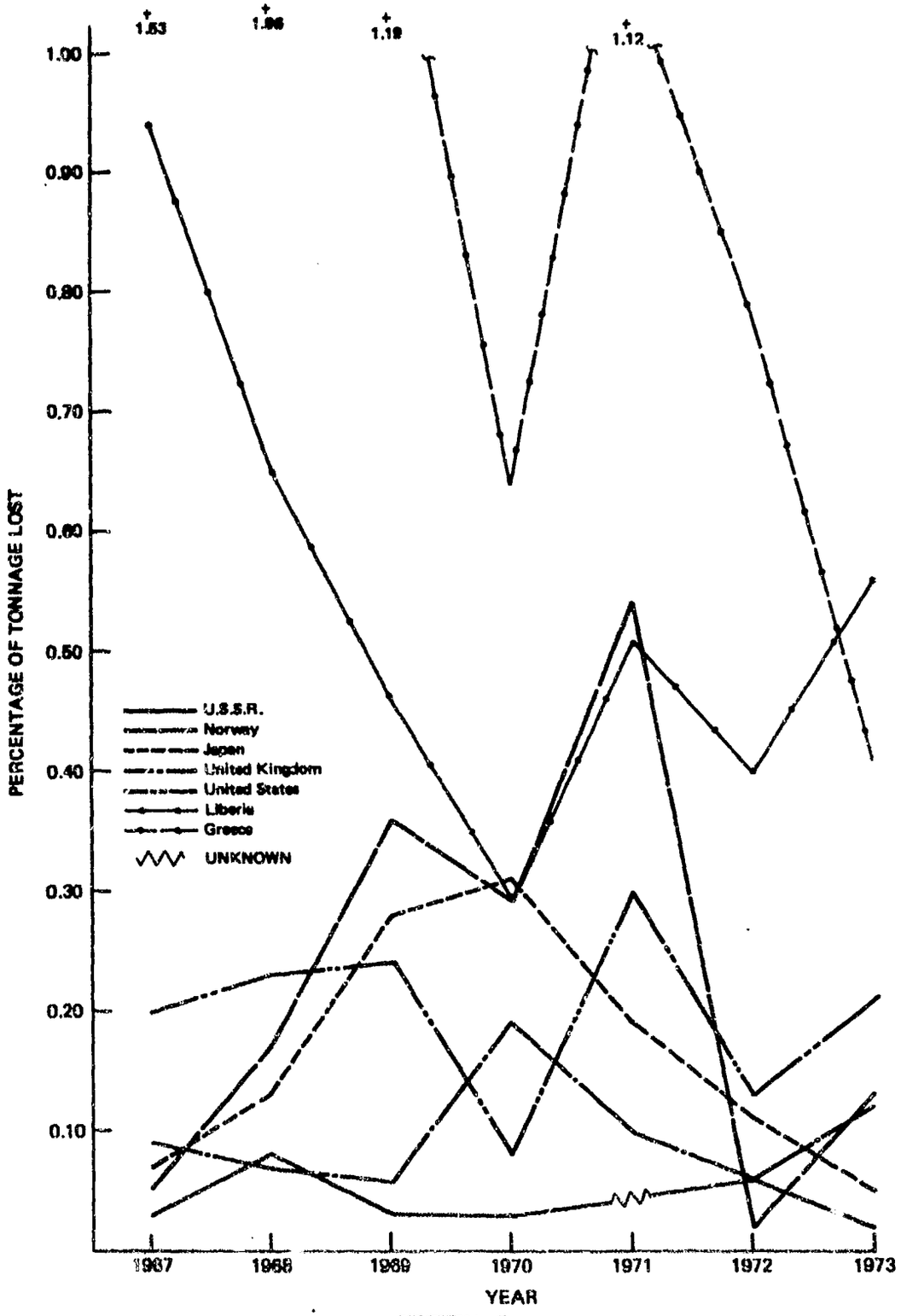

FIGURE 5

COMPARISON OF SAFETY PERFORMANCE OF SEVEN LARGEST MERCHANT FLEETS

Based on Lloyd's 1974 gross tonnage of vessels, 100 gross tons and over.

Lloyd's Statistics show that in the period 1967 to 1973 Great Britain lost 78 vessels totaling 175,732 gross tons, compared to a U.S. loss of 108 vessels totaling 246,072 tons. During this time, the United States has operated a smaller merchant fleet than that of the United Kingdom in both numbers of ships and total gross tonnage.

Since human error is the largest single cause of merchant marine casualties, it might be concluded from the Lloyd's Statistics that U.S. crews do not perform as well as those of the United Kingdom.

The USCG Annual Statistics of Casualties are published each year in the January issue of the Proceedings of the Marine Safety Council. They constitute the major source of U.S. casualty statistics. The data are comprehensive but difficult to apply directly to human-error analysis because of the way they are categorized, usually by a single cause.

Any absolute reliance on these data assumes that all casualties are reported, all are correctly categorized, and estimates are accurate. These criteria are rarely met in any data base and are subject to question in this case. For instance, the USCG admits some inconsistencies and is particularly concerned about dollar loss estimates. There is rarely only one cause for a casualty. Normally a chain of causes can be traced and assignment of a single cause is a highly subjective judgment.

Table 1 is a comparison of various types of vessels, casualty locations, and casualty costs resulting from material failure. It is assumed that most casualties not classified as material failure involve some element of human error. Therefore, Table 1 gives an indication, by inference, of the magnitude and incidence of casualties related to human error.

Items 1 and 2 in Table 1 show the number of casualties and the number of vessels. A casualty, such as a collision, may involve two or more vessels, and therefore the number of casualties is less than the number of ships involved. Since the concern is with crew performance aboard ship, the vessel figure is more meaningful. In the vessel category, the 15% material failure suggests that 85% of the casualties may have involved some type of human error. This figure is consistent with a 1972 estimate that 85% of the amount paid out in U.S. insurance claims annually was related to human failure.[62]

Perhaps the data on vessels totally lost are the most meaningful. The loss of a vessel rarely escapes reporting, and these data, although comprising relatively few vessels, exclude minor groundings and machinery malfunctions. The 16% to 18% material casualties for FY 1974 tend to support the general estimate that 85% of merchant vessel casualties are human-error caused.

Comparison of items 18 to 23 in Table 1 confirms beliefs that human error is more prevalent in inland operations than off shore.

Other possible conclusions that might be drawn from Table 1 are that larger ships are more likely than smaller vessels to be involved in human-error

TABLE 1

MATERIAL FAILURES IN
MERCHANT MARINE CASUALTIES

USCG Annual Statistics of Casualties FY 1974

	Category	Total Number	Number Attributed to Material Failure	Percentage Attributed to Material Failure
1.	Number of casualties	3388	756	22%
2.	Number of vessels	5413	820	15%
3.	Number of inspected vessels	1763	338	19%
4.	Number of uninspected vessels	3650	482	13%
5.	Inspected vessels totally lost	54	9	16%
6.	Uninspected vessels totally lost	298	55	18%
7.	Foreign vessels	288	16	05%
8.	Inspected freighters	488	148	30%
9.	Inspected tankers	210	58	28%
10.	Uninspected tugs	1395	87	06%
11.	Vessels over 10,000 tons	711	155	22%
12.	Vessels 1,000 to 10,000 tons	951	94	10%
13.	Vessels over 500 feet	848	189	22%
14.	Vessels less than 10 years old	2210	302	14%
15.	Vessels 10 to 20 years old	1209	163	13%
16.	Vessels 20 to 30 years old	915	156	17%
17.	Vessels 30 years and over	1079	199	18%
18.	Atlantic Ocean casualty	168	55	33%
19.	Pacific Ocean casualty	371	187	50%
20.	Gulf Ocean casualty	136	45	33%
21.	Inland Atlantic casualty	603	87	14%
22.	Inland Gulf casualty	659	85	13%
23.	Inland Pacific casualty	476	157	33%
24.	Estimated loss (vessel) x 1000	$101,090	$14,779	15%
25.	Estimated loss (cargo) x 1000	$ 12,287	$ 786	06%
26.	Estimated loss (property) x 1000	$ 41,272	$ 746	02%
27.	Total estimated loss x 1000	$154,649	$16,311	11%

accidents (items 10, 11, 12, 13) and that vessels in the 10- to 20-year-old category have the lowest percentage of material failure (items 14, 15, 16, 17).

The Marine Index Bureau is a commercial depository for illness and injury data on personnel in the U.S. merchant marine. The Bureau publishes a statistical analysis of these data. The March 21, 1975, analysis stated that "employment aboard deep-sea U.S. flag vessels reached a 50-year low in 1974". In 1974, there were, on the average, 24,900 seafaring jobs. In 1925, there were 56,600 seagoing jobs, and in 1945, the peak during World War II, there were 161,000 seagoing jobs. The analysis shows that as job totals decline the rate of reported illnesses and injuries rises.

For 1974, illness and injury affected 68.1% of the seagoing work force. The most numerous illnesses reported were respiratory infections (5.56% of the seagoing work force), gastro-intestinal (4.39%), arthritis (2.54%), skin (2.24%), and teeth (2.13%). The most prevalent injuries reported in 1974 were contusions, etc., to extremities (9.57% of the seagoing work force), back sprain (6.47%), extremity fracture (4.85%), and head contusions (2.49%).

Reported injuries by type of accident were 13.9% falls on the same level, 13.1% assault or altercation, 12.5% slip (not fall) or overexertion, 12.2% struck by an object, and 11.8% foreign bodies in the eye.

Of particular interest to this study are the data in Table 2 on psychoneurosis, epilepsy, alcoholism and drugs, suicide, and fainting or dizziness.

TABLE 2

SELECTED STATISTICS ON THE HEALTH OF THE U.S. SEAGOING WORK FORCE

Category	No. of Cases 1974			Percentage of all Ratings of Total Work Force				
	Deck Officers	Engine Officers	Total all Ratings	1970	1971	1972	1973	1974
Psychoneurosis	8	15	235	1.16	0.90	0.83	0.88	0.94
Epilepsy	3	2	39	0.14	0.10	0.13	0.12	0.16
Alcoholism; drugs	3	4	47	0.34	0.19	0.23	0.20	0.19
Suicide	0	1	2	0.03	0.02	0.01	0.05	0.01
Fainting; dizziness	5	17	194	0.77	0.60	0.69	0.71	0.78

Statistics held by the U.S. Department of Commerce, Office of Maritime Manpower, on average ages of seagoing personnel are particularly pertinent to this study. As Table 3 shows, the average age for all major categories continues to climb and is approaching 50 years in each major job category.

TABLE 3

SEAMEN'S EMPLOYMENT ANALYSIS, NATIONWIDE MEDIAN AGES

(Including Great Lakes)

1962-63 to 1970, 1972, 1974

Year	Licensed Deck	Licensed Engine	Radio	Staff	Unlicensed Deck	Unlicensed Engine	Cooks Stewards	Others[1]
1962-63	45.2	47.3	48.2	42.7	39.9	43.1	47.2	--
1966	45.0	46.6	48.1	42.4	39.1	42.3	45.4	37.4
1967	45.2	46.8	48.3	43.6	41.8	44.3	46.5	42.0
1968	45.1	46.8	47.9	44.2	41.7	43.3	45.6	38.6
1969	45.4	46.7	48.4	45.0	42.1	43.3	45.9	40.6
1970	45.9	47.0	49.1	45.9	43.7	44.7	47.9	41.3
1972	47.1	48.0	49.9	47.1	45.1	46.3	49.0	38.0
1974	48.5[2]	48.7	50.9	48.8	46.1	47.4	49.4	43.7

[1]Includes Medical, Nuclear, and other classifications.

[2]Includes Masters for the first time.

CHAPTER 6

JOB DESCRIPTIONS

To gain a proper understanding of human error in the merchant marine, it was necessary to develop a clear and consistent description of the various types of work aboard ship. Although most of the Panel members had some form of shipboard experience, they needed job descriptions as a starting point for examining the sources of human error.

Job descriptions for merchant marine activities have been documented in many forms and levels of detail. Many are vague and the data seldom include exposure time. It appeared to the Panel that, if there were to be any appreciation of the opportunity for human error, some measure of exposure was required.

A payroll automation project undertaken by MTRB[44] in 1968 was studied by the Panel as a possible source of data on hourly exposure by tasks. From these data, a typical work routine was restructured for 25 jobs over a 12-day coastal voyage on a 37,000 DWT tanker with a crew of 37. This material was then organized into the job descriptions given in Tables 4 through 9. Because the job descriptions were taken from payroll data, the hours may be somewhat inflated. For instance, excused absences are paid time in which work was not actually performed. Also, in some cases a full hour might be paid for less than a full hour's work. The tables list work routines for six jobs, i.e., licensed deck, unlicensed deck, licensed engineer, unlicensed engineer, radio, and stewards. The licensed deck jobs exclude the master but include the chief mate, the 2nd mate, and the 3rd mates. Table 4 shows that in this case the chief mate's position included watchstanding. When excused absences are deducted from the total hours paid, the chief mate was working more than 12 hours a day on widely varying tasks. In addition to watchstanding, the chief mate supervised cargo stowage and tank cleaning and tended to administrative matters. The 2nd and 3rd mates worked approximately 9 hours per day after excused absences are deducted. Their primary duties were watchstanding, with some time worked on cargo stowage and discharge.

The unlicensed deck jobs aboard the tanker were ordinary seaman (OS), able-bodied seaman (AB), and boatswain. Examples of these jobs in Table 5 show that all unlicensed deck personnel were assigned maintenance tasks, including chipping, painting, and cleaning. In addition, some of the jobs require watchstanding, with some men standing watch and performing maintenance tasks simultaneously. Excluding excused absences, the watchstanders on average were paid for more hours per day than the day workers. The ABs aboard ship rotate as helmsmen and therefore serve a key conning function. In the examples provided, the quartermaster, able-bodied seaman (QM/AB), and the able-bodied seaman (AB) were paid approximately 14 and 12 hours per day respectively.

The licensed engineering jobs aboard the tanker included the chief engineer and the 1st, 2nd, and 3rd assistant engineers. As shown in Table 6,

the routine watchstanding duties are covered by the 2nd and 3rd assistant engineers. The chief engineer averaged approximately 8 hours per day primarily in supervisory functions. The watchstanders also perform maintenance and repair work.

The unlicensed engineering jobs aboard the tanker are the chief pumpman and 2nd pumpman, engineman, and wiper, as shown in Table 7. The engineman is the primary unlicensed watchstander.

The radioman averaged 11.1 hours per day in the example shown in Table 8.

The steward's jobs are all maintenance and hotel functions. Job descriptions for the chief steward, chief cook, 2nd cook, galleyman, messmen, and utilities are shown in Table 9.

Overtime provisions in maritime labor contracts provide an incentive for long work hours aboard ship and in some cases the number of overtime hours worked are at the discretion of the individual, consistent with sound management and supervision.

TABLE 4

LICENSED DECK PERSONNEL

Title and Payroll Data	Work Breakdown	Action	Hours
Chief Mate			
Days worked - 12	Maintain and repair structure and hull	Painting	3.0
Hours paid - 168	Prepare and process paperwork		3.0
Hours paid per day - 14.0	Rig, spot, and trim cargo gear		4.0
	Load, stow, and distribute voyage stores		4.0
	Excused absences		16.0
	Load, stow, and discharge liquid cargo		18.0
	Stand anchoring, docking, shifting, or canaling watch		7.0
	Stand routine sea watch		80.0
	Prepare and process other paperwork		8.0
	Process information system		4.0
	Clean cargo tanks		
	Special port arrival and departure duties		
	Prepare and process hatch lists, cargo plans, etc.		-
	Other duties		1.0
	Prepare and process overtime pay		4.0
			168.0
2nd Mate			
Days worked - 12	Stand anchoring, docking, shifting, or canaling watch		9.0
Hours paid - 118	Load, stow, and discharge liquid cargo		14.0
Hours paid per day - 9.83	Stand routine sea watch		80.0
	Prepare and process logs and log abstracts		2.0
	Excused absences		8.0
	Other duties		5.0
			118.0

Table 4 (Continued)

Title and Payroll Data	Work Breakdown	Action	Hours
3rd Mate			
Days worked - 12	Stand anchoring, docking, shifting, or canaling watch		9.0
Hours paid - 117			8.0
Hours paid per day - 9.75	Excused absences		78.0
	Stand routine sea watch		5.0
	Other duties		2.0
	Prepare and process log and log abstracts		15.0
	Load, stow, and discharge liquid cargo		117.0

TABLE 5

UNLICENSED DECK PERSONNEL

Title and Payroll Data	Work Breakdown	Action	Hours
Deck Maintenance-AB			
Days worked - 7	Maintain and repair cargo handling equipment	Paint/Coat	8.0
Hours paid - 53.5	Stand anchoring, docking, shifting, or canaling watch		4.5
Hours paid per day - 7.64	Maintain and repair structure and hull	Chip/Scrape	8.0
	Maintain and repair structure and hull on watch	Chip/Scrape	8.0
	Maintain and repair structure and hull on watch	Paint/Coat	12.0
	Rig, spot, and trim cargo gear		4.0
	Contract provision compensation		1.0
	Excused absences		8.0
			53.5
Quartermaster-AB			
Days worked - 7	Stand anchoring, docking, shifting, or canaling watch		5.0
Hours paid - 99.5	Load, stow, and discharge liquid cargo		20.0
Hours paid per day - 14.2	Contract provision compensation		1.0
	Load, stow, and distribute voyage stores		3.5
	Rig, spot, and trim cargo gear		2.0
	Maintain and repair structure and hull	Chip/Scrape	14.0
	Maintain and repair structure and hull	Paint/Coat	4.0
	Maintain and repair structure and hull on watch		4.0
	Maintain and repair structure and hull on watch	Clean	8.0
	Maintain and repair cargo handling equipment	Paint/Coat	2.0

Table 5 (Continued)

Title and Payroll Data	Work Breakdown	Action	Hours
	Stand routine sea watch		24.0
	Sanitary work	Clean	4.0
	Clean cargo spaces	Clean	4.0
	Excused absences		4.0
			99.5
Able-bodied Seaman			
Days worked - 12	Maintain and repair structure and hull	Chip/Scrape	16.0
Hours paid - 145	Maintain and repair structure and hull	Paint/Coat	12.0
Hours paid per day - 12.0	Maintain and repair structure and hull on watch		7.0
	Maintain and repair structure and hull on watch	Paint/Coat	2.0
	Maintain and repair structure and hull on watch	Chip/Scrape	1.0
	Maintain and repair structure and hull on watch	Lubricate	1.0
	Maintain and repair safety equipment	Paint/Coat	4.0
	Stand anchoring, docking, shifting, or canaling watch		8.0
	Rig, spot, and trim cargo gear		2.0
	Load, stow, and discharge liquid cargo		19.0
	Excused absences		4.0
	Stand routine sea watch		68.0
	Wash down, general		1.0
			145.0
Ordinary Seaman			
Days worked - 12	Stand anchoring, docking, shifting, or canaling watch		8.0
Hours paid - 120	Load, stow, and discharge liquid cargo		19.0
Hours paid per day - 10.0	Stand routine sea watch		67.0
	Maintain and repair cargo handling equipment	Clean	3.0

Table 5 (Continued)

Title and Payroll Data	Work Breakdown	Action	Hours
	Maintain and repair structure and hull	Paint/Coat	1.0
	Maintain and repair structure and hull on watch		7.0
	Maintain and repair structure and hull on watch	Paint/Coat	3.0
	Maintain and repair structure and hull on watch	Lubricate	1.0
	Clean cargo spaces	Clean	3.0
	Rig, spot, and trim cargo gear		1.0
	Contract provision compensation		1.0
	Excused absences		4.0
	Special port arrival and departure duties		1.0
	Wash down, general		1.0
			120.0
Boatswain			
Days worked - 8	Maintain and repair cargo handling equipment	Paint/Coat	8.0
Hours paid - 60	Dump trash and garbage		1.0
Hours paid per day - 7.5	Stand anchoring, docking, shifting, or canaling watch		3.0
	Maintain and repair structure and hull	Chip/Scrape	8.0
	Maintain and repair structure and hull on watch	Paint/Coat	12.0
	Maintain and repair structure and hull on watch	Chip/Scrape	8.0
	Clean cargo spaces	Clean	4.0
	Contract provision compensation		2.0
	Rig, spot, and trim cargo gear		4.0
	Excused absences		5.0
	Load, stow, and discharge liquid cargo		3.0
			60.0

TABLE 6

LICENSED ENGINEERING PERSONNEL

Title and Payroll Data	Work Breakdown	Action	Hours
Chief Engineer			
Days worked - 12	On call		8.0
Hours paid - 99	Prepare and process maintenance records		4.0
Hours paid per day - 8.25	Prepare and process logs and log abstracts		10.0
	Special port arrival and departure duties		3.0
	Maintain and repair galley and plumbing equipment	Repair	4.0
	Maintain and repair safety equipment	Clean	3.0
	Process information system		18.0
	Prepare and process repair lists		11.0
	Drills and training		1.0
	Maintain and repair propulsion equipment	Overhaul	8.0
	Prepare and process requisition lists and inventories		21.0
	Prepare and process overtime pay		1.0
	Sanitary work		3.0
	Maintain and repair propulsion equipment	Overhaul	4.0
			99.0
1st Assistant Engineer			
Days worked - 12	Attend meetings		7.0
Hours paid - 122	Excused absences		8.0
Hours paid per day - 10.1	Load, stow, and discharge heavy lift cargo		1.0
	Process information system		4.0
	Prepare and process requisition lists and inventories		29.0
	Stand maneuvering watch		17.0
	Maintain and repair safety equipment	Clean	4.0

Table 6 (Continued)

Title and Payroll Data	Work Breakdown	Action	Hours
	Maintain and repair galley and plumbing equipment	Repair	7.0
	Maintain and repair galley and plumbing equipment	Fabricate	4.0
	Maintain and repair propulsion equipment on watch	Clean	4.0
	Maintain and repair propulsion equipment on watch	Lubricate	1.0
	Maintain and repair propulsion equipment on watch	Install	6.0
	Drills and training		1.0
	Load, stow, and discharge liquid cargo		9.0
	Prepare and process overtime pay		4.0
	On call		8.0
	Maintain and repair propulsion equipment	Overhaul	8.0
			122.0
2nd Assistant Engineer			
Days worked - 12	Excused absences		16.0
Hours paid - 116	Stand routine sea watch		76.0
Hours paid per day - 9.66	Maintain and repair propulsion equipment	Clean	3.0
	Maintain and repair propulsion equipment	Repair	3.0
	Maintain and repair propulsion equipment	Overhaul	7.0
	Maintain and repair propulsion equipment	Install	4.0
	Take on bunkers		3.0
	Stand maneuvering watch		4.0
			116.0
3rd Assistant Engineer			
Days worked - 12	Excused absences		15.0
Hours paid - 138	Stand port watch		2.0
Hours paid per day - 11.5	Maintain and repair propulsion equipment	Clean	5.0

Table 6 (Continued)

Title and Payroll Data	Work Breakdown	Action	Hours
	Maintain and repair propulsion equipment	Install	3.0
	Maintain and repair propulsion equipment	Test	1.0
	Maintain and repair propulsion equipment	Overhaul	3.0
	Maintain and repair electrical generation and distribution equipment	Replace	10.0
	Maintain and repair electrical generation and distribution equipment	Overhaul	4.0
	Stand routine sea watch		85.0
	Maintain and repair cargo handling equipment	Overhaul	8.0
	Maintain and repair galley and plumbing equipment	Replace	2.0
			138.0

TABLE 7

UNLICENSED ENGINEERING PERSONNEL

Title and Payroll Data	Work Breakdown	Action	Hours
Chief Pumpman			
Days worked - 12	Load, stow, and discharge liquid cargo		18.0
Hours paid - 133	Ballasting		37.0
Hours paid per day - 11.0	Contract provision compensation		2.0
	Maintain and repair cargo handling equipment	Lubricate	24.0
	Maintain and repair cargo handling equipment	Overhaul	8.0
	Maintain and repair cargo handling equipment on watch	Overhaul	4.0
	Maintain and repair cargo handling equipment on watch	Lubricate	16.0
	Excused absences		8.0
	Maintain and repair structure and hull	Replace	8.0
	Maintain and repair propulsion equipment	Overhaul	8.0
			133.0
2nd Pumpman			
Days worked - 6	Load, stow, and discharge liquid cargo		17.0
Hours paid - 69	On call		8.0
Hours paid per day - 11.5	Contract provision compensation		1.0
	Drills and training		1.0
	Maintain and repair galley and plumbing equipment	Clean	8.0
	Maintain and repair galley and plumbing equipment	Repair	4.0
	Maintain and repair galley and plumbing equipment	Fabricate	4.0
	Maintain and repair safety equipment	Clean	4.0
	Maintain and repair propulsion equipment	Repair	4.0

Table 7 (Continued)

Title and Payroll Data	Work Breakdown	Action	Hours
	Maintain and repair propulsion equipment	Clean	3.0
	Maintain and repair propulsion equipment on watch	Clean	4.0
	Maintain and repair propulsion equipment on watch	Lubricate	1.0
	Maintain and repair propulsion equipment on watch	Install	6.0
	Maintain and repair cargo handling equipment	Repair	4.0
			69.0
Engineman			
Days worked - 12	Load, stow, and discharge liquid cargo		18.5
Hours paid - 114	Stand port watch		2.5
Hours paid per day - 9.50	Stand routine sea watch		61.0
	Maintain and repair structure and hull	Paint/Coat	4.0
	Excused absences		4.0
	Receive medical treatment		24.0
			114.0
Wiper			
Days worked - 12	Load, stow, and distribute voyage stores		4.0
Hours paid - 103	Wash down, general		40.0
Hours paid per day - 8.58	Sanitary work		12.0
	Maintain and repair structure and hull	Paint/Coat	20.0
	Maintain and repair structure and hull	Chip/Scrape	6.0
	Maintain and repair structure and hull on watch	Chip/Scrape	2.0
	Maintain and repair propulsion equipment	Clean	3.0
	Maintain and repair propulsion equipment on watch	Clean	4.0
	Excused absences		8.0
	Dump trash and garbage		4.0
			103.0

TABLE 8

RADIO PERSONNEL

Title and Payroll Data	Work Breakdown	Action	Hours
Radioman			
Days worked - 12	Routine communications watches		38.0
Hours paid - 134	Prepare and process other paperwork		28.0
Hours paid per day 11.1	On call		56.0
	Maintain and repair radio and communications equipment	Test	1.0
			2.0
	Receive, transmit, and process messages	Replace	1.0
	Maintain and repair safety equipment		8.0
	Load, stow, and discharge unitized cargo		134.0

TABLE 9

UNLICENSED STEWARD'S PERSONNEL

Title and Payroll Data	Work Breakdown	Action	Hours
Chief Steward			
Days worked - 13	On call		8.0
Hours paid - 107	Load, stow, and distribute voyage stores		3.0
Hours paid per day - 8.23	Supervisory work, food		96.0
			107.0
Chief Cook			
Days worked - 12	Prepare routine meals, crew		96.0
Hours paid - 106	Load, stow, and distribute voyage stores		5.0
Hours paid per day - 8.83	Clean galley		3.0
	Prepare and process requisition lists and inventories		2.0
			106.0
2nd Cook			
Days worked - 12	Prepare routine meals, crew		96.0
Hours paid - 99	Clean galley		3.0
Hours paid per day - 8.25			99.0
Galleyman			
Days worked - 12	Wash dishes		53.0
Hours paid - 109	Contract provision compensation		2.0
Hours paid per day - 9.08	Load, stow, and distribute voyage stores		5.0
	Prepare routine meals, crew		43.0
	Clean galley		3.0
	Clean crew rooms		3.0
			109.0

Table 9 (Continued)

Title and Payroll Data	Work Breakdown	Action	Hours
Officer Messman			
Days worked - 12	Prepare routine meals, crew		3.0
Hours paid - 96	Serve routine meals, crew		90.5
Hours paid per day - 8	Clean dining room		2.5
			96.0
Crew Messman			
Days worked - 12	Prepare routine meals, crew		3.0
Hours paid - 96	Serve routine meals, crew		90.5
Hours paid per day - 8	Clean dining room		2.5
			96.0
Bed/room Utility Man			
Days worked - 12	Clean passageway and ladders		2.0
Hours paid - 96	Clean officers rooms		94.0
Hours paid per day - 8			96.0
Steward Utility Man			
Days worked - 1	Prepare routine meals, crew		1.5
Hours paid - 1.5			1.5
Hours paid per day - 1.5			

CHAPTER 7

CASUALTY FLOW DIAGRAMS

The Panel developed casualty flow diagrams as an aid to understanding the relationship between merchant marine casualties and human error. The purpose of the diagrams was to identify those junctures at which human error could become a factor in casualties. The Panel exercised care to avoid confusing this process with fault tree analysis, which is a considerably more sophisticated technique.

A properly executed fault tree analysis of the causes of merchant marine casualties would have been a massive, if not impractical, undertaking because of the extremely large number of permutations and combinations of circumstances in merchant marine operation. Such an undertaking also would have been prohibitive because not enough is yet known to quantitatively define suspected human errors and their interaction in maritime casualties.

The Panel's casualty flow diagrams are shown as Figures 6 through 11. These diagrams logically display the interrelationship of possible causes of the two most undesirable events that can happen at sea: the loss of or damage to a ship and the death or injury of personnel. These two top-level events are shown in Figure 6.

A ship can be lost or damaged as a result of three events: foundering (Figure 7), explosion or fire (Figure 8), or grounding or collision (Figure 9). Death of or injury to a crew member can result from deliberate events such as criminal acts or suicide as well as from inadvertent events like burns, drowning, electrocution, falling, being hit, natural causes, poisoning, suffocation, or horseplay (Figure 10).

The purpose of these diagrams is to provide a systematic means of relating merchant marine casualties to human behavior.* When the Panel established that human error was a possible contributor to an event leading to the loss of a ship or death and injury, the type of such human error was classified. It soon became apparent that most human error can be reduced to a limited number of types. The Panel thus defined 13 types of human error into which all potentially harmful human behavior was grouped (Figure 11).

It should be emphasized that both the diagrams and the human-error classes represent an oversimplified presentation of the causes of maritime casualties. In actual accident situations, the cause can rarely be limited to

*Each element in these diagrams should be considered as mutually independent and equally capable of contributing to a casualty, although it is recognized that they may be interdependent and only contributory in a limited manner in some cases.

a single event or error. An accident or casualty usually involves a series of events and errors that may involve sequences and combinations of human acts of commission or omission and material failure.

To illustrate how the loss of a ship might be traced to a specific type of human error, consider the following hypothetical case. Ship X and Ship Y are steaming on a collision course. Ship X is the privileged vessel and Ship Y the burdened vessel. The mate on watch on Ship Y is consulting charts in the chart room and is unaware of the presence of Ship X. The mate returns to the bridge and notices the oncoming privileged vessel and orders a turn. Although an emergency maneuver is not called for, the relatively limited time available requires expeditious action. The helmsman misinterprets the command and a collision results. Normally this type of casualty would be loosely classified as "human Error", and those specific human behavioral factors so critical to effective corrective action to avoid future accidents of this nature would never be sought. But in this hypothetical case, continued investigation showed a history of drunkenness on the part of the helmsman. Subsequent evidence revealed that drinking may have caused the helmsman to misinterpret the order and to be unaware that his actions were steering the vessel into danger. The collision would therefore be traced in Figure 9 to a misinterpreted communication caused by drunkenness on the part of the helmsman.

The previous example is an oversimplification. In most cases, casualties involve a variety of causes. One factor may cause another, or they may happen coincidentally. Also, there are primary causes as well as contributory or secondary causes, and differentiating between the two may require arbitrary judgment. For instance, in the previous example, why did the mate stay so long in the chart room? Was his inattention any more or less significant than the helmsman's act? Which was actually the primary cause of the casualty? The answers to these questions might be answered by the investigators and analysts who studied the case or they might never be discovered. However, there are a variety of countermeasures that can be developed that will reduce the probability of both of these types of human errors going undetected or recurring, and this is the primary benefit of the casualty flow diagrams.

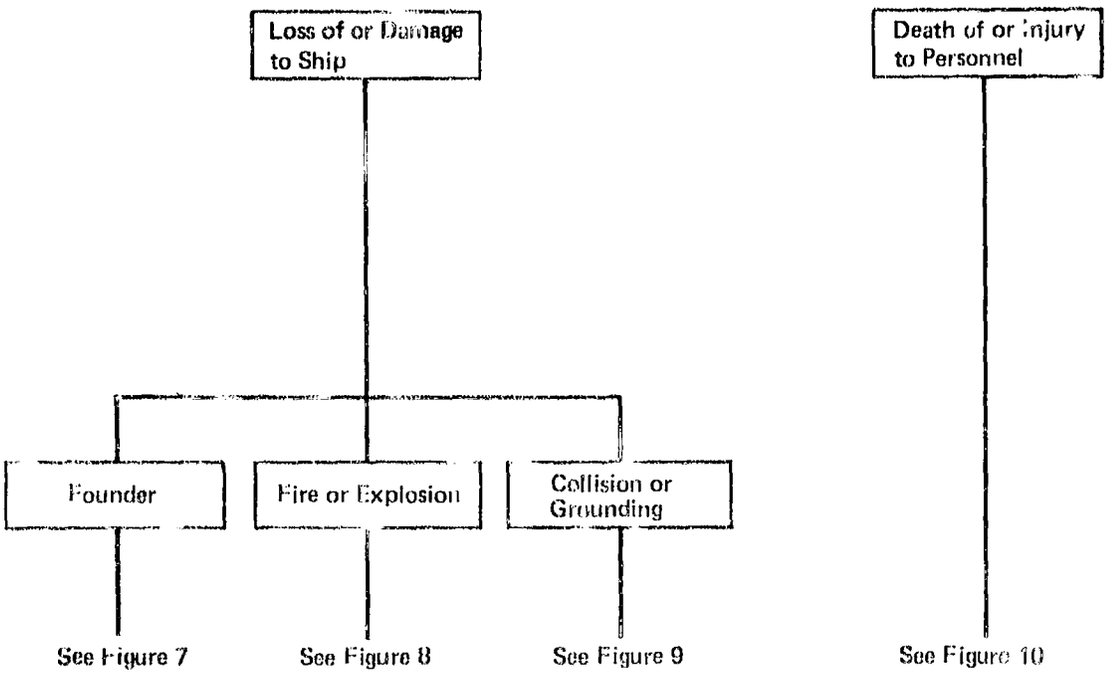

FIGURE 6

CASUALTY FLOW DIAGRAM OVERVIEW

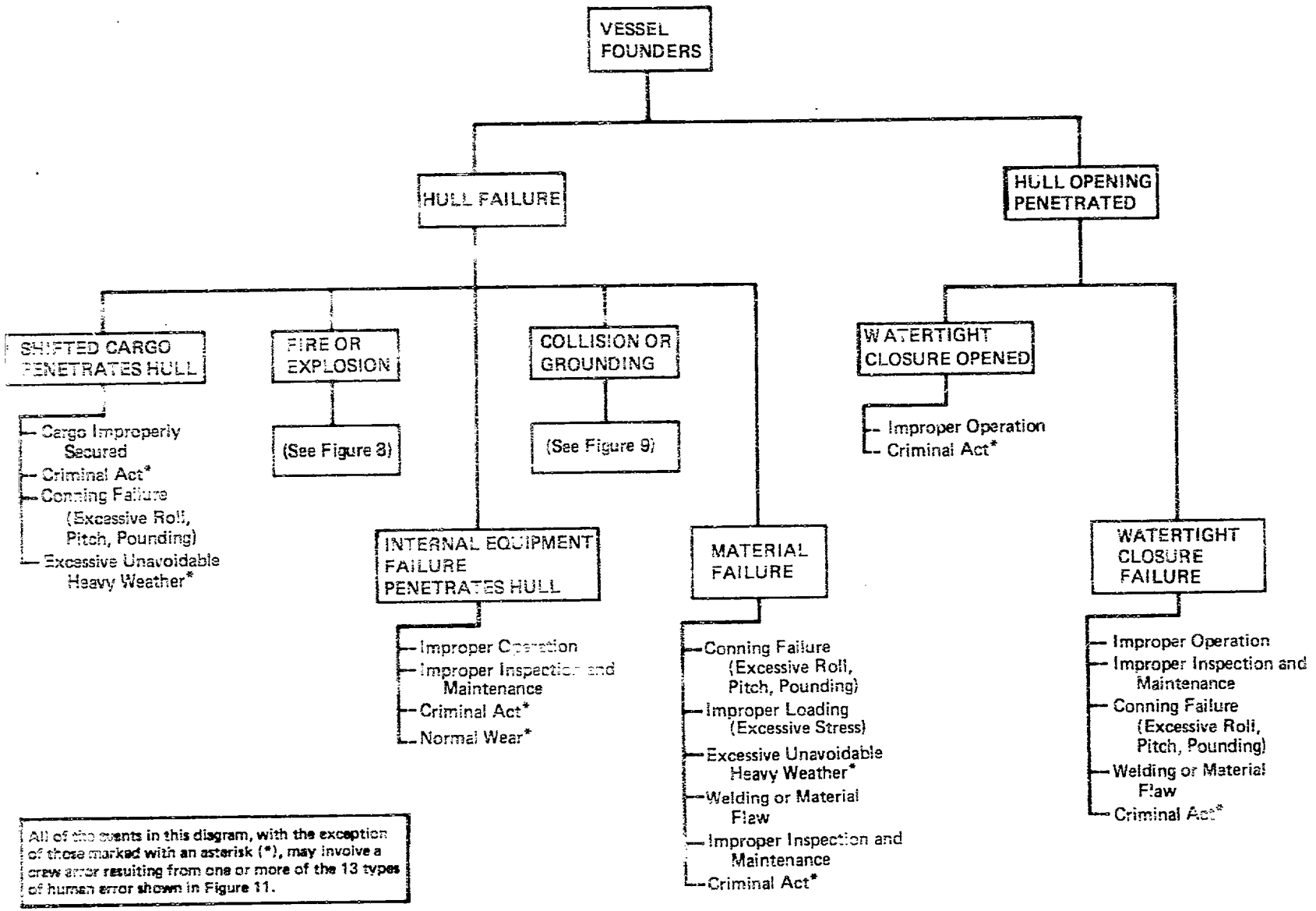

FIGURE 7

CASUALTY FLOW DIAGRAM FOR FOUNDERING

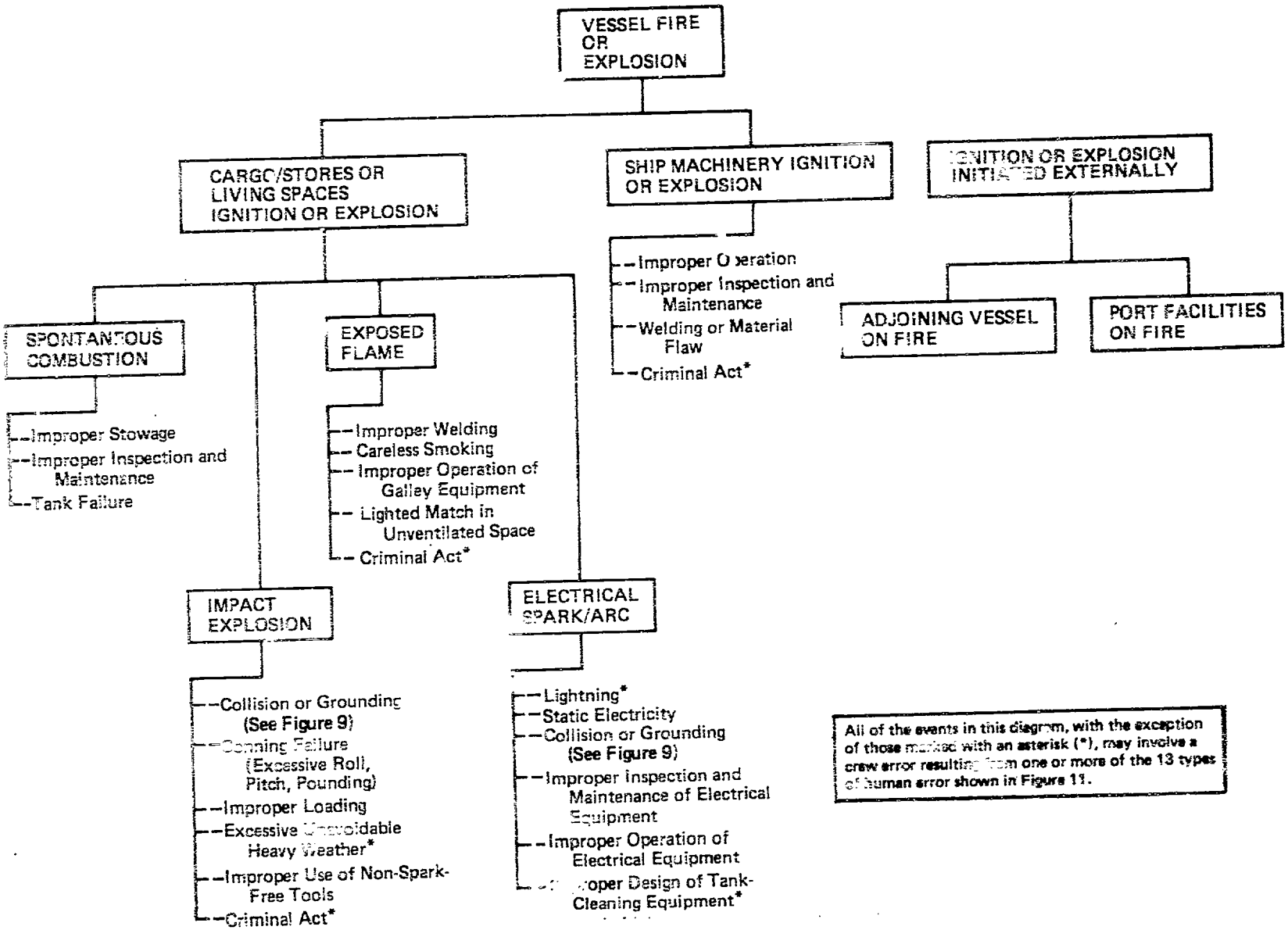

FIGURE 8

CASUALTY FLOW DIAGRAM FOR FIRE OR EXPLOSION

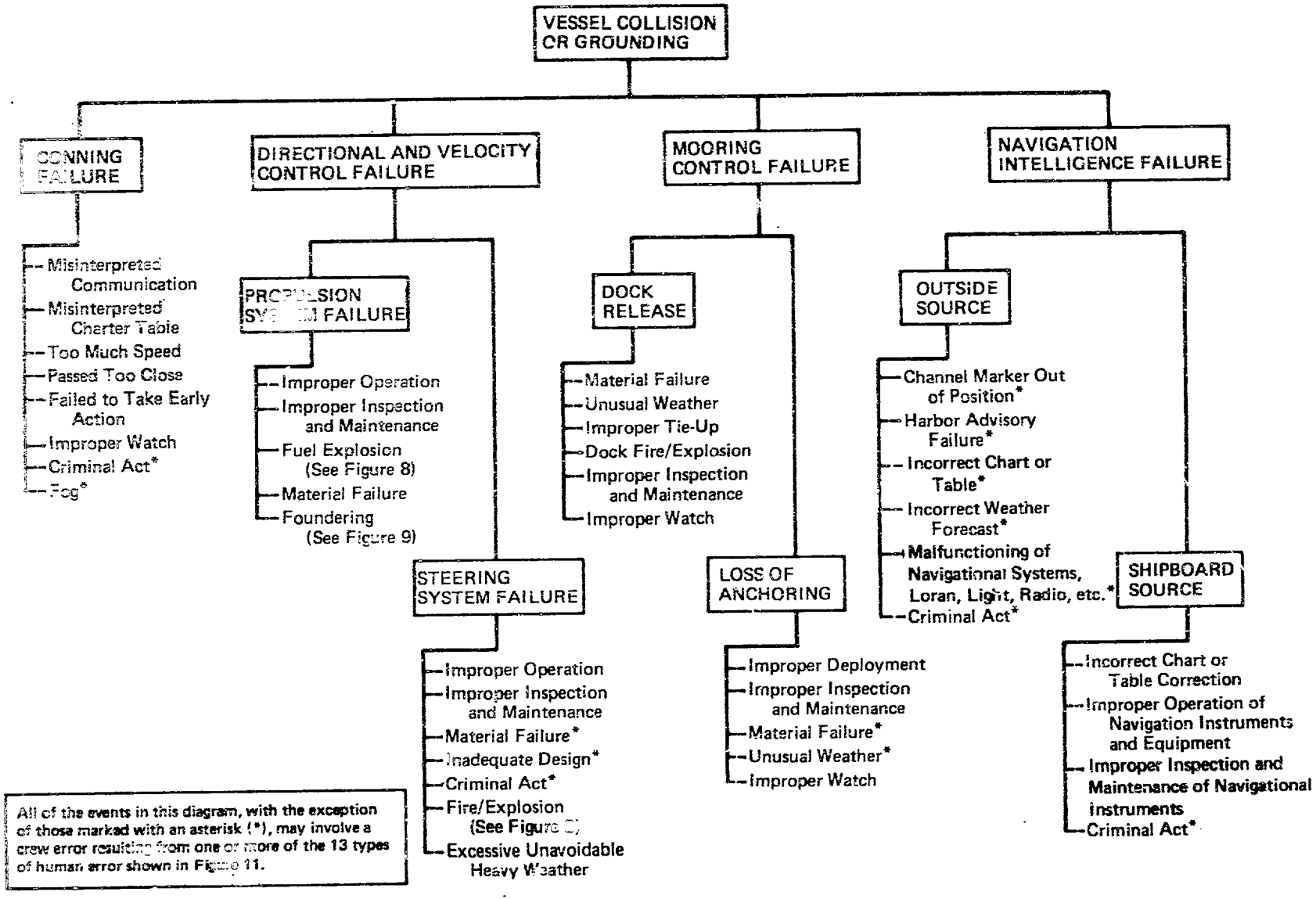

FIGURE 9

CASUALTY FLOW DIAGRAM FOR COLLISION OR GROUNDING

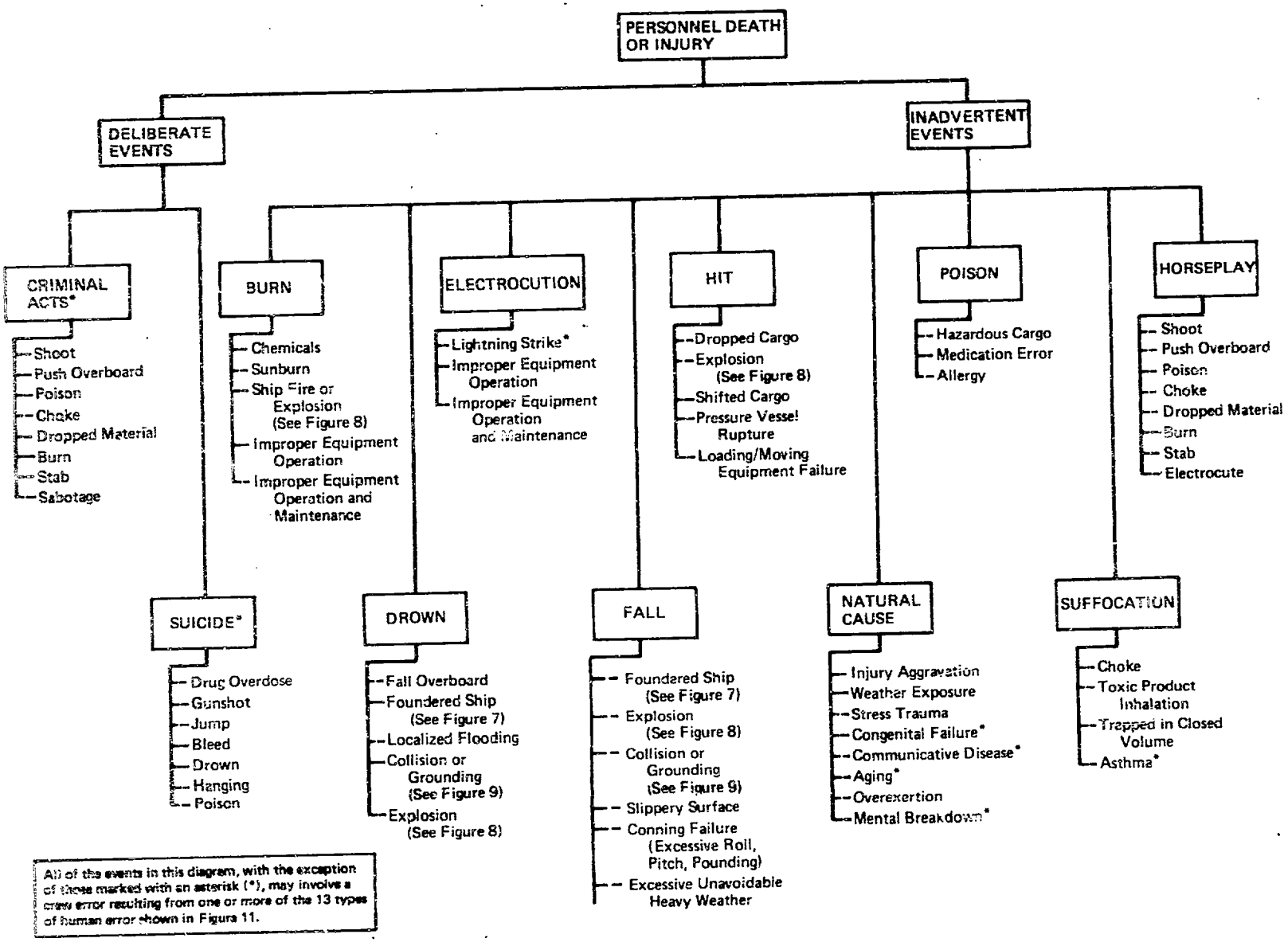

FIGURE 10

CASUALTY FLOW DIAGRAM FOR PERSONNEL DEATH OR INJURY

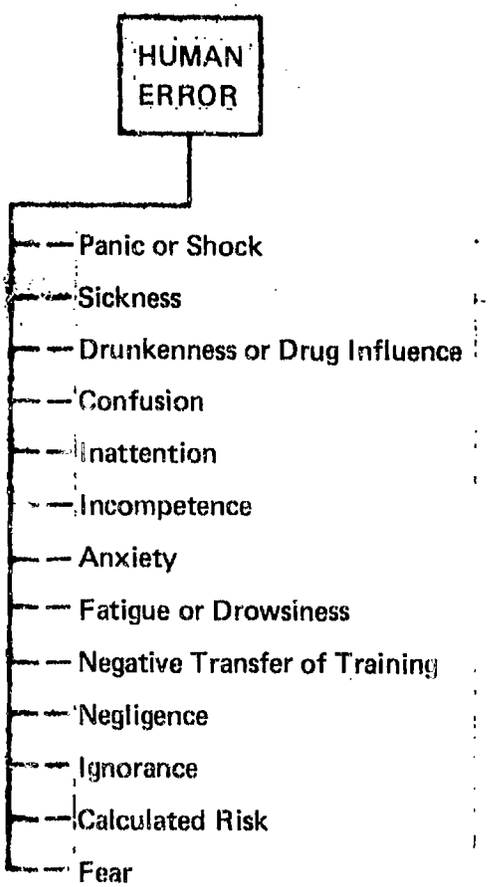

FIGURE 11

CATEGORIES OF HUMAN ERROR

CHAPTER 8

SUMMARY OF IN-DEPTH SURVEY

This chapter is a summary of a study completed in July 1975 by Lakeview Research Inc. entitled "Human Causal Factors in Maritime Casualty and Near Casualty in the United States Merchant Marine", Volumes I, II, and III.

The Lakeview study was completed for the United States Maritime Administration's National Maritime Research Center at Kings Point at the recommendation of the Panel preparing this study (the Panel on Human Error in Merchant Marine Safety).

The Panel prepared an interim report in June 1973 entitled *Human Error in Merchant Marine Safety, Interim Report*. This report recommended that the Maritime Administration support an in-depth survey by private consultants under contract with the Personnel Research Division of the National Maritime Research Center (NMRC) at Kings Point. The Panel provided technical support to the NMRC in selecting the research firm and in monitoring the progress of the survey.

The objective of the in-depth survey was to obtain information regarding human error as it relates to U.S. merchant marine casualties with special emphasis on near accidents. In addition to the description of behaviors and casualties, a further objective was to determine the frequency of occurrence of human error in various categories. The primary goal of the survey was to collect information to develop priorities for research into causes of merchant marine casualties due to human error.

To prepare for the in-depth survey, the Panel conducted surveys and distributed questionnaires at two maritime schools in October 1973. The results from this questionnaire were also to be a substitute data base for the Panel in the event the Maritime Administration did not undertake the in-depth survey. The data collected were used to develop the collection instrument used in the Maritime Administration in-depth survey. Because the in-depth survey was completed, the data gathered in the preliminary survey were not included in this study. However, in the limited categories it covered, it generally supported and confirmed the findings of the final survey.

The Maritime Administration, on the Panel's recommendation, decided in March 1974 to undertake the survey project through its facilities at the National Maritime Research Center at Kings Point. A request for proposal was published on March 20, 1974, and Lakeview Research, Inc., of Peekskill, New York, was awarded a contract effective June 3, 1974.

The project was completed in July 1975 and submitted to the Panel in August 1975. The report consists of Volume I, Summary Report; Volume II,

Statistical Analysis of Data (computer printout sheets); and Volume III, Data Analysis Codebook. In addition, punch cards containing all of the study data were turned over to the Maritime Transportation Research Board and the National Maritime Research Center for follow-on research.

CONDUCT OF IN-DEPTH SURVEY

The survey consisted of two parts, interviews and questionnaires. The interviews were conducted to establish the dimensions and variables of human error and to gain experience for developing and distributing the questionnaire. The interviewers had marine experience (one was a licensed engineering officer, another was a licensed deck officer) with graduate degrees in psychology-related fields (one had a master's degree in psychology, one had a doctorate in education, and the third had a doctorate in psychology). Interviews with 74 persons were completed before the questionnaire was developed. Through March 1975, a total of 153 successful interviews were conducted. Interviews were held with seagoing personnel, Coast Guard officers, regulatory authorities, and company officials. They were conducted in a variety of situations, most generally at the interviewee's place of business, whether on a ship, in a union hall, or in an office. In each case, the interviewer introduced himself, explained the nature of the study, and assured the interviewee that his anonymity would be preserved.

The other major part of the study was the development, distribution, and analysis of the questionnaire. The purpose of the questionnaire was to expand the data base of the study as much as possible. The questionnaire was designed as a "critical incident" interview, posing a series of factual questions interspersed with open-end and attitudinal questions. Every effort was made to remove any similarity to an adversary proceeding or a licensing examination. Several pre-tests were run on the questionnaire and a fourth version was circulated to the Panel on Human Error for approval prior to distribution. The final version of the questionnaire contained 192 questions and 44 pages. A copy of the questionnaire is given in Appendix I of this report.

The questionnaire was distributed to unions, pilot associations, maritime academies, shipping companies, and directly to men aboard ship. A total of 359 questionnaires were returned of 1,400 sent. Of these, 254 were of high quality. Only the answers to direct-observation questions were used from low-quality questionnaires. The gross response rate was 25.6%; the high-quality response rate was 18.1%.

SAMPLE CHARACTERISTICS

Those returning completed questionnaires were as follows:

Pilot	9.8%
Master	19.7%
Deck officer	38.2%
Chief engineer	7.9%
Engineering officer	9.1%
Tug and harbor personnel	10.2%
Other	5.1%

When compared with available age statistics (Chapter 5), the sample is considerably younger than the population of active seafarers as a whole. The average ages of the respondent groups were as follows:

Masters	47.5 years
All deck	42.8 years
All engine	43.2 years
All officers	42.9 years

Of the respondents, 42% sailed primarily in international operations, 22.4% sailed in coastwise operations, and 14.6% sailed in harbor operations; 24% sailed on general cargo ships, 20.6% on containerships, and 30.0% on tankers. Of the respondents, 46% graduated from the U.S. Merchant Marine Academy at Kings Point and 31.4% from state maritime colleges. In terms of union membership, 56.9% were associated with the International Order of Masters, Mates, and Pilots and 11.9% with the Marine Engineers' Beneficial Association.

STUDY FINDINGS

After the survey data were collected, analyzed, and collated, the findings were grouped by cause. Some of the results are presented here.

Personnel Turnover and Casualty

Seventy-eight percent [167] of those responding to the question felt that there was a relationship between personnel turnover and casualties.* The following are quotations pertaining to personnel turnover from the interviews:

1. Interview 040: "At one time, there were very similar ships and very similar cargoes. Men could take what they learned from one ship to another ship. Handling characteristics, engine rooms, and routines were all similar. Today, however, the fleets and cargoes are heterogeneous. A mate from a 500-foot ship can bid and get a job on a 900-foot ship.... They can transfer to wherever they like without being qualified to handle the equipment. They can learn by on-the-job experience. Some captains and companies could care less about training."

2. Interview 127: "Many American ships carry Decca sets in addition to Loran. With rotary shipping few officers except the captain have much experience using it. This means particularly calibrating it properly when changing lanes and being aware when it is off tuning."

3. Interview 223: "The captain feels that he cannot teach an old dog new tricks. Many of the men he has sailed with are either unable to learn or resentful of new methods, new equipment, and new concepts in marine

*The percentage listed is the percentage of those responding to the question. It does not include responses to low-quality questionnaires. The number in brackets refers to the actual number making up the percentage.

"transportation. They are mostly old Liberty ship sailors of WW II vintage. They cannot communicate adequately either verbally or in writing. His second and third mates are currently 65 and 73 years old respectively."

4. Interview 232: "At one time there were custom and tradition and it was rigid but not today. There are too many different ships and captains. When a man relieves today he isn't told particulars of the ships. If I line up all the officers, I bet they wouldn't know that we have loop-type fire mains or where the CO_2 room is."

5. Interview 258: "Rotary shipping constantly recycles second and third mates. Most are good because they wait for this ship, but it is a constant training process educating about the hatches, winches, bridges, etc. Although the concept is good, there is less officer stability.... Now the talk for the next contract is to rotate chief mates through the hall. This is too much. Who is to assist docking these ships when the mate is not familiar with them? It seems to me that to satisfy a few fellows in the hall, the union is asking for safety problems."

6. Interview 408: "Unlicensed relief crew is good because we have an agreement with the S.I.U. to have the same men when we were in port. This is not true with the engineers."

7. Interview 903: "One thing is firm. Dry cargo mates should sail only dry cargo, tanker mates on tankers. Both are different in outlook and performance. Old dogs do not learn new tricks. Firings, beefs, foul-ups occur in this area when a dry cargo mate decides to take a tanker up and vice versa."

8. Interview 986: "Particularly disastrous is the MMP rotary shipping concept. The company has no control over the management, training, and operating practices of its own personnel. The company is forced to accept incompetence, untrained personnel, no more key men, or can they place personnel as they see fit."

Physical Limitations and Casualties

When asked if they had ever been in a casualty or near-casualty where a sudden illness (heart attack, fainting, stroke, dizziness, etc.) of someone aboard was a major causal factor, 15% [37] of those responding to the question answered "yes". Of those responding, 31% [11] identified the helmsman as the person with the illness. Twenty-three percent [58] of those responding felt that impaired eyesight of someone on the bridge had been related to an emergency. Of those responding to the question on eyesight, 33% [19] identified the pilot and 25% [14] identified the master as the person with the impaired eyesight. When asked whether the height or weight of a man had ever been a factor in an emergency situation, 14% [34] of those responding to the question answered "yes".

The following quotations from interviews highlight some of these problems:

1. Interview 223: "The captain relates age to the inability to physically perform job requirements. He feels that many current officers cannot move with sufficient agility to climb ladders, adequately inspect hatches and holes, etc. He feels that their sight and hearing also leave much to be desired."

2. Interview 408: "After a while a man's hearing starts to go. They can't hear you or the bells any more. During a physical they get throat, lungs, and x-rays, which is minimal. They are not examined for hearing or seeing impairment. On MSC ships they used earplugs and on a Farrell ship we used the earphones that allowed us to hear voices but not the engines.... Another guy would fail to call us when he got in trouble, then he couldn't stay down there to sort things out. He would begin to throw up. After a while, I made him carry a bucket."

3. Interview 915: "Unfit for duty is something else. That comes from the public health doctors, and they usually know nothing about shipping. I had a case where a doctor gave a seaman a fit for duty with the stipulation that the seaman has three shots a day. A lot of them are kids out of medical school....Unfit for duty means broken bones, communicable diseases or dependence on alcohol with the shakes. Usually a seaman is sent to public health by the shipping company after an accident. If a guy wants to get back to sea, a doctor will let him. Public health has its own physical."

Emotional Stability

Twenty-seven percent [66] of those responding to a question whether emotional instability of anyone aboard ship had ever been a contributory factor to a casualty or near-casualty answered "yes". Nineteen percent [10] identified unlicensed engineering personnel, 17% [9] identified the master, and 15% [8] identified an unlicensed deck worker as the unstable person. When asked how often they were required to take pre-employment physicals, 16% [39] of the respondents said "never", 40% [55] said before every ship, 3% [7] said twice a year, 31% [77] said once a year, and 28% [69] identified some other period.

The following interview excerpts refer to the problem of emotional instability:

1. Interview 291: "The devil, sin, and demonically possessed or influenced men have more to do with marine and other casualties than most people will be willing to believe. I had a gift of the holy spirit called the discernment of spirits for a while and could see an evil spirit in the eyes of a man which would have a burning hateful appearance and these men comprised up to 40 to 60% of some crews. The knowledge in this case gave no power so I had to suffer taunts but take no action against them. (When I spotted them, they also spotted me, and their taunts were subtle so as not to alert the bystanders.)"

2. Interview 355: "We get some real crazies. The last trip I had a guy who waved his arms and talked to himself on deck. It was worth the $500 to have him sent home from Portsmouth."

In addition to the interviews, some qualitative remarks were contained in the questionnaire. The following are some of those relative to the problem of emotional stability:

1. Pilot: "Change of course to avoid imaginary objects."

2. Master: "Second officer was changing courses and plotting false positions with no apparent reason.... Epileptics pulling a fit when securing for sea, working on deck, and while steering."

3. Deck officer: "Two men cut three fire hoses into pieces, threw overboard...locked in ship's hospital...endangered ship and lives."

4. Master: "Emotionally unfit engineer stopped ship without orders while in dense coastal traffic."

Alcohol and Drugs

Alcohol use appears to bear a direct relationship to casualties and near-casualties. More than half of those responding, 53% [130], cited instances where drunkenness of a crew member, officer, or pilot was a factor in an incident. Drugs do not appear to be a serious problem. Only 9% [21] of those responding to the question about drugs cited them as a causal factor in merchant marine casualties.

There were many references in the interviews to the use of alcohol and its detrimental effect on the performance of crewmen. The following are a sample:

1. Interview 288: "They said it was obvious in listening to the Norwegian captain that he was drunk and didn't know what was going on."

2. Interview 318: "I have sailed with three of the four mates drunk. The captain still took her out, seaworthy or not; that's what he was being paid for."

3. Interview 369: "The second officer was a good man when sober but every trip on one night watch would take over the watch well gassed up. He also couldn't in his stupor evaluate the evasive action necessary to avoid vessels visible less than 5 miles away."

In addition there were some responses to the questionnaire that referred directly to the problem of drinking. The following are a sample:

1. Master: "QM relieved wheel at 000 in an intoxicated state and then suddenly swung the ship's rudder to starboard in a narrow channel."

2. Master: "In emergency, resorted to drinking and fell overboard and drowned."

3. Master: "Seaman was drunk when he came to the wheel on the bridge and was steering the wrong course."

4. Master: "Master was inebriated upon leaving anchorage. Chief mate quietly took over and alert QM cooperated."

5. Master: "A problem drinker had whiskey aboard and had the whole watch drunk. Several mates saved the ship before running aground. No action was taken because of seniority of the men."

6. Deck officer: "One bad day it seemed as if everyone on the bridge had a snoot full. Helmsman unable to steer. Mates on watch unable to obey orders. Master gave improper orders."

7. Master: "It is part of the code of the sea to protect drunk officers. Some day I may be in the same situation."

Failure of Operational Discipline

A number of instances were reported where personnel failed to perform expected functions. Twenty-six percent [54] recalled casualties resulting from failures to follow operating procedures; 32% [18] of those said procedures were not followed because personnel "didn't want to bother". Some 43% [97] said that when they reported aboard a new ship they were usually left to shift for themselves.

The following sample of quotations from interviews gives examples of poor bridge discipline:

1. Interview 374: "Some masters even expect you to work on charts running the coast.... When the vessel is on Iron Mike, the mate on watch can be working in the chart room and both he and his AB or OS are absorbed in other pursuits. No one is minding the store."

2. Interview 319: "Many captains don't want you to use the radar because it is too delicate and might break. They have no confidence in the mate.... I don't like maneuvering with the radio on because with the pilot's orders, radar plots, and everything, it gets too confusing.... The ship's signals sound aren't used as much as they used to be because people just don't want to be bothered.... The radio between the bridge and a foreign ship is not used because the watch doesn't want to bother because they have no interest or there might be a language barrier."

Crew Discipline and Disciplinary Action Taken

Results of the survey suggest that appropriate disciplinary action is rarely taken for violations of regulations or rules. For instance, 44% [55] of those who recalled a casualty or near-casualty related to drunkenness indicated that no disciplinary action was taken. In a similar vein, 34% [54] of those responding to the question reported dissatisfaction with U.S. Coast Guard enforcement of disciplinary actions.

Casualty and Near-Casualty Experience

A total of 126 descriptions of casualties were reported in detail in questions 16, 17, and 18 of the questionnaire (see Appendix I). They were broken down into the following categories:

Groundings	24.8%
Collision	48.8%
Fire, explosion	8.8%
Foundering	3.2%
Death, injury	7.2%
Cargo loss	1.0%
Equipment damage	4.8%
Pollution spill	1.0%
Other	1.0%

Most Common Cause of Casualty

Inattention was ranked as the most common cause of human error from a list of 13 causal factors (Question 183, Appendix I) by 29% [70] of those responding. The next most common causes, ranked in order, were: incompetence, 14% [34]; drunkenness, 12% [30]; fatigue, 9% [23]; panic, 7% [18]; confusion, 7% [18]; calculated risk, 5% [12]; and negligence, 5% [11].

Harbor and Port Facilities

Harbor and port facilities were generally deemed marginal for today's ships. Twenty-seven percent [62] of those responding to the question cited harbor and port facilities as being troublesome in bad weather. An additional 13% [31] said they were dangerous to impossible in less than perfect weather.

The following sample of interviews referred to the problem of inadequate harbors and port facilities:

1. Interview 114: "The Houston Ship Canal was built in 1919 and is only 400 feet wide and was never meant for ships of the length, beam, and deadweight tons in today's trade."

2. Interview 127: "At one time the 48-foot depth in a channel was sufficient water for any ship. Today's large tankers draw over 55 feet. Many of the 48-foot soundings are not charted."

3. Interview 143: "We have the last ships now at Morgan Point. Yesterday I brought back a ship with three tugs; I couldn't hold it in the strong ebb tide and wind and she rested against the bank. Finally I got her going and in she went."

4. Interview 636: "Has been on present containership 5 months and considers it one of the most difficult and tricky to steer he has ever encountered. Ship runs away from you with application of 10 degrees rudder, particularly to the left.... Many near misses, particularly in 7-hour transit of Houston Ship Canal and in the close ditch to New Orleans."

Pilots and Pilotage

There is a potential for casualties in the ambiguity between the responsibilities of the pilot and the captain in pilotage waters. A number of respondents, 40% [81] of those answering the question, reported a dangerous

incident as a result of a conflict between the captain and the pilot. In the opinion of those answering the question, a collision was the casualty most likely to result from such a conflict. Seventeen percent [13] of those recalling a conflict cited drunkenness as the cause; 40% cited over controlling in ship handling. When asked what happens when a pilot comes aboard, 47% [90] of those answering said that he takes complete charge, 20% [38] said that he advises the captain and it is then the captain's responsibility to make all decisions.

The following quotations from the interviews are on the subject of the pilot-captain relationship:

1. Interview 006: "When the pilot comes aboard, everybody sits back. The watch assumes he knows all. In one case the skipper watched while a ship was driven into a collision."

2. Interview 012: "The harbor pilots are regulated by the state and the Coast Guard. It is the harbor pilots who are accountable, not the docking pilots. The docking pilots are hired with the tug. The same pilots keep popping up in collisions and groundings."

3. Interview 348: "A captain suggested full throttle.... The pilot suggested full stern. The captain did not feel that the ship would respond but rather would drive deep into the bank; however, not knowing, he complied with the pilot's suggestion. Fortunately it worked."

4. Interview 636: "The helmsman in this instance cautioned the pilot to give him a course rather than a rudder command. But the helmsman, who knows the ship, decides what rudder it would take to move the ship 35 degrees to the right. Many older pilots would take the advice from no one short of the captain and if he is below will continue to give orders his own way by rudder, not committing himself on a change in course. If the pilot so continues, the helmsman has no recourse but to follow the order. The mate on watch can make a thing of it and call the master to the bridge but in these confined waters it is not soon enough. Things happen quickly."

5. Interview 912: "The harbor pilots are not ship captains and they take risks that are unnecessary. They are concerned about keeping their place in the rotation. Sometimes there are two or three abreast in a 300-foot channel and none will give."

The following are samples of written responses on the questionnaire that apply to the problem of the master-pilot relationship:

1. Pilot: "Captain did not understand the effect of a bank suction and put engines from full ahead to full astern. A collision resulted and the captain was fired."

2. Master: "Pilot fell asleep and was relieved of duty. Met with master and sued. Pilot probably drunk but no proof available."

3. Master: "Pilot under influence of intoxicants. . . This happens two or three times a year, usually in the winter. I refuse to let a man who staggers into the wheelhouse handle the ship."

4. Deck officer: "Captain took over several times and shamed the pilot. Many pilots feel they are indispensible and the vessel cannot proceed without their penultimate conn."

Fatigue and Disorientation

Of those responding to the question, 31% [77] said that excessive fatigue had contributed to a casualty or near-casualty. Sixty-one percent [106] of those answering said that the amount of time on watch or work tired the men involved. In most cases they were referring to captains on watch continuously for long periods and to men involved with docking, undocking, watch, or canal transits without adequate rest periods.

The following sample quotations from interviews refer to fatigue:

1. Interview 012: "When a ship is assigned, the tug mate operates the tugboat, while the tug captain operates as pilot on the ship. On the tug, they work 6 on/6 off. Say he works 0000 to 0600, at 0700 he has to pilot a ship, this takes say 3 hours, then at noon he takes his trick at the wheel for 6 hours. He is overworked."

2. Interview 265: "I get more calls between the hours of 10 p.m. and 5 a.m. This is because, with the contract, inexperienced watch officers are on duty and no one else is around. Today there are no permanent deck watch officers. The contract says they have to get off after 6 months. The 12 to 4 is perpetually tired and he misses a meal. My 12 to 4 brought the ship in, stands a watch until 5 p.m. tonight, and will take the ship out at midnight tonight. Nothing will happen but he is just not going to be sharp."

3. Interview 318: "The chief mate suffers from chronic fatigue. I was up when they brought her in today, worked hard all day, and will be on the anchor tonight when she goes out. Tomorrow morning I am working at 8 o'clock to give the boatswain instructions."

4. Interview 972: "A master with a perfect 20-year record was in jeopardy of having his license either revoked or suspended for negligence by the USCG. His ship was grounded in a case in which the master was found completely at fault. The MMP contention is that many excessive hours on a bridge cause fatigue, with poor weather and visibility contributing."

5. Interview 996: "The direct heart of the matter is the master-pilot relationship. The USCG charges negligence on the master's part, leaving the bridge in conn of a pilot, although in practice this is standard operating procedure and brings up usefulness of a pilot to relieve fatigued, etc."

The following are samples of written remarks taken from the questionnaire concerning fatigue:

1. Pilot: "Excessive tiredness caused hallucinations vivid enough for a pilot to order a course change in the middle of a narrow channel, resulting in a grounding. He had been on duty continuously for 18 hours working in bad weather without rest periods."

2. Pilot: "Such conditions are nonexistent in today's merchant marine if the individual takes advantage of rest periods."

3. Master: "Fatigue is dangerous, an all-too-common characteristic on short-turnaround containerships. I have been up for 48 hours continuously piloting, docking, and undocking."

Calculated Risk

The acceptance of calculated risk appears to be a major cause of casualties. The ability to make schedules is viewed by the largest group of respondents as the single most important factor in a company's evaluation of a captain's performance. When asked what three among 12 criteria they considered most important to their company in grading a captain's performance, 40% [74] of those responding indicated that making schedules was the prime criterion. In second place, checked by 18% [33] of those responding, was minimizing operating costs. Eleven percent [20] of those responding cited amount of overtime. When asked how often a captain could refuse to take a ship out or delay sailing without trouble from the front office, 38% [62] said "seldom" or a maximum of three times, 26% [42] stated that there was no limit (as the situation demands), and 23% [37] said that it was up to the captain.

When asked how the company feels about meeting schedules in poor conditions, 50% [102] of those responding said that there was strong pressure to meet schedules.

Most respondents, 62% [143] said that a captain will accept risks rather than be viewed as a "crybaby". Eighty-seven percent [192] agreed that a captain must do all in his power to meet an ETA. Fifty-two percent [121] said that calculated risks are part of the game and should be treated as an operational expense. Seventy-five percent [174] agreed that scheduling ships to ports with minimum tolerance for maneuverability is in the nature of a calculated risk.

Personnel behavior supports their attitude statements; 99.6% of the sample who have had sea experience reported sailing on a ship that they personally knew was unseaworthy.

The following interview samples tend to support the contention that acceptance of high risk is a cause of casualties:

1. Interview 094: "When the XXX suffered severe cargo damage, the captain slowed down in heavy seas. He was fined because he did not make the schedule. If there is a guaranteed cargo delivery, there is bound to be hull damage."

2. Interview 114: "After a history of tankers getting stuck drawing deep draft of 40 feet, the pilots ruled not to take tankers out with more than 39-foot draft. After much fighting, all companies have accepted except one because they claim the extra foot is a financial loss of $60,000 a week."

3. Interview 232: "Sometimes a shore person will suggest we sail with no tugs or sail in limited visibility. This reduces his port operating expense. The young captains are more subject to this pressure because they don't know how much water the company official draws. If we come into an anchorage in fog, his budget gets an expense of a launch and reliefs."

4. Interview 905: "A company dropped a safety program in 1969 which offered a good bonus to tugs and crews with the least accident claims. It was observed that the result was decreased productivity, slowdown in task completion, the desire to opt for less hazardous jobs, to tow upriver rather than carry a big floating crane, etc."

The following is a sample of written comments in the questionnaire:

1. Deck officer: "I feel the company considers me and my license expendable. The only way to induce the company to stop risking me and my license would be to make the operations manager directly responsible personally and financially for all maritime casualties of his ships."

2. Tug and harbor craft personnel: "It's part of the job and we get paid for it. Mines cave in; planes fall; ships sink. So it's a safer life than walking down a Manhattan street after dark."

Navigation Aids

Those interviewed felt that navigation aids contribute to casualties in some cases. Fifty-five percent [114] of those responding to the question said that they found that shore lights camouflaged running lights of other vessels on clear nights. When asked what types of navigation aids need the most improvement, those responding listed range lights, channel markers, radio communications, channel lights, RDF stations, Loran, audio signals, and buoy systems, in that order. When asked what improvements they would make in the buoy beacon and light tower system along the coast of the United States, those responding listed better and stronger lights, radar reflectors, more and better ranges, transponders, and larger buoys, in that order. Twenty-nine percent [59] of those responding said they had experienced a casualty or near-casualty because a channel light in a harbor was confusing or misleading. Most of those experienced difficulty in losing marker or vessel lights in the shore lights.

The following sample of written responses in the questionnaire tend to emphasize the navigation aids problem:

1. Master: "Increase size of structures to make daytime visibility greater."

2. Master: "Standardized lights, buoys, etc.; have all mid-channel buoys painted a brighter color.... All approach lights to be high-intensity green lights.... Radar recognition signals on all beacons."

3. Deck officer: "Light tower should have strobe lights with short-range continuous RDF and long-range DF beacons. Offshore buoys should have radar reflectors and racon.... Give each shore station an identity transponder for radar use."

4. Deck officer: "Vessel grounded and broke up because range lights blended beautifully with shore lights. No, it wasn't me, I got there a little later."

5. Deck officer: "Notice to mariners was two months late. Went into Tampa and all channel buoys were changed."

Radar and Bridge Equipment

Fifty-seven percent [112] of those responding indicated that the fathometer was the piece of bridge equipment least likely to be used to its full potential. Only 9% [18] cited the radar and 29% [58] checked the RDF. In the opinion of those answering the question, the equipment was not used because it was a bother. Fifty-one percent [107] of those responding stated that their ships were equipped with direct bridge-to-engine control. Of those, 57% [60] said it was used. Of those indicating that bridge control equipment was not used, 73% [35] said the reason was union difficulties.

When asked what kind of radar display they preferred, 55% [103] of those responding indicated relative motion, ship's head up, 23% [43] indicated relative motion, north up, and 23% [43] indicated true motion, stabilized. The preference of radar seems to be based on whether or not the mate is used to it. When asked if they had ever experienced difficulty in trying to divide attention between the radar and other bridge duties, 58% [111] of those responding answered "yes". When asked about the general policy concerning the use of radar, 67% [138] said they could use it at will; 32% [66] said they could use it as needed; only 1% [2] said that it was off unless the captain was on the bridge. Sixty-eight percent [141] of those responding said that there were two or more radars on their present ship. In general, they were both in use during periods of poor weather and fog. Thirty-four percent [66] of those responding indicated they had relied on someone else's radar in bringing a ship in or out of a harbor. Only 31% [67] of those responding said a check-off list was used in testing the steering gear and navigational equipment on a ship prior to leaving port.

The following written responses on the questionnaire apply to radar and bridge equipment:

1. Deck officer: "There is too much reliance on radar, loran, and other navigational aids by young officers. When all of the instruments go dead, the man who has lost the art of manual piloting and navigation is in real trouble."

2. Master: "In my experience as a port captain, I found that radar causes more accidents than it eliminates in harbors. Men rely too heavily on the radar and fail to keep a good lookout."

3. Pilot: "Dropped my glasses while marking on instruments too small, but guess I am getting too old."

4. Master: "Poor maintenance of bridge instruments causes problem. On one ship RPM indicators were wired backwards, reading astern for ahead."

Communications and Signaling Problems

About a third of those responding, 32% [66] recalled a failure to use sound signals as a contributory cause of a casualty or near-casualty. There seems to be some degree of ambivalance about the value of sound signals, since the majority 52% [105] feel they are of limited usefulness. Most men prefer to supplant or supplement them with VHF radio. The ship-to-shore radio is viewed as useful, but about a third, 35% [69] ignored it in traffic situations for a variety of reasons. The basic problem with the radio appears to be overuse, too much chatter, etc.

The following are samples of written comments on the questionnaire that apply to sound signals and communications:

1. Master: "Most tug and harbor craft ignor harbor passing signals as do pleasure craft and fishermen."

2. Chief engineer: "Running in fog, tracking a ship on radar, we came so close we lost the target. The whistle malfunctioned; only blew one blast, instead of two to indicate our maneuver. We came so close we could hear the mate on the other ship shouting orders to his men. The visibility was so poor, we never saw them."

3. Master: "Sound signals not so useful in today's crowded harbors. Suggest strobe-type lights for masthead."

4. Master: "VHF is better. Sound signals are ok and last resort and/or for legal protection."

Rules of the Road

The rules are viewed as necessary but restrictive and outmoded. When questioned on rules of the road, 29% [57] of those responding said that they had been in a situation where strict obedience to the rules was a contributing factor to a marine casualty or near-casualty. Almost half of those responding, 48% [110] feel justified in departing from the rules to meet normal expectation in operations. Difficulties with the rules seem to involve a privileged ship that has had to maneuver to avoid collision or a multiple-ship situation in which the correct action was unclear.

The following samples of written comments in the questionnaire were applicable to the rules of the road:

1. Pilot: "Not possible under the general prudential rule except to stop ship in fog with strong current setting ship to shore or toward another object."

2. Master: "I never hesitate to disregard rules when obedience to them would lead to danger under those circumstances."

3. Deck officer: "Over and over you have the right-of-way, you know it's a collision course, you must hang on until the next to the last moment."

APPENDIX I

U. S. DEPARTMENT OF COMMERCE
MARITIME ADMINISTRATION
NATIONAL MARITIME RESEARCH CENTER
KINGS POINT, N. Y. 11024

TO: Members of the Maritime Community

The size and speed of modern ships, the hazard inherent in some cargos, and the congestion of sea lanes and harbors have greatly increased the risks of marine transportation.

As an aid in planning a program of research and training to reduce Merchant Marine casualties, the National Academy of Sciences and the National Maritime Research Center need your aid in collecting information about the causes of casualty. The kind of information most needed is the sort which never appears in Coast Guard investigations or NTSB Casualty Reports - eye witness accounts of the human actions which led to marine accidents or near misses.

Only the cooperation of the man on the scene can provide this information.

This study has the approval and support of the Maritime Administration, the Unions, shipping companies and the American Board of Underwriters. A reduction of marine casualties is in everyone's interest.

Yours truly,

Martin J. Schwimmer

Martin J. Schwimmer
Director of Personnel Research

MJS/BB '75

Appendix I (Cont.)

NATIONAL MARITIME RESEARCH CENTER - NATIONAL ACADEMY OF SCIENCES

MARINE CASUALTY STUDY

TO: Study participants

This study is concerned both with casualty and with near casualty.

A marine casualty is any incident which causes damage to or loss of a ship or cargo, damage to a shore installation, or death or serious injury to a crew member. Casualties include such incidents as grounding and stranding, fire and explosion, collision and foundering.

A near casualty or "near miss" is defined for the purpose of this study as any situation which would have resulted in a casualty if it were not for someone taking immediate or emergency action.

This questionnaire is being sent to professionals in every sector of the maritime community. A broad variety of areas is covered and it is unlikely that you will have direct knowledge of them all. Answer those questions that are relevant to your personal experience. Feel perfectly free to answer any question openly and frankly. The information most needed is the kind that only you can supply: insight into human action at all levels of the maritime industry which contribute to marine casualty.

Your absolute anonymity is assured!

In recounting your experience with maritime casualties and near casualties, try to cover the following points:

WHO was involved:	ranks and positions (no names).
WHAT happened:	type of incident, type of ship(s), equipment and facilities.
WHERE did it happen:	location, sea and weather.
WHEN did it happen:	time of day, month, year.
WHY did it happen:	if you know why.

If you need more space than provided to answer a question, use the back of the page. When you are finished, return the questionnaire in the postage free envelope provided. To assure anonymity, DO NOT PUT YOUR NAME ON EITHER THE QUESTIONNAIRE OR THE ENVELOPE!

THANK YOU FOR YOUR COOPERATION AND ASSISTANCE - GOOD SAILING!

Appendix I (Cont.)

MARINE CASUALTY STUDY

1. From the list below, check your current position or the position in which you last sailed; your highest position, license, or rating; all other positions in which you have been employed at any time in your maritime career.

	POSITION	CURRENT OR LAST	HIGHEST	ANY OTHER
1.	Pilot			
2.	Master			
3.	Chief Mate			
4.	2nd Mate			
5.	3rd Mate			
6.	Bosun			
7.	Quartermaster			
8.	Carpenter			
9.	Deck maintenance			
10.	AB			
11.	OS			
12.	Radio Officer			
13.	1st. Asst. Radio Officer			
14.	Chief Engineer			
15.	1st. Asst. Engineer			
16.	2nd. Asst. Engineer			
17.	3rd Asst. Engineer			
18.	Jr. Asst. Engineer (lic.)			
19.	Midshipman or Cadet			
20.	Electrician			
21.	Reefer Engineer			
22.	Machinist			
23.	Plumber			
24.	Pumpman			
25.	Tankerman			
26.	Fireman			
27.	Oiler			
28.	Watertender			
29.	Wiper			
30.	Chief Purser			
31.	Chief Steward			
32.	Cook			
33.	Steward			
34.	Master, tug			
35.	Mate, tug			
36.	Deckhand, tug			
37.	Engineer, tug			
38.	Engine (unlic.), tug			

Appendix I (Cont.)

POSITION	CURRENT OR LAST	HIGHEST	ANY OTHER
39. ABS, USCG Inspector			
40. Insurance Co. Official			
41. Port Official			
42. Local Gvt. Official			
43. Shipping Co. Official			
44. Towing Co. Official			
45. Union Official			
46. Instructor, Fed. Acad.			
47. Instructor, State Acad.			
48. Instructor, Union Acad.			
49. Instructor, Other			
50. Other (specify)			

2. If you are licensed, in what year did you receive your highest license? _____

3. Are you by trade a: Coast Pilot_____; Federal Pilot_____; State Pilot_____. If a licensed State Pilot, in what year did you receive your original license?_____

   What waters do you pilot?_____

4. How old are you?_____

5. In what state do you live?_____ _____

6. How many years total seagoing experience have you had?_____

7. When did you last work on a ship? Month_____ Year_____

8. About how many months a year do you ship out?_____

9. Check your primary area of operation:
   International _____; Coastwise _____; Harbor _____

10. Are you a company employee, working exclusively for one company or organization? Yes _____; No _____

11. Check the kind of ships you usually ship out on:

_____ General cargo	_____ Harbor tug
_____ Container ship	_____ Coast or ocean tug
_____ Tanker	_____ Harbor craft
_____ Ore or bulk carrier	_____ Oil or mining support
_____ Passenger or cruise	_____ Coast Guard
_____ Other (specify) _____	

12. If you are licensed, in what school did you prepare for your <u>original</u> license?

_____ Union sponsored school
(specify) _____

_____ U.S. Maritime Commission School
(specify) _____

_____ U. S. Merchant Marine Academy

_____ State Maritime College
(specify) _____

_____ U.S.M.C. Correspondence Course

_____ Other
(specify) _____

13. In what school, if any, did you prepare for upgrading to your current license? (specify) _____

14. Have you ever attended any advanced, postgraduate or professional maritime training schools? Yes _____; No _____

Which ones? (specify) _____

_____

15. Which of the following Unions have you been affiliated with in your career?

_____ A.M.O.	_____ L.T.P.A.
_____ M.M.P.	_____ U.M.W.
_____ N.M.U.	_____ U.S.W.
_____ S.I.U.	_____ I.B.U.
_____ M.E.B.A. Dist. 1	_____ A.P.A.
_____ M.E.B.A. Dist. 2	_____ Other (specify) _____
_____ S.U.P.	_____ None
_____ M.F.U.	_____ Company Union
_____ M.C.S.	

(If more space is needed, please use back of page)

HARBOR or DOCKING INCIDENTS

16. Briefly describe any marine casualty or near casualty you have witnessed, either as a participant or as an observer, during the last five years in a HARBOR or DOCKING (U.S. or foreign) situation. If you need more space, use the back of this page. Draw a picture if it would make your description clearer.

	First incident	Second incident
1. What happened? (casualty or near casualty) grounding, fire, explosion, collision, foundering, death, etc.		
2. When did it occur? (month, year, time of day)		
3. Where did it occur?		
4. Type of ship(s) involved.		
5. Personnel responsible. (positions, no names)		
6. Role you played. (participant, observer, etc.)		
7. Weather conditions.		
8. Major causal factors.		
9. What could have prevented it?		

COASTWISE or INLAND RULES INCIDENTS

17. Briefly describe any marine casualty or near casualty you have witnessed, either as a participant or as an observer, during the last five years in a COASTWISE or INLAND RULES situation. If you need more space, use the back of this page. Draw a picture if it would make your explanation clearer.

	First incident	Second incident
1. What happened? (casualty or near casualty) grounding, fire, explosion, collision, foundering, death, etc.		
2. When did it occur? (month, year, time of day)		
3. Where did it occur?		
4. Type of ship(s) involved.		
5. Personnel responsible. (positions, no names)		
6. Role you played. (participant, observer, etc.)		
7. Weather conditions.		
8. Major causal factors.		
9. What could have prevented it?		

OCEAN or INTERNATIONAL RULES INCIDENTS

18. Briefly describe any marine casualty or near casualty you have witnessed, either as a participant or as an observer, during the last five years in an OCEAN or INTERNATIONAL RULES situation. If you need more space, use the back of this page. Draw a picture if it will make your explanation clearer.

	First incident	Second incident
1. What happened? (casualty or near casualty) grounding, fire, explosion, collision, foundering, death, etc.		
2. When did it occur? (month, year, time of day)		
3. Where did it occur?		
4. Type of ship(s) involved.		
5. Personnel responsible. (positions, no names)		
6. Role you played. (participant, observer, etc.)		
7. Weather conditions.		
8. Major causal factors.		
9. What could have prevented it?		

19. A "near miss" in a harbor situation may be defined broadly as any occasion in which an unanticipated or emergency action has to be taken to avoid a casualty. What is your broad definition of a "near miss" in the open sea? _____

_____

_____

20. In your experience, to what extent are accidents related to personnel turnover? _____

_____

21. Number, in order of importance, your reasons for remaining aboard a ship for more than one voyage. (Most important is 1, next most important is 2, etc.)

_____ Good working conditions

_____ Good money

_____ Good run

_____ Best way to get your own ship

_____ Assigned to ship by company

_____ Living conditions

_____ Fine Captain, a pleasure to sail with

_____ Good Shipmates

_____ Doubts about getting another good job soon

_____ Other (specify) _____

_____

22. Have you ever been in a casualty or near casualty situation where the sudden illness (heart attack, fainting, "fit", stroke, dizziness, etc.) of someone aboard was a major casual factor? Yes _____: No _____.

What happened? _____

_____

_____

_____

(If more space is needed, please use back of page.)

23. Have you ever been in a situation where impaired sight of someone on the bridge was related to the emergency condition? Yes _____; No _____.

What happened? _____

_____

_____

24. Considering overall physical characteristics, have you ever been in an emergency situation where height or weight of a man on your ship played a causal part? Yes _____ ; No _____

How was size related to the casualty or near casualty?

_____

_____

_____

25. Was drunkenness of anyone aboard your ship ever a causal factor of a casualty or near casualty? Yes _____; No _____

What happened? _____

_____

_____

What disciplinary action (if any) was taken? _____

_____

26. Has the use of drugs by men aboard your ship ever contributed to a casualty or near casualty. Yes _____; No _____

What happened? _____

_____

_____

What disciplinary action (if any) was taken? _____

_____

_____

27. Has the emotional stability of anyone aboard your ship ever been a contributing factor to a casualty or near casualty? Yes _____; No _____.

What happened? _____

_____

28. How often do you have to take pre-employment physicals before job assignment?

_____ before every ship
_____ twice a year
_____ once a year
_____ other period (specify) _____
_____ never

29. How regularly have you had your hearing tested in a pre-employment physical?

Always _____; Often _____; Rarely _____; Never _____

30. Check all the things that were tested in your last pre-employment physical.

_____ Heart
_____ Blood pressure
_____ Vision
_____ Hearing
_____ Hernia

31. Have you ever been in a dangerous situation because someone aboard your ship was certified as "Fit for Duty" but was really unfit for duty? Yes _____; No _____

What happened? _____

_____

_____

32. Have you or a close friend ever had an "Unfit for Duty" slip issued? Yes _____; No _____

What was it issued for? _____

What agency issued it? _____

33. In your experience, racial tensions aboard ship: (Select one)

_____ are non existant.
_____ are present but do not interfere with operations.
_____ interfere with operations to a limited extent.
_____ represent a major source of personnel unrest and interfere with operations.
_____ other (specify) _____

_____

_____

34. Have you ever experienced a situation where interpersonal hostility due to racial tensions contributed to a casualty or near casualty? Yes _____; No _____

What happened? _____

_____

_____

35. Has any helmsman, OIC, or watch officer ever fallen asleep on duty on your ship? Yes _____; No _____

What disciplinary action was taken? _____

_____

_____

Excessive FATIGUE means being so tired that the job cannot be done properly. Sluggish actions, sleeping or nodding on watch, etc.

36. Has excessive fatique of anyone on watch ever contributed to a casualty or near casualty on your ship? Yes _____; No _____

What happened? _____

_____

_____

37. Did the amount of time on watch or work tire the men involved? Yes _____; No _____

If yes, how are they working?

_____ one-on, one-off or 6+6

_____ the Captain or watch were on duty continuously for long periods.

_____ the men involved worked without required rest periods, what with docking, undocking, watch, cargo, canal transits, etc.

_____ the men tried to work until the job was finished.

_____ excessive heat during work period.

_____ work done on watch

_____ Overtime

_____ excessive overtime

_____ other (specify) _____

_____

38. When does fatigue become a problem for bridge personnel on your ship?

_____ on entering port

_____ on leaving port

_____ in the open sea

_____ other (specify) _____

39. Have visibility limitations because of ship structure (deck structure, A frames, derricks, cranes, etc.) or deck cargo ever been a contributing factor in a casualty or near casualty?
Yes _____; No _____

What happened? _____

_____

_____

40. Have you ever had to conn a ship from a location other than the bridge in order to avoid obstructions to visibility?
Yes _____; No _____.

DISORIENTATION means momentarily being unable to determine your position or bearing in relationship to your surroundings.

41. Have you ever temporarily become confused about directions or disoriented because of adverse weather conditions, radical maneuvering, visual interference, or any other distraction?

Yes _____; No _____.

If you answered yes, please describe the experience and the circumstances surrounding it.

_____

_____

_____

About how many times a year does this happen?_____

42. Have you ever observed someone else become disoriented?

Yes _____; No _____.

If Yes, what happened and what do you think caused it?

_____

_____

_____

43. Has temporary disorientation of you or someone aboard your ship ever been the cause of a near miss or a casualty.

Yes _____; No _____.

If Yes, what happened? _____

_____

_____

44. Have you ever been in a situation where the Captain's quarters were so far from the bridge that it was difficult for him to respond and orient himself to an emergency situation when called?

Yes _____; No _____.

45. What are the characteristics of your present (or last) vessel?

Length _____; Beam _____; Draft _____;

DWT(approx.) _____; Horsepower(approx.) _____;

Age(approx.) _____; Type of Propulsion _____;

Radar type _____; Bulbous bow: Yes _____; No _____

Bow thrustors Yes _____; No _____

46. What type of ship: (check one)

_____ General cargo

_____ Container ship

_____ Tanker

_____ Ore or bulk carrier

_____ Passenger or cruise

_____ Harbor tug

_____ Coast or ocean tug

_____ Harbor craft

_____ Oil or mining support

_____ Other _____

47. With respect to the above ship, how suitable are harbor and port facilities?

_____ Experience little difficulty at any time.

_____ Not much trouble under ideal conditions, have some trouble in bad weather.

_____ Dangerous in less than perfect conditions.

_____ Cannot use most harbor facilities.

_____ Other (specify) _____

_____

48. If your ship is equipped with a bulbous bow or with bow thrustors, have you experienced any difficulty with piers and docks? Yes _____; No _____.

What kind of difficulty? _____

_____

49. In general, on busy days, do you find room in most harbors for: (answer with respect to the above ship)

Anchoring Yes _____; No _____

Turning Yes _____; No _____

Passing Yes _____; No _____

Waiting and delaying Yes _____; No _____

Maneuvering into pier Yes _____; No _____

Maneuvering around bridges Yes _____; No _____

50. Have you ever had any problems, with the ship described in Question 45, in passing through narrow span bridges?

Yes _____; No _____

What happened? _____

51. Have you ever had any problems, with any ship, with bridges failing to open in front of you? Yes _____; No _____

What happened? _____

_____

52. Is the draft of your present (or last) ship so great that you must wait for high tide to enter your usual harbors? Yes _____; No ___

53. Have you ever run aground or grounded in a shallow channel in your present (or last) ship? Yes _____; No _____

What happened? _____

_____

_____

_____

(If more space is needed, please use back of page)

54. How would you describe the bow lookout on most of the ships you have been on?

_____ reports what he sees and hears

_____ generally does his job well, misses a few

_____ cannot be trusted

_____ other (specify) _____

55. How do you know the lookout can see adequately?

_____ from experience with him and others

_____ the USCG checked him out when he got his original certificate

_____ I don't know

56. How could communications between the lookout and the bridge be improved?

_____

_____

_____

57. Can you suggest anything in the way of equipment which will improve the accuracy and reliability of information from the bow?

_____

_____

_____

58. Have you ever received inaccurate information from the bow lookout? Yes _____; No _____ It was;

_____ reported wrong bearing of a sighting

_____ reported wrong light color

_____ ship reported as buoy or vice versa

_____ reported illusion of ship or buoy

_____ other (specify) _____

_____ reported wrong sound signal

59. How do you know what the lookout is actually doing at his station? _____

_____

60. How often are Local Pilots given a rundown on a ship's steering and handling characteristics when they board?

_____ Almost every time

_____ Often

_____ Rarely

_____ Hardly ever

61. Is it best for the Local Pilot to:

_____ Tell the QM where he wants to head and let the QM decide how much rudder he needs to get there

_____ Call out specific rudder commands

_____ Take the helm himself

62. On converted ships, have you found that the engine and rudder are adequate for harbor maneuverability?

Yes _____; Marginal _____; No _____

63. When transferring rudder commands to the helmsman, have you every experienced a situation where the helmsman gets confused and turns the helm the wrong way? Yes _____; No _____

Why do you thing this occurred? _____

_____

64. Have you ever been in a situation where it was uncertain if the bow or the stern of the ship was swinging? Yes _____; No _____

Under what circumstances did this occur? _____

_____

65. When facing aft and giving helm commands, does the decision to give right or left rudder commands get confusing?

Yes _____; No _____

66. Have you ever been in a casualty or near casualty situation where ship handling difficulties were a major causal factor?

Yes _____; No _____

What happened? _____

_____

67. Although the law requires the Chief Mate, lookout, and Bos'un, etc. to man the bow and anchor in confined waters, and tight channels, in your experience what is the compliance with this law?

_____ The bow is fully manned whenever required

_____ A partial crew mans the bow when no difficulty is expected

_____ The bow is rarely manned, except for the lookout, unless difficulty is expected

_____ The bow is often unmanned in foul weather since this is the worst spot to order any human being

_____ other (specify) _____

68. Have you ever experienced difficulty because the anchor could not be released when needed?

Yes _____; No _____

What happened? _____

_____

_____

69. If the anchor ever failed to release when the signal was given what was the cause of failure?

Mechanical _____; Human_____

What happened? _____

_____

_____

70. Have you ever suffered a casualty or near casualty in an anchorage? Yes _____; No _____

Was this because:

_____ wind and current severe, anchor dragged

_____ anchorage congested

_____ other ships anchored improperly

_____ local ships, harbor vessels, dredges etc. operating in anchorage

_____ other (specify) _____

71. In the general maneuvering situation into and out of port, etc. would it be safer to have more men on watch?

Yes _____; No _____

If YES, how should they be used? _____

_____

72. Pleasure and fishing craft in coastal sea lanes: (Select one)

_____ cause little trouble

_____ are a problem but can generally be avoided

_____ pose a severe problem to large, high speed ships

_____ Other (specify) _____ _____

73. When a Pilot comes aboard and mans the bridge, what generally happens?

_____ He takes complete charge of conning, maneuvering, and engine speed, without the Captain's direction.

_____ He takes charge of conning, maneuvering, and engine speed as advised by the Captain.

_____ He advises the Captain what speeds and maneuvers must be made, then upon Captain's decision, assumes the conn, assisting the Captain.

_____ The Captain makes all decisions, using the Pilot strictly as an advisor.

74. Have you ever witnessed an incident in which conflict between Captain and Pilot put the ship in a dangerous situation?

Yes _____; No _____

What happened? _____

_____

_____

75. Have you ever witnessed an accident or near miss because a tug had insufficient power or was ineptly handled?

Yes _____; No _____

What happened? _____

_____

_____

76. Do the tugs assigned to your vessel appear to have sufficient power to handle it in all weather conditions?

Yes _____: No _____

77. Rank order the following types of harbor traffic according to the difficulty they cause in entering and leaving harbor. (Most difficult is #1, etc.)

_____ Fishing vessels in channel

_____ Ferry boats crossing channel

_____ Tugs with tows

_____ Self propelled barges

_____ Dredges and other semi-fixed craft

_____ Other ocean going vessels

_____ Pleasure craft

_____ Other (specify) _____

78. Do you experience difficulty or potential hazard entering or leaving harbor because of. (Check those that apply)

_____ Insufficient channel depth

_____ Insufficient channel width

_____ Narrow bridge span

_____ Limited overhead bridge clearance

_____ Blind spots where channels converge

_____ Excessive cross channel traffic

_____ Poor ship to ship communication

_____ Inadequate turning basins

_____ Poor visibility because of prevailing weather conditions

_____ Other (specify) _____

79. Have you ever had a casualty or near miss at the blind intersection of two harbor channels? Yes _____; No _____

What happened? _____

_____

_____

80. Does your company favor the use of Coast Pilots in such congested areas as the North Sea, English Channel, Baltic, etc.

Yes _____; No _____

81. Company policy aside, would you prefer the use of Coast Pilots in areas such as the above. Yes _____; No _____

State a reason for your answer _____

_____

82. As a Pilot, have you ever taken a ship in or out when you felt the risk was excessive because of poor weather conditions?

Yes _____; No _____

Why did you take the action you did? _____

_____

83. From your experience, what is the most dangerous location in most harbors? _____

_____

84. Have you ever had to back up a very tired Pilot?

Yes _____; No _____

Was he a Docking Pilot _____; Harbor Pilot _____; Coastal Pilot _____

85. If you are a Pilot, how many ships do you handle each week? _____

What day of the week do you take the most ships? _____

What kind of Pilot are you? _____

86. For a Pilot working in limited visibility, who is the most important?

_____ Bow lookout

_____ Helmsman

_____ Captain

_____ Mate on watch

_____ Other (specify) _____

87. How does your company measure a Captain's performance? Select the three most important from the following:

_____ Crew turnover per trip

_____ Amount of overtime

_____ Amount of cargo carried

_____ Making schedules, being on time

_____ Amount of turnaround time and longshore costs

_____ Man hours lost in accidents

_____ Tug, Pilot and launch costs, etc.

_____ Passage time, port to port time

_____ Fuel oil expended

_____ Minimizing operating and maintenance costs

_____ Minimizing cargo damage

_____ Other (specify) _____

88. In your company, how often can a Captain refuse to take a ship out or delay sailing without trouble from the front office?

_____

89. How does your company feel about meeting schedules in poor conditions? (check one)

_____ Company insists that schedules be met at all costs

_____ Strong pressure to meet schedules but left to Captains' discretion to accept prudent risks

_____ Captain is on his own as to trade off between schedule and risk

_____ Company safety oriented but leaves Captain decide what risks to be taken

_____ Company safety oriented and insists no risk whatever be taken to meet schedules

90. Approximately how much does it cost to operate your vessel per hour? $ _____

TO WHAT EXTENT DO YOU AGREE OR DISAGREE WITH THE FOLLOWING STATEMENTS IN QUESTIONS 91 THROUGH 95.

91. Captains of large ships and of tugs will often chance proceeding under adverse conditions rather than face front office criticism as a "cry baby".

_____ Agree completely

_____ Generally agree

_____ Uncertain

_____ Generally disagree

_____ Completely disagree

92. Once longshore gangs are ordered and an ETA set, it is up to the Captain to do all in his power to meet the schedule.

_____ Agree completely

_____ Agree generally

_____ Uncertain

_____ Generally disagree

_____ Completely disagree

93. Calculated risks are part of the game and are necessary if a company is to remain in business. Losses should be treated as an operational expense.

_____ Agree completely

_____ Generally agree

_____ Uncertain

_____ Generally disagree

_____ Completely disagree

94. Scheduling larger, deep draft vessels to ports with minimum tolerance for maneuverability is in the nature of a calculated risk.

_____ Agree completely

_____ Generally agree

_____ Uncertain

_____ Generally disagree

_____ Completely disagree

95. Calculated risk situations never involve departure from the Rules of the Road.

_____ Completely agree

_____ Generally agree

_____ Uncertain

_____ Generally disagree

_____ Completely disagree

96. Calculated risks involving ship handling might best be defined as:

_____ One(s) which involve standing the ship in a more or less dangerous situation for a period of time

_____ One(s) which could involve standing the ship in danger for a period of time

_____ Simply a difficult route choice over an easier, longer route choice

_____ None of the above I would describe calculated risk as _____

_____

97. In committing a ship to a calculated risk situation, successful completion is presumed contingent upon: (rank order in terms of importance) (1 most important, 2 next, etc.)

_____ Everyone involved executing his job in a professional manner

_____ Cool headedness prevailing

_____ Optimum, efficient machinery performance

_____ That known "adverse conditions" do not worsen

_____ That the "other fellow" (if one is involved) does what he is expected to do

_____ Luck

_____ Other (specify) _____

98. How do you feel about accepting calculated risks as part of this job? _____

_____

_____

99. Have you ever sailed on a ship which you knew to be "unseaworthy"? Yes _____; No _____

In what way was the ship unseaworthy?_____

_____

Why did you sail on her? _____

_____

_____

100. Have you ever witnessed a casualty or near casualty which resulted from somone trying to outguess or anticipate what another ship would do? Yes _____; No _____

What happened? _____

_____

_____

101. In your experience, are new personnel aboard ship thoroughly briefed on their duties in emergency situations?

Yes _____: No _____

102. Is this knowlege ever tested by emergency drills?

Yes _____; No _____; Rarely _____

103. Who in your experience instructs bridge personnel of their specific duties in emergency situations?

_____

104. When something goes wrong, do the seamen aboard your ship:

_____ Carry out preplanned emergency procedures

_____ Wait to be told what to do

_____ Take action on their own

_____ Try to avoid getting involved if it is not their immediate concern

_____ Other (specify) _____

105. Does your company have a safety program?

Yes _____; No _____

106. What kind of program is it? (Check those that apply)

_____ Generally propaganda about safety

_____ Training in safe procedures

_____ Bonuses and rewards for safe operations

_____ Company safety inspections, safety officers

_____ Other (specify) _____

_____ _____

107. In your opinion, is the program adequate?

Yes _____; No _____

108. In an emergency situation, how do you know what to do?

_____ Common sense

_____ Contract spells it out

_____ Tradition and custom

_____ Remembered from USCG examinations

_____ Practice drills with other personnel

_____ Experience, it has almost always happened before

_____ Other (Specify) _____

_____

110. Does your ship have a damage control program?

Yes _____; No _____

111. On the ship you are currently on, are maintenance and operating manuals easily available?

Yes _____; No _____

How do you get them? _____ _____

Have you reviewed any of them? Yes _____; No _____

112. Do you find that shore lights camouflage the running lights of other vessels on clear nights?

Yes, often _____; Sometimes _____; Rarely _____

113. In your opinion, what type of aids to navigation need the most improvement?

_____ Range lights _____ Channel lights

_____ Channel markers _____ RDF stations

_____ Radio communications _____ LORAN

_____ Audio signals, bells, horns

_____ Other (specify) _____

114. What improvements would you make to the buoy, beacon, light tower system along the coast of the U.S. to keep pace with new ship size and speed? _____

_____

_____

_____

115. Have you ever experienced a casualty or near casualty because the channel lights in a harbor were confusing or misleading?

Yes _____; No _____

What happened? _____

_____

_____

116. Have you ever experienced a casualty or near casualty because charts were not kept up to date.

Yes _____; No _____

What happened? _____

_____

_____

117. From your experience, are decisions to turn the ship in a potentially dangerous situation usually based on:

_____ Visual observation

_____ Radar plot and track

_____ Other (Specify) _____

_____

118. Which of the following pieces of bridge equipment are most likely not to be used to their full potential? (Check those that apply)

_____ Fathometer

_____ Radar

_____ Radio direction finder

_____ Loran

_____ Ship to ship radio

_____ Gyrocompass

119. Why is this so: (Check those that apply)

_____ It is usually broken

_____ Don't know how to operate it

_____ It is saved for emergencies

_____ Using it is a bother

_____ The watch is too busy

_____ Other (specify) _____

120. Is your present ship equipped with direct bridge to engine control? Yes _____; No _____

Is it used? Yes _____; No _____

Why not? _____

_____

121. If you are a deck officer, what kind of radar display do you prefer?

_____ True motion, stabilized (Decca type)

_____ Relative motion (North up)

_____ Relative motion (ships head up)

Why do you prefer this type? _____

_____

122. Have you ever gotten into a tight situation because the radar provided a false sense of security? Yes _____; No _____

What happened? _____

_____

123. Are you qualified to operate LORAN _____; OMEGA _____; DECCA NAVIGATOR _____? (check those that apply)

Where did you receive your training? _____

_____

124. Have you ever experienced difficulty in trying to divide your attention between the radar and other bridge duties?

Yes _____; No _____

How did you decide what to concentrate on? _____

_____

125. On you present ship, can you get the standby to come to the bridge immediately?

Yes _____; No _____

If not, why not? _____

_____

126. On the ships you usually sail, what is the general policy on using the radar?

_____ Leave it off unless the Captain is on the bridge

_____ Use it when you want but only when you really need it

_____ Leave it on, use it at will

127. From your experience, when the general policy is not to use the radar freely, what is the usual reason given?

_____ No one aboard to repair it

_____ Too delicate and might break down

_____ M.G. sets make noise over the Captain's quarters

_____ The Captain doesn't like it

_____ You should learn to do without it

_____ It should be saved for when you really need it

_____ Other (please list) _____

_____

128. Are there two or more radars aboard your present ship?

Yes _____; No _____

Under what conditions are two radars used simultaneously?

_____

_____

129. In confined waters, in periods of fog, falling snow, or heavy rain, the Local Pilot may be the only one who can interpret the radar correctly?

Yes _____; No _____

130. Have you ever relied on someone elses radar (nearby ship, shore station, etc.) when bringing a ship in or out of harbor?

Yes _____; No _____

131. Have you ever experienced a casualty or near casualty because someone had difficulty in reading bridge instrumentation because of poor design or lighting?

Yes _____; No _____

What happened? _____

_____

_____

132. Prior to leaving port, testing the steering gear and navigational equipment is performed on your ship by:

_____

_____

Is a written check-off list used? Yes _____; No _____

If something is wrong, what do you do?_____

_____

_____

133. Have you ever been in a casualty or near casualty situation where failure to follow specified operating procedures by one of the men aboard your ship was a major causal factor?

Yes _____; No _____

What happened? _____

_____

_____

134. What was the procedure that was neglected?

_____

135. Who determined the operating procedure?

_____ Captain

_____ Other officer (specify) _____

_____ Traditional custom

_____ USCG

_____ A manual or reference

_____ Other (specify) _____

136. Why wasn't the procedure followed?

_____ Didn't know what to do

_____ Didn't want to bother

_____ Was in a hurry

_____ Busy doing other tasks

_____ Followed the wrong procedure

_____ Other (specify) _____

137. When you come aboard a new ship, are you usually:
(check those that apply)

_____ Left to shift for yourself

_____ Introduced to watchmates

_____ Asked about your past experience

_____ Fully briefed on ship and duties

_____ Other (specify) _____

138. If you were not fully instructed in duties and equipment operations, is it because:

_____ You were expected to know

_____ The person you replaced left without bothering to tell you

_____ It is not customary on board this ship

_____ You were expected to read the job description

_____ It is in the contract

_____ Other (specify) _____

139. The rules which apply to Masters and Mates for radar plotting and interpretation on the high seas and International waters should be the same for pilotage waters.

_____ Agree completely

_____ Generally agree

_____ Uncertain

_____ Generally disagree

_____ Completely disagree

140. It has been said that the new, large, high speed (22-33kt.) vessels present peculiar problems in navigation and Rules of the Road compliance. In your experience, what are some of these problems?

_____

_____

_____

_____

141. In your experience, what are some of the Rules of the Road compliance problems with the super large VLCCs with their limited maneuverability?

_____

_____

_____

_____

142. Have you ever been in a situation where strict obedience to the Rules of the Road was a contributing factor in a marine casualty or near casualty?

Yes _____; No _____

What happened? _____

_____

_____

_____

(If more space is needed, please use back of page)

143. Many collisions have resulted from failure to use sound signals. If your ship has ever failed to use a sound signal, why do you think it occurred?

_____ Confusion over what to do

_____ Didn't want to bother

_____ Didn't want to disturb crew or Captain

_____ Didn't hear other signal because of interfering noise.

_____ Didn't know what signal to sound

_____ Would add to the confusion of a difficult situation

_____ Other (specify) _____

_____

144. Have you ever experienced a casualty or near casualty situation because of failure of either party to use proper sound signals?

Yes _____; No _____

What happened? _____

_____

_____

145. How often do you confirm a sound signal with VHF?

_____ Regularly

_____ Sometimes

_____ Rarely

146. In your experience, how often are the required whistle signals used in and around harbors?

_____ Rarely

_____ Not as often as necessary

_____ As often as necessary

_____ Too often

147. How useful do you think sound signals actually are in today's crowded harbors? _____

_____

_____

(Continued #147 question, next page)

What would you suggest as a substitute for sound signals?

_____

_____

148. Have you ever experienced a situation in which sounding the signals required by the Rules of the Road would have made the situation more serious by confusing other ship?

Yes _____; No _____

What was the situation? _____

_____

149. Have language difficulties between your ship and another ship, or between your ship and a foreign shore facility ever been the major cause of a casualty or near casualty?

Yes _____, No _____

150. Have language difficulties aboard <u>your</u> ship ever contributed to a casualty or near casualty?

Yes _____; No _____

What happened? _____

_____

_____

151. From your experience, is the ship to ship radio ignored in most traffic situations? Yes _____; No _____

If yes, why? _____

_____

152. Are there men on your watch who cannot readily speak and understand English? Yes _____; No _____

153. Have you ever had an experience where communications between bridge and Engine room resulted in a close call or casualty?

Yes _____; No _____

What happened? _____

_____

_____

154. Was the poor communications due to hostility between the bridge and engine officers?

Yes _____; No _____

155. Under what circumstances do you use the ship to ship communications channel? _____

_____

156. When is ship to ship communications most useful? (rank order)

_____ In dealing with harbor cross traffic

_____ At blind channel intersections

_____ in fog and lowered visibility

_____ In establishing passing agreements in channels

_____ In meeting situations under bridges

_____ In docking and close in maneuvering

_____ Other (specify) _____

157. What difficulties have you had with ship to ship communications? (rank order)

_____ Range too short

_____ Too much chatter, fishing vessels and harbor craft

_____ Unreliable equipment

_____ Requires too much attention, distracting

_____ Unable to understand language of foreign ships

_____ Other (specify) _____

158. When are ship to ship radio channels busiest (rank Order)

_____ In daylight, low visibility situations

_____ At night

_____ In bad weather at any time of day

_____ In good fishing weather

_____ Other (specify) _____

159. Have you ever experienced a casualty or near casualty because a piece of shipboard equipment failed, apart from any human error?

Yes _____; No _____

What happened? _____

_____

_____

What specifically failed? _____

Why do you think it failed? _____

_____

160. Was the equipment "seaworthy" when the voyage started?
Yes _____; No _____

161. Had the equipment been recently repaired by a shore facility?
Yes _____; No _____

162. What kind of company made the repair?

_____ The original manufacturer

_____ A specialist firm for that type of equipment

_____ The shipyard

_____ Unknown

_____ Other (specify) _____

163. Did the equipment require additional service aboard ship after the shore gang got done? Yes _____; No _____

164. How well was the crew aboard ship prepared to handle the maintenance work? _____

_____

165. What are the two most annoying problems with shipboard equipment repair? (check two)

_____ Spare parts take too long to get

_____ Difficulty getting correct part

_____ Crew lacks knowledge

_____ Limited budget

_____ Wrong tools

_____ Other (specify) _____

166. Have you ever had a dangerous incident that involved the cargo?

Yes _____; No _____

167. How was the cargo involved: (check one)

_____ cargo shored, blocked, or secured incorrectly

_____ cargo stowage had adverse effect on the stability and handling of the ship

_____ Deck cargo blocked the view of the watch

_____ Fire broke out in the cargo

_____ Other (specify) _____

168. Why did the above occur?

_____ The shore gang is not held responsible

_____ Did not know what the cargo was

_____ Ship overloaded with deck cargo

_____ Mate or Captain did not check stability calculations

_____ Other (specify) _____

169. Have you ever experienced a casualty or near casualty when loading or unloading dangerous or flammable cargo?

Yes _____; No _____

What happened? _____

_____

_____

170. Have you ever experienced a casualty or near casualty when cleaning flammable cargo tanks or holds?

Yes _____; No _____

What happened? _____

_____

_____

171. Have you ever experienced severe cargo damage because the cargo was improperly secured?

Yes _____; No _____

172. Have you ever experienced a casualty or near casualty where the design of the ship was a major causal factor?

Yes _____; No _____

What happened? _____

_____

_____

173. On occasion, seamen tend to fall back on traditional or fixed patterns of behavior when in a tricky situation. Some of these are "Never turn left", "When in danger of collision, always turn toward the oncoming ship's stern" etc. Have you ever experienced a situation where reliance on these rules of thumb was a causal factor in a casualty or near casualty?

Yes _____; No _____

What happened? _____

_____

_____

174. From the list below, select the two most common reasons for men having operating problems on your ship. (check two)

_____ Failed to pass or get information from the relief

_____ Unfamiliar with mechanical equipment on board

_____ Unfamiliar with control dials, switches, etc.

_____ Did not report to Captain, Chief, or 1st.

_____ Disregarded test results, radar display, etc.

_____ Didn't know what was going on

_____ Other (specify) _____

175. Have you ever experienced a situation where you asked for help from one of the men on your ship but were ignored.

Yes _____; No _____

Why do you think this happened? _____

_____

_____

_____

176. What has been your experience, good or bad, with Coast Guard Material Inspectors?

_____

_____

_____

177. What has been your experience, good or bad, with Coast Guard disciplinary actions?

_____

_____

_____

178. Do you consider Coast Guard licensing examinations fair and equitable?

Yes _____; No _____

If you do not consider them fair, how would you change them?

_____

_____

_____

179. What are the qualifications of most of the Coast Guard Officers you have experienced in your maritime career: (check one)

_____ Highly qualified, complete knowledge of all aspects of job

_____ A good knowledge of rules and procedures but limited practical experience.

_____ Limited experience and spotty knowledge of procedures.

_____ Unqualified to judge actions of maritime personnel by virtue of inexperience.

180. How would you improve the relationship between the Merchant Marine and the Coast Guard?

_____

_____

_____

(If more space is needed, please use back of page)

181. From your own experience, pick the three most common errors of bridge personnel from the following list. Rank them 1, 2, 3 in order of frequency.

	Common	Critical
1. Couldn't see oncoming ship on radar but assumed he could see us.		
2. Maintain insufficient speed for steerage.		
3. Excessive speed for conditions		
4. Failed to plot targets.		
5. Turn wheel the wrong way. (wrong rudder commands)		
6. Read chart wrong, lost position.		
7. Misjudged effects of current and wind.		
8. Could not appreciate momentum of ship, late response.		
9. Didn't give, or ignored sound signals.		
10. Insufficient time to decide, decided too late.		

182. Now go back over the list and pick the three most critical items, those errors most likely to result or contribute to a casualty or near casualty.

183. From the list below, rank the three most common causes of human error. (Most common is #1, etc.)

_____ Panic	_____ Fatigue
_____ Sickness	_____ Negligence
_____ Drunkenness	_____ Ignorance
_____ Confusion	_____ Calculated risk
_____ Inattention	_____ Fear
_____ Incompetence	_____ Other _____
_____ Anxiety	_____ Overconfidence

Now go back over the list and circle the single item you feel is the most important cause of marine casualty.

184. Rank order the following types of marine casualties from the most common to the least common according to your experience: (most common is #1, next 2, etc.)

_____ Grounding

_____ Fire and/or explosion

_____ Collision

_____ Foundering

185. In your entire seagoing career, estimate how many actual casualties you have witnessed.

_____

186. Now, approximately how many near casualties or near misses have you witnessed?

_____

_____

187. Based on your experience, what would you say is the correct ratio between near casualties and real casualties?

_____ 5:1 _____ 200:1

_____ 10:1 _____ 400:1

_____ 20:1 _____ 1000:1

_____ 50:1 _____ Other (specify) _____

_____ 100:1

188. If you would like to add any material on the causes of marine casualty, not covered in the questionnaire, feel free to use the following space.

_____

_____

_____

_____

_____

_____

_____

189. How do the following groups contribute to, or fail to contribute to, safety of marine operations? Feel free to say whatever you want in this section. Here is the chance to get some gripes off your chest.

COAST GUARD INSPECTORS _____

SHORESIDE OPERATIONS PERSONNEL _____

MAINTENANCE AND REPAIR PERSONNEL _____

DECK OFFICERS _____

ENGINE OFFICERS _____

UNLICENSED PERSONNEL _____

SHIPS CAPTAINS _____

THE DESIGN OF MODERN SHIPS _____

PORT AUTHORITIES AND OTHER REGULATORY AGENCIES _____

OWNERS AND/OR CHARTERERS _____

HARBOR CRAFT OPERATORS _____

UNIONS _____

190. What actions should be taken immediately to reduce the risks of marine operations?

191. What type of research should be undertaken by the government to reduce marine casualties?

_____

_____

_____

_____

_____

192. Is there any type of equipment you would like to have on board to make your job easier and/or safer that you do not have now?

What is it? _____

_____

_____

Thank You Very Much For Your Cooperation

Please Return the Questionnaire in the Envelope Provided.

Do Not Put Your Name on Either the Questionnaire or the Envelope

GOOD SAILING!

APPENDIX II

METHODOLOGY FOR RANKING RECOMMENDATIONS

Recommendation areas were evaluated by a sub-panel according to five basic criteria:

Criteria	Criteria Weighting
1. Severity of Error Addressed	2 points
2. Probability of Error Causing Casualty	3 points
3. Economic Impact of Adoption	1 point
4. Feasibility of Adoption	1 point
5. Likelihood of Eliminating or Controlling Error	2 points

Each sub-panel member rated each recommendation area on a scale of one to ten for each of the five criteria. These ratings were then multiplied by the criteria weighting to produce a relative weighting number for each recommendation area. The recommendation areas were then ranked in order.

The calculations are shown in Table 10.

TABLE 10

RATED RECOMMENDATION AREAS

Rank	Relative Weighting Number	Recommendation Area	SEVERITY Ave. Rate	x 2 Weight	PROBABILITY Ave. Rate	x 3 Weight	COST OF C/A Ave. Rate	x 1 Weight	FEASIBILITY Ave. Rate	x 1 Weight	LIKELIHOOD OF CONTROLLING Ave. Rate	x 2 Weight
1	67	Vigilance and Attentiveness	7	14	9	27	3		7		8	16
2	63	Pilot/Master Relationship	6	12	6	18	10		7		8	16
2	63	Bridge Design	8	16	7	21	7		5		7	14
3	61	Operating Standards	7	14	7	21	6		8		6	12
4	55	Physical Qualifications	5	10	6	18	7		8		6	12
5	52	Vessel Familiarization	6	12	5	15	6		5		7	14
5	52	Boredom/Job Satisfaction	7	14	6	18	6		4		5	10
6	50	Fatigue	7	14	7	21	6		3		3	6
7	47	Calculated Risk	8	16	4	12	8		5		3	6
8	45	Alcohol Use	5	10	5	15	6		8		3	6
9	44	Radar	5	10	5	15	7		4		4	8
10	43	Sound Signals	5	10	5	15	10		4		2	4
11	37	Lights and Markers	5	10	3	9	6		4		4	8
12	32	Rules of the Road	3	6	2	6	9		9		1	2

Weight Factor

2	Severity of Error Addressed
3	Probability of Error Causing Casualty
1	Economic Impact of Adoption (Inverse Order)
1	Feasibility of Adoption (Social, Political, Technical)
2	Likelihood of Eliminating/Controlling Error

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report examines the problem of human error in merchant marine safety. It is organized into two separate parts, with Part I treating the conclusions and recommendations and Part II the supportive information and analytic techniques.

(continued)

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20. Abstract (continued)

The study employs a literature review, a data base evaluation, job descriptions, casualty flow diagrams, and an in-depth survey in its overall analysis of human error problems aboard merchant vessels.

The recommendations are aimed at developing countermeasures against human acts of commission or omission that lead to merchant marine casualties. Recommendations are made in 21 specific areas.