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NAVAL PERSONNEL AND TRAINING RESEARCH LABORATORY

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SEA STATES AND SHIPBOARD OPERATOR PERFORMANCE AND MAINTENANCE

Lynn A. Lacey

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SEA STATES AND SHIPBOARD OPERATOR PERFORMANCE AND MAINTENANCE

Prepared for the

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San Diego, California 92132

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Research Memorandum SRM 71-5

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SUMMARY

A. Problem

The purpose of this survey is to evaluate the effects of sea states on the operation and maintenance of radar, radio, and sonar shipboard equipment.

B. Background

Little research has been conducted on the effects of sea state conditions on the operation and maintenance of shipboard equipment. The present research extends the available data on the effects of sea states.

C. Approach

Operation and Maintenance Evaluation questionnaires, requiring evaluation of the effects of sea states, were administered to students and instructors at Class "B" and "C" Schools.

D. Findings and Conclusions

1. Operation Questionnaire

Both operator and equipment performance are increasingly hindered as sea state conditions become rougher. However, most ship operating time is in lower sea states.

The types of problems that hinder radar, radio, and sonar operators can be grouped into problems that hindered all of the operators and problems specific to each type of equipment. Examples of common problems include seasickness, equipment displacement, personal balance-motility problems, seating difficulty, and fatigue. Examples of specific problems include radar scope difficulty and radio interference.

The types of problems that hinder equipment performance include problems common to radar, sonar, and radio equipment and problems specific to each type of equipment. Common problems include equipment displacement. Specific problems include quenching for sonar equipment, radar signal degradation for radar equipment, and transmitter adjustment for radio equipment.

While the rough sea environment has little effect on the stated desire to make a career in the Navy, it has a somewhat greater effect on the desirability of sea duty. Consequently, it would seem that a stable ship, such as a semi-submerged type, would enhance the desirability of shipboard sea duty.

Each of the Operation Questionnaire samples believed that the overall operation of their equipment would be "some" to "much" improved on a completely stable ship.

2. Maintenance Questionnaire

While maintainer performance is increasingly hindered at higher sea state conditions, most ship operating time is at lower sea states. A greater amount of equipment maintenance is also required at higher sea states.

The types of problems that hinder maintainers include problems common to radio-radar maintainers and sonar maintainers. Problems include seasickness, equipment displacement, maneuverability problems, safety hazards, and pitch and roll conditions.

The types of problems that require equipment maintenance include corrosion-water damage, antenna problems, and equipment displacement-vibration problems for radio-radar equipment. Topside equipment damage, vibration and shock damage, and equipment displacement required maintenance of sonar equipment.

Again, for the Maintenance Questionnaire subjects, the rough sea environment has little effect on the desire for a Navy career and a somewhat greater effect on the desirability of shipboard sea duty.

Each of the Maintenance Questionnaire samples believed that the overall maintainability of their equipment would be "some" to "much" improved if placed on a completely stable ship.

E. Recommendations

Based upon results of this limited research, it is recommended that:

1. Research to determine the feasibility of developing stable Navy ships be expanded.

2. Further personnel research be conducted to more accurately assess the effects of unstable ship conditions on personnel and equipment performance and equipment operation and maintenance.

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FOREWORD

The research described in this report was performed by the Human Factors Support Research Department of the Naval Personnel and Training Research Laboratory, San Diego, California, in support of the Advanced Design Group, Code 1405, Naval Undersea Research and Development Center (NUC), San Diego, California.

The author wishes to express appreciation to Dr. T. Lang, Code 1405, NUC, San Diego, California, whose assistance and guidance greatly facilitated completion of this research. Special appreciation is also expressed to the Commanding Officers, Fleet Anti-Submarine Warfare School, San Diego, California, Fleet Anti-Air Warfare Training Center, San Diego, California, and the Service Schools Command, Naval Training Center, San Diego, California, who generously permitted many of their personnel to participate in this study.

SEA STATES AND SHIPBOARD OPERATOR PERFORMANCE AND MAINTENANCE

A. PURPOSE

The Advanced Design Group of the Naval Undersea Research and Development Center is studying the feasibility of a new semi-submerged ship concept that is expected to greatly improve ship performance, would require little technological risk, and could be developed with a short lead time.

Operational capabilities of current U. S. Navy ships are severely hampered in rough seas. Conventional ships tend to roll, pitch, and heave, which results in water over the deck, slamming at the bow, and high structural stresses (Lang, 1969). Fifty-eight percent of U. S. Navy combatant ships are over 20 years old, with an average age of 17.5 years, whereas less than one percent of the Soviet Navy ships are that old. Spare parts are not available for some of our oldest ships, and rust and corrosion are taking a high toll (Lang, 1969).

Relative to conventional ships having the same displacement, the semi-submerged ship concept is expected to provide:

1. Greatly improved seaworthiness at all speeds.
2. Higher speed and greater maneuverability.
3. Improved sensor and towing performance, and more stable aircraft and weapon launching capabilities.
4. Lower wave drag.
5. Increased topside weight capacity and deck space.
6. Greater propulsor efficiency and burst speed capability by using polymer drag reduction.
7. Level flight in most sea states by using control surfaces.
8. Reduced vulnerability to torpedoes and cruise missiles. (Lang, 1969)

The semi-submerged ship concept is expected to provide ships with a substantial improvement in the effectiveness with which shipboard personnel can perform their tasks in high sea states. The operational need for such a ship concept depends greatly on how well shipboard personnel are able to perform their tasks in the rolling, heaving, pitching environment that exists on current ships. That is, does the current shipboard environment with rolling, heaving, and pitching have a significant detrimental effect on shipboard personnel performance? Therefore, the present research was conducted with the following objectives:

1. To determine the effects of motion on shipboard personnel performance, including operator and maintainer performance.

2. To determine the effects of motion and other effects of rough seas on shipboard equipment, including equipment operation and maintenance requirements.

3. To determine to what degree the rough sea environment affects the desirability of shipboard duty and to determine how important it is to the desire for a Navy career.

B. BACKGROUND

Baker and Buckner (1966) conducted an extensive literature review on the effects of motion on human performance to determine the availability of data relevant to the operators' task aboard an air/sea craft. Two hundred and thirty reports were studied, including eight reviews of the motion sickness literature published between 1942 and 1955. The eight reviews covered from 42 to 382 technical papers. They concluded that there have been virtually no studies designed to answer the questions of degree of impairment or duration of impairment in any motion environment similar to the air/sea craft operational environment.

Warhurst and Cerasani (1969) in a study conducted aboard the USS GLOVER, found that (1) ship motion causes an irrelevant stress on crew members; (2) some irrelevant stress may actually be beneficial; (3) the effect of roll stabilization equipment is diphasic, it reduces intolerable roll amplitudes but tends to induce higher linear accelerations; (4) roll stabilization should be active from dead-in-water through flank speed since mission requirements include extensive operations at low speeds. Except for this study, little research has been conducted on the effects of sea states on the operation of shipboard equipment. The present survey attempts to extend available data on the effects of sea states on shipboard equipment and personnel performance.

C. PROCEDURE

1. Questionnaire Administration and Population

a. Operation questionnaire. The Operation Questionnaire (See Appendix A) was administered to 127 members of the Fleet. The questionnaires were administered to: 37 students and instructors at the Radarman (RD) "B" School, Fleet Anti-Aircraft Warfare Training Center, San Diego, California; 66 students and instructors at the Radioman (RM) "B" School, Service Schools Command, Naval Training Center, San Diego, California; and 24 Surface Operator Training Instructors, Fleet Anti-Submarine Warfare School, San Diego, California. Table 1 presents background information for the subjects administered the Operation Questionnaire.

b. Maintenance questionnaire. The Maintenance Questionnaire (See Appendix B) was administered to: 17 students and instructors at the Electronic Technician (ET) "C" School, Service Schools Command, Naval Training Center, San Diego, California, and 35 Surface Maintenance Instructors, Fleet Anti-Submarine Warfare School, San Diego. Table 2 presents background data for the subjects administered the Maintenance Questionnaire.

Table 1.

Background Information for Operation Questionnaire Samples

Information	RD "B" School	RM "B" School	ASW School
Rating	Frequency	Frequency	Frequency
Radarman	35	0	0
Radioman	1	61	0
Sonar Technician	0	0	24
Communications Technician	0	2	0
Not Specified	1	3	0
Total	37	66	24
Pay Grade	Frequency	Frequency	Frequency
E4	4	1	0
E5	8	15	0
E6	14	34	10
E7	3	8	4
E8	0	0	0
E9	1	0	1
Chief (Pay grade unspecified)	6	5	9
Not Specified	1	3	0
Total	37	66	24
Present or Last Sea Tour-Ship Type	Frequency	Frequency	Frequency
Carrier	2	11	1
Cruiser	2	5	1
Destroyer	23	13	17
Amphibious	3	13	0
Mine Sweep	1	5	0

Table 1. (Continued)

Information	RD "B" School	RM "B" School	ASW School
Present or Last Sea Tour-Ship Type	Frequency	Frequency	Frequency
Submarine	1	6	0
Auxiliary	1	7	0
Other	3	6	5
Not Specified	1	0	0
Total	37	66	24
Previous Sea Tours	Mean Years [a]	Mean Years [b]	Mean Years [c]
Ship Type			
Carrier	1.00	.56	.25
Cruiser	.51	.24	.29
Destroyer	3.14	1.09	5.21
Amphibious	.84	.86	.00
Mine Sweep	.27	.33	.54
Submarine	.16	.83	.17
Auxiliary	.54	.67	.29
Other	.05	.24	.50
Responsibility for Equipment	Frequency	Frequency	Frequency
Operate	7	8	3
Supervise Operation	17	27	14
Supervise and Operate	13	31	7
Total	37	66	24

Note --

[a] N = 37

[b] N = 66

[c] N = 24

Table 2.

Background Information for Maintenance Questionnaire Samples

Information	ET "C" School	ASW School
Rating Specialty	Frequency	Frequency
Radarman	2	0
Sonar Technician	2	35
Electronics Technician	13	0
Total	17	35
Pay Grade	Frequency	Frequency
E4	5	0
E5	4	2
E6	4	11
E7	1	6
E8	1	1
E9	1	0
Chief (Pay grade unspecified)	1	15
Total	17	35
Present or Last Sea Tour-Ship Type	Frequency	Frequency
Carrier	0	0
Cruiser	1	0
Destroyer	5	34
Amphibious	6	0
Mine Sweep	0	0
Submarine	0	0
Auxiliary	2	0
Other	2	1
Total	16	35

Table 2. (Continued)

Information	ET "C" School	ASW School
Previous Sea Tours-Ship Types	Mean Years[a]	Mean Years[b]
Carrier	.53	.11
Cruiser	.06	.00
Destroyer	1.53	5.29
Amphibious	.06	.09
Mine Sweep	.00	.23
Submarine	.00	.03
Auxiliary	.53	.14
Other	.29	.26
Responsibility for Equipment	Frequency	Frequency
Maintain	7	12
Supervise Maintenance	4	12
Supervise and Maintain	5	11
Not Specified	1	0
Total	17	35

Note --

[a] N = 17

[b] N = 35

2. The Questionnaires

a. Operation questionnaire. The Operation Questionnaire (See Appendix A) was designed to elicit evaluations of the effects of three different sea states on operator and equipment performance. The Questionnaire is divided into two sections, a Background section and an Evaluation section. The Background section deals with the subjects' rating, pay grade, past and present shipboard sea duty experience, rough sea environmental effects on desirability of sea duty and career motivation, type of equipment being evaluated, and the subjects' responsibility for the equipment.

The Evaluation section is further divided into three subsections. Each subsection is headed by a critical incident type statement which defines a sea state. Subjects were asked to think of a time when their ships were operating in three different sea states. A number of questionnaire items which were to be answered with regard to each sea state follow each critical incident statement. The items include 5-point rating scales evaluating the degree to which the operator's performance was hindered at the sea state, the amount of time that the operator's performance was hindered at the sea state, the degree to which equipment performance was hindered at the sea state, and the amount of time while the ship was operating at sea that the ship was in the sea state. Each rating scale item consists of the descriptive terms, "very little", "little", "somewhat", "much", and "very much." Each response was scored one through five with "very little" scored one and "very much" scored five. Two open ended questions were also included in each subsection. One asked what type of problem hindered the operator. The other asked what type of problem hindered equipment performance. A final question asked how much the overall operation of the equipment would be improved if the subject's ship was fully unaffected by all sea states.

b. Maintenance questionnaire. The Maintenance Questionnaire (See Appendix B) was designed to elicit evaluations of the effects of three different sea states on maintainer performance and maintenance requirements of shipboard equipment. The Questionnaire is divided into two sections, a Background section and an Evaluation section. The Background section contains the same items as the Background section for the Operation Questionnaire.

The Evaluation section is divided into three subsections. Each subsection is headed by a critical incident type statement which defines a sea state. Subjects were asked to think of a time when their ships were operating in three different sea states. A number of questionnaire items which were to be answered with regard to each sea state follow each critical incident statement. The items include 5-point rating scales evaluating the degree to which maintainers' performance is hindered at the sea state, the amount of time maintainers' performance is hindered at the sea state, the amount of equipment maintenance required at the sea state, and the amount of time while their ships are operating at sea that their ships were in the sea state. The rating scale items contain the choices "very little", "little", "somewhat", "much", and "very much", and were

scored one through five. Two open ended questions are also included. One asks what type of problem hindered the maintainer at the sea state. The other asks what type of equipment problem required maintenance. A final 5-point rating scale asked how much the overall maintainability of the equipment would be improved if the subject's ship was fully unaffected by all sea states.

3. Analysis of Rating Scale Items

a. Operation questionnaire. The experimental variables consist of three sea state conditions; high, medium, and low; and three types of shipboard equipment; radar, radio, and sonar. Each 5-point rating scale item in the Evaluation section of the Questionnaire was analyzed using the design presented in Table 3. Because of funding limitations on the scope of this survey, no statistical tests were computed.

TABLE 3

Experimental Design for 5-Point Rating Scale Items

	Type of Equipment		
Sea State	Radar	Radio	Sonar
Low	a	a	a
Medium	a	a	a
High	a	a	a

Note --

[a] Each 5-point rating scale item in the Evaluation section was analyzed by type of equipment at each sea state.

b. Maintenance questionnaire. Each 5-point rating scale item in the Evaluation section was also analyzed using the experimental design presented in Table 3. No statistical tests were computed due to funding limitations on the scope of the survey.

4. Analysis of Open Ended Questions

a. Operation questionnaire. The open ended questions in the Evaluation section were content analyzed using an a posteriori approach. That is, categories were allowed to emerge from the written responses so that

the categories would best fit the empirical data. The results of the content analysis are contained in the Results and Discussion section.

b. Maintenance questionnaire. The open ended question in the Evaluation section were also content analyzed and the results are presented in the Results and Discussion section of the report.

D. RESULTS AND DISCUSSION

1. Desirability of Sea Duty and Career Motivation

a. Operation questionnaire. Subjects were asked to rate the effects of the rough sea environment on the desirability of sea duty and on career motivation. Results of these ratings are presented in Table 4. The rough sea environment apparently has little effect on career motivation for each of the samples, but a somewhat greater effect on the desirability of sea duty.

Table 4

Mean Ratings[a] for Desirability of Sea Duty
and Career Motivation for the Operation Questionnaire Samples

Item	RM "B" School		RD "B" School		ASW School	
	N[b]	$\bar{X}$[c]	N	$\bar{X}$	N	$\bar{X}$
Desirability of Sea Duty	65	2.51	37	3.11	24	3.04
Career Motivation	64	2.00	37	2.00	24	2.12

Note --

[a] 1 = very little affected, 2 = little affected, 3 = somewhat affected
4 = much affected, 5 = very much affected

[b] Number of subjects

[c] Arithmetic mean

b. Maintenance questionnaire. Again, the rough sea environment apparently has little effect on career motivation, and a somewhat greater effect on the desirability of sea duty for each of the subjects administered the Maintenance Questionnaire. Mean ratings on the two items are presented in Table 5.

Table 5

Mean Ratings[a] for Desirability of Sea Duty
and Career Motivation for the Maintenance Questionnaire Samples

Item	ET "C" School		ASW School	
	N[b]	$\bar{X}$[c]	N	$\bar{X}$
Desirability of Sea Duty	17	2.94	35	3.11
Career Motivation	17	2.12	35	2.34

Note --

[a] 1 = very little affected, 2 = little affected, 3 = somewhat affected, 4 = much affected, 5 = very much affected

[b] Number of subjects

[c] Arithmetic mean

2. Sea State Evaluation

a. Operation questionnaire. Mean ratings for the 5-point rating scale items evaluating the effects of sea states on shipboard personnel and equipment performance are presented in Table 6, Table 7, and Table 8, for the RM "B" School, RD "B" School, and the ASW School samples.

For each of the samples, operator performance is hindered very little at low sea states, a great deal more at medium sea states, and somewhat more at high sea states Along with increases in the amount that operators are hindered at rougher sea states, operators are hindered a greater amount of time at each sea state as conditions become rougher.

Table 6

Mean Ratings [a] on the Operation Questionnaire for the RM "B" School Sample

Item	Low Sea State		Medium Sea State		High Sea State	
	N[b]	$\bar{X}$[c]	N	$\bar{X}$	N	$\bar{X}$
Operator Performance Hindered	66	1.29	65	3.12	64	3.80
Amount of Time Operator Hindered	66	1.29	65	2.92	63	3.71
Equipment Performance Hindered	66	1.39	64	2.27	60	2.92
Amount of Time Equipment Performance Hindered	66	1.32	64	2.33	60	3.02
Amount of Time at Sea State	66	3.26	65	2.63	63	1.68

Note --

[a] 1 = very little, 2 = little, 3 = somewhat, 4 = much, 5 = very much

[b] Number of subjects

[c] Arithmetic mean

Table 7

Mean Ratings [a] on the Operation Questionnaire for the RD "B" School Sample

Item	Low Sea State		Medium Sea State		High Sea State	
	N [b]	$\bar{X}$ [c]	N	$\bar{X}$	N	$\bar{X}$
Operator Performance Hindered	37	1.40	37	3.49	35	4.57
Amount of Time Operator Hindered	37	1.38	37	3.27	35	4.37
Equipment Performance Hindered	37	1.40	37	2.89	35	3.97
Amount of Time Equipment Performance Hindered	37	1.38	37	2.70	35	3.89
Amount of Time at Sea State	37	3.38	37	2.84	35	1.54

Note --

[a] 1 = very little, 2 = little, 3 = somewhat, 4 = much, 5 = very much

[b] Number of subjects

[c] Arithmetic mean

Table 8

Mean Ratings[a] on the Operation Questionnaire for the ASW School Sample

Item	Low Sea State		Medium Sea State		High Sea State	
	N[b]	$\bar{X}$[c]	N	$\bar{X}$	N	$\bar{X}$
Operator Performance Hindered	24	1.33	24	3.42	24	4.79
Amount of Time Operator Hindered	23	1.30	24	3.50	24	4.71
Equipment Performance Hindered	24	1.17	24	3.00	24	4.75
Amount of Time Equipment Performance Hindered	24	1.17	24	3.17	24	4.58
Amount of Time at Sea State	24	3.33	24	2.92	24	1.83

Note --

[a] 1 = very much, 2 = little, 3 = somewhat, 4 = much, 5 = very much

[b] Number of subjects

[c] Arithmetic mean

Equipment performance is also hindered to a greater extent as sea state conditions become more severe. Again, along with increases in the extent to which equipment performances are hindered as a function of rougher sea state conditions, equipment performances are hindered a greater amount of time at high sea states than at lower sea states.

While both equipment and operator performances are hindered to a greater extent at high sea states, little ship operating time was in a high state, somewhat more time was spent in a medium sea state, and much of ship operating time was spent in a low sea state.

"Operator Hindered" question responses and "Time at Sea State" question responses are presented graphically in Figure 1 for the ASW subjects. The graphical presentation shows the relationship between the operator being hindered and sea state conditions. At a low sea state operators are hindered little and much ship operating time is spent at the low sea state. While sonar operators are hindered to a greater degree at high sea states, little ship operating time is at high sea states. Stability of the means for the items is evident.

"Equipment Operation" question responses and "Time at Sea State" are presented graphically in Figure 2 for ASW subjects. Again, as for operators being hindered, at a low sea state equipment performance is hindered little and much ship operating time is at a low sea state. While sonar equipment operation is hindered to a greater extent at high sea states little ship operating time is at high sea states. Stability of the means for the items is also evident.

b. Maintenance questionnaire. Mean ratings for the 5-point rating scale items evaluating the effects of sea state conditions on shipboard maintainer performance and equipment maintenance requirements are presented in Table 9 and Table 10, for the ET "C" School and ASW School subjects.

For each of the samples maintainer performance is hindered little at a low sea state, a great deal more at a medium sea state, and somewhat more at a high sea state. The higher the sea state, the more the maintainer's performance is hindered, and for a greater amount of time.

While the maintainer's performance is hindered more and for a greater amount of time at higher sea states, ships operate most of the time in lower sea state conditions.

A greater amount of equipment maintenance is also required as sea state conditions become more severe. However, in general, little equipment maintenance is required as a result of sea state conditions.

3. Open Ended Questions

a. Operation questionnaire. Results of the content analysis of open ended questions for the RM "B" School (radio equipment) subjects are

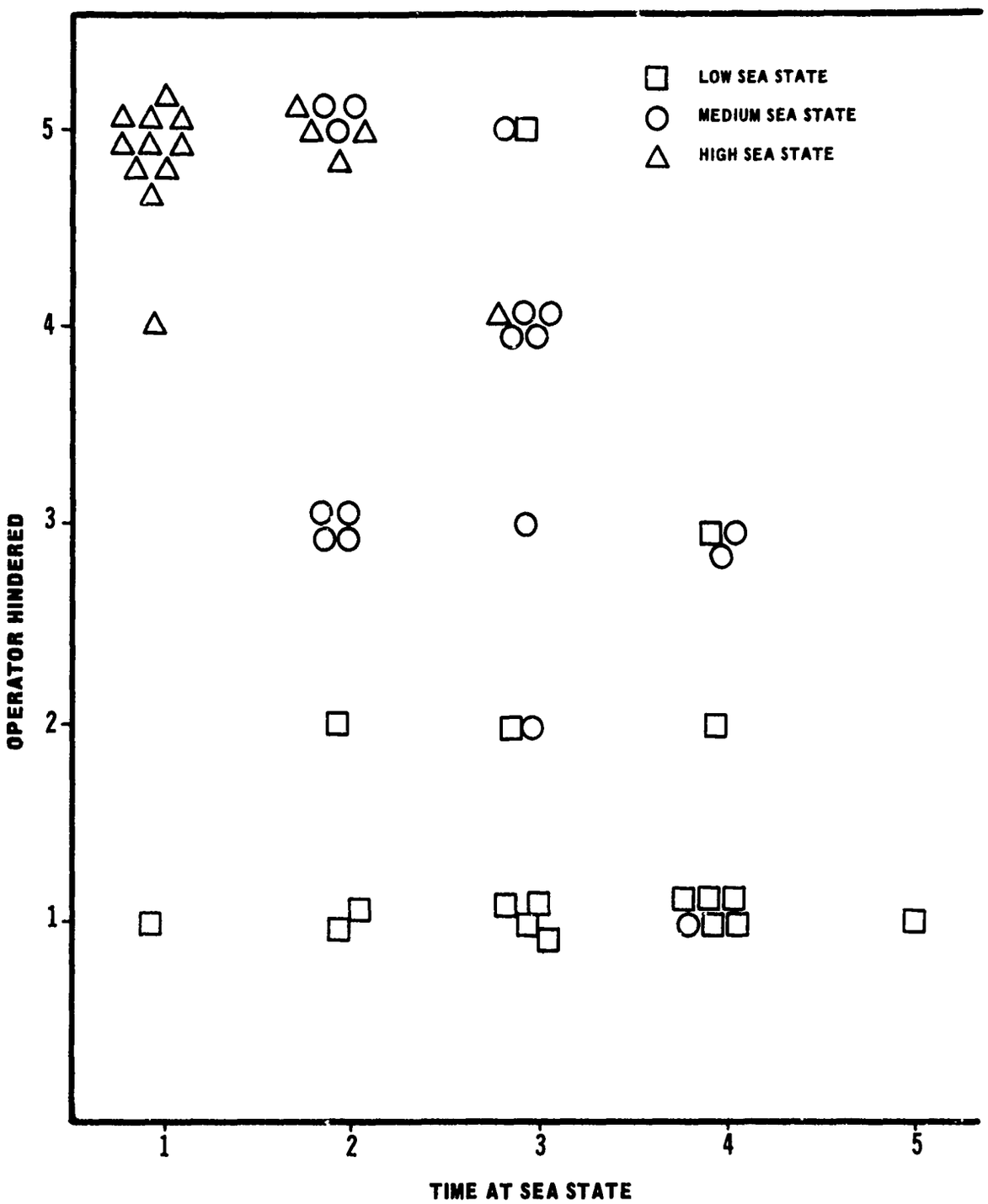

Figure 1. Operator Hindered Responses and Time at Sea State for Sonar Operators with Destroyer Last Shipboard Duty

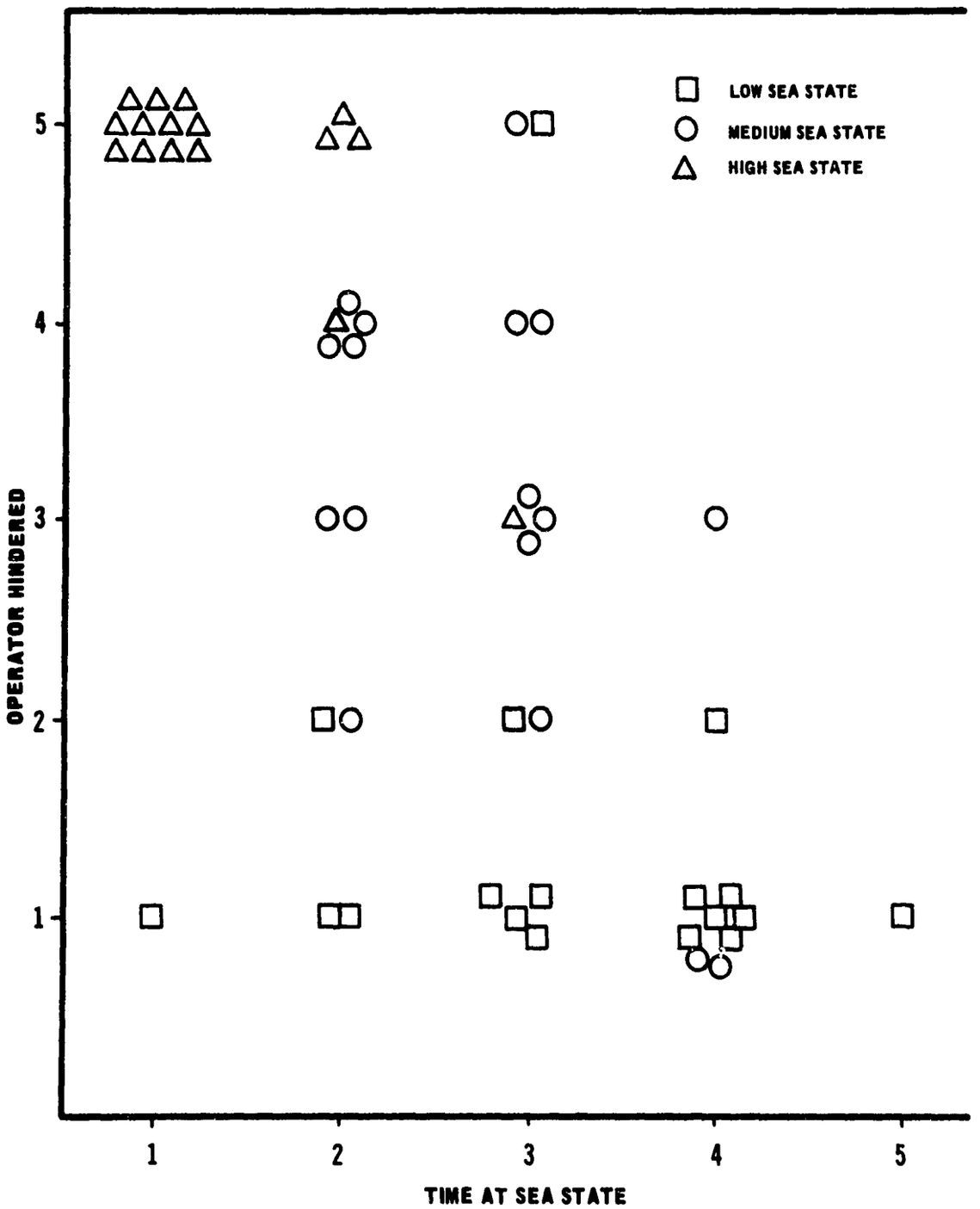

Figure 2. Equipment Performance Hindered Responses and Time at Sea State for Sonar Operators with Destroyer Last Shipboard Sea Duty

Table 9

ET "C" School Maintenance Mean Ratings[a]

Item	Low Sea State		Medium Sea State		High Sea State	
	N[b]	$\bar{X}$[c]	N	$\bar{X}$	N	$\bar{X}$
Maintainer Performance Hindered	17	1.53	17	3.76	15	4.53
Amount of Time Maintainer Hindered	17	1.47	17	3.59	15	4.87
Amount of Time at Sea State	17	3.35	17	2.82	15	1.60
Equipment Maintenance Required	17	1.59	16	2.25	15	2.60

Note --

[a] 1 = very little, 2 = little, 3 = somewhat, 4 = much, 5 = very much

[b] Number of subjects

[c] Arithmetic mean

Table 10

ASW School Maintenance Mean Ratings[a]

Item	Low Sea State		Medium Sea State		High Sea State	
	N[b]	$\bar{X}$[c]	N	$\bar{X}$	N	$\bar{X}$
Maintainer Performance Hindered	35	1.74	35	3.94	33	4.79
Amount of Time Maintenance Hindered	35	1.80	35	3.94	33	4.85
Amount of Time at Sea State	35	3.29	35	3.17	33	1.91
Equipment Maintenance Required	35	1.20	35	1.94	33	2.18

Note --

[a] 1 = very little, 2 = little, 3 = somewhat, 4 = much, 5 = very much

[b] Number of subjects

[c] Arithmetic mean

presented in Table 11 and Table 12 for the "Operator Hindered" question and the "Equipment Performance Hindered" question. Complete coding outlines are in Appendix C for the "Operator Question" and Appendix D for the "Equipment Question."

For the "Operator Question", at a low sea state, the most frequent responses are "No Problems", "No Answer", and "Seasickness." At a medium sea state most frequent responses are "Personal Balance-Motility Problems", "Seasickness", and "Equipment Displacement." Again at a high sea state, "Personal Balance-Motility Problems", "Seasickness", and "Equipment Displacement" are most frequent. "Equipment Displacement" is defined as movement of equipment or tools.

For the "Equipment Operation" question, most frequent responses at a low sea state are "No Problem", "No Answer", "Transmitters Out of Adjustment and Noise", and "Antenna Problems." At a medium sea state, "Transmitters Out of Adjustment and Noise", "Antenna Problems", "No Answer", "No Problem", and "Equipment Displacement" are most frequent. At a high sea state, "Antenna Problems", "Transmitters Out of Adjustment and Noise", and "Equipment Displacement" appear most frequently.

Results of the content analysis for the RD "B" School (radar equipment) subjects are presented in Table 13 and Table 14 for the "Operator Hindered" and "Equipment Performance Hindered" question. For the "Operator" questions (See Appendix E for complete coding outline) at a low sea state, the most frequent responses are "No Problems", "No Answer". "Seasickness", and "Sea Return." At a medium sea state, "Seasickness", "Personal Balance-Motility Problems", "Seating Difficulty", "Fatigue", and "Radar Scope Difficulty" are most frequent. The same categories are most frequent at a high sea state.

For the "Equipment" questions (See Appendix F for complete coding outline) at a low sea state, "No Problem", "No Answer", and "Sea Return" are most frequent. At a medium sea state, "Sea Return", "Antenna Problems", "Radar Signal Degradation", and "Equipment Displacement" are most frequent. The same categories are most frequent at a high sea state.

Results of the content analysis for the sonar operators' "Operator Hindered" question are presented in Table 15, and Table 16 contains results of the "Equipment Performance Hindered" question. Most frequent responses for the "Operator" question at a low sea state (See Appendix G for complete coding outline) are "No Problems", "No Answer", "Fatigue", "Scope Problems", and "Miscellaneous." For a medium sea state, "Seasickness", "Seating Difficulty", "General Operation Difficulty", "Fatigue", and "Miscellaneous" are most frequent. "Seasickness", "Seating Difficulty", "General Operation Difficulty", "Personal Balance-Motility Problems", and "Equipment Displacement" are most frequent at a high sea state.

At a low sea state (See Appendix H for complete coding outline) the most frequent responses are "No Problem", "No Answer", and "Miscellaneous Problems" for the "Equipment Operation Hindered" question. At a

Table 11

Radio Operator Hindered
Open Ended Question

Category	Low Sea State		Medium Sea State		High Sea State	
	Proportion[a]	Rank[d]	Proportion[b]	Rank[d]	Proportion[c]	Rank[d]
1. Seasickness	.16	3	.25	2	.32	1
2. Equipment Displacement	.01	8.5	.12	3	.16	3
3. Personal Balance - Motility Problems	.06	6	.30	1	.24	2
4. Seating Difficulty	.01	8.5	.07	5	.06	5.5
5. Equipment Problem	.09	4	.07	5	.07	4
6. No Problems	.32	1	.05	7.5	.01	9
7. No Answer	.25	2	.07	5	.06	5.5
8. Miscellaneous	.07	5	.05	7.5	.05	7
9. Fatigue	.03	7	.02	9	.03	8

Note --

[a] Proportion based on 69 responses

[b] Proportion based on 84 responses

[c] Proportion based on 103 responses

[d] Categories were ranked from most frequent to least frequent

Table 12

Radio Equipment Operation Hindered

Open Ended Question

Category	Low Sea State		Medium Sea State		High Sea State	
	Proportion[a]	Rank[d]	Proportion[b]	Rank[d]	Proportion[c]	Rank[d]
1. Transmitters Out of Adjustment and Noise	.12	3	.20	1	.23	2.5
2. Antenna Problems	.09	4	.18	2.5	.24	1
3. Equipment Displacement	.01	8	.15	4	.23	2.5
4. Electrical Power Loss	.01	8	.04	7.5	.04	7
5. Equipment Heating	.07	5	.04	7.5	.04	7
6. General Damage to Equipment	.04	6	.07	6	.07	5
7. No Problem	.32	1.5	.14	5	.04	7
8. Miscellaneous Problems	.01	8	.01	9	.02	9
9. No Answer	.32	1.5	.18	2.5	.11	4

Note --

[a] Proportion based on 69 responses

[b] Proportion based on 74 responses

[c] Proportion based on 84 responses

[d] Categories were ranked from most frequent to least frequent

Table 13

Radar Operator Hindered
Open Ended Question

Category	Low Sea State		Medium Sea State		High Sea State	
	Proportion[a]	Rank[d]	Proportion[b]	Rank[d]	Proportion[c]	Rank[d]
1. Seasickness	.11	3	.28	1	.30	1
2. Equipment Displacement	.00	10	.05	6	.06	6
3. Personal Balance-Motility Problems	.00	10	.19	2	.20	2
4. Seating Difficulty	.00	10	.14	3	.14	3
5. Equipment Problems	.05	6	.00	11	.00	11
6. No Problems	.39	1	.02	10	.02	10
7. No Answer	.24	2	.04	8	.03	8.5
8. Miscellaneous	.03	8	.04	8	.05	7
9. Fatigue	.05	6	.12	4	.11	4
10. Radar Scope Difficulty	.05	6	.09	5	.08	5
11. Sea Return	.08	4	.04	8	.03	8.5

Note --

[a] Proportion based on 38 responses

[b] Proportion based on 57 responses

[c] Proportion based on 66 responses

[d] Categories were ranked from most frequent to least frequent

Table 14

Radar Equipment Performance Hindered

Open Ended Question

Category	Low Sea State		Medium Sea State		High Sea State	
	Proportion[a]	Rank[d]	Proportion[b]	Rank[d]	Proportion[c]	Rank[d]
1. Sea Return	.15	3	.29	1	.13	4
2. Antenna Problems	.05	5	.17	2.5	.25	1
3. Equipment Displacement	.00	9.5	.13	4	.15	3
4. Electrical Power Loss	.00	9.5	.06	6	.06	7
5. Equipment Heating	.00	9.5	.00	10.5	.01	10
6. General Damage to Equipment	.05	5	.06	6	.07	5.5
7. No Problem	.33	1.5	.02	9	.00	11
8. Miscellaneous Problems	.03	7	.06	6	.07	5.5
9. No Answer	.33	1.5	.04	8	.04	8
10. Radar Signal Degradation	.05	5	.17	2.5	.16	2
11. Equipment Secured	.00	9.5	.00	10.5	.03	9

Note --

[a] Proportion based on 39 responses

[b] Proportion based on 52 responses

[c] Proportion based on 67 responses

[d] Categories were ranked from most frequent to least frequent

Table 15

Sonar Operator Hindered
Open Ended Question

Category	Low Sea State		Medium Sea State		High Sea State	
	Proportion[a]	Rank[d]	Proportion[b]	Rank[d]	Proportion[c]	Rank[d]
1. Seasickness	.04	6	.26	1	.32	1
2. Equipment Displacement	.00	8.5	.06	8	.07	5
3. Personal Balance-Motility Problems	.00	8.5	.09	6	.12	4
4. Seating Difficulty	.00	8.5	.14	2	.20	2.5
5. General Operation Difficulty	.00	8.5	.11	3.5	.20	2.5
6. No Problems	.40	1	.03	9.5	.00	9.5
7. No Answer	.24	2	.09	6	.00	9.5
8. Miscellaneous	.08	4.5	.03	9.5	.05	6
9. Fatigue	.16	3	.11	3.5	.02	7.5
10. Scope Problems	.08	4.5	.09	6	.02	7.5

Note --

[a] Proportion based on 25 responses

[b] Proportion based on 35 responses

[c] Proportion based on 41 responses

[d] Categories were ranked from most frequent to least frequent

Table 16

Sonar Equipment Operation Hindered
Open Ended Question

Category	Low Sea State		Medium Sea State		High Sea State	
	Proportion[a]	Rank[d]	Proportion[b]	Rank[d]	Proportion[c]	Rank[d]
1. Quenching	.04	4.5	.39	1	.32	1
2. Noise	.00	8	.11	3.5	.10	3
3. Safety Problem	.00	8	.11	3.5	.06	6
4. Sonar Signal Degradation	.00	8	.14	2	.26	2
5. Vibration	.00	8	.00	10	.06	6
6. General Damage to Equipment	.04	4.5	.04	8	.06	6
7. No Problem	.46	1	.07	5.5	.00	9.5
8. Miscellaneous Problems	.12	3	.04	8	.00	9.5
9. No Answer	.33	2	.07	5.5	.06	6
10. Water Problems	.00	8	.04	8	.06	6

Note --

[a] Proportion based on 24 responses

[b] Proportion based on 28 responses

[c] Proportion based on 31 responses

[d] Categories were ranked from most frequent to least frequent

medium sea state "Quenching", "Sonar Signal Degradation", "Noise", and "Safety Problem" are most frequent. "Quenching", "Sonar Signal Degradation", and "Noise" are most frequent at a high sea state.

b. Maintenance questionnaire. Results of the content analysis of open ended questions for the ASW School (sonar equipment) sample are presented in Table 17 and Table 18 for the "Maintainer Hindered" and "Maintenance Required" questions. Complete coding outlines are in Appendix I and Appendix J for the "Maintainer Hindered" and "Maintenance Required" questions. For the "Maintainer" questions at a low sea state, "No Problem", "No Answer", "Equipment Displacement", "Pitch and Roll Conditions", and "Miscellaneous" are most frequent. "Safety Hazards", "Personal Balance-Motility Problems", "Equipment Displacement", and "Pitch and Roll Conditions" are most frequent at a medium sea state. At a high sea state, "Safety Hazards", "Personal Balance-Motility Problems", "Pitch and Roll Conditions", and "Equipment Displacement" are most frequent.

For the "Equipment Maintenance Required" questions at a low sea state, "No Answer", "No Problem", and "General Equipment Damage" are most frequent. "No Answer", "Vibration-Shock Caused Damage", "General Equipment Damage", "Normal Maintenance Problems", and "No Problem" are most frequent at a medium sea state. At a high sea state, "No Answer", "Vibration-Shock Damage", "General Equipment Damage", "Equipment Calibration", "No Problem", and "Topside Equipment Damage" are most frequent.

Results of the content analysis for the ET "C" School subjects (radio and radar equipment) are in Table 19 for the "Maintainer Hindered" question, and Table 20 contains results for the "Maintenance Required" question. Complete coding outlines for the two questions are in Appendix K and Appendix L. At a low sea state, "No Answer", "Personal Balance-Motility Problems", and "No Problems" are most frequent for the "Operator" question. "Personal Balance-Motility Problems", "Equipment Displacement", "Safety Hazards", and "No Answer" are most frequent at a medium sea state. At a high sea state, "Personal Balance-Motility Problems", "Pitch and Roll Conditions", "Safety Hazards", and "No Answer" are most frequent.

For the "Maintenance Required" questions at a low sea state, "No Answer", "Normal Maintenance Problems", "Corrosion-Water Damage", and "No Problem" are most frequent. Most frequent responses at a medium sea state include "Equipment Displacement-Vibration Damage", "No Answer", and "Normal Maintenance Problems." At a high sea state, "No Answer", "Equipment Displacement-Vibration Damage", "Corrosion-Water Damage", and "Antenna Problems" are most frequent.

4. Limitations

The present research presents valuable questionnaire data concerning the effects of sea states on shipboard equipment operation and maintenance. However, the validity of the findings may be somewhat limited by limitations inherent in the questionnaire approach. The data is based on questionnaire responses; no experimental evaluations of the effects of sea states were

Table 17

Sonar Maintainer Hindered

Open End Question Responses

Category	Low Sea State		Medium Sea State		High Sea State	
	Proportion[a]	Rank[d]	Proportion[b]	Rank[d]	Proportion[c]	Rank[d]
1. Seasickness	.00	8	.04	5.5	.05	6
2. Equipment Displacement	.11	4	.22	3	.12	4
3. Personal Balance-Motility Problems	.06	7	.24	2	.19	2
4. Safety Hazards	.09	6	.27	1	.40	1
5. Pitch and Roll Conditions	.11	4	.16	4	.16	3
6. No Problem	.29	1	.00	8	.00	8
7. No Answer	.23	2	.04	5.5	.05	6
8. Miscellaneous	.11	4	.02	7	.05	6

Note --

[a] Proportion based on 35 responses

[b] Proportion based on 45 responses

[c] Proportion based on 43 responses

[d] Categories were ranked from most frequent to least frequent

Table 18

Sonar Maintenance Required
Open End Question Responses

Category	Low Sea State		Medium Sea State		High Sea State	
	Proportion[a]	Rank[d]	Proportion[b]	Rank[d]	Proportion[c]	Rank[d]
1. Normal Maintenance Problems	.06	4	.11	4.5	.05	7.5
2. Topside Equipment Damage	.03	6	.05	6.5	.08	5
3. Vibration-Shock Caused Damage	.00	8.5	.18	2	.21	2
4. General Equipment Damage	.11	3	.13	3	.15	3
5. Equipment Displacement	.00	8.5	.03	8.5	.03	9
6. No Problem	.26	2	.11	4.5	.08	5
7. No Answer	.49	1	.32	1	.28	1
8. Miscellaneous	.03	6	.05	6.5	.05	7.5
9. Equipment Calibration	.03	6	.03	8.5	.03	5

Note --

[a] Proportion based on 35 responses

[b] Proportion based on 38 responses

[c] Proportion based on 39 responses

[d] Categories were ranked from most frequent to least frequent

Table 19

Radio-Radar Maintainer Hindered

Open End Question Responses

Category	Low Sea State		Medium Sea State		High Sea State	
	Proportion[a]	Rank[d]	Proportion[b]	Rank[d]	Proportion[c]	Rank[d]
1. Seasickness	.06	5	.09	5	.05	5.5
2. Equipment Displacement	.00	7.5	.18	2.5	.00	7.5
3. Personal Balance-Motility Problems	.24	2	.32	1	.27	1.5
4. Safety Hazards	.00	7.5	.18	2.5	.18	3.5
5. Pitch and Roll Conditions	.06	5	.05	6.5	.27	1.5
6. No Problems	.18	3	.05	6.5	.00	7.5
7. No Answer	.41	1	.14	4	.18	3.5
8. Miscellaneous	.06	5	.00	8	.05	5.5

Note --

[a] Proportion based on 17 responses

[b] Proportion based on 22 responses

[c] Proportion based on 22 responses

[d] Categories were ranked from most frequent to least frequent

Table 20

Radio-Radar Maintenance Required

Open End Question Responses

Category	Low Sea State		Medium Sea State		High Sea State	
	Proportion[a]	Rank[d]	Proportion[b]	Rank[d]	Proportion[c]	Rank[d]
1. Normal Maintenance Problems	.29	2	.22	2.5	.00	6
2. Corrosion-Water Damage	.12	3	.00	6.5	.20	3.5
3. Antenna Problems	.00	6	.06	4.5	.20	3.5
4. Equipment Displacement/Vibration Damage	.00	6	.44	1	.25	2
5. No Problem	.05	4	.00	6.5	.00	6
6. No Answer	.53	1	.22	2.5	.35	1
7. Miscellaneous	.00	6	.06	4.5	.00	6

Note --

[a] Proportion based on 17 responses

[b] Proportion based on 18 responses

[c] Proportion based on 20 responses

[d] Categories were ranked from most frequent to least frequent

gathered. While the research relies on the ability of subjects to judge the effect of factors that influence their performance, experienced Naval personnel were used as subjects. Another factor that may limit the generality of the findings is the lack of statistical testing of hypotheses. Within the scope of these limitations, the present research extends the available data concerning the effects of sea states on the operation and maintenance of shipboard equipment.

5. Stable Ship Effects

a. Operation questionnaire. Included in the questionnaire was a 5-point rating scale asking if the ship was fully unaffected by all sea states, how much the overall operation of the equipment would be improved. For the samples the overall operation would be somewhat to much improved [RM "B" School ($\bar{X}$ = 2.93, N = 54); RD "B" School ($\bar{X}$ = 3.45, N = 31); ASW School ($\bar{X}$ = 4.08, N = 24)].

b. Maintenance questionnaire. Included in the questionnaire was a 5-point rating scale asking if the ship was fully unaffected by all sea states, how much the overall maintainability of the equipment would be improved. For the samples the overall maintenance of the equipment would be somewhat to much improved [ET "C" School ($\bar{X}$ = 3.38, N = 16); ASW School ($\bar{X}$ = 3.94, N = 34)].

E. CONCLUSIONS

1. Operation Questionnaire

Both operator and equipment performance are increasingly hindered as sea state conditions become rougher. However, most ship operating time is in lower sea states.

The types of problems that hinder radar, radio, and sonar operators can be grouped into problems that hindered all of the operators and problems specific to each type of equipment. Examples of common problems include seasickness, equipment displacement, personal balance-motility problems, seating difficulty, and fatigue. Examples of specific problems include radar scope difficulty and radio interference.

The types of problems that hinder equipment performance include problems common to radar, sonar, and radio equipment and problems specific to each type of equipment. Common problems include equipment displacement. Specific problems include quenching for sonar equipment, radar signal degradation for radar equipment, and transmitter adjustment for radio equipment.

While the rough sea environment has little effect on the stated desire to make a career in the Navy, it has a somewhat greater effect on the desirability of sea duty. Consequently, it would seem that a stable ship, such as a semi-submerged type, would enhance the desirability of shipboard sea duty.

Each of the Operation Questionnaire samples believed that the overall operation of their equipment would be "some" to "much" improved on a completely stable ship.

2. Maintenance Questionnaire

While maintainer performance is increasingly hindered at higher sea state conditions, most ship operating time is at lower sea states. A greater amount of equipment maintenance is also required at higher sea states.

The types of problems that hinder maintainers include problems common to radio-radar maintainers and sonar maintainers. Problems include seasickness, equipment displacement, maneuverability problems, safety hazards, and pitch and roll conditions.

The types of problems that require equipment maintenance include corrosion-water damage, antenna problems, and equipment displacement-vibration problems for radio-radar equipment. Topside equipment damage, vibration and shock damage, and equipment displacement required maintenance of sonar equipment.

Again, for the Maintenance Questionnaire subjects, the rough sea environment has little effect on the desire for a Navy career and a somewhat greater effect on the desirability of shipboard sea duty.

Each of the Maintenance Questionnaire samples believed that the overall maintainability of their equipment would be "some" to "much" improved if placed on a completely stable ship.

F. RECOMMENDATIONS

Based upon results of this limited research, it is recommended that:

1. Research to determine the feasibility of developing stable Navy ships be expanded.

2. Further personnel research be conducted to more accurately assess the effects of unstable ship conditions on personnel and equipment performance and equipment operation and maintenance.

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APPENDIX A

Operation questionnaire

As part of a program [illegible] ship, [illegible] are being administered questionnaires to determine the effects of sea states on shipboard equipment operations.

Answer questions 6 - 29 with reference to your present or last shipboard sea duty ship type.

1. Rating: _____

2. Rate: _____

3. Shipboard Sea Duty

a. Present or last shipboard sea duty:

1. Ship type: ☐ carrier ☐ cruiser ☐ destroyer ☐ amphibious ☐ mine sweep ☐ submarine ☐ auxiliary ☐ other (specify)_____

2. Ship name:

b. Past shipboard sea duty:

Ship Type	Years of Shipboard Sea Duty
Carrier	_____
Cruiser	_____
Destroyer	_____
Amphibious	_____
Mine Sweep	_____
Submarine	_____
Auxiliary	_____
Other (specify) _____	_____

4. How much does the rough sea environment affect the desirability of shipboard sea duty?

☐ very little ☐ little ☐ some ☐ much ☐ very much

5. How important is the rough sea environment to your desire for a career in the Navy?

☐ not important ☐ somewhat important ☐ average importance ☐ above average importance ☐ extremely important

6. Type of equipment: ☐ radar ☐ sonar ☐ radio ☐ other (specify)

_____

7. Your responsibility for equipment: ☐ operate ☐ supervise operator

---

Think of a time when your ship was operating in a light to moderate breeze with one to two foot waves and a smooth to moderate sea state.

8. How much was the operator's performance hindered by this sea state?

☐ very little ☐ little ☐ some ☐ much ☐ very much

9. While operating at this sea state how much time was the operator's performance hindered?

☐ very little ☐ little ☐ some ☐ much ☐ very much

10. What type of problem hindered the operator?

11. How much was the equipment performance hindered at this sea state?

☐ very little ☐ little ☐ some ☐ much ☐ very much

12. While operating at this sea state, how much time was the equipment performance hindered?

☐ very little ☐ little ☐ some ☐ much ☐ very much

13. What type of problem hindered the equipment performance?

14. While operating at sea, how much time was your ship in this sea state?

☐ very little ☐ little ☐ some ☐ much ☐ very much

Think of a time when your ship was operating in a fresh to strong breeze, 4-12 foot waves, and a rough to very rough sea state.

15. How much was the operator's performance hindered by this sea state?

☐ very little ☐ little ☐ some ☐ much ☐ very much

16. While operating at this sea state, how much time was the operator's performance hindered?

☐ very little ☐ little ☐ some ☐ much ☐ very much

17. What type of problem hindered the operator?

18. How much was the equipment performance hindered at this sea state?

☐ very little ☐ little ☐ some ☐ much ☐ very much

19. While operating at this sea state, how much time was the equipment performance hindered?

☐ very little ☐ little ☐ some ☐ much ☐ very much

20. What type of problem hindered the equipment performance?

21. While operating at sea, how much time was your ship in this sea state?

☐ very little ☐ little ☐ some ☐ much ☐ very much

Think of a time when your ship was operating in a moderate to whole gale or storm, 20-40 foot waves, and a high to extremely high sea state.

22. How much was the operator's performance hindered by this sea state?

☐ very little ☐ little ☐ some ☐ much ☐ very much

23. While operating at this sea state, how much time was the operator's performance hindered?

☐ very little ☐ little ☐ some ☐ much ☐ very much

24. What type of problem hindered the operator?

25. How much was the equipment performance hindered at this sea state?

☐ very little ☐ little ☐ some ☐ much ☐ very much

26. While operating at this sea state, how much time was the equipment performance hindered?

☐ very little ☐ little ☐ some ☐ much ☐ very much

27. What type of problem hindered the equipment performance?

28. While operating at sea, how much time was your ship in this sea state?

☐ very little ☐ little ☐ some ☐ much ☐ very much

29. If your ship was fully unaffected by all sea states, how much would the overall operation of this type of equipment be improved?

☐ very little ☐ little ☐ some ☐ much ☐ very much

APPENDIX B

Maintenance Questionnaire

As part of a program to develop better Navy ships, you are being administered questionnaires to determine the effects of sea states on shipboard equipment maintenance.

Answer questions 6 - 26 with reference to your present or last shipboard sea duty ship type.

1. Rating: _____

2. Rate: _____

3. Shipboard Sea Duty

a. Present or last shipboard sea duty:

1. Ship type: ☐ carrier ☐ cruiser ☐ destroyer ☐ amphibious
☐ mine sweep ☐ submarine ☐ auxiliary
☐ other (specify)_____

2. Ship name:

b. Past shipboard sea duty:

Ship Type	Years of Shipboard Sea Duty
Carrier	_____
Cruiser	_____
Destroyer	_____
Amphibious	_____
Mine Sweep	_____
Submarine	_____
Auxiliary	_____
Other (specify) _____	_____

4. How much does the rough sea environment affect the desirability of shipboard sea duty?

☐ very little ☐ little ☐ some ☐ much ☐ very much

5. How important is the rough sea environment to your desire for a career in the Navy?

☐ not important ☐ somewhat important ☐ average importance
☐ above average importance ☐ extremely important

6. Type of equipment: ☐ radar ☐ sonar ☐ radio ☐ other (specify)

_____.

7. Your responsibility for equipment: ☐ maintain ☐ supervise maintenance.

Think of a time when your ship was operating in a light to moderate breeze with one to two foot waves and a smooth to moderate sea state.

8. How much was the maintainer's performance hindered by this sea state?

☐ very little ☐ little ☐ some ☐ much ☐ very much

9. While operating at this sea state, how much time was the maintainer's performance hindered?

☐ very little ☐ little ☐ some ☐ much ☐ very much

10. What type of problem hindered the maintainer?

11. While operating at sea, how much time was your ship in this sea state?

☐ very little ☐ little ☐ some ☐ much ☐ very much

12. How much equipment maintenance was required because of this sea state?

☐ very little ☐ little ☐ some ☐ much ☐ very much

13. What type of problem required maintenance?

Think of a time when your ship was operating in a fresh to strong breeze, 4-12 foot waves, and a rough to very rough sea state.

14. How much was the maintainer's performance hindered by this sea state?

☐ very little ☐ little ☐ some ☐ much ☐ very much

15. While operating at this sea state, how much time was the maintainer's performance hindered?

☐ very little ☐ little ☐ some ☐ much ☐ very much

16. What type of problem hindered the maintainer?

17. While operating at sea, how much time was your ship in this sea state?

☐ very little ☐ little ☐ some ☐ much ☐ very much

18. How much equipment maintenance was required because of this sea state?

☐ very little ☐ little ☐ some ☐ much ☐ very much

19. What type of problem required maintenance?

Think of a time when your ship was operating in a moderate to whole gale or storm, 20-40 foot waves, and a high to extremely high sea state.

20. How much was the maintainer's performance hindered by this sea state?

☐ very little ☐ little ☐ some ☐ much ☐ very much

21. While operating at this sea state, how much time was the maintainer's performance hindered?

☐ very little ☐ little ☐ some ☐ much ☐ very much

22. What type of problem hindered the maintainer?

23. While operating at sea, how much time was your ship in this sea state?

☐ very little ☐ little ☐ some ☐ much ☐ very much

24. How much equipment maintenance was required because of this sea state?

☐ very little ☐ little ☐ some ☐ much ☐ very much

25. What type of problem required maintenance?

26. If your ship was fully unaffected by all sea states, how much would the overall maintainability of the equipment be improved?

☐ very little ☐ little ☐ some ☐ much ☐ very much

APPENDIX C

Radio Operator Coding Outline

1. Seasickness

   Code in this category mention of seasickness, illness or discomfort.

2. Equipment Displacement

   Code in this category mention of flying or sliding objects, picking up or avoiding moving objects, drawers sliding open, objects falling from racks.

3. Personal Balance-Motility Problems

   Code in this category mention of difficulty in moving about, being unbalanced, inability to self-navigate, having to hold on, being bounced around, coordination problems.

4. Seating Difficulty

   Code in this category mention of chairs not remaining stationary, not able to stay seated, not able to stay at equipment position.

5. Equipment Problems

   Code in this category mention of equipment problems not covered by category #2 above. For example, shifts in frequencies, had to shut down equipment.

6. No Problems

   Code in this category responses of "none" or "no problems" or similar responses.

7. No Answer

   Code in this category if subject did not respond with a written answer.

8. Miscellaneous

   Code in this category responses not covered by categories 1-7 above.

9. Fatigue

   Specific mention of being tired or fatigued, but not seasick.

APPENDIX D

Radio Equipment Operation Coding Outline

1. Transmitters Out Of Adjustment and Noise

   Transmitters drifting, unstable. Lose tolerance of transmitter. Unable to keep on frequency, unstable. Out of phase. Equipment picks up noise, oscillations.

2. Antenna Problems

   Specific mention of antenna breaking, clunking. Salt or water on antenna. Wires associated with antenna damaged. Loss of antenna.

3. Equipment Displacement

   Equipment moving, sliding, bounced around, shifting. Drawers opening. Vibration loosens, vibration.

4. Electrical Power Loss

   Loss of electrical power, broadcast. Electrical load dropped.

5. Equipment Heating

   Equipment overheats because air conditioning is secured, shut off. Heat, excess heat. Poor ventilation, overheating.

6. General Damage to Equipment

   Equipment damage; normal electrical, electronic problems; wear and tear on equipment.

7. No Problem

   Specific mention of "no problems." Use of "none." If no response at all code under category 9.

8. Miscellaneous Problems

   Code in this category problems not covered by categories 1-7 above.

9. No Answer

   Code under this category if no written response is given.

APPENDIX E

Radar Operator Coding Outline

1. Seasickness

   Mention of seasickness, illness, or discomfort.

2. Equipment Displacement

   Flying or sliding objects, picking up or avoiding moving objects, drawers sliding open, objects falling from racks, having to secure equipment.

3. Personal Balance-Motility Problems

   Maneuverability difficulty, being unbalanced, balance problems, inability to self-navigate, having to hold on, bounced around, coordination problems.

4. Seating Difficulty

   Chairs not remaining stationary, not able to stay seated, not able to stay at equipment position, poor seating.

5. Equipment Problems

   Mention of equipment problems not covered by category #2 above. For example, equipment calibration, age of equipment.

6. No Problems

   Code in this category responses of "none", "no problems", or "not applicable".

7. No Answer

   Code in this category if no written response is present.

8. Miscellaneous

   Code in this category responses not covered by categories 1-7 and 9.

9. Fatigue

   Code in this category mention of being tired or fatigued, too much time on equipment, shortage of personnel, watches too long, strain on operator.

10. Radar Scope Difficulty

    Difficulty in maintaining plots, getting bearings accurate, affects detection of targets, difficult to work on charts, difficulty in giving marks, maintaining hand logs, contacts not held constantly, difficulty in reading radar scope.

APPENDIX F

Radar Equipment Operation Coding Outline

1. Sea Return

   Sea return, only if no problem mentioned as caused by. Weather, atmospheric conditions.

2. Antenna Problems

   Specific mention of antenna breaking, sea water splashing antenna. Rotation problems, antenna had to be stopped or secured. Antenna useless, stalled.

3. Equipment Displacement

   Equipment moving, sliding, bounced around, shifting, flying objects. Vibration, vibration loosens equipment, jarred loose.

4. Electrical Power Loss

   Loss of electrical power, fuses blown.

5. Equipment Heating

   Equipment overheats because air conditioning is secured. Heat, excess heat, poor ventilation, overheating.

6. General Damage to Equipment

   Equipment damage, down time greater for equipment, equipment falling apart, equipment failures, useless.

7. No Problem

   Specific mention of "no problems", "none." General comments indicating no difficulty. If no written response code under category #9.

8. Miscellaneous Problems

   Problems not covered by other categories.

9. No Answer

   Code under this category if no written response is given.

10. Radar Signal Degradation

    Fluctuation in signal, loss of detection ranges, reduction of detection ranges. False impression picked up, target identification difficult. Radar picks up mostly waves, reduced sensitivity, presentation lost. Track not kept on contact, not good radar contact.

Radar Equipment Operation Coding Outline
(Continued)

X. Equipment Secured

No other problem mentioned.

APPENDIX G
Sonar Operator Coding Outline

1. Seasickness

   Seasickness, illness, discomfort.

2. Equipment Displacement

   Missile hazards, avoiding moving objects, secure equipment.

3. Personal Balance-Motility Problems

   Balance problems, having to hold on, bounced around, coordination problems.

4. Seating Difficulty

   Difficulty in remaining in chair, sitting, having to hang onto chair, strapped in chair.

5. General Operation Difficulty

   Concentration on equipment interrupted, distracted by rolling ship, unable to determine data from console, unable to operate, difficulty gaining or maintaining contact.

6. No Problems

   "No problems", "none", other responses indicating no problems caused by sea state.

7. No Answer

   No written response is present.

8. Miscellaneous

   Responses not covered by other categories.

9. Fatigue

   Tired or fatigues, too much time on equipment, shortage of personnel, watches too long, boredom, drowsiness.

10. Quenching and Noise Effect on Scope

    Quenching of sonar scope, scope blank due to quenching, sea noise, quenching.

APPENDIX H

Sonar Equipment Operation Coding Outline

1. Quenching

   Quenching, quenching effect, equipment quenches.

2. Noise

   Noise interference, excessive sea noise, noise generated in system.

3. Safety Problems

   Safety, safety problems.

4. Sonar Signal Degradation

   Reduced detection range, loss of signal, echo, unable to maintain contact.

5. Vibration

   Vibration

6. General Damage to Equipment

   Wear out equipment, equipment damage.

7. No Problem

   "No problem", "None." General comments indicating no problems.

8. Miscellaneous Problems

   Problems not covered by other categories.

9. No Answer

   No written response.

10. Water Problems

    Not being able to keep water from equipment.

APPENDIX I

Radio-Radar Maintainer Coding Outline

1. Seasickness

   Seasick, irritable, nauseous

2. Equipment Displacement

   Having to keep equipment secured, equipment rolling, sliding.

3. Personal Balance-Mobility Problems

   Unsteady, unbalanced, lose balance, difficulty climbing ladders, carrying equipment, both hands needed for support.

4. Safety Hazards

   Unsafe to open equipment, hazardous conditions, safety hazards.

5. Pitch and Roll Conditions

   Extreme roll conditions, roll, rocking, not able to work under conditions.

6. No Problems

   "No problems", "none".

7. No Answer

   No written response.

8. Miscellaneous

   Comments not covered by above categories.

APPENDIX J

Radio-Radar Equipment Maintenance Coding Outline

1. Normal Maintenance Problems

   Normal maintenance, normal problems, normal equipment failures, natural problems.

2. Corrosion-Water Damage

   Corrosion, sea water in equipment, water, or ice damage.

3. Antenna Problems

   Antenna problems, loss

4. Equipment Displacement-Vibration Damage

   Vibration causes failure, damage, equipment jars, having to secure equipment because of damage, shock problems, equipment breaks loose and is damaged.

5. No Problems

   "No problem", "none."

6. No Answer

   No written response.

7. Miscellaneous

   Comments not covered by above categories.

APPENDIX K

Sonar Maintainer Coding Outline

1. Seasickness

   Seasick, irritable, nauseous.

2. Equipment Displacement

   Movement of equipment, equipment had to be secured, gear and equipment rolls and slides.

3. Personal Balance-Motility Problems

   Unable to stand, thrown into equipment, unsteady, unbalanced, having to support self.

4. Safety Hazards

   Unsafe to open equipment, hazardous conditions, safety hazards, maintenance is dangerous, mention of danger.

5. Pitch and Roll Conditions

   Extreme roll conditions, rolling, rocking, not able to maintain under conditions, general comments about rough conditions causing problems.

6. No Problems

   "None", "no problems." General comments indicating no problems or normal problems only.

7. No Answer

   No written response.

8. Miscellaneous

   Comments not covered by other categories.

APPENDIX L

Sonar Equipment Maintenance Coding Outline

1. Normal Maintenance Problems

   Normal maintenance, normal problems, normal failures, not related to sea state.

2. Topside Equipment Damage

   Topside equipment preservation, repair of topside equipment damage.

3. Vibration-Shock Caused Damage

   Parts coming loose and damaged, components break down because of vibration, shock-vibration inflicted casualties.

4. General Equipment Damage

   System casualties, multiple problems, specific problems not part of normal maintenance.

5. Equipment Displacement

   Equipment sliding, moving, securing equipment.

6. No Problems

   "No problems", "none," "not applicable."

7. No Answer

   No written response.

8. Miscellaneous

   Comments not covered by above categories.

9. Equipment Calibration

   Calibration, adjust circuits.