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ENLISTED MANNING LEVELS AND SHIP PERFORMANCE

Technical Note 76-9 June 1976

ENLISTED MANNING LEVELS AND SHIP PERFORMANCE

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FOREWORD

This study was performed in support of advanced development subproject ZPN01.04, Improved Manpower Utilization.

The invaluable assistance by members of the Fleet Training Group, San Diego--especially LCDR BRICKETT, LCDR JOHNSON and YN1 BEAUSALIEL--greatly facilitated the collection of Refresher Training data.

J. J. CLARKIN
Commanding Officer

SUMMARY

Problem

Manpower and funding for operation and maintenance tend to be in short supply. Thus, there is a need to ensure that manpower allocated to ships is sufficient to meet operational requirements without being in excess of the required levels.

Purpose

This investigation was undertaken to determine the relationship between the operational effectiveness of Navy ships and the manning level of selected enlisted ratings.

Approach

The relationship between manning levels and ship performance was investigated on 105 naval ships over the period from January 1972 to January 1975. Manning levels in the study were expressed as the ratio of the number of personnel allocated to the ships to the number authorized. Scores achieved on final battle problems (FBP) following refresher training were used as the measure of ship performance. Independent variables included in the study were type of ship, paygrade, rating, and function area. Correlation coefficients were computed between manning level and performance for various combinations of the independent variables. These were tested for statistical significance. Kruskal-Wallis one-way analyses of variance were used to evaluate the effect of the major independent variables.

Tests for significance were made at the 0.2 level. This level was used instead of the customary 0.05 level to minimize the chances of a Type II statistical error, i.e., the chances of concluding that manning levels have no effect when, in fact, an effect is present. This conservative approach was felt to be necessary because of the risk of degrading ship performance in the event the Type II error did occur.

Findings

A total of 350 correlation coefficients were computed. Of these, 44 were significant in the positive direction, 41 were significant in the negative direction and 265 were not significant. Results of the Kruskal-Wallis one-way analyses of variance indicate that paygrades of enlisted personnel have a significant effect within the Engineering, Communications, Navigation, and Electronics FBP areas. In general, an increase in the number of personnel in the lower paygrades tends to degrade performance and an increase in the number of personnel in the higher paygrades tends to

improve performance. Ship type and enlisted ratings were found to have slight effects on the relationship between manning levels and FBP scores. CIC was the only functional area in which consistent relationships were not found.

Conclusions

The operational effectiveness of Navy ships, as measured by FBP scores, is affected by the manning level of selected enlisted ratings. Therefore, the hypothesis that ship performance is insensitive (within reasonable limits) to enlisted manning levels should be rejected.

Recommendations

Caution should be used in reducing the manpower allocated to ships, especially in the higher paygrades. To the extent possible, billets in the higher paygrades should not be filled with personnel from lower paygrades (p. 12).

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INTRODUCTION

Problem

Manpower, particularly in the highly skilled ratings, tends to be in short supply. Funding for operation and maintenance likewise is limited. Consequently, there is a need to ensure that manpower allocated to ships is sufficient to meet operational requirements without being in excess of the required levels. If it can be shown that manpower can be reduced (within reasonable limits) without degradation to ship performance, a contribution will have been made to the solution of the manpower and funding problems. Conversely, if it is shown that the operational effectiveness of ships is sensitive to enlisted manning levels, this information would be useful for planners responsible for the manning of ships. Operational effectiveness is defined, for the purpose of this study, as the ship's ability to accomplish its mission in a combat environment.

Objective

The objective of this study is to determine the extent to which the operational effectiveness of Navy ships is affected by manning levels of selected enlisted ratings.

Background

The relationship between manning levels and ship performance was explored in 1969-70 in a methodological study conducted by the Center for Naval Analysis (CNA).[1] The investigation was limited to DD-type destroyers in the Atlantic Fleet. As a measure of ships' performance, CNA used refresher training operational readiness inspection (REFTRA ORI) scores. Refresher training on the DDs covered a period of about 7 weeks, during which time crew members were monitored by experienced observers from the Fleet Training Group (FTG). Key functional areas which were monitored and inspected by these observers included the Combat Information Center (CIC), Navigation, Communications, Engineering, Seamanship, Weapons, Electronics, Antisubmarine Warfare, and Damage Control. Performance was evaluated weekly. At the completion of the training period, the ships received an Operational Readiness Inspection (ORI), which consisted of an operational exercise, final battle problems, and an ASW experience. Ships were given numerical scores in each functional area and a composite or total score. The scores were based on factors such as organization and preparation, mission performance, maintenance of displays, etc.

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[1] Lockman, R. F., Stoloff, P. H., Manheimer, B. H., Hardgrave, J. B., & Story, W. F. Naval readiness analysis system methodology study, Vol I, Study methods and results (Study No. 27). Institute of Naval Studies of the Center for Naval Analysis, January 1970.

In the CNA study, few relationships were found between manning levels and ship performance. This finding has important implications for the problem of manpower allocation aboard Navy ships. If ship performance is generally insensitive (within reasonable limits) to manning levels, then some reduction in manning levels may be possible. Before this assumption can be made, however, the relationship between manning levels and ship performance should be investigated for a representative sample which includes all types of naval ships, not just the DD-type destroyers. This investigation was undertaken in the present study.

Refresher training during the period covered by the present investigation was similar to that evaluated in the CNA study. Each ship conducted its own basic training. However, for more advanced team training, each ship was provided with a customized training package tailored to its mission.[2] This package consisted of (1) a training readiness evaluation (TRE) to establish the initial level of training and equipment status, (2) standard training requirements (STRs) consisting of exercises in specific functional areas such as Engineering and Communications, and (3) final battle problems (FBP), during which the entire ship participated in a simulated battle lasting for a period of 2 to 3 hours. As in the earlier training exercises, crew performance was observed by 30 to 60 skilled FTG instructor/observers. These instructor/observers instructed inexperienced personnel and objectively evaluated the exercises and battle problems.

The FBP served as the final examination at the conclusion of the refresher training period. Its purpose was to test the battle organization of the ship, i.e., the ability of the various departments to function together as a team in simulated combat operations. Since the FBP is the most realistic test of combat readiness that could be devised by the Navy within reasonably fiscal constraints, it represented the best available measure of ship performance during combat. For this reason, the FBP score was selected as the measure of operational effectiveness used in the present study.

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[2] Mumford, S. J. Human resource management and operational readiness as measured by refresher training on Navy ships (NPRDC Tech. Rep. 76-32). San Diego: Navy Personnel Research and Development Center, February 1976. (DDC Availability No. AD A022 372)

APPROACH

The performance of 105 Pacific Fleet ships that underwent refresher training in San Diego from January 1972 to January 1975 was evaluated. Of these ships, 26 underwent refresher training twice during the evaluation period. Since turnover on board naval ships is relatively high, it was decided to use the data from both refresher training exercises. Data acquired during a ship's second exercise was treated as an independent observation. Thus, a total of 131 observations were made.

These observations involved a wide variety of ship types and classes, as shown by Table 1. For the purposes of the evaluation, the ship types listed in Table 1 were classified into four general types: (1) Amphibious ships, (2) Carriers, (3) Destroyers, and (4) Support ships.

Table 1

Number and Type of Ships
Included in the Evaluation

Type	Number	Type	Number
Amphibious Ships		Destroyers	
AE	11 (2)	DD	9
AF	2 (1)	DDG	5
AFS	3 (1)	DE	18
AO	4	DEG	2
AOE	3 (1)	DLG	3
AOR	3 (1)	Total	37
AR	2	Support Ships	
ATF	9 (1)	LKA	5 (1)
Total	37 (7)	LPA	2 (1)
Carriers		LPD	12 (5)
CV	2 (1)	LSD	9 (2)
CVA	11 (5)	LST	14 (3)
CVAN	2 (1)	Total	42 (12)
Total	15 (7)	Overall Total	131 (26)

Note. Number of repeated observations in parentheses.

The functional areas included in the observation and the ratings that impact on these areas are listed in Table 2. Only those ratings which are commonly found on board all four ship types and which have a direct impact on the ship's operational performance were included. A man holding a specific rating, of course, does not have to be assigned directly to a functional area in order to affect the function. For example, the performance of OS personnel in CIC can affect Navigation, etc.

Table 2

Functional Areas and Ratings

Functional Area	Rating
Engineering	MM, EN, MR, BT, EM, HT, FN
Gunnery	GM, FT, BM
CIC	ET, RM, EW, OS
Communications	ET, RM, OS, SM
Navigation	QM, OS
Electronics	ET, RM, OS
Damage Control	MM, EN, MR, BT, EM, HT, BM, FN, SN

To facilitate the evaluation of the relationship between manning levels in specific ratings and ship performance, enlisted personnel, within rates, were combined by paygrades into three separate rate groups. These groups are listed in Table 3.

Table 3

Grouping of Enlisted Personnel
by Paygrades

Rate Group	Paygrade
1. Supervisory[a]	E-6 through E-9
2. Journeyman	E-4 and E-5
3. Apprentice	E-2 and E-3

[a]Since enlisted personnel in the E-6 paygrade generally exercise a strong supervisory role, it was decided to consider them as part of the supervisory group.

Manning level was expressed as the ratio of the number of people assigned within a rate group to the number authorized for that rate group. To compute this ratio, data was extracted from the most current (relative to the FBP date) quarterly Enlisted Distribution and Verification Report (BUPERS Report 1080-14). Ship performance was measured by scores received in the FBP for the functional areas listed in Table 2. Correlation coefficients were then computed between manning level and FBP score for various combinations of ship type, functional area, rating, and paygrade.

Tests of significance were made at the 0.2 level. Thus, if the statement is made that ship performance is sensitive to enlisted manning levels, we would expect that the odds could be as large as 2 out of 10 that our statement is in error (Type I statistical error). This level was selected, rather than the customary 0.05 level (expecting to be in error 5 times out of 100), to reduce the chance of a Type II statistical error, i.e., concluding that ship performance is not sensitive to enlisted manning levels when, in fact, ship performance is sensitive to enlisted manning levels.

The rationale for reducing the chance of a Type II statistical error is based on an assessment of the probable actions that might result from the conclusions obtained in this study and the relative costs or gains for accurate and inaccurate conclusions. Table 4 summarizes the two alternative conclusions that could be made and the costs or gains associated with the accuracy of these conclusions.

Table 4

Potential Outcomes on Operational Effectiveness of
Decisions Based on Correct and Incorrect Correlations

Conclusion	Accuracy of Conclusion	
	Correct	Incorrect
Ship performance sensitive to enlisted manning level	+	0 (Type I error)
Ship performance insensitive to enlisted manning level	0	- (Type II error)

If it is concluded that ship performance is sensitive to enlisted manning levels, this would indicate to Navy planners that (1) certain rates are especially critical for operational effectiveness and should be maintained at a high manning level, (2) an optimum billet configuration may be devised for each ship based on a criteria of operational effectiveness, and (3) if manning must be reduced, reduction in certain identified rates would have a minimal impact on operational effectiveness. If, then, this conclusion is correct and these (or similar) actions were taken, the Navy would benefit by improving its operational readiness posture. If, however, the conclusion is incorrect (Type I error), operational readiness would not be affected since, in fact, operational effectiveness is insensitive to enlisted manning levels.

On the other hand, if it is concluded that ship performance is insensitive to enlisted manning levels, Navy planners would have a basis for reducing enlisted manning levels or substituting lower paygrade personnel in higher paygrade billets. Given a correct conclusion, these or similar actions would not affect the operational effectiveness of the ship. However, if the conclusion is incorrect (Type II error), it is likely that operational effectiveness would be degraded if these actions were taken. Therefore, the greatest cost to the Navy is associated with Type II errors.

A total of 350 correlation coefficients were computed and tested for significance. An additional step was necessary to determine if the obtained relationships between manning levels and ship performance could be systematically attributed to functional area, ship type, rating, or paygrade. Kruskal-Wallis one-way analysis of variance[3] was performed using the correlation coefficients converted to ranks as the dependent variable and functional area, ship type, rating, and paygrade as separate independent variables in the ANOVAs.

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[3] Siegel, S. Nonparametric statistics. New York: McGraw-Hill, 1956.

FINDINGS

The correlation coefficients between manning levels (ratio of the number of personnel allocated to number authorized) and ship performance (FBP score) are presented in Table 5. The correlation coefficients were tested for significance at the 0.2 level, and those which differed significantly from zero are marked by an asterisk. Of the 350 coefficients in the table, 44 are positively significant, 41 are negatively significant, and 265 are not significant. The figures in parentheses in Table 5 are the sample size for the correlation coefficients. Variations in sample size are due to either no authorized personnel in a particular rate group or no FBP score in a specific functional area.

Table 5 shows that the relationship between the enlisted manning level of a rate group and FBP score, within specific functional areas, ship types, and paygrades vary from -.98 (CIC, EW, Amphibious ships, E2-3) to .53 (Engineering, HT, Destroyers, E6-9). It is not clear, from an inspection of Table 5, if systematic trends exist that would clarify the effect of functional area, rating, ship type, and paygrade on the manning level--performance relationship.

To explore the possibility of finding systematic relationships and to extend the generality of the findings reported in Table 5, the Kruskal-Wallis one-way analysis of variance procedure was used. The correlation coefficients reported in Table 5 were converted to ranks (i.e., -.98 = 1 to .58 = 350), and a series of nonparametric analyses of variance were performed, both across and within functional areas. The results of these analyses are reported in Table 6. The stastic value (H) reported in Table 6 has been corrected for tied ranks when this procedure would produce a substantive effect on the test of significance.

As shown by Table 6, no systematic effects on the relationship between enlisted manning levels and FBP scores are observed for functional area, ship type, and paygrade across functional areas. However, such effects are observed for enlisted ratings. Table 7 reports the mean correlations (using r to z transformations) for the 17 enlisted ratings in this study. The mean correlations found for EM (.10), HT (.11), GM (.13), FN (-.15), EW (-.28), and SN (-.15) are relatively larger than those found for the remaining ratings. These correlations suggest that increasing the manning level of EM, HT, and GM ratings has a positive effect on FBP scores, while increasing the FN, EW and SN manning levels has an overall negative effect.

Table 5

Correlations Between FBP Scores and Manning Levels, and (Sample Sizes)

Functional Areas	Ratings	Carriers			Destroyers			Amphibious Ships			Support Ships		
		E2-3	E4-5	E6-9	E2-3	E4-5	E6-9	E2-3	E4-5	E6-9	E2-3	E4-5	E6-9
Engineering	MM	-.19 (13)	.02 (13)	-.05 (13)	-.28* (37)	-.11 (37)	.09 (37)	.10 (28)	-.16 (28)	-.33* (28)	.04 (28)	.18 (29)	.08 (28)
	EN	-.06 (12)	.42* (13)	.01 (13)	-.24 (25)	.26* (37)	.13 (33)	.12 (39)	-.14 (42)	.07 (42)	.19 (35)	-.06 (37)	-.20 (35)
	MR	-.45* (13)	.25 (13)	-.44* (13)	-.29 (10)	.22 (35)	.40* (13)	.10 (18)	.06 (40)	-.11 (31)	-.23 (14)	.38* (27)	-.20 (10)
	BT	-.41* (13)	.28 (13)	.22 (13)	-.28* (36)	.28* (37)	-.07 (37)	-.37* (31)	.12 (42)	-.19 (30)	-.13 (27)	.30* (28)	.10 (28)
	EM	.49* (13)	.08 (13)	.28 (13)	-.35* (37)	.05 (37)	.39* (37)	.00 (42)	.29* (42)	-.16 (42)	.07 (37)	.00 (37)	.19 (37)
	HT	.28 (13)	.44* (13)	.10 (13)	.08 (36)	-.05 (37)	.53* (36)	-.29* (40)	.40* (42)	-.03 (42)	-.05 (35)	.27* (37)	.09 (36)
	FN	-.44* (13)	-- --	-- --	.11 (37)	-- --	-- --	-.19 (42)	-- --	-- --	-.14 (37)	-- --	-- --
Gunnery	BM	-- --	.27 (15)	.02 (15)	-- --	-.18 (37)	-.14 (37)	-- --	.27* (42)	-.11 (42)	-- --	.16 (36)	-.03 (36)
	GM	.44* (13)	.39* (15)	.35 (15)	-.09 (34)	.37* (37)	-.12 (37)	.06 (42)	.00 (42)	.20 (41)	.06 (27)	-.16 (36)	.03 (27)
	FT	.14 (9)	.45* (14)	-.39* (13)	.27* (36)	-.16 (37)	-.18 (37)	.04 (37)	-.30* (42)	.27* (32)	.14 (24)	-.06 (27)	.33* (18)
CIC	OS	.08 (15)	-.04 (15)	-.03 (15)	.07 (37)	-.14 (37)	.19 (37)	.01 (42)	.04 (42)	-.06 (42)	.37* (28)	.08 (30)	.13 (29)
	EW	.12 (14)	-.02 (15)	-.37* (15)	.32 (11)	.13 (37)	-.24* (35)	-.98* (4)	.47* (12)	-.31 (8)	-- --	-.58 (3)	-- --
	RM	.12 (15)	.11 (15)	-.09 (15)	-.08 (37)	.19 (37)	-.08 (37)	-.06 (42)	-.36* (42)	.22* (42)	-.15 (30)	.03 (30)	.11 (29)
	ET	.38* (15)	-.36* (15)	.37* (15)	.09 (37)	.05 (37)	-.13 (36)	.09 (33)	-.26* (42)	.10 (41)	.11 (25)	.20 (30)	.02 (25)

Note. Sample sizes in parentheses.
* $p \leq 0.20$ (two-tailed test)

Table 5 (Continued)

Functional Areas	Ratings	Carriers E2-3	Carriers E4-5	Carriers E6-9	Destroyers E2-3	Destroyers E4-5	Destroyers E6-9	Amphibious Ships E2-3	Amphibious Ships E4-5	Amphibious Ships E6-9	Support Ships E2-3	Support Ships E4-5	Support Ships E6-9
Communications	SM	-.16	-.07	-.12	.27*	-.14	-.13	.19	-.04	-.04	.11	-.02	-.13
		(15)	(15)	(15)	(31)	(36)	(37)	(41)	(42)	(42)	(34)	(36)	(27)
	RM	.04	-.16	.16	-.11	-.15	-.33*	.29*	-.30*	.16	-.29*	-.10	-.05
		(15)	(15)	(15)	(37)	(37)	(37)	(42)	(42)	(42)	(36)	(36)	(34)
	ET	.19	-.48*	-.03	.27*	-.24*	.08	-.17	.09	.07	.03	.06	.14
		(15)	(15)	(15)	(37)	(37)	(36)	(33)	(42)	(41)	(26)	(36)	(31)
	OS	.38*	-.46*	.12	-.21	-.39*	.42*	.11	-.10	.29*	-.04	-.16	-.06
		(15)	(15)	(15)	(37)	(37)	(37)	(42)	(42)	(42)	(30)	(36)	(31)
Navigation	QM	.23	-.02	-.26	-.17	.07	.12	-.05	-.04	-.04	-.01	-.23*	-.03
		(14)	(14)	(14)	(25)	(37)	(37)	(41)	(42)	(42)	(34)	(37)	(37)
	OS	.34	-.41*	.30	.07	-.10	.26*	.20*	-.01	.36*	-.20	-.19	.02
		(14)	(14)	(14)	(37)	(37)	(37)	(42)	(42)	(42)	(30)	(37)	(32)
Electronics	ET	-.14	-.53*	.04	-.24*	-.01	.04	-.33*	.05	.23*	-.33*	-.01	.31*
		(15)	(15)	(15)	(37)	(37)	(36)	(33)	(42)	(41)	(25)	(27)	(23)
	RM	-.48*	.17	.37*	-.19	-.01	.02	.02	-.05	.05	-.36*	-.02	-.21
		(15)	(15)	(15)	(37)	(37)	(37)	(42)	(42)	(42)	(27)	(27)	(27)
	OS	-.32	-.20	-.04	.06	-.04	.19	.09	-.03	.00	-.08	-.07	.37*
		(15)	(15)	(15)	(37)	(37)	(37)	(42)	(42)	(42)	(26)	(27)	(27)
Damage Control	MM	.05	-.20	.10	-.11	-.13	.00	-.08	.02	-.23	.04	.03	.13
		(15)	(15)	(15)	(37)	(37)	(37)	(28)	(28)	(28)	(28)	(29)	(28)
	EN	-.16	.46*	-.19	-.03	-.30*	-.09	.00	-.35*	.04	-.04	-.06	-.06
		(14)	(15)	(15)	(25)	(37)	(33)	(39)	(42)	(42)	(35)	(37)	(35)
	MR	.11	.22	-.20	-.45*	-.18	-.27	-.14	.29*	-.03	.03	.09	.15
		(15)	(15)	(15)	(10)	(35)	(13)	(18)	(40)	(31)	(14)	(27)	(10)
	BT	.10	-.22	-.22	.05	.13	-.20	-.15	-.03	-.23	-.10	.10	-.12
		(15)	(15)	(15)	(36)	(37)	(37)	(31)	(42)	(30)	(27)	(28)	(28)
	EM	.17	.24	.15	-.14	.13	.06	.03	.19	.22*	.00	.08	-.09
		(15)	(15)	(15)	(37)	(37)	(37)	(42)	(42)	(42)	(37)	(37)	(37)
	HT	.18	-.03	-.16	-.02	.18	.16	-.27*	.32*	.12	.09	-.05	.27*
		(15)	(15)	(15)	(36)	(37)	(36)	(40)	(42)	(42)	(35)	(37)	(36)
	BM	--	.10	-.06	--	-.37*	.12	--	.02	.03	--	-.31*	.04
		--	(15)	(15)	--	(37)	(37)	--	(42)	(42)	--	(37)	(37)
	FN	-.56*	--	--	.15	--	--	-.20	--	--	.14	--	--
		(15)	--	--	(37)	--	--	(42)	--	--	(37)	--	--
	SN	-.56*	--	--	.04	--	--	-.22*	--	--	.19	--	--
		(15)	--	--	(37)	--	--	(42)	--	--	(37)	--	--

Note. Sample sizes in parentheses.
* $p \leq 0.20$ (two-tailed test)

Table 6

Kruskal-Wallis One-Way Analyses of
Variance Across and Within Functional Areas

Source	df	H	Test of Significance[b]
Across Functional Areas			
Functional Area	6	6.89	
Ship Type	3	1.06	
Rating	16	23.47	S
Paygrade	2	2.78	
Within Functional Areas			
Ship Type Within:			
Engineering	3	1.67	
Gunnery	3	5.69	S
CIC	3	1.42	
Communications	3	2.57	
Navigations	3	2.49	
Electronics	3	2.55	
Damage Control	3	1.92	
Rating Within:			
Engineering	6	7.73	
Gunnery	2	1.29	
CIC	3	1.50	
Communications	3	1.15	
Navigation	1	1.77[a]	S
Electronics	2	.23	
Damage Control	8	11.98	S
Paygrade Within:			
Engineering	2	14.19	S
Gunnery	2	1.49	
CIC	2	1.19	
Communications	2	10.20	S
Navigation	2	4.16	S
Electronics	2	11.78	S
Damage Control	2	1.23	

[a]Corrected for ties.

[b]S = $p \leq 0.20$

Table 7

Mean Correlation Between Manning Level and FBP Scores by Rating

Rating	$\bar{r}$	Rating	$\bar{r}$
MM	-.04	BM	-.01
EN	-.01	GM	.13
MR	-.03	FT	.05
BT	-.05	EW	-.28
EM	.10	RM	-.05
HT	.11	ET	-.01
FN	-.15	OS	.03
		SM	-.02
		QM	-.04
		SN	-.16

A significant effect due to ship type was observed within the Gunnery functional area (Table 6). Table 8 presents mean correlations within this functional area for the four ship categories. Since the GM, FT, and BM ratings impact on this area (Table 2), it appears that Gunnery FBP performance of Carriers is sensitive, overall, to manning levels in these ratings, and that Gunnery FBP scores for the other three ship types are not.

Table 8

Mean Correlation Between Manning Level and Gunnery FBP Scores by Ship Type

Ship Type	$\bar{r}$
Carrier	.22
Destroyer	-.03
Amphibious Ships	.05
Support Ships	.06

Significant effects due to ratings were found within the Navigation and Damage Control functional areas. Table 9 reports the mean correlations associated with these findings. As shown, within Navigation, the mean correlations for both the OS and QM ratings are slight; the significant effect shown in Table 6 was caused by the reversal in the direction of the relationships (positive for OS and negative for QM). Within Damage Control, the most pronounced effect appears to be the negative relationship between the manning level of FN and SN personnel and Damage Control FBP scores.

Table 9

Mean Correlation Between Manning Level and Navigation, and Damage Control FBP Scores by Rating

Rating	$\bar{r}$
Navigation	
OS	.05
QM	-.04
Damage Control	
MM	-.03
EN	-.06
MR	-.03
BT	-.08
EM	.09
HT	.07
BM	-.06
FN	-.14
SN	-.16

Significant effects due to paygrade were observed within Engineering, Communications, Navigation, and Electronics. Table 10 reports the mean correlations associated with these findings. Engineering FBP performance appears to be enhanced by increasing levels of journeyman (E4-5) personnel but degraded by increasing levels of apprentice (E2-3) personnel. The most dominant effect in the Communications and Navigation functional areas appears to be a degregation of FBP performance with increasing levels of journeyman (E4-5) personnel. The manning levels of apprentice (E2-3) and supervisory (E6-9) personnel, overall, appears to have a slight positive effect on Communications and Navigation FBP scores. In the Electronics functional area, increased manning at the apprentice (E2-3) and, to some extent, at the journeyman (E4-5) levels appears to degrade performance; but increased manning at the more skilled supervisory level (E6-9) enhances it.

Table 10

Mean Correlation Between Manning Level and Engineering, Communications, Navigation, and Electronics FBP Scores by Paygrade

Functional Area	E2-3	E4-5	E6-9
Engineering	-.10	.16	.04
Communications	.06	-.17	.04
Navigation	.05	-.12	.09
Electronics	-.20	-.07	.12

DISCUSSION

The objective of the present study, as stated earlier, was to determine if manning levels (within reasonable limits) have an effect on ship operational effectiveness. Based on the results of the earlier CNA study, there appeared to be a good chance that some reduction in manning levels could be accomplished if it could be shown that ship performance was relatively insensitive to manning levels. Results of the present study, however, do not support this general hypothesis. Manning levels within Engineering, Communications, Navigation, Electronics, and Damage Control functional areas were found to have a significant effect on their FBP scores. Specifically, manning levels at different paygrades had a significant effect on Engineering, Communications, Navigation, and Electronics FBP scores, and manning levels for different ratings had a significant effect on Navigation and Damage Control FBP scores. One must, therefore, reject the hypothesis that ship performance is insensitive to manning levels. In view of this finding, it is apparent that a great deal of caution should be exercised in reducing manning below authorized levels at the higher paygrades.

The strongest, most systematic effect found in this study was the impact of paygrade on specific FBP scores. It appears that increasing the manning level of personnel in the lower paygrades is detrimental to FBP performance, while increasing the manning level of personnel in the higher paygrades tends to improve FBP performance. These results, however, are affected by functional area and the operative skill level (paygrade) for the specific functional area. For example, within Engineering, the operative skill level might be considered to be at the E4-5 level. Increasing the manning level at this level is associated with improved Engineering FBP performance, but increasing the manning level at the lower level (E2-3) is associated with decreased FBP performance. In the more technical areas of Communications, Navigation, and Electronics, the operative skill level is most likely E6 and higher, with the result that increased manning levels at the E4-5 paygrades is associated with a decrement in FBP performance.

Within Damage Control, paygrade did not have a significant effect but enlisted ratings did have a significant effect. Of the mean correlations reported in the text, those for FN and SN were the most devient from the others, and both were negative. These findings could also be interpreted in terms of the operative skill level for a functional area since the FN and SN ratings are those individuals who are in the lowest paygrades (in this study defined as E2-3) and who are not formally striking for a specific rating. Therefore, FN and SN ratings would fall below the probable operative skill level in the Damage Control functional area.

It should be emphasized that the findings reported in this study are based on historical data using a relatively short-term simulation of battle conditions as the measure of ship performance. It is inappropriate to extend these results to the long-term performance of a ship occurring over the course of a typical deployment or extended hostile engagement.

It might be hypothesized, however, that the impact of manning levels would become more pronounced if long-term performance measures are used. For the short-term battle simulation used in this study, it is possible that the ship's crew could be sufficiently motivated and managed to adequately meet the demands of the simulated exercise, especially when one considers that it occurs at the end of an intensive training period where all efforts are focused on upgrading skills and teamwork. On the other hand, performance over a longer time frame might be more affected by manpower shortages due to the effects of fatigue, decrements in motivation, increased requirements for sound leadership and management of personnel resources, and less flexibility to maintain and upgrade critical skills.

An additional impediment to extending these results is the fact that although the study did make use of historical data which is sufficient for the present purpose, the lack of experimental rigor makes it impossible to quantify with great accuracy the long-range effect of various manning structures aboard ships. Such factors as training level, experience, work assignments of specific rates, interactive manning postures, and appropriateness of manpower authorizations were not examined. To approach a definitive answer to the question of manning level impacting on performance, much more stringent control would be required in the experimental design.

Finally, this study focused entirely on the operational performance of the ship. It did not consider, for example, the maintenance, administrative, or support functions aboard the ship. Nor did it consider the impact of manning level on the satisfaction, motivation, or training of enlisted personnel.

CONCLUSIONS

It is concluded on the basis of the findings in this study that ship performance is affected by enlisted manning levels. Performance tends to be adversely affected by increasing the number of personnel in the lower paygrades while decreasing the number at the higher paygrades. The relationship between manning levels and performance is slightly affected by the ship type and enlisted rating.

RECOMMENDATIONS

It is recommended that caution be used in reducing manpower allocated to ships, especially in the higher paygrades. To the extent possible, billets in the higher paygrades should not be filled with personnel in the lower paygrades.