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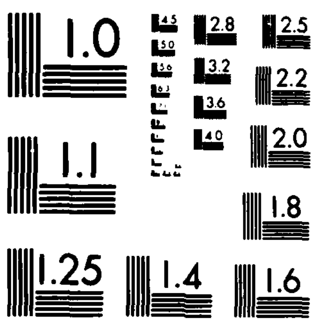

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# THE INTERRELATIONSHIP OF PERSONNEL LOSSES, PROMOTIONS, TOUR LENGTHS, AND NAVY MANNING

NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER
SAN DIEGO, CALIFORNIA



NAVY PERSONNEL RESEARCH
AND
DEVELOPMENT CENTER
San Diego, California 92152

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# THE INTERRELATIONSHIP OF PERSONNEL LOSSES, PROMOTIONS, TOUR LENGTHS, AND NAVY MANNING

Stephen W. Sorensen
Dudley E. Cass

Rehab Group, Inc.
San Diego, California 92106

Reviewed by
Thomas A. Blanco

Released by
James F. Kelly, Jr.
Commanding Officer

Navy Personnel Research and Development Center
San Diego, California 92152

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The objective of this report is to document efforts to develop and verify the theoretical interrelationships of losses, promotions, and tour lengths and their impact on Navy manning by pay grade and duty type. Theoretical models were developed for rotation, average tour length, and manning. Cohort analysis using longitudinal data for the boiler technician (BT) rating was applied to verify the theory. Cohorts were defined as populations entering either a new pay grade or duty type.

Results showed that two major cohorts--promotions-in and rotations-in--for a pay grade/duty type have significantly different survival behavior patterns and comprise unequal proportions of manning. Average tour length was verified to be a function of assigned tour length and the continuation rate. Sea tour lengths longer than 3 years did not increase sea manning at the pay grade for which the tour was assigned but did impact sea manning at the next higher pay grade. Results clearly indicate that any sea-shore rotation model must include the effects of promotions and losses.

## FOREWORD

This research and development was performed in support of Navy decision coordinating paper Z1186-PN (Impact of Fleet Configuration on Requirements for Support Manpower), subproject Z1186-PN.08 (Manpower Utilization), under the sponsorship of the Deputy Chief of Naval Operations (Manpower, Personnel, and Training). The objective of this subproject is to conduct a systematic assessment of the feasibility and impact of alternative maintenance/assignment strategies on manpower utilization.

This report describes an initial attempt to quantify the interrelationships of personnel losses, promotions, and tour lengths, and their impact on Navy manning by pay grade and duty type. This effort identified rotation resource tradeoffs and showed that, to develop a realistic sea-shore rotation model, promotion and loss flows are as important as rotation flows. Further work is needed to quantify the effects of large changes in tour lengths or promotion flow points, which cause shifts along the length of service (LOS) dimension.

The contracting officer's technical representative was Mr. Thomas A. Blanco.

JAMES F. KELLY, JR.
Commanding Officer

JAMES W. TWEEDDALE
Technical Director

# SUMMARY

## Problem

Tradeoff analysis of sea-shore rotation involves more than just proportional adjustments to tour lengths. The interrelations of losses, promotions, and tour lengths are complex; and their impacts on Navy manning (personnel levels), not easily understood. Previous attempts to model sea-shore rotation have generally proved unsatisfactory, either because their underlying theory was too simplistic or because of excessive data requirements.

Since the recent development of the survival tracking file (STF), cohorts of individuals can be identified and tracked to obtain detailed information on their survival, attrition, promotion, and rotation over time. This information can then be used as the basis for the formulation and verification of the primal interrelations involved in rotation/manning tradeoff analysis.

## Purpose

The purposes of this effort were to develop and verify the theoretical interrelationship of losses, promotions, and tour lengths and determine their impact on manning by pay grade and duty type.

## Approach

Theoretical models were developed for rotation, average tour length, and manning (by duty type/pay grade). Cohort analysis, using longitudinal data from the boiler technician (BT) rating, was then applied to verify the theoretical models. Cohorts were defined as populations entering either a new pay grade or duty type. Longitudinal aspects were measured based on time in a cohort rather than on length of service (LOS). Finally, a cohort-based single pay grade sea-shore rotation model was developed to analyze tradeoffs of rotations-in vs. promotions-in to a pay grade/duty type.

## Results

Results showed that the two distinct cohorts for each duty type and pay grade, promotions-in and rotations-in, have different survival behavior. Also, for many pay grades and duty types, promotions-in comprise the majority of manning. For example, for BT E-5 sea manning, promotions-in make up over 80 percent of the total man-years.

Average tour length was found to be a function of the assigned tour length and continuation (surviving population after attrition and promotion). The lower the continuation rate, the lower the average tour length for a given assigned tour length. Because of low continuation rates for BTs in the lower pay grades (E-6 and below), sea tour lengths longer than 3 years did not significantly increase sea manning at the pay grade for which the tour was assigned, but did impact sea manning at the next higher pay grade.

The theoretical formulas for average tour lengths and manning by pay grade and duty type were verified using longitudinal data for BTs. Results showed that the formulas were valid for each pay grade and duty type (E-4 and above).

## Conclusions and Future Direction

Longitudinal data from the STF can be used to assess the tradeoffs in manning by pay grade and duty type and to estimate the effects of changes in losses, promotions, and tour lengths. In developing a realistic sea-shore rotation model to estimate Navy manning by pay grade and duty type, promotion and loss flows are as important as rotation flows.

The cohort-based single pay grade sea-shore rotation models were useful to identify rotation resource tradeoffs, but further work is needed to quantify the effects of large changes in tour lengths or promotion flow points, which cause shifts along the LOS dimension. Such shifts may result in different survival rates, average tour lengths, and input flows for individual cohorts. Therefore, the next step in developing a useful sea-shore rotation model is to explore the LOS dimension of losses, promotions, and type duty distribution.

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# INTRODUCTION

## Problem

In the past, sea tour lengths have been calculated by multiplying the shore tour length by the ratio of sea billets to shore billets at each pay grade.[1] Recent theoretical work by Sorensen (1982) demonstrated that this calculation is not meaningful in the presence of attrition and promotion. Within a Navy enlisted occupation (rating), promotions into a pay grade and duty type (sea-shore) make up a significant part of manning (personnel level). This factor is ignored by the manning ratio calculation method described above.

## Background

Although it has been known for some time that sea-shore rotation tradeoffs require more than simple proportional adjustments to tour lengths, the interrelationship of losses, promotions, and tour lengths and their impact on Navy manning are complex and not easily understood. In the past, sea-shore rotation models have been developed at various levels of aggregation and with different, often conflicting, assumptions. Generally, these models have not been operationally employed, often because data requirements were too large and cumbersome or because the model assumptions produced results that were clearly wrong.

A major reason for the lack of a useful sea-shore rotation model has been the lack of a longitudinal personnel data base. Previous models captured personnel flow behavior by using extracts from snapshots of the enlisted master record (EMR). EMR-based analysis could only work with aggregated groups of individuals and project a population into the future by applying transition rates. However, since the recent development of a survival tracking file (STF) (Gay & Borack, 1981, 1982), which contains longitudinal data from the EMR on each individual in the Navy from September 1977, cohorts of individuals can be identified and tracked to obtain detailed information on survival, attrition, promotion, and rotation over time.

Table 1, which compares previous models of sea-shore rotation, shows that they differ from each other as to the level of aggregation, the assumption of steady state, the use of loss and promotion rates, and the inclusion of a length of service (LOS) dimension. One purpose of the current work was to obtain information on the validity of model assumptions.

## Objectives

The objectives of this effort were to develop a single pay grade sea-shore rotation tradeoff model that considers the interrelationships of losses, promotions, and tour lengths and to validate the model calculations of personnel levels by pay grade and duty type using longitudinal data.

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[1]Billets are positions or jobs, whether encumbered or not. Billets may be constrained by funding limitation or berthing constraints or both. The calculation can be used for either constrained or unconstrained billets.

Table 1

Comparison of Rotation Models

| Study | Level of Aggregation | Steady-state | Losses and Promotions | LOS Dimension |
|---|---|---|---|---|
| Rantschler (1974) | Linked regions, linked pay grades | Yes | Yes[a] | No |
| Rowe and Smith (1978) | All-Navy, one pay grade | Yes | No | No |
| Borgen, Segal, and Thorpe (1972) | All-Navy, one pay grade | Yes | Yes[b] | No |
| Butterworth (1973) | All-Navy, linked pay grades | Yes | Yes[c] | No |
| Waterman, Maurer, and Huntzinger (1979) | All-Navy, linked pay grades | Yes | Yes[d] | No |
| Maurer (1979) | All-Navy, by pay grade and LOS | Projection | Yes[e] | Yes |
| Blanco, Liang, and Sorensen (1982) | Linked regions, linked pay grades | Yes | Yes[d] | Partial |

[a]Losses occur only at the end of a tour. Promotions occur during a tour. No real data used.

[b]Losses occur only from sea. Promotions occur at the end of a tour. This is the traditional rotation model.

[c]Loss and promotion rates are persons per month rather than a fraction of the population. No real data used.

[d]Losses and promotions in these studies (and in current study) treated identically; the rates are a fraction of the population per time.

[e]Continuation rate has an LOS dimension. The model projects the current Navy population forward.

## APPROACH

### Underlying Theory

#### Average Tour Length

Originally, the theoretical models were developed by considering the effect of continuation rate, c, on rotation. If a is the annual net loss rate from a pay grade and p is the annual promotion-in rate, then $c = 1 - p - a$ when a, p, c are fractions of the population. Assume that c is uniform throughout the pay grade and constant over time, and that I is the number of individuals who rotate to sea each year in the pay grade. Then, the number of individuals who rotate out at the end of the assigned sea tour, T, is

$$R = Ic^T .$$

This formula results from considering the individuals I over the tour. At the end of the first year of the tour, only Ic individuals remain in the cohort since Ia individuals attrited and Ip individuals were promoted. At the end of the second year, only $Ic^2$ individuals remain, and so on.

Based on these ideas, a formula can be derived for the average tour length actually served in the pay grade by the individuals I. The formula (whose derivation is described in Appendix A) is

$$T_{avg.} = \frac{c^T - 1}{\log c} .$$

Using this formula, the total manning for a steady-state situation when I individuals are input each year is

$$\text{Manning} = I \; T_{avg}.$$

If no attrition or promotion occurs, the average tour length equals T and manning is I times T. These are the expectations underlying the traditional proportional sea-shore rotation models.

A Simple Rotation Model

The model calculates manning by equating the flows into and out of each duty type for each pay-grade group:

Input = Promotions-in + Rotations-in

Output = Promotions-out + Rotations-out + Losses.

Losses were expressed as a constant annual attrition rate times the manning level at a pay grade and duty type. Promotions-in and promotions-out were calculated to fill vacancies due to losses for all pay grades (i.e., losses at higher pay grades filtered down to impact lower pay grades). Rotations-out were estimated from the continuation rate and tour length. The number of individuals left to rotate after a tour of length T is the input times $c^T$ where c is the continuation rate. Rotations-in were the rotations-out from the other duty types.

This model assumes that promotion rate, attrition rate, and continuation rate apply uniformly to the entire population of the pay grade and duty type. However, the input consists of two distinct cohorts, promotions-in and rotations-in. These cohorts may not have the same promotion rates, attrition rates, and continuation rates.

Implications

The simple rotation model discussed above has a major implication regarding the sources of manning. If an individual rotates to sea at pay grade E-5 and is promoted to E-6 during the tour, then, after promotion, that individual is counted in the sea manning at E-6, not at E-5.

It is important to understand that, although enlisted personnel are assigned to units, not billets, the shortages and overages in the billet manning for each unit are compared with Navy-wide shortages and overages. If a unit is short an E-5 in the rating relative to other units in the Navy, then an E-5 individual will be assigned to that unit (after consideration of personal wishes, permanent change of station (PCS) costs, and other factors). The individual is then counted with the unit's E-5 manning. When the individual is promoted to E-6, he may continue doing the same job he did at E-5, but he is now counted with the unit's E-6 manning. Thus, the unit may again be short in E-5 manning.

Even though it was demonstrated that manning in a duty type at a pay grade has two sources, promotions-in and rotations-in, the sea-shore rotation ratio that is currently used to set tour lengths considers only one source of manning--rotations-in. Exploring the relative importance of the two sources of manning is an important part of this effort's approach.

The second part of the approach concerns the setting of tour lengths. For example, what should the assigned sea tour length at E-5 be to achieve the maximum possible manning at E-5 or E-6? Under current Navy policy, the projected rotation date is not changed by promotion. This is important since long sea tour lengths normally assigned to E-5s to improve manning at the E-5 level may actually impact E-6 manning more (due to promotions from E-5 to E-6 at sea).

Finally, the third part of the approach addresses the issue of continuation or survival in a pay grade and duty type. The simple model is based on a continuation rate that is applied to the entire pay grade. However, the preceeding discussion observes that the manning at a pay grade and duty type consists of two parts, promotions-in and rotations-in. The attrition rates, promotion rates, and continuance rates of both promotions-in and rotations-in are also analyzed and compared.

## Data Source and Organization

### Structure of the Extract

The STF (Gay & Borack, 1981, 1982) was the data source used to validate the theoretical results. Data were extracted from the STF for individuals who were boiler technicians (BTs) in their last record on the file (N = 22,088). For each individual, the pay grade and sea-shore code were obtained for each quarter from September 1977 to March 1982. In addition, the hard end of active obligated service (EAOS) date, accounting code (by quarter), and reenlistment quality control code were extracted. The reenlistment quality control code was used to identify Navy retirees; and the hard EAOS date, the cause of a loss. The accounting code identified temporary duty assignments. The STF extract file is described in Appendex B.

### Processing Logic

The following logic is used to process an individual: Say, for example, data were needed on the subsequent behavior of individuals who rotate into sea duty at E-5. Each individual's record on the STF extract would be checked for pay grade E-5 with rotation to sea duty, and tracked from the time of rotation to sea duty as an E-5 until he is promoted, is demoted, attrites (retire, EAOS, other), or rotates. All individuals who rotate to sea duty at E-5 in a quarter make up one cohort: The expected behavior of each cohort is determined by the observed collective behavior of its individual members.

Eighteen separate cohorts of individuals who rotate to sea duty at E-5 can be tracked from the 19 quarters of STF data. No cohort was possible for the first quarter since a cohort is defined by a change of duty and changes cannot be identified in the first quarter on the extract.

In practice, separate passes at the STF extract were not made for each pay grade. Instead, rotations to sea duty or shore duty were processed for all nine pay grades on a single pass. For these runs, the entire record of each individual is processed since he might rotate to shore duty as an E-5, back to sea duty as an E-5, to shore duty again as an E-6, and to sea duty as an E-6 within the 19 quarters. In this case, the individual would be counted in four different cohorts.

A few special cases were important. If an individual left the Navy, he was counted as an attrite. If that individual subsequently came back, then all time spent in duty or in grade was assumed lost, and he was counted as new to the duty or to the grade. If an individual served neutral duty or temporary duty, he was assumed to be still in his last duty type. A rotation was assumed to be sea duty to shore duty or shore duty to sea duty. Sea duty to neutral duty was assumed to be still sea duty.

The arrangement of the STF file allows great flexibility in defining cohort types. Particular cohort types that were processed include: (1) promotions in each duty, (2) rotations at a pay grade, (3) rotations at a pay grade with subsequent promotions ignored, and (4) rotations at a pay grade with subsequent promotions and rotations ignored.

STF processing contained some limitations. Lateral transfers into and out of the BT rating were not included. Promotions into a pay grade were taken to include nonpromotion changes such as demotions and entry from outside the Navy. Some of these limitations can be treated in later work.

### Aggregate Cohort Data

For each cohort type, 18 quarterly cohort samples were obtained. The samples were not equal in length, ranging from 18 quarters to 1 quarter. An example of a quarterly cohort is shown in Table 2. Here 48 BTs rotated to sea duty in pay grade E-6 in the second quarter of FY 1979. The number of losses (by type) and survivors are shown for each quarter.

Aggregate cohort data were obtained from the 18 quarterly cohort samples. The aggregate cohort data for survival of E-6 rotations to sea duty are shown in Table 3. The aggregate numbers are obtained by adding the corresponding quarter's numbers for each quarterly data set. In other words, the numbers for a quarter in the aggregate cohort data are the sums of the numbers for the same quarter in each quarterly cohort data set. Although 883 individuals were counted in the 18 quarterly cohorts, the individual columns of the aggregate cohort data do not sum to 883 since the quarterly cohort data were of different lengths. In Table 2, the accumulated percentages (for, say, Promote) followed the expected increasing and decreasing order. For the aggregate cohort data in Table 3, the accumulated percentages are almost, but not quite, in order. The aggregate cohort data are most accurate for the early quarters since more information existed there.

## Cohort Analysis in a Simple Tradeoff Model

As stated earlier, manning at a rating, pay grade, and duty type comes from two sources: rotations-in and promotions-in. Annual manning, the number of man-years of personnel in some status (grade, duty) over a year, can be expressed by the formula:

$$M = R \quad T_R + P \quad T_P$$

where M is manning, R is annual rotations-in, P is annual promotions-in, and $T_R$ and $T_P$ are average tour lengths for rotations-in and promotions-in respectively. The average

Table 2

Cohort Data for Survival of BT Rotations to Sea in Pay Grade E-6 in second quarter, 1979

| | Quarters | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Type Losses (Cumulative) | 1 (%) | 2 (%) | 3 (%) | 4 (%) | 5 (%) | 6 (%) | 7 (%) | 8 (%) | 9 (%) | 10 (%) | 11 (%) | 12 (%) |
| Retire | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 2 (4.2) | 2 (4.2) | 2 (4.2) | 4 (8.3) | 4 (8.3) | 4 (8.3) |
| EAOS | 0 (0) | 0 (0) | 1 (2.1) | 1 (2.1) | 1 (2.1) | 1 (2.1) | 2 (4.2) | 2 (4.2) | 2 (4.2) | 2 (4.2) | 2 (4.2) | 3 (6.3) |
| Attrite | 0 (0) | 0 (0) | 2 (4.2) | 2 (4.2) | 2 (4.2) | 2 (4.2) | 2 (4.2) | 2 (4.2) | 2 (4.2) | 2 (4.2) | 2 (4.2) | 2 (4.2) |
| Demote | 1 (2.1) | 1 (2.1) | 1 (2.1) | 3 (6.3) | 4 (8.3) | 4 (8.3) | 4 (8.3) | 4 (8.3) | 4 (8.3) | 4 (8.3) | 4 (8.3) | 4 (8.3) |
| Promote | 0 (0) | 2 (4.2) | 6 (12.5) | 8 (16.7) | 8 (16.7) | 8 (16.7) | 13 (27.1) | 17 (35.4) | 21 (43.8) | 23 (47.9) | 23 (47.9) | 24 (50.0) |
| Rotate | 0 (0) | 1 (2.1) | 1 (2.1) | 1 (2.1) | 2 (4.2) | 2 (4.2) | 3 (6.3) | 3 (6.3) | 3 (6.3) | 3 (6.3) | 3 (6.3) | 3 (6.3) |
| Survivors | 47 (97.9) | 44 (91.7) | 37 (77.1) | 33 (68.8) | 31 (64.6) | 31 (64.6) | 22 (45.8) | 18 (37.5) | 14 (29.2) | 10 (20.8) | 10 (20.8) | 8 (16.7) |

Cohort: E-6 FY 79-2
Beginning Population: 48

Table 3

Aggregate Cohort Data for Survival of BT Rotations to Sea in Pay Grade E-6

| | Quarters | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Type Losses (Cumulative) | 1 (%) | 2 (%) | 3 (%) | 4 (%) | 5 (%) | 6 (%) | 7 (%) | 8 (%) | 9 (%) | 10 (%) | 11 (%) | 12 (%) | 13 (%) | 14 (%) | 15 (%) | 16 (%) | 17 (%) |
| Retire | 0 (0) | 2 (0.3) | 3 (0.4) | 4 (0.6) | 9 (1.5) | 13 (2.3) | 17 (3.3) | 21 (4.6) | 19 (4.6) | 21 (5.6) | 22 (6.9) | 19 (6.7) | 17 (7.3) | 11 (5.6) | 11 (6.8) | 10 (8.5) | 4 (5.8) |
| EAOS | 0 (0) | 3 (0.4) | 17 (2.4) | 31 (4.6) | 33 (5.3) | 41 (7.2) | 44 (8.4) | 40 (8.8) | 42 (10.2) | 42 (11.2) | 36 (11.3) | 33 (11.7) | 30 (12.8) | 27 (13.6) | 22 (13.6) | 16 (13.6) | 9 (13.0) |
| Attrite | 0 (0) | 5 (0.6) | 10 (1.4) | 12 (1.8) | 16 (2.6) | 20 (3.5) | 19 (3.6) | 17 (3.8) | 16 (3.9) | 15 (4.0) | 14 (4.4) | 13 (4.6) | 11 (4.7) | 11 (5.6) | 10 (6.2) | 5 (4.2) | 4 (5.8) |
| Demote | 4 (0.5) | 13 (1.7) | 19 (2.6) | 24 (3.6) | 26 (4.2) | 23 (4.0) | 22 (4.2) | 21 (4.6) | 17 (4.1) | 15 (4.0) | 15 (4.7) | 14 (5.0) | 10 (4.3) | 10 (5.1) | 7 (4.3) | 5 (4.2) | 4 (5.8) |
| Promote | 30 (3.6) | 56 (7.1) | 71 (9.9) | 89 (13.2) | 103 (16.7) | 114 (19.9) | 129 (24.7) | 126 (27.8) | 132 (32.2) | 133 (35.5) | 118 (37.0) | 115 (40.8) | 103 (44.0) | 85 (42.9) | 70 (43.2) | 58 (49.2) | 34 (49.3) |
| Rotate | 1 (0.1) | 15 (1.9) | 16 (2.2) | 16 (2.4) | 17 (2.8) | 17 (3.0) | 21 (4.0) | 25 (5.5) | 24 (5.9) | 23 (6.1) | 25 (7.8) | 25 (8.9) | 23 (9.8) | 24 (12.1) | 23 (14.2) | 16 (13.6) | 11 (15.9) |
| Survivors | 803 (95.8) | 690 (88.0) | 583 (81.1) | 498 (73.9) | 413 (66.9) | 345 (60.2) | 271 (51.8) | 203 (44.8) | 160 (39.0) | 126 (33.6) | 89 (27.9) | 63 (22.3) | 40 (17.1) | 30 (15.2) | 19 (11.7) | 8 (6.8) | 3 (4.3) |

Cohort: E-6 FY 78-1 thru 82-1 Aggregate
Beginning Population: 883

tour lengths are for that particular pay grade and duty type. An E-5 individual who is assigned to sea duty at E-5 may serve a part of his tour at E-5 and a part at E-6. During the first part, he will serve an average tour of $T_{R5}$ in the manning for E-5 sea duty. In the second part, he will serve an average tour $T_{P6}$ for new promotions into E-6 sea duty.

This single pay grade rotation model was used to analyze manning tradeoffs of rotations-in vs. promotions-in. The annual rotations-in and promotions-in and the average tour lengths for each pay grade and duty type were obtained from STF survival curves.

## RESULTS

### Survival of Cohorts in a Duty Type

Each duty type for each pay grade was broken into two distinct cohorts--promotions-in and rotations-in. The purpose was to find the similarities and differences in the two cohorts. This is important because an aggregated pay grade sea-shore rotation model uses a single continuation rate for the entire pay grade.

Figures 1 and 2 give the aggregate survival curves by quarter for E-5 BTs at sea for each cohort. The sources of loss differ markedly by cohort. The reasons for this may be systemic but not necessary to discuss. The point is that, since the grade is not homogeneous, aggregation is inappropriate. For new E-5 promotions at sea duty (Figure 1), losses occur mainly from EAOS (nonreenlistments) and rotation. For E-5 rotations to sea duty (Figure 2), most losses are promotions to E-6. The same pattern holds for E-5 BTs at shore duty. Consequently, it is not accurate to apply attrition rates, promotion rates, or rotation rates uniformly to an entire pay-grade population. Those phenomena are specific to a cohort.

### Annual Inputs and Average Tour Lengths

Table 4 provides estimates of average annual inputs and average quarterly tour lengths based on the 18 cohorts from STF. The estimates of average tour lengths are valid only for that pay grade and duty, since a rotation or a promotion was considered a loss to each duty type and pay grade, even though the individual may have remained in the Navy. The average annual input was computed by multiplying the average quarterly input of the 18 quarters by 4.

The quarterly average tour length was calculated from the aggregate survival curve for each duty type and pay grade by the following formula:

$$T_{avg} = \frac{\sum_{k=1}^{17} k * (S_{k-1} - S_k) + 18 * S_{17}}{S_0}$$

where $S_k$ is the percentage still surviving at the end of quarter k (refer to Table 3 where $S_0 = 100\%$, $S_1 = 95.8\%$, $S_2 = 88\%$, etc.). Thus, $S_{k-1} - S_k$ is the percentage lost in quarter k, and k is also the tour length in quarters that the percentage lost served. The final term, $S_{17}$, is the percentage surviving at the end of the 17th quarter. The final survivors were arbitrarily assigned a tour length of 18 quarters. This may underestimate their true tour length but, in practice, $S_{17}$ was always small enough that the error was not important.

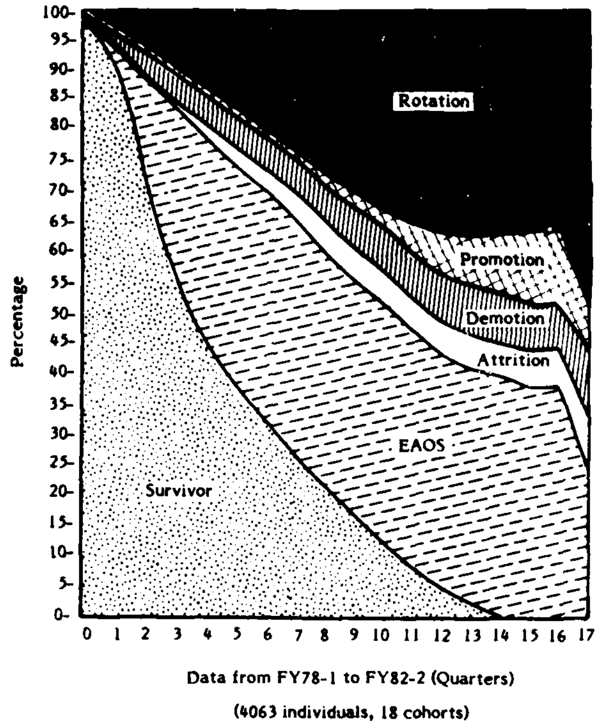


Figure 1. BT sea pay grade E-5 after promotion survivor curves.

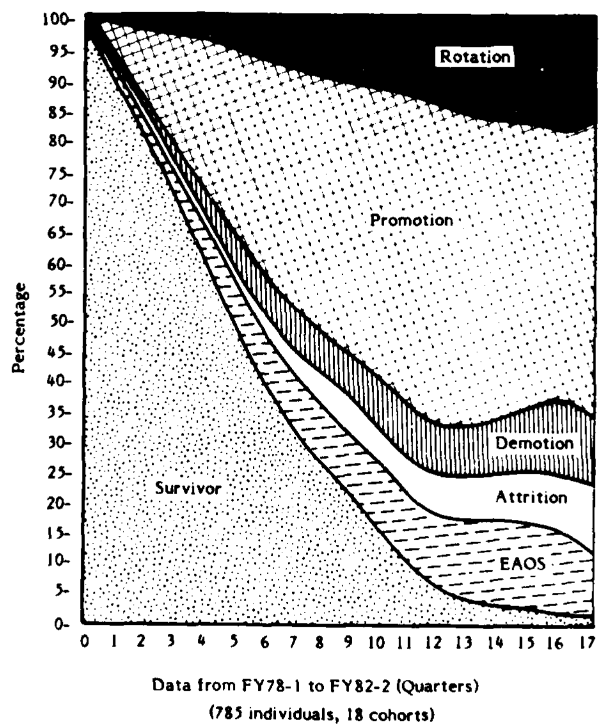


Figure 2. BT sea pay grade E-5 after rotation survivor curves.

Table 4

BT Annual Flows and Average Tour Lengths

| Pay Grade/ Tour | | Avg. Tour Length (Qtrs.) | | Annual Input | |
|---|---|---|---|---|---|
| | | Promotions-in | Rotations-in | Promotions-in | Rotations-in |
| E-1 | Sea | 2.9 | 2.0 | 308.4[a] | 607.2 |
| | Shore | 2.2 | 2.2 | 1484.4[a] | 25.2 |
| E-2 | Sea | 3.3 | 3.6 | 1540.4[a] | 1094.0 |
| | Shore | 1.8 | 2.6 | 598.4[a] | 50.4 |
| E-3 | Sea | 4.5 | 4.8 | 2035.2 | 307.2 |
| | Shore | 2.1 | 3.0 | 638.8 | 60.0 |
| E-4 | Sea | 4.8 | 6.3 | 1656.4 | 413.6 |
| | Shore | 2.2 | 4.1 | 510.8 | 151.2 |
| E-5 | Sea | 5.4 | 6.1 | 902.8 | 174.4 |
| | Shore | 5.0 | 6.7 | 186.4 | 335.6 |
| E-6 | Sea | 8.6 | 8.4 | 149.6 | 196.4 |
| | Shore | 5.2 | 7.5 | 189.2 | 134.4 |
| E-7 | Sea | 8.7 | 9.1 | 122.4 | 80.4 |
| | Shore | 7.1 | 8.6 | 60.8 | 111.6 |
| E-8 | Sea | 6.2 | 6.7 | 29.2 | 27.2 |
| | Shore | 7.7 | 7.9 | 37.6 | 33.2 |
| E-9 | Sea | 7.1 | 8.2 | 12.0 | 14.8 |
| | Shore | 8.0 | 11.3 | 21.2 | 16.4 |

[a]May include new inputs to Navy. Flows at the lower three pay grades are very fast.

Since the manning is the sum of (1) the average tour length for promotions-in times the number of promotions-in and (2) the average tour length for rotations-in times the number of rotations-in, the relative importance of each resource for manning fill can be calculated. The results are shown in Table 5. The usual way of thinking about manning by duty type and pay grade is to assume that all manning comes from rotations. In fact, in many cases, promotions-in play a larger role. For example, results indicate that promotions-in account for 82.1 percent of total BT E-5 man-years at sea duty.

Average Tour Length and Assigned Tour Length

The theoretical model for average tour length presented in the approach and derived in Appendix A indicates that average tour length actually served by an individual in a pay grade and duty type is much less than his assigned tour length if continuation rates are low.

The STF longitudinal data allowed the calculation of average tour lengths served after rotation into a specific pay grade and duty. Table 4 showed the average quarterly tour lengths for rotations-in at each pay grade. These average tour lengths have two limitations. First, they are average tour lengths only in terms of the pay grade in which

Table 5

BT Manning by Duty Type and Pay Grade by Source

| Pay Grade/ Tour | | Promotions-in | Rotations-in | Total | Percentages Promo-tions-in | Rota-tions-in |
|---|---|---|---|---|---|---|
| E-1 | Sea | 223.59[a] | 303.60 | 527.19 | 42.4 | 57.6 |
| | Shore | 816.42[a] | 13.86 | 830.28 | 98.3 | 01.7 |
| E-2 | Sea | 1270.83[a] | 984.60 | 2255.43 | 56.3 | 43.7 |
| | Shore | 269.28[a] | 32.76 | 302.04 | 89.2 | 10.8 |
| E-3 | Sea | 2289.60 | 368.64 | 2658.24 | 86.1 | 13.9 |
| | Shore | 335.37 | 45.00 | 380.37 | 88.2 | 11.8 |
| E-4 | Sea | 1987.68 | 651.42 | 2639.10 | 75.3 | 24.7 |
| | Shore | 280.94 | 154.98 | 435.92 | 64.4 | 35.6 |
| E-5 | Sea | 1218.78 | 265.96 | 1484.74 | 82.1 | 17.9 |
| | Shore | 233.00 | 562.13 | 795.13 | 29.3 | 70.7 |
| E-6 | Sea | 321.64 | 412.44 | 734.08 | 43.8 | 56.2 |
| | Shore | 245.96 | 252.00 | 497.96 | 49.4 | 50.6 |
| E-7 | Sea | 266.22 | 182.91 | 449.13 | 59.3 | 40.7 |
| | Shore | 107.92 | 239.94 | 347.86 | 31.0 | 69.0 |
| E-8 | Sea | 45.26 | 45.56 | 90.82 | 49.8 | 50.2 |
| | Shore | 72.38 | 65.57 | 137.95 | 52.5 | 47.5 |
| E-9 | Sea | 21.30 | 30.34 | 51.64 | 41.2 | 58.8 |
| | Shore | 42.40 | 46.33 | 88.73 | 47.8 | 52.2 |

[a]May include new inputs to Navy. Flows at the lower three pay grades are very fast.

they were assigned. Second, they do not allow for estimates of average tour length for a given assigned tour length. The analysis was therefore extended to overcome these limitations.

The average tour length formula of the previous section was modified to include assigned tour length as a variable. The revised formula is:

$$T_{avg}(T) = \frac{\sum_{k=1}^{T} (S_{k-1} - S_k)\,k + S_T * (T + 1)}{S_0}$$

The formula gives the average tour length $T_{avg}$ as a function of assigned tour length T. Both T and $T_{avg}$ are in quarters. Again $S_k$ is the percentage of input surviving at the end of quarter k where $S_0$ = 100 percent. $S_T$ is the percentage of individuals left at T to rotate.

The above formula could not be applied directly to the survival curves in Figures 1 and 2 since those curves are based on losses, including rotations and promotions. The rotation and promotion losses could not be introduced directly since persons who rotate or promote might subsequently attrite. Consequently, new survival curves were calculated for two cohorts using the following logic:

1. Select all individuals who rotate into a duty and pay grade. Keep them in the cohort until they attrite (retire, EAOS, other) or promote.

2. Select all individuals who rotate into a duty and pay grade. Keep them in the cohort until they attrite (retire, EAOS, other).

The first cohort gives survival for all individuals who rotate into a duty and pay grade. The second cohort gives survival for all individuals who rotate into a duty and pay grade regardless of subsequent promotions. Since rotations were not taken out, the formula can be used for any rotation point T.

The first half of Table 6 shows the average tour length of an individual assigned to sea duty at a pay grade as a function of an assigned tour length. Individuals who subsequently promote are counted as a loss to that duty and pay grade. In the second half of Table 6, the same calculations are made, but promotions are not counted as a loss.

Figure 3 illustrates the data in Table 6 for E-5s. In Figure 3, the "expected" line shows the average tour length an individual would serve after rotation into the pay grade and duty if there is no loss. On this line, the average tour length equals assigned tour length. For the "all-Navy" line, an individual is rotated to sea as an E-5 and may be subsequently promoted (or demoted), but remains on sea duty. This line gives the average sea tour length he serves as a function of the assigned sea tour length. The "E-5 only" line gives the average tour length an individual serves in the duty and pay grade to which he was assigned.

Based on the data in the top half of Table 6, an E-5 BT will serve an average tour length at E-5 of 6.35 quarters for an assigned tour length of 12 quarters (3 years). For an assigned tour length of 18 quarters (4-1/2 years), the E-5 BT will serve an average tour length of 6.61 quarters. Therefore, with an assigned tour length of 12 quarters, the Navy could obtain 96.2 percent (6.35 ÷ 6.61 x 100%) of the average tour length at E-5 for a one-third lower assigned tour (from 4-1/2 years to 3 years). The bottom half of Table 6 shows that, although longer assigned sea tour lengths may not significantly improve average tour length (and hence manning) at a pay grade, the longer assigned sea tour lengths may improve the manning at the next higher pay grade. For example, the E-5 average sea tour length at all pay grades for an assigned tour length of 18 quarters is 14.20 quarters, with 7.6 quarters (14.2 - 6.6), or over half the sea tour, spent at the next higher pay grade, E-6.

## Model Validation and Tradeoffs between Manning Sources

Table 7 compares the estimated manning, based on inputs and average tour lengths, with average BT personnel levels from STF. The only significant differences are in E-1--E-3 BT manning that includes training. The survival curves treated neutral duty and temporary duty as continuations of previous duty. This causes an overestimate of average tour length for the E-1--E-3 levels where most training occurs. Nevertheless, the manning formula and the average tour length formula presented in this report appear to be valid for higher pay grades (E-4 and above) and can be used to help determine the tradeoffs necessary to improve manning by pay grade and duty type.

This analysis only considered small changes (10%) in the variables. Small changes that have big impacts may be realizable without significantly altering current Navy policies. On the other hand, large changes in the variables could occur only by altering

Table 6

Average vs. Assigned Sea Tour Lengths
in Quarters for BTs

| Assigned Tour Length | Average Tour Length | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | E-1 | E-2 | E-3 | E-4 | E-5 | E-6 | E-7 | E-8 | E-9 |
| | | | | Average Tour Only at Assigned Pay Grade | | | | | |
| 1 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 2 | 1.41 | 1.87 | 1.91 | 1.96 | 1.88 | 1.95 | 2.00 | 1.96 | 2.00 |
| 3 | 1.63 | 2.48 | 2.72 | 2.85 | 2.68 | 2.84 | 2.94 | 2.88 | 2.98 |
| 4 | 1.75 | 2.89 | 3.38 | 3.65 | 3.38 | 3.67 | 3.86 | 3.76 | 3.96 |
| 5 | 1.82 | 3.16 | 3.86 | 4.33 | 4.00 | 4.42 | 4.76 | 4.53 | 4.94 |
| 6 | 1.87 | 3.34 | 4.22 | 4.87 | 4.52 | 5.10 | 5.58 | 5.21 | 5.71 |
| 7 | 1.91 | 3.44 | 4.46 | 5.28 | 4.97 | 5.73 | 6.30 | 5.76 | 6.39 |
| 8 | 1.93 | 3.50 | 4.62 | 5.59 | 5.36 | 6.27 | 6.94 | 6.18 | 7.02 |
| 9 | 1.95 | 3.55 | 4.73 | 5.82 | 5.70 | 6.76 | 7.53 | 6.57 | 7.62 |
| 10 | 1.96 | 3.58 | 4.79 | 6.00 | 5.98 | 7.20 | 8.08 | 6.84 | 8.05 |
| 11 | 1.97 | 3.60 | 4.83 | 6.12 | 6.20 | 7.57 | 8.52 | 6.93 | 8.44 |
| 12 | 1.98 | 3.61 | 4.85 | 6.22 | 6.35 | 7.90 | 8.88 | 7.05 | 8.83 |
| 13 | 1.99 | 3.61 | 4.86 | 6.29 | 6.45 | 8.18 | 9.21 | 7.17 | 9.19 |
| 14 | 1.99 | 3.62 | 4.86 | 6.34 | 6.51 | 8.41 | 9.50 | 7.33 | 9.49 |
| 15 | 1.99 | 3.62 | 4.87 | 6.37 | 6.55 | 8.64 | 9.78 | 7.38 | 9.70 |
| 16 | 1.99 | 3.63 | 4.87 | 6.39 | 6.58 | 8.83 | 10.00 | 7.44 | 9.70 |
| 17 | 1.99 | 3.63 | 4.88 | 6.39 | 6.60 | 8.97 | 10.22 | 7.53 | 9.70 |
| 18 | 1.99 | 3.63 | 4.89 | 6.39 | 6.61 | 9.10 | 10.48 | 7.53 | 9.70 |
| | | | | Average Tour Including Tours at Higher Pay Grades | | | | | |
| 1 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 2 | 1.99 | 2.00 | 1.99 | 1.99 | 1.98 | 2.00 | 2.00 | 2.00 | 2.00 |
| 3 | 2.98 | 2.98 | 2.97 | 2.97 | 2.94 | 2.98 | 2.98 | 2.99 | 2.98 |
| 4 | 3.94 | 3.94 | 3.91 | 3.91 | 3.87 | 3.94 | 3.95 | 3.96 | 3.95 |
| 5 | 4.88 | 4.89 | 4.82 | 4.85 | 4.78 | 4.87 | 4.93 | 4.88 | 4.93 |
| 6 | 5.79 | 5.81 | 5.70 | 5.75 | 5.68 | 5.77 | 5.81 | 5.73 | 5.68 |
| 7 | 6.68 | 6.71 | 6.55 | 6.63 | 6.54 | 6.64 | 6.63 | 6.46 | 6.34 |
| 8 | 7.55 | 7.59 | 7.34 | 7.47 | 7.38 | 7.48 | 7.39 | 7.12 | 6.97 |
| 9 | 8.41 | 8.45 | 8.09 | 8.27 | 8.19 | 8.30 | 8.12 | 7.74 | 7.55 |
| 10 | 9.26 | 9.30 | 8.77 | 9.02 | 8.97 | 9.10 | 8.79 | 8.25 | 7.98 |
| 11 | 10.08 | 10.10 | 9.41 | 9.73 | 9.73 | 9.86 | 9.40 | 8.64 | 8.37 |
| 12 | 10.87 | 10.86 | 10.01 | 10.40 | 10.46 | 10.59 | 9.93 | 8.96 | 8.76 |
| 13 | 11.61 | 11.59 | 10.55 | 11.05 | 11.17 | 11.29 | 10.47 | 9.28 | 9.12 |
| 14 | 12.35 | 12.29 | 11.06 | 11.66 | 11.84 | 11.97 | 10.98 | 9.56 | 9.42 |
| 15 | 13.05 | 12.85 | 11.47 | 12.20 | 12.49 | 12.61 | 11.49 | 9.80 | 9.63 |
| 16 | 13.57 | 13.15 | 11.81 | 12.75 | 13.09 | 13.22 | 11.95 | 9.99 | 9.63 |
| 17 | 13.88 | 14.30 | 12.12 | 13.28 | 13.65 | 13.78 | 12.44 | 10.16 | 9.63 |
| 18 | 14.17 | 13.65 | 12.40 | 13.72 | 14.23 | 14.35 | 13.00 | 10.26 | 9.63 |

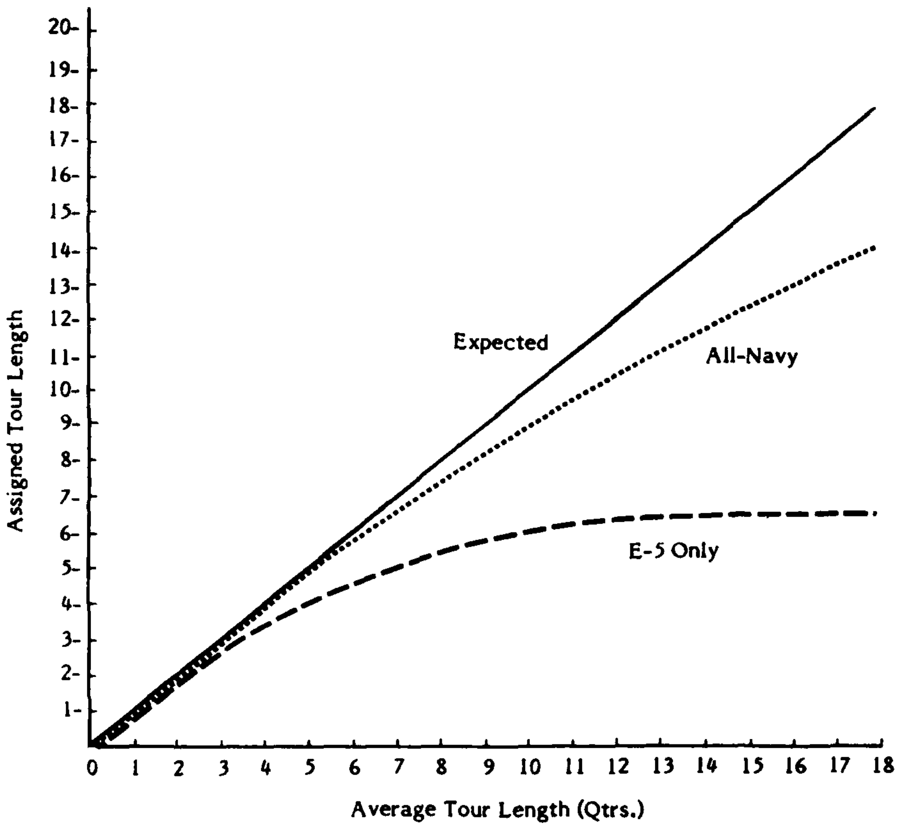


Figure 3. BT E-5 average sea tour lengths (in months).

Table 7

BT Personnel by Pay Grade and Duty Type, Actual and Estimated

| Pay Grade | BT Sea Duty Personnel | | BT Shore Duty Personnel | |
|---|---|---|---|---|
| | Actual | Estimated | Actual | Estimated |
| E-1/3 | 3419 | 5440 | 80 | 1512 |
| E-4 | 2505 | 2639 | 200 | 435 |
| E-5 | 1420 | 1485 | 704 | 795 |
| E-6 | 726 | 734 | 504 | 498 |
| E-7 | 427 | 449 | 261 | 348 |
| E-8 | 103 | 90 | 99 | 138 |
| E-9 | 60 | 52 | 69 | 89 |

Navy organization and policies. In addition, the rotation tradeoff model is accurate only for small changes because of the way the data were obtained. The survival curves on which average tour lengths are based are influenced by some LOS factors, such as retirement and EAOS. Any major shifts in policy might change the survival curves so that average tour length based on old policies would not be accurate. The inputs into each cohort (rotations-in and promotions-in) are also influenced by LOS.

Effects of Increasing Assigned BT Sea Tour Length at E-5

Only sea manning at E-5 is considered in the following tradeoff analysis. From Table 4, the formula for BT E-5 sea duty manning is:

$$M = 902.8 * \frac{5.4}{4} + 174.4 * \frac{6.1}{4} .$$

The purpose of increasing the assigned sea tour length at E-5 is to raise the average tour length and thereby increase manning. The present average sea tour length at E-5 for new rotations into sea is 6.1 quarters. From Figure 3 (the curve for average sea tour length as a function of assigned tour length), the maximum possible average tour length is 6.6 quarters. No matter how large the assigned tour length is set, the maximum impact on E-5 (barring a change in E-6 promotion policy) is 6.6 quarters. Thus, the most that the Navy can increase manning at E-5 sea by increasing the assigned sea tour length at E-5 is

$$174.4 * \frac{6.6 - 6.1}{4} = 21.8 \text{ man-years.}$$

Effect of Increasing Annual BT Rotations-in

The total number of rotations into a duty type varies widely from pay grade to pay grade. At E-5, the rotations into sea are small and have limited potential for increase. The reason is that an individual usually ends his initial sea tour at E-5 and then rotates to shore. By the time he returns to sea, he is already an E-6 or he is promoted soon after.

Increased annual rotations into sea could occur from a shorter shore tour length at E-5. If the 174.4 annual rotations into sea at E-5 are increased by 10 percent, the total increase in manning is

$$17.44 * \frac{6.1}{4} = 26.6 \text{ man-years.}$$

Effect of Increasing First Assigned BT Sea Tour Length

The first assigned sea tour length is set at E-1--E-3 and has a major effect on sea manning at E-5. Most individuals assigned to sea on their first tour are still in that assignment when they are promotd to E-5. From Table 4, the annual flow of these new promotions averages 902.8 individuals. Thus, a small increase in the average tour length of these individuals causes a major increase in E-5 sea manning.

The average sea tour length after promotion into E-5 is 5.4 quarters. If this can be increased by half a quarter (10%), the increase in E-5 sea manning is

$$\frac{.5}{4} * 902.8 = 112.9 \text{ man-years.}$$

That increase in average sea tour length may result from increasing the assigned tour length for the first tour. Also, some evidence indicates that individuals are brought ashore before the end of their assigned tour.

Effect of Increasing BT Annual Promotions-in

The total number of promotions into a duty type is an artifact of the promotion point to E-5, which is not controlled by the distributors. Nevertheless, it is useful to see the effect of a 10 percent increase in annual promotions into E-5 sea duty, assuming no change in average tour length. Such an increase might occur if fewer individuals are rotated to shore at E-4 before the end of their assigned tour. If the 902.8 promotions into E-5 sea are increased by 10 percent, the effect on manning is

$$90.28 * \frac{5.4}{4} = 121.9 \text{ man-years.}$$

The results of the tradeoff analysis show that E-5 sea duty manning is increased at least five times more by increasing new promotions-in or their remaining tour length than by increasing rotations-in or their assigned tour length.

## CONCLUSIONS AND FUTURE DIRECTION

Longitudinal personnel data from STF was used to validate a sea-shore rotation model and to investigate tradeoffs between manning resources for a rating's pay grade/duty type. STF is a good data source for rotation analysis. It captures short-term changes like temporary duty and clearly distinguishes these flows from permanent rotation. It permits (1) accurate representation of survival probabilities for duty assignments over time for well-defined cohorts, and (2) neutral duty to be grouped with an individual's preceding duty assignment so that tours are not broken artificially.

The data confirmed the main ideas of the model. Manning for a pay grade/duty type depends on two resources--promotions-in and rotations-in. Longer assigned tours at a pay grade have little impact on manning at the pay grade itself, although they do influence manning at higher grades.

Attrition rates, promotion rates, and continuation rates are not uniform for a pay grade. Instead, they differ, depending on the cohort (e.g., new promotions at sea).

The single pay grade rotation model, based on longitudinal data, can be used to identify possible tradeoffs in manning and to estimate the effects of slight changes in tour lengths. The pay grade models may not be able to handle large changes in tour lengths since these would result in a shift along the LOS dimension. Such a shift results in different survival curves, average tour lengths, and input flows for individual cohorts.

The effects of significant changes in tour patterns and promotion patterns need to be investigated for a complete analysis of possible rotation tradeoffs to achieve adequate manning and to determine the best possible sea-shore tour patterns for an enlisted rating community. Further work is necessary to explore other ratings and the LOS dimension in rotation modeling.

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# APPENDIX A

# EFFECT OF CONTINUATION ON MANNING AND AVERAGE TOUR LENGTH

## EFFECT OF CONTINUATION ON MANNING AND AVERAGE TOUR LENGTH

Formula for Average Tour Length

In this appendix, a theoretical formula to estimate total manning and average tour lengths for a given continuation rate is derived and its consequences discussed. The formula assumes uniform attrition and promotion for a pay grade.

Continuation rate (c) is defined as 1.0 minus the loss rate (a) minus the promotion rate (p):

$$c = 1 - a - p.$$

For BT journeymen, the historical annual loss rate is .250 and the historical annual promotion rate is .069. For BT supervisors, the historical annual loss rate is .198. Consequently, the continuation rate for journeymen is .681 and the continuation rate for supervisors is .802.

Let I be the number of individuals input into a duty type (sea or shore at a pay-grade group). Let c be the continuation rate for that pay-grade group. Then, after a time t (in years, since the continuation rate is annual), the number of individuals from the original cohort who are still present is $Ic^t$. When the assigned tour length is T and all the cohorts are equal in size, the total manning in the duty type is:

$$\text{Manning} = \int_0^T Ic^t dt = I \int_0^T c^t dt = \frac{I\,(c^T - 1)}{\log c}$$

where log is the natural logarithm.

The average tour length served by an individual is:

$$\text{Average } T = \frac{\text{Manning}}{I} = \frac{c^T - 1}{\log c}\ .$$

Note that this formula can be derived directly without going through manning, but the derivation is longer.

The maximum average tour length for $o < c < 1$ is found by taking the limit as T approaches infinity.

$$\text{Max Avg } T = -\frac{1}{\log c}.$$

The average tour length when $c = 1$ is found by taking the limit as c approaches 1.

$$\lim_{c \to 1} \frac{c^T - 1}{\log c} = \lim_{c \to 1} \frac{Tc^{T-1}}{1/c} = T.$$

This is the average tour length of the traditional rotation model. Thus, the formulation in this section converges to the traditional model as the continuation rate approaches 1.0.

Average Tour Length vs. Assigned Tour Length

Table A-1 shows the theoretical results for average tour length, given different assigned tour lengths and continuation rates. Note that, with a continuation rate greater than .9, the average tour length approaches the assigned tour length. For continuation rates of .8 and below, however, the average tour length is considerably less than the assigned tour length. Recall that the continuation rate of journeymen BTs is .681.

Table A-1

Average Tour Length (Months)

| Cont. Rate | Assigned Tour 26 | 36 | 46 | 56 | 66 | 76 | Max Avg |
|---|---|---|---|---|---|---|---|
| 0.40 | 11.30 | 12.26 | 12.71 | 12.91 | 13.01 | 13.06 | 13.10 |
| 0.45 | 12.36 | 13.66 | 14.32 | 14.67 | 14.84 | 14.93 | 15.03 |
| 0.50 | 13.46 | 15.15 | 16.10 | 16.63 | 16.93 | 17.10 | 17.31 |
| 0.55 | 14.58 | 16.73 | 18.04 | 18.84 | 19.32 | 19.62 | 20.07 |
| 0.60 | 15.72 | 18.42 | 20.18 | 21.33 | 22.08 | 22.57 | 23.49 |
| 0.65 | 16.90 | 20.21 | 22.51 | 24.13 | 25.25 | 26.04 | 27.86 |
| 0.70 | 18.11 | 22.10 | 25.07 | 27.28 | 28.91 | 30.13 | 33.64 |
| 0.75 | 19.35 | 24.12 | 27.87 | 30.82 | 33.14 | 34.97 | 41.71 |
| 0.80 | 20.62 | 26.24 | 30.92 | 34.79 | 38.02 | 40.69 | 53.78 |
| 0.85 | 21.92 | 28.49 | 34.24 | 39.25 | 43.63 | 47.46 | 73.84 |
| 0.90 | 23.25 | 30.87 | 37.84 | 44.24 | 50.09 | 55.46 | 113.89 |
| 0.91 | 23.52 | 31.36 | 38.60 | 45.30 | 51.50 | 57.22 | 127.24 |
| 0.92 | 23.79 | 31.85 | 39.37 | 46.39 | 52.94 | 59.04 | 143.92 |
| 0.93 | 24.06 | 32.35 | 40.16 | 47.50 | 54.42 | 60.93 | 165.36 |
| 0.94 | 24.33 | 32.86 | 40.95 | 48.64 | 55.94 | 62.88 | 193.94 |
| 0.95 | 24.61 | 33.37 | 41.76 | 49.80 | 57.51 | 64.89 | 233.95 |
| 0.96 | 24.88 | 33.88 | 42.58 | 50.99 | 59.12 | 66.97 | 293.96 |
| 0.97 | 25.16 | 34.40 | 43.42 | 52.20 | 60.77 | 69.12 | 393.97 |
| 0.98 | 25.44 | 34.93 | 44.26 | 53.44 | 62.47 | 71.34 | 593.98 |
| 0.99 | 25.72 | 35.46 | 45.13 | 54.71 | 64.21 | 73.63 | 999.99 |

Assume that the annual input from rotation or promotion into the tour was 1200 persons. Then the total manning in that duty type is 100 times the average monthly tour length. For a continuation rate above .90, longer assigned tour lengths result in significant increases in manning. However, for a continuation rate of .80, the increase in manning from longer assigned tour lengths is not great and total manning fill is not high.

Continuation Rate Impact

Table A-2 shows the impact on average tour length (and hence, manning) of 5 and 10 percent improvements in the continuation rate. For a continuation rate of .681, the total manning (with an input of 1200 persons) for a 60-month assigned tour is 2666. If the assigned tour length is cut to 48 months, manning is reduced to 2452 persons. However, if the cut also increases continuation by 5 percent, then manning is 2642, which is near the original figure. Even with no improvement in continuation, the manning reduction from the 12-month cut in tour length was less than 10 percent.

Table A-2

Average Tour Length When Continuation is Improving for Assigned Tours

| Assigned Tour | Continuation Rate | | |
|---|---|---|---|
| | 0.681 | 0.715 | 0.749 |
| 10.00 | 8.56 | 8.72 | 8.89 |
| 12.00 | 9.96 | 10.19 | 10.42 |
| 14.00 | 11.28 | 11.59 | 11.88 |
| 16.00 | 12.52 | 12.90 | 13.28 |
| 18.00 | 13.68 | 14.14 | 14.61 |
| 20.00 | 14.77 | 15.32 | 15.87 |
| 22.00 | 15.79 | 16.43 | 17.08 |
| 24.00 | 16.75 | 17.48 | 18.23 |
| 26.00 | 17.65 | 18.48 | 19.33 |
| 28.00 | 18.49 | 19.42 | 20.37 |
| 30.00 | 19.28 | 20.31 | 21.36 |
| 32.00 | 20.02 | 21.15 | 22.31 |
| 34.00 | 20.72 | 21.95 | 23.22 |
| 36.00 | 21.37 | 22.70 | 24.08 |
| 38.00 | 21.98 | 23.41 | 24.90 |
| 40.00 | 22.56 | 24.08 | 25.68 |
| 42.00 | 23.09 | 24.72 | 26.43 |
| 44.00 | 23.60 | 25.32 | 27.14 |
| 46.00 | 24.07 | 25.89 | 27.81 |
| 48.00 | 24.52 | 26.42 | 28.46 |
| 50.00 | 24.93 | 26.93 | 29.07 |
| 52.00 | 25.32 | 27.41 | 29.66 |
| 54.00 | 25.69 | 27.87 | 30.22 |
| 56.00 | 26.03 | 28.30 | 30.75 |
| 58.00 | 26.36 | 28.71 | 31.26 |
| 60.00 | 26.66 | 29.09 | 31.74 |

## APPENDIX B

## BT STF COHORT DATA BASE RECORD LAYOUT

## BT STF COHORT DATA BASE RECORD LAYOUT

From the STF file containing data for enlisted personnel from FY 77-4 through FY 82-2, an extract was created containing one record for each individual identified as a BT (rating code = 4000) in his last record on the STF.

This record, which is illustrated in Figure B-1, contains the following information:

1. Active duty service date (YYMM).[1]
2. EAOS (hard) from first (EAOS1) and last record (EAOS2) on STF (YYMM).
3. EAOS change code and quarter (1-19) of change.[1]
4. Reenlistment quality code and quarter in which it was entered.[1]
5. Accounting category code.[2]
6. Strength indicator code.[2]
7. Pay grade code.[2]
8. Sea-shore code.[2]

Recort Layout BT STF Extract

| Data | Begin Position | Type | Length |
|---|---|---|---|
| ADSD | 1 | A | 4 |
| EAOS1 | 5 | A | 4 |
| EAOS2 | 9 | A | 4 |
| EAOS Change Code | 13 | A | 1 |
| EAOS Change Qtr | 14 | P'99' | 2 |
| Reenlistment Qual Code | 16 | A | 1 |
| RQC Qtr | 17 | P | 2 |
| ACC (19) | 19 | A | 1 |
| FILL | 38 | -- | 1 |
| SCIND (19) | 39 | A | 1 |
| FILL | 58 | -- | 1 |
| Pay Grade Code (19) | 59 | A | 1 |
| FILL | 78 | -- | 1 |
| Sea Shore Code (19) | 79 | A | 1 |
| FILL | 98 | -- | 1 |

Figure B-1. Record layout BT STF extract.

[1]Last occurrence, if data appears more than once.

[2]For each quarter, FY 77-4 through FY 82-2, individual had record on STF (otherwise, set to ".").

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