



**NAVAL  
POSTGRADUATE  
SCHOOL**

**MONTEREY, CALIFORNIA**

**THESIS**

**FORECASTING UNITED STATES MARINE CORPS  
SELECTED RESERVE END STRENGTH**

by

Nathan N. Emery

March 2010

Thesis Co Advisors:

William H. Hatch  
Samuel E. Buttrey  
Michelle Dolfini-Reed

**Approved for public release, distribution is unlimited**

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE March 2010	3. REPORT TYPE AND DATES COVERED Master's Thesis	
4. TITLE AND SUBTITLE Forecasting United States Marine Corps Selected Reserve End Strength			5. FUNDING NUMBERS	
6. AUTHOR(S) Nathan N. Emery				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government. IRB Protocol number _____.				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release, distribution is unlimited			12b. DISTRIBUTION CODE	
13. ABSTRACT (maximum 200 words)  This thesis developed a manpower model to forecast Selected Marine Corps Reserve end strength by forecasting losses with exponential smoothing. The data came from the Reserve Manpower Model (legacy model) and the results were compared with the historical strength data to determine if the research model provided more desirable results. This model is specific to the Marine Corps Selected Reserve. The proposed model's predictions were closer to actual strength numbers than the legacy model's predictions were, as measured by standard deviation and range.				
14. SUBJECT TERMS Forecasting, Accessions, Losses, Manpower, Enlisted, Officer, Reserve, Modeling, Exponential Smoothing, Marine Corps			15. NUMBER OF PAGES 52	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UU	

NSN 7540-01-280-5500

Standard Form 298 (Rev. 8-98)  
Prescribed by ANSI Std. Z39.18

THIS PAGE INTENTIONALLY LEFT BLANK

**Approved for public release, distribution is unlimited**

**FORECASTING UNITED STATES MARINE CORPS  
SELECTED RESERVE END STRENGTH**

Nathan N. Emery  
Captain, United States Marine Corps  
B.A., History, University of Idaho, 2002  
B.A., American Studies, University of Idaho, 2002  
B.S., Political Science, University of Idaho, 2002

Submitted in partial fulfillment of the  
requirements for the degree of

**MASTER OF SCIENCE IN MANAGEMENT**

from the

**NAVAL POSTGRADUATE SCHOOL  
March 2010**

Author: Nathan N. Emery

Approved by: William H. Hatch  
Co-Advisor

Samuel E. Buttrey  
Co-Advisor

Michelle Dolfini-Reed  
Co-Advisor

William Gates  
Dean, Graduate School of Business and Public Policy

THIS PAGE INTENTIONALLY LEFT BLANK

## **ABSTRACT**

This thesis developed a manpower model to forecast Selected Marine Corps Reserve end strength by forecasting losses with exponential smoothing. The data came from the Reserve Manpower Model (legacy model) and the results were compared with the historical strength data to determine if the research model provided more desirable results. This model is specific to the Marine Corps Selected Reserve.

The proposed model's predictions were closer to actual strength numbers than the legacy model's predictions were, as measured by standard deviation and range.

THIS PAGE INTENTIONALLY LEFT BLANK

# TABLE OF CONTENTS

<b>I.</b>	<b>INTRODUCTION.....</b>	<b>1</b>
	<b>A. PURPOSE.....</b>	<b>1</b>
	<b>B. BACKGROUND.....</b>	<b>1</b>
	<b>C. EXISTING MODEL FORECAST ACCURACY.....</b>	<b>1</b>
	<b>D. SCOPE AND METHODOLOGY.....</b>	<b>5</b>
	<b>E. ORGANIZATION OF THE STUDY.....</b>	<b>5</b>
<b>II.</b>	<b>LITERATURE REVIEW .....</b>	<b>7</b>
	<b>A. MANPOWER PLANNING .....</b>	<b>7</b>
	<b>B. PREVIOUS ACCESSION STUDIES .....</b>	<b>8</b>
	<b>C. PREVIOUS LOSS STUDIES.....</b>	<b>8</b>
	<b>D. CURRENT RESERVE MANPOWER MODEL .....</b>	<b>8</b>
	<b>1. Davis, Kimble, Hattiangadi (2007) .....</b>	<b>9</b>
<b>III.</b>	<b>DATA AND METHODOLOGY .....</b>	<b>13</b>
	<b>A. INTRODUCTION.....</b>	<b>13</b>
	<b>B. DATA .....</b>	<b>13</b>
	<b>C. DESCRIPTIVE STATISTICS.....</b>	<b>13</b>
	<b>D. METHODOLOGY.....</b>	<b>15</b>
<b>IV.</b>	<b>MODEL ESTIMATIONS.....</b>	<b>17</b>
	<b>A. MODEL .....</b>	<b>17</b>
	<b>B. EXPONENTIAL SMOOTHING MODEL RESULTS FOR FY00- FY08.....</b>	<b>17</b>
<b>V.</b>	<b>SUMMARY AND RECOMMENDATIONS.....</b>	<b>19</b>
	<b>A. SUMMARY.....</b>	<b>19</b>
	<b>B. RECOMMENDATIONS.....</b>	<b>19</b>
	<b>C. AREAS FOR FUTURE RESEARCH.....</b>	<b>19</b>
	<b>1. Survival Analysis.....</b>	<b>19</b>
	<b>2. Pay Grade Transition Matrix .....</b>	<b>20</b>
	<b>3. Accession and Retention Cost Benefit Analysis .....</b>	<b>20</b>
	<b>4. Forecasting by Recruiting District .....</b>	<b>21</b>
	<b>5. Active Component to Reserve Component Conversion     Rate Analysis .....</b>	<b>21</b>
<b>APPENDIX A. MODEL FORECAST USERS .....</b>		<b>23</b>
	<b>A. EXTERNAL AGENCIES .....</b>	<b>23</b>
	<b>B. INTERNAL FUNCTIONS .....</b>	<b>24</b>
	<b>C. RESERVE AFFAIRS DIVISION .....</b>	<b>25</b>
	<b>1. Reserve Affairs Management (RAM).....</b>	<b>25</b>
	<b>2. Reserve Affairs Coordination (RAC).....</b>	<b>25</b>
	<b>3. Reserve Affairs Plans (RAP).....</b>	<b>25</b>
	<b>a. Policy .....</b>	<b>25</b>
	<b>b. PIT .....</b>	<b>26</b>

c. <i>Manpower</i> .....	26
4. MCTFS Cycles—Total Force Data Warehouse .....	27
5. RCCPDS Files—Defense Manpower Data Center .....	27
<b>APPENDIX B. STRENGTH CATEGORIES</b> .....	<b>29</b>
<b>LIST OF REFERENCES</b> .....	<b>31</b>
<b>INITIAL DISTRIBUTION LIST</b> .....	<b>33</b>

## LIST OF FIGURES

Figure 1.	Selected Reserve Strength from FY04 through FY08 .....	2
Figure 2.	FY08 Forecast Departs from Actuals.....	3
Figure 3.	Comparison of SELRES End Strengths. ....	4

THIS PAGE INTENTIONALLY LEFT BLANK

## LIST OF TABLES

Table 1.	Differences from Observed Losses .....	14
Table 2.	Legacy Model Descriptive Statistics. ....	15
Table 3.	Research Model Descriptive Statistics. ....	15
Table 4.	Research Model $\alpha$ Values .....	18

THIS PAGE INTENTIONALLY LEFT BLANK

## LIST OF ACRONYMS AND ABBREVIATIONS

AC	Active Component
ACTSTACD	Activation Status Code
ADOS	Active Duty Operational Support
AR	Active Reserve
ASR	Authorized Staffing Report
CNA	Center for Naval Analyses
DASN-RA	Deputy Assistant Secretary of the Navy for Reserve Affairs
DC	Deputy Commandant
DJSMCR	Date Joined SMCR
DMDC	Defense Manpower Data Center
DoD	Department of Defense
DODTCPG	DoD Training Category Pay Group
DODTTC	DoD Transaction Type Code
EAS	End of Active Service
FY	Fiscal Year
FYDP	Five-Year Defense Program
GAO	Government Accountability Office
GWOT	Global War on Terrorism
HQMC	Headquarters Marine Corps
IADT	Initial Active Duty for Training
IMA	Individual Mobilization Augmentee
M&RA	Manpower and Reserve Affairs
MCRC	Marine Corps Recruiting Command
MCTFS	Marine Corps Total Force System
MDSD	Mandatory Drill Stop Date
MI	Manpower Information
MISSO	Manpower Information Systems Support Office
NDA	National Defense Authorization Act
OSD-RA	Office of the Secretary of Defense for Reserve Affairs
PBs	Programmed Budgets
PIT	Policy; Promotions, Incentives and Training

RA	Reserve Affairs
RAM	Reserve Affairs Management
RAP	Reserve Affairs Plans
RC	Reserve Component
RCC	Reserve Component Code
RCCPDS	Reserve Components Common Personnel Data System
RECC	Reserve End of Current Contract
ResCat	Reserve Category
RPMC	Reserve Personnel Marine Corps
SELRES	Selected Reserve
SMCR	Selected Marine Corps Reserve (Units)
T/O	Tables of Organization
TECOM	Training and Education Command
TFDW	Total Force Data Warehouse
TFMMR	Total Force Manpower Models Reengineering
ULB	Uniform Legislative Budget
USMC	United States Marine Corps

## ACKNOWLEDGMENTS

First and foremost, I want to thank my beautiful wife Angela for the sacrifices she endured throughout this process. Only she knows the true cost of this research. Thank you for encouraging me when I faltered. Thank you for leading me when I failed. I love you more than you can ever know, and I will cherish you forever.

I also want to thank my eight children; Asha, Maysoon, Mona, Faisal, Bryan, Danielle, Nawal, and Noah, who unknowingly loaned their father to this process. I recognize that every moment spent on research was time stolen from you. I am forever grateful to God for blessing me with all of you. I cannot imagine a life without you. Any father would be proud to have you as his children.

I thank serendipity for bringing all of you into my life. Without you, I would be nothing but a hermit.

I would also like to thank professors Hatch and Buttrey. Your patience over the past four years is truly appreciated. Throughout the data and IT problems, and a total restart midway through this process, you were nothing short of receptive and encouraging. I am not sure how you managed to continue caring despite the long stretches of communication silence.

To my unsuspecting third Co-Advisor, Dr. Michelle Dolfini-Reed, I am grateful for your guidance. Your selflessness in assisting me with the rewrites were a blessing. Your clarity helped me organize my thoughts into a coherent process. You were relentless in ensuring that I remained on task when time was down to the wire.

Nancy Sharrock, I thank you for taking on the task of formatting my research when I waited until the last possible minute.

Pam Silva, I appreciate your clarification of the entire submission process, and most of all, for forcing me to stop and take a breath when I panicked.

THIS PAGE INTENTIONALLY LEFT BLANK

# I. INTRODUCTION

## A. PURPOSE

The purpose of this research is to refine the current Reserve Manpower Model to more accurately forecast United States Marine Corps (USMC) personnel requirements.

## B. BACKGROUND

Since fiscal year 2004 (FY04) Congress has authorized the United States Marine Corps Selected Reserve (SELRES) a personnel end strength<sup>1</sup> at 39,600 Marines. Congress allows each service to deviate a maximum of three percent above or below authorized levels. The Marine Corps Reserve has fallen below the three percent variance since 2007 and risks Congress decreasing its authorization and budget, if it continues to demonstrate that it cannot maintain its authorized strength.

The Reserve Manpower Planner manages SELRES strength by adding expected gains to the current personnel strength, and subtracting expected losses to forecast the end strength. This process is updated monthly to improve the accuracy of the end strength forecast.

## C. EXISTING MODEL FORECAST ACCURACY

The evolution of the existing model was driven in part by the need to forecast losses. Unlike the active component (AC) Marine Corps, the reserve component (RC) has relied primarily on accurate loss forecasts, because the Marine Corps historically has not had an annual RC retention mission. Accuracy of loss forecasts was the product of monthly monitoring of losses and

---

<sup>1</sup> End strength refers to the number of Marines in the Marine Corps on September 30 of each year. The end strength figure is authorized annually in the National Defense Authorization Act (NDAA).

subsequent adjustment of the end strength forecast. This method of “looking back” to estimate the future was sufficient as long as the losses followed historical trends. Losses diverged from historical trends in the summer of 2008 and represented a turning point in the Reserve Manpower Model’s accuracy. Figure 1 charts the decreasing SELRES strength between FY04 to FY08. Figure 2 displays the end strength departure from the forecasts.

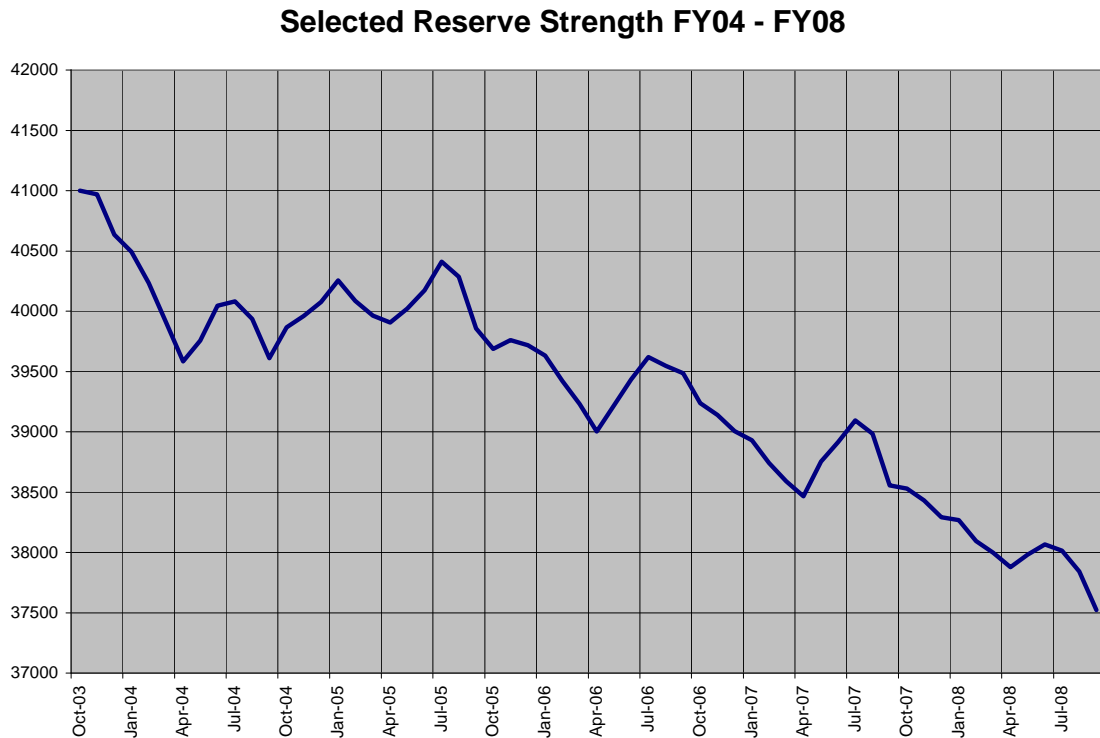


Figure 1. Selected Reserve Strength from FY04 through FY08

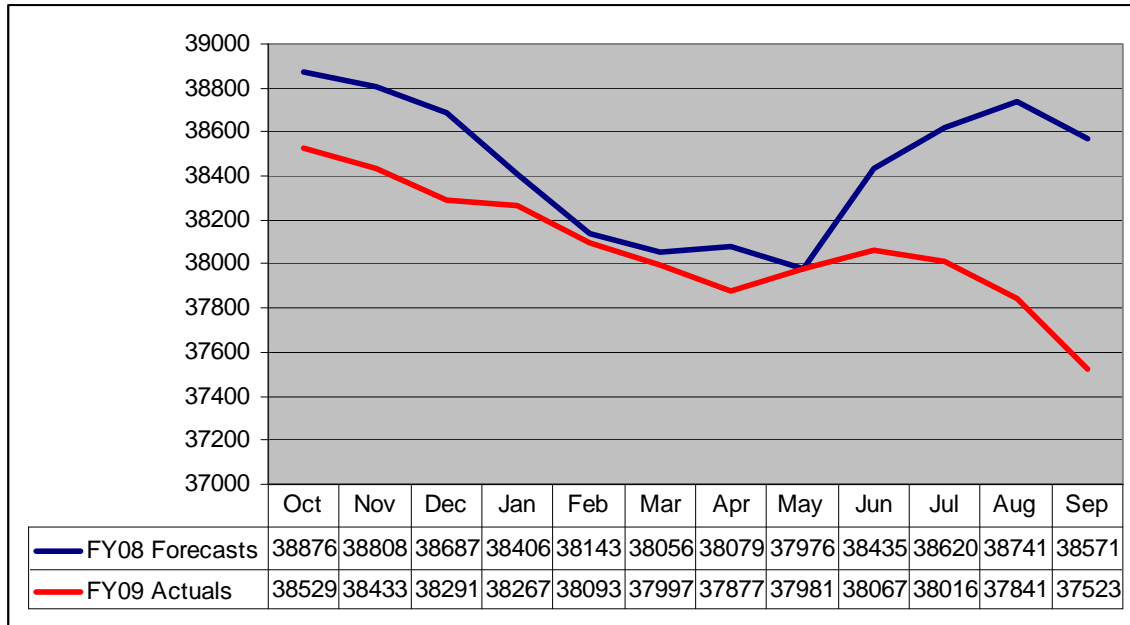


Figure 2. FY08 Forecast Departs from Actuals.

The end of FY06 marked a significant change in SELRES end strength. In September 2007, the SELRES end strength fell below the 39,600 authorization for the first time in 16 years. The year ended with only 39,486 Marines, just 0.3% short, but within the allowable 2% variance.<sup>2</sup> Figure 3 compares historical end strengths between FY90 and FY09, illustrating the steady decline in end strength.

<sup>2</sup> Reserve Manpower Model.

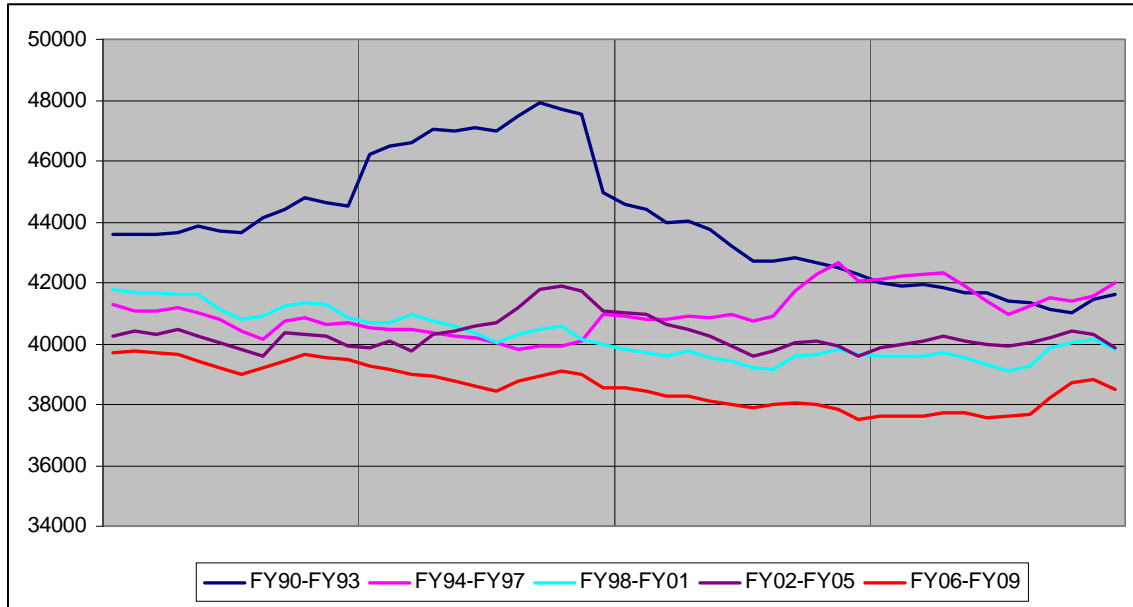


Figure 3. Comparison of SELRES End Strengths.

In FY07, the Reserve Affairs (RA) planner initially forecasted end strength to reach 39,447, but by September 2007, the forecast had decreased to 38,469: 2.9% short of the authorization and 2.5% lower than forecasted. FY08 started with an end strength forecast of 38,876, but by May 2008, it had decreased to 37,976, 4.1% short of the authorization, now beyond the acceptable 3% limit.<sup>3</sup> Historically, May and June are periods of personnel strength increases (see Figure 1). This is due, in part, to high school and college graduates joining the Marine Corps during these months in numbers disproportionate from those of the other ten months of the year. However, the RA planner's forecasted strength forecast for the end of June 2008 was an anomaly: the personnel strength had begun to level off earlier than expected, despite the progress in executing the accession mission. In July and August 2008, the personnel strength continued to decrease. The August end strength forecast had fallen to a strength of 38,798, 2% short of the authorization.

<sup>3</sup> The 2008 National Defense Authorization Act increased the end strength variance from 2% to 3 percent.

#### **D. SCOPE AND METHODOLOGY**

The current model forecasts losses with a weighted moving average of previous year's losses. In this research, I will examine the effect of incorporating a process that exponentially smooths the loss forecast within the Reserve Manpower Model by adjusting for error between forecasts and previous observations. The current model applies the weighted moving average uniformly to every category of losses. In my research, I will apply a unique smoothing factor to each category of losses, as each category can be assumed to behave independently of the others.

#### **E. ORGANIZATION OF THE STUDY**

Chapter II of the study is a literature review of the current model, previous accession studies, and previous loss studies. Chapter III describes the data used to conduct this research. Chapter IV defines the Reserve Manpower Model and discusses the model's specifications in depth. Chapter V summarizes the results of the thesis and makes recommendations for further research in the area of forecasting Reserve end strength.

THIS PAGE INTENTIONALLY LEFT BLANK

## II. LITERATURE REVIEW

### A. MANPOWER PLANNING

Manpower planning is the sum of three basic components: current strength, accessions and losses. The process of forecasting accession requirements is the continuous recalculation of these three parts at various points during the manpower cycle. Forecasting future accession requirements to ensure that statutory end-strength thresholds are attained demands forecasting models be as accurate as possible. This research examines the latter two components of manpower planning—accessions and losses with respect to the current reserve manpower model.

The accuracy of the Reserve Manpower Model drives programmed budgets in the Future Year Defense Plan and establishes the requirements that determine how many billets on the Reserve Component's Tables of Organization (T/O) are slated for each year on the Authorized Staffing Report (ASR). Forecast deviations result in unexecuted budgeted pay accruals, which can accumulate, to tens of millions of dollars.

Recent deviations in the model means that the Marine Corps has under-executed its Reserve Personnel Marine Corps (RPMC) budget. Unexecuted pay accruals often draw the attention of Congress, which then levy a "mark"<sup>4</sup> upon the RPMC budget. Marks are a routine occurrence near the end of each fiscal year, as recouped pay accruals represent an immediate savings in defense spending, or more often, the means to pay for an unfunded or underfunded requirement.

Unsuccessful justification for the retention of unexecuted RPMC funds results in the loss of unexecuted budget. More importantly, a pattern of

---

<sup>4</sup> "Marks" require P&R finance staff to conduct an audit of their budget execution and justification for retaining the unexecuted RPMC funds.

unexecuted funds may signal to Congress that the RPMC budget is either too large or that the pay accrual amounts are over estimated. This could possibly result in a reduction of statutory end strength authorizations. This, in effect, would be an embodiment of budget driven requirements vice mission driven requirements, an undesirable manner of determining personnel requirements in support of the National Defense Strategy.

## **B. PREVIOUS ACCESSION STUDIES**

Studies addressing accessions in the Marine Corps have been limited to active component accessions. This research utilizes the annual accession mission for the Reserve because the literature examining reserve accessions is very limited.

## **C. PREVIOUS LOSS STUDIES**

There have been many studies that attempt to estimate manpower losses or describe the variables that significantly contribute to losses in order to estimate future losses with respect to current strength. This research examines one study that examines losses. In 2008, Orrick utilized a logit<sup>5</sup> regression, which compared end of active service (EAS) losses to non-EAS losses and was able to forecast losses with some success. This cannot be directly translated to the SELRES population however, because the active and reserve components are inherently different.

## **D. CURRENT RESERVE MANPOWER MODEL**

The current Reserve Manpower Model originated as an ad hoc collection of processes and routines performed by the Reserve Manpower Planner on a monthly schedule. The data produced are entered into a spreadsheet in order to forecast Reserve End Strength for the end of the current fiscal year.

---

<sup>5</sup> The logit is the logarithm of the odds of a binary outcome.

## 1. Davis, Kimble, Hattiangadi (2007)

The spreadsheet utilized by the Reserve Manpower Planner at the beginning of FY07 contained data derived from several databases, policy documents and calculations, entered manually by the planner, usually on a monthly basis. The planner recognized that the column limitations of the software would soon inhibit the model's performance and requested that Studies & Analysis Division fund a "Quick-Response Study" to be conducted by the Center for Naval Analyses (CNA).<sup>6</sup>

To address this issue, CNA assisted in revising the model that extended its functional capacity. The revised spreadsheet would bridge the gap between the planner's spreadsheet and full operational capability of the Total Force Manpower Models Reengineering (TFMMR) program by transposing the columns and rows. TFMMR will eventually replace the planner's model. The reader should note that the procedures directed in Davis (2007) were no longer being performed in their entirety by May 2008; however, the logic utilized was still representative of the model and it serves as a documentation of the logic used until the end of FY08. The CNA model significantly simplified the planner's spreadsheet and reduced the potential for error via automated calculations and an accompanying user's guide.

The model forecasts end strength via the following formula:

$$\text{End Strength Forecast} = \text{Actual End Strength} - \text{Loss Forecast} + \text{Gain Forecast}$$

The Gain Forecast is calculated by the formula:

$$\text{Gain Forecast} = \text{Next Month's Accessions} + \text{Next Month's Mobilization Forecast}$$

The Loss Forecast is calculated by the formula:

$$\text{Loss Forecast} = \text{Weighted Sum of Historical Attrition Rates} * (\text{Last Month's EOM Forecast} + \text{Accession Mission} - (\text{Mobilization Forecast} * \text{Mobilization Effect}))$$

---

<sup>6</sup> Microsoft Excel 2003 and earlier versions were limited to 65,536 rows and 256 columns of data (<http://office.microsoft.com/en-us/excel/HA101375451033.aspx>).

The CNA verified and validated the formulas the planner was using in the spreadsheet during the design of the CNA model.

The CNA model was not intended to be an improved version of current processes or modeling. Rather, it focused on redesign of the planner's spreadsheet in a short amount of time in order to fill the gap between the planner's spreadsheet's data capacity and the full operational capability of the TFMMR program. The CNA model continued to use the original forecasting logic, which forecasted an approximate end strength that held very closely with historic observed monthly end strength levels. This is problematic because when the SELRES strength began a downward trend, the forecast was not responsive enough to account for the changing trend and continued to forecast an increasing strength when in fact, strength was declining drastically.

The current forecasting logic transferred from the planner's spreadsheet to the model contributes to forecasting inaccuracies in two ways. The first issue involves the Gain Forecast calculation in the End Strength Forecast equation. The Gain Forecast is the sum of planned accessions for the future period, as set forth in DC M&RA Memo-01, and mobilizations. The latter should not be included in the equation. Mobilized Marines are assigned a Component Code of KM, identifying them as mobilized and they are additionally assigned an Activation Status Code (ACTSTACD). Mobilized Marines count against Active Component end strength in one of two ways: either they are involuntary mobilized (ACTSTACD "ZM") or have been voluntarily mobilized (ACTSTACD "ZA") for more than three years of the previous four years. Marines with an ACTSTACD of ZM count towards the AC end strength as soon as they are mobilized; however, Title 10 USC directs an offsetting increase in authorized end strength resulting in a net end strength gain to the Active Component of zero. Marines with an ACTSTACD of ZA count against the AC end strength only after they have accumulated more than 1095 days (three years) of ADOS in the previous 1460

days (four years).<sup>7</sup> These Marines count against AC end strength without an offsetting end strength increase, resulting in a net end strength gain. This limitation was a provision of the 2005 NDAA intended to discourage the circumventing of statutory end strength limitations by mobilizing Marines for GWOT billets paid for by GWOT funds. Therefore, mobilized Marines should be calculated in the End Strength Forecast calculation, not the monthly calculation.

The second issue with the End Strength Forecast calculation is in the Loss Forecast. This variable is comprised of five variables: the weighted sum of historical attrition rates, previous month's end of month forecast, planned accessions, mobilization forecast, and mobilization effect. Both mobilization forecast and mobilization effect should be omitted from monthly accounting for reasons explained in the previous paragraph. The weighted sum of historical attrition rates variable is erroneously being applied against previous month's end of month forecast and the planned accessions minus mobilizations (product of forecast and effect). The application of the weighted sum against planned accessions is incorrect because accessions have already been calculated in the previous month's end of month forecast variable. More notable, the weighted sum of historical attrition rates assumes that the future can be represented by the past. This amounts to a trendline forecast, which is completely dependent on past losses to forecast future losses. However, if losses decrease over the next few months, the forecast will not significantly adjust for it due to the weight of all historic losses. That erratic loss history causes an erratic loss forecast that is always lagged by at least one period.

---

<sup>7</sup> There is no provision for leap-day in this limitation.

THIS PAGE INTENTIONALLY LEFT BLANK

### **III. DATA AND METHODOLOGY**

#### **A. INTRODUCTION**

This chapter provides an overview of the data used in the forecast model and the methodology used to forecast gains, losses and end strength. Analysis of the data may reveal a more accurate means of forecasting gains and losses, which would lead to more accurate end strength forecasts.

#### **B. DATA**

The data sources for this research were the Reserve Components Common Personnel Data System (RCCPDS)<sup>8</sup> monthly files and the Marine Corps Total Force System (MCTFS)<sup>9</sup> end of month cycle files. Selected Reserve data were then extracted from the monthly files for FY94 through FY08 and entered into the new model.

#### **C. DESCRIPTIVE STATISTICS**

The descriptive statistics for both models are shown in Table 1. The mean error of the legacy model produced loss forecasts that were 10 Marines greater than what was actually observed. The research model's forecast mean was 11 Marines greater than the observed losses. Initially, this suggests that the legacy model is slightly more accurate. However, when we consider the confidence interval around the mean, we see that both model produce the same similar confidence intervals. In the legacy model, we can be 95 percent sure that the model will produce a loss forecast that is between -1 and 21 Marines from the monthly observed losses. In the research model, we can be 95 percent sure that

---

<sup>8</sup> RCCPDS files are stored in accordance with DoDI 7730.54, March 31, 2008 Incorporating Change 1, November 13, 2009 at the Defense Manpower Data Center (DMDC) in Seaside, CA.

<sup>9</sup> MCTFS files are stored in the Total Force Historical Data Warehouse (TFDW) by the Manpower Information (MI) Division at Manpower and Reserve Affairs (M&RA), Headquarters, USMC on Marine Corps Base Quantico, VA.

the model will produce a loss forecast that is between 1.5 to 20.5 Marines greater than the monthly observed losses. Both intervals have the same spread, but this is of little importance to the planner. What *is* of importance is the range of the differences between the forecast and the observed values. As explained previously, a wider range of errors will cause the forecast to vary greatly in the FYDP. This can be analogized as an unmanned fire hose. The changes near the origin may be small, but at the opposite end, it is whipping violently.

The results from both models were compared to the actual strength figures for FY05 through FY09. The descriptive statistics for both the legacy model and the research model are below in Tables 1 and 2. The results of the research model were slightly more desirable due to a smaller standard deviation and a smaller range of observed values.

Month	Legacy Difference from Actual	Research Difference from Actual
31-Oct-05	-121	81
30-Nov-05	-29	23
31-Dec-05	9	4
31-Jan-06	9	23
28-Feb-06	-4	1
31-Mar-06	-15	13
30-Apr-06	12	26
31-May-06	7	-15
30-Jun-06	18	-23
31-Jul-06	-32	-21
31-Aug-06	-28	-38
30-Sep-06	-36	-39
31-Oct-06	-29	14
30-Nov-06	-34	-60
31-Dec-06	-22	-33
31-Jan-07	-6	8
28-Feb-07	-11	-38
31-Mar-07	12	-7
30-Apr-07	30	30
31-May-07	6	8
30-Jun-07	-1	-3
31-Jul-07	-28	7
31-Aug-07	-11	-9
30-Sep-07	-22	-39

Month	Legacy Difference from Actual	Research Difference from Actual
31-Oct-07	6	44
30-Nov-07	44	18
31-Dec-07	73	43
31-Jan-08	32	33
29-Feb-08	27	12
31-Mar-08	-4	10
30-Apr-08	14	0
31-May-08	46	1
30-Jun-08	13	-7
31-Jul-08	-33	22
31-Aug-08	-12	-22
30-Sep-08	33	32
31-Oct-08	40	40
30-Nov-08	30	14
31-Dec-08	37	36
31-Jan-09	61	57
28-Feb-09	20	11
31-Mar-09	5	-3
30-Apr-09	17	1
31-May-09	34	33
30-Jun-09	81	61
31-Jul-09	100	110
31-Aug-09	61	20
30-Sep-09	58	62

Table 1. Differences from Observed Losses

Mean	10
Standard Error	5
Median	9
Standard Deviation	38
Sample Variance	1431
Kurtosis	2
Skewness	0
Range	221
Minimum	-121
Maximum	100
Sum	457
Count	48
Confidence Interval	-1 to 21
Confidence Level(95.0%)	11.0

Table 2. Legacy Model Descriptive Statistics.

Mean	11
Standard Error	5
Median	11
Standard Deviation	33
Sample Variance	1067
Kurtosis	1
Skewness	0
Range	170
Minimum	-60
Maximum	110
Sum	537
Count	48
Confidence Interval	1.5 to 20.5
Confidence Level(95.0%)	9.5

Table 3. Research Model Descriptive Statistics.

#### D. METHODOLOGY

Personnel strength is calculated in accordance with the Department of Defense (DoD) RCCPDS instruction. The RCCPDS files stored at DMDC represent the only reliable and commonly retrievable Reserve personnel strength

information. Each monthly file was cross-tabulated by DoD Training Category Pay Group (DODTCPG) code and Rank (officer or enlisted). The data from the 112 resultant tables were compiled and entered into the new model.

## IV. MODEL ESTIMATIONS

### A. MODEL

The model forecasts end strength monthly via the following formula:

$$\text{End Strength Forecast} = \text{Actual End Strength} - \text{Exponentially Smoothed Loss Forecast} + \text{Gain Forecast}$$

The Gain Forecast is calculated by the formula:

$$\text{Gain Forecast} = \text{Next Month's Accessions} + \text{Next Month's Mobilization Forecast}$$

The Loss Forecast is calculated by the formula:

$$\text{Loss Forecast} = \alpha * \text{Last Month's Losses} + (1 - \alpha) * \text{Last Month's Forecasted Losses}$$

The Loss Forecast is repeated for every category of enlisted and officer in the SELRES. This method allows for the forecast to correct itself based on the error observed between the forecast losses and the observed losses. Additionally, utilizing individual alphas for each category of the research model allows us to capture, to a certain degree, the unexpected losses we are currently unable to forecast.

### B. EXPONENTIAL SMOOTHING MODEL RESULTS FOR FY00-FY08

The research model used Alphas between 0.5 and 1.0. The Alphas were selected by creating a spreadsheet-based tool to compare the forecast loss errors between FY05 and FY09. Then, the best Alphas produced were utilized in the loss forecast formula (Table 3).

Loss Category	alpha
SMCR Officer	0.80
SMCR Enlisted	0.80
IMA Officer	0.90
IMA Enlisted	0.90
AR Officer	0.60
AR Enlisted	1.00
IADT Officer	0.50
IADT Enlisted	1.00
IADT Grad Officer	0.50
IADT Grad Enlisted	0.90

Table 4. Research Model  $\alpha$  Values

The research model produced a slightly smaller standard deviation and a much smaller sample variance. This is desirable to the planner because forecasting errors have budget implications in the current year and across the Five-Year Defense Program (FYDP).

## **V. SUMMARY AND RECOMMENDATIONS**

### **A. SUMMARY**

This thesis developed a manpower model to forecast Selected Marine Corps Reserve end strength by forecasting losses with exponential smoothing. The data came from the Reserve Manpower Model (legacy model) and the results were compared with the historical strength data to determine if the research model provided more accurate results. This model is specific to the Marine Corps Selected Reserve.

The results of the model were slightly more desirable than the legacy model, due to a smaller standard deviation, smaller range of observed values.

### **B. RECOMMENDATIONS**

I recommend that the planner change the loss forecast calculation in the Reserve Manpower Model to include exponentially smoothed data. The result is a forecast that is more responsive to errors between the loss forecast and the observed losses, a smaller standard deviation and range. Additionally, the research model produced a slightly more desirable end strength forecast.

### **C. AREAS FOR FUTURE RESEARCH**

#### **1. Survival Analysis**

The accurate forecasting of losses is an essential component of any manpower model. Forecasting losses for the Selected Reserve is especially difficult due to the large population of Marines who are non-obligors and can leave at their own volition.

Currently, modeling Reserve manpower without a finite retention mission relegates the planner to only one active means of influencing end strength:

accession planning. When forecasting end strength, the planner must estimate losses for the year in which he or she is planning accessions. Survival analysis would provide greater insight as to why obligors and non-obligors in the Selected Reserve continue to serve in the reserve after their obligation has ended, as well as identify variables correlated to first term attrition.

## **2. Pay Grade Transition Matrix**

The personnel strength of the Selected Reserve contains a characteristic unique to the Reserve: Many of the Marines received their present grade while a member of the active component or subsequently were promoted while a member of the reserve. Since the active and reserve components promote differently, this requires the construction of a transition matrix to be three-dimensional as each pay grade beyond Private and Second Lieutenant has two possible precedents.

A reserve pay grade transition matrix would provide both the Reserve Affairs Plan section and the Reserve Manpower Planner with a means to forecast obligor and non-obligor end strength.

## **3. Accession and Retention Cost Benefit Analysis**

The Reserve Personnel Marine Corps (RPMC) account allocates an accrual rate dependent on the rank and reserve category for each budgeted piece of end strength. Every loss of end strength beyond the figure estimated at the time of the accession planning results in unexecuted manpower funds. Conversely, every Marine in the Selected Reserve has a predetermined budgetary cost. Therefore, the means to analyze the efficiency of retention over accessions exist. The retention of first-term reserve Marines can then be managed by pay grade with the aid of a transition matrix. Additionally, this analysis could provide the Reserve Affairs Plans section with the means to identify retention bonus caps by pay grade as well.

#### **4. Forecasting by Recruiting District**

Reserve Marines are generally accessed from an area within 100 miles of the unit at which they will drill. This dynamic then defines the characteristics of the Marines within a particular unit.

#### **5. Active Component to Reserve Component Conversion Rate Analysis**

When an applicant contractually obligates himself to the Marine Corps, the prescribed Military Service Obligation is for a combined total of eight years. There are multitudes of combinations in which the obligation can be performed; of primary interest are Marines who transfer from the Active Component to the Selected Reserve.

Future research should examine the conversion rate from various states of Active Component service to service in the Selected Reserve. The conversion rates of former Active Component Marines who transferred to the Individual Ready Reserve and then later transferred to the Selected Reserve should be studied as well.

THIS PAGE INTENTIONALLY LEFT BLANK

## APPENDIX A. MODEL FORECAST USERS

The Reserve End Strength Model is the foundation for several functions within the Reserve Affairs Division (RA) division of Manpower and Reserve Affairs, Headquarters Marine Corps (HQMC). The model also supports several agencies external to the Marines Corps, as well as several functions within HQMC.

### A. EXTERNAL AGENCIES

The office of the Deputy Assistant Secretary of the Navy for Reserve Affairs (DASN-RA) utilizes the monthly strength figures produced by the model to gauge the effectiveness of Marine Corps policies and programs, as well as an indicator as to how close the SELRES end strength will be to 39,600. The Secretary of the Navy may waive the Marines Corps' variance from the authorized strength should the SELRES end strength fall within two percent above or below the authorized strength.<sup>10</sup>

The Office of the Secretary of Defense for Reserve Affairs (OSD-RA) utilizes the monthly strength figures produced by the model to gauge the effectiveness of Marines Corps policies and programs in contrast with those of the Navy Reserve, Army Reserve, Army National Guard, Air Force Reserve, and the Air National Guard. OSD-RA also uses the forecasts to determine whether the SELRES end strength will fall within the two percent variance waiveable by the Secretary of the Navy. The Secretary of Defense may waive the Marine Corps' variance from the authorized strength should the SELRES end strength fall outside the two percent threshold but no more than three percent above or below the authorized strength.<sup>11</sup>

---

<sup>10</sup> Title 10 U.S.C. 691.

<sup>11</sup> Title 10, U.S.C.(a) authorizes a Presidential waiver of end strength limitations during war or national emergency. On 28 August 2008, the President issued a continuation of the national emergency with respect to certain terrorist attacks effective until September 2009. Executive Order 13223 delegated the Presidential waiver authority to the Secretary of Defense. Secretary of Defense Memorandum, dated September 14, 2001, delegated the Presidential waiver authority to the Service Secretaries.

The Government Accountability Office (GAO) utilizes the monthly strength figures produced by the model to determine how accurately the Program Budget submissions are executed as forecasted. Mid-year reviews are conducted to identify budget shortfalls and excesses in order to assess whether or not budget increases or decreases are warranted.

## **B. INTERNAL FUNCTIONS**

The Programs and Resources branch (P&R) of Manpower Management division, HQMC utilizes the monthly figures generated by the Reserve Manpower Model to determine the average monthly strength by reserve category (ResCat) and rank for the SELRES. These averages are then used to calculate differential<sup>12</sup> amounts for the associated ResCat and rank iterations. The sum products of the accrual figures and the model's forecasts are used to forecast future budget needs (programmed budgets or PBs). The PBs are submitted to the OSD Comptroller for inclusion in the Joint Budget Book, also known as the "J-Book." The J-Book submissions are then compared by the GAO with budget executions throughout the year for accuracy.

Marine Corps Recruiting Command (MCRC, pronounced "mick-rick") utilizes the model forecasts to determine how much effect the assigned recruiting mission is having on end strength. When the end strength forecast varies, MCRC can expect an offset in the following FY recruiting mission.

Training and Education Command (TECOM, pronounced "tee-comm") utilizes the model figures and forecasts to judge how much of the recruit population is in boot camp and how much of the student population in its various schools are Reserve Marines. The model forecasts also signal how much remaining Reserve Marine population is yet to enter training for the fiscal year.

---

<sup>12</sup> A differential is a budget-planning factor determined by the 2-year average strength of each Reserve manpower type. There are separate differentials for the officers and enlisted of each reserve manpower type.

## **C. RESERVE AFFAIRS DIVISION**

Reserve Affairs division utilizes the monthly figures to determine how well the functional areas of each of the division's sections are faring with regard to end strength.

### **1. Reserve Affairs Management (RAM)**

The model supports the functions of RAM by providing loss and gain data associated with the Active Reserve (AR) program. The model also provides RAM with the accessions that can be expected via MCRC, as well as revealing how many additional AR Marines will need to be accessed via the direct efforts of RAM. Prior to FY09, accessions into the AR program were not processed by MCRC.

### **2. Reserve Affairs Coordination (RAC)**

The model supports the functions of RAC by reporting the number of Reserve Marines serving on Active Duty Operational Support (ADOS). Marines on ADOS count against the Active Component or Active Reserve end strength dependent upon the amount of ADOS time served in certain areas. RAC manages the assignment of Marines to ADOS who require waivers due to high-year active service guidelines. Reserve Marines on ADOS may count against active or reserve end strength depending upon several factors.

### **3. Reserve Affairs Plans (RAP)**

The RAP section of RA division is subdivided into three functional areas: Policy; Promotions, Incentives and Training (PIT); and Manpower.

#### ***a. Policy***

The model aids policy with data support for congressional testimony preparation. Frequently, the Deputy Commandants and other General

Officers must testify before Congress regarding their perspective functional areas. The testimony is prepared in part by policy when comments including Reserve Component testimony is required. Additionally, the forecasts of the model aid in identifying program inefficiencies and provide data in support of Uniform Legislative Budget (ULB) requests.<sup>13</sup>

***b. PIT***

The model supports the functions of the PIT by providing grade strength data to form the promotion plan. The end strength forecast also provides the PIT with a ballpark figure of the next FY's school seat requirements.

***c. Manpower***

The model supports the functions of manpower by providing all data to the aforementioned external agencies, internal functions and Reserve Affairs division.

---

<sup>13</sup> Unified Legislation and Budget requests are proposals to public law. A ULB must have the support of two of the four services in order to obtain consideration for change of the law. An example of a ULB would be a request to change the minimum parameters for a bonus or incentive.

#### **4. MCTFS Cycles—Total Force Data Warehouse**

A snapshot of the data contained in MCTFS is taken and stored for future retrieval nearly every day. These snapshots called “cycles.” MCTFS cycles contain certain fields of every Marine’s MCTFS data. The data in a particular cycle allows us to see what a Marine’s MCTFS record contained at a specific point in time. Daily cycles are stored and maintained in the TFDW, managed by the Manpower Integration branch at Manpower and Reserve Affairs.

This research used several data elements of the daily cycles. They are:

- Mandatory Drill Stop Date (MDSO)—The MDSO is the date that a Marine is no longer obligated to participate in drills<sup>14</sup>
- Reserve Component Code (RCC)—The RCC differentiates what a Marine’s reserve participation requirements are.
- Reserve End of Current Contract (RECC)—The RECC date minus the contract length identified by the RCC tells us how long a Marine has been in the Selected Reserve
- Date Joined SMCR (DJSMCR)—The DJSMCR field tells us when a Marine first entered the SMCR. If the Marine is an obligor, this field is utilized in conjunction with the MDSO to determine when his drilling obligation will expire.

#### **5. RCCPDS Files—Defense Manpower Data Center**

The files that contain the monthly manpower strength information<sup>15</sup> are called the Reserve Components Common Personnel Data System files (RCCPDS files). The TFDW maintains a shared data environment of current and historical individual and aggregate data<sup>16</sup>. The data is stored in accordance with

---

<sup>14</sup> MCO P1001R.1K defines this field as the Mandatory Drill Participation Stop Date (MDPSD) in paragraph 2101(2). When the data are extracted from the MCTFS, the software renames this field to MDSO for entry in the model.

<sup>15</sup> DoD Instruction 1215.06 defines the official manpower categories for the seven reserve components in the DoD.

<sup>16</sup> Statement of Lieutenant General Ronald S. Coleman, Deputy Commandant for Manpower and Reserve Affairs before the Personnel Subcommittee of the House Armed Services Committee concerning recruiting, retention & policy overview on February 15, 2007.

(DoDI 7730.54),<sup>17</sup> which defines the data elements that are to be maintained in RCCPDS and the MISSO 15/16 in Kansas City, MO. During the process that creates the RCCPDS file, another file called the “transaction file” is created. The DODTTC<sup>18</sup> field of the transaction file identifies gains, losses and transfers into and out of each reserve manpower category. This research categorizes the transactions by cross-tabulating gains, losses and transfers by reserve category. This isolates each transaction and ResCat<sup>19</sup> combination so they can be utilized to more accurately calculate forecasts.

---

<sup>17</sup> DoD Instruction 7730.54 defines composition of the RCCPDS file.

<sup>18</sup> Department of Defense Transaction Type Code.

<sup>19</sup> Reserve Category.

## **APPENDIX B. STRENGTH CATEGORIES**

1. SMCR Officer (DODTCPG = SA, UQ)
2. SMCR Enlisted (DODTCPG = SA, UQ)
3. SMCR Total
4. IMA Officer (DODTCPG = TB)
5. IMA Enlisted (DODTCPG = TB)
6. IMA Total
7. AR Officer (DODTCPG = SG)
8. AR Enlisted (DODTCPG = SG)
9. AR Total
10. IADT Officer (DODTCPG = UF, UP, UX, UT)
11. IADT Enlisted (DODTCPG = UF, UP, UX, UT)
12. IADT Total
13. Officer Total
14. Enlisted Total
15. Selected Reserve Total

THIS PAGE INTENTIONALLY LEFT BLANK

## LIST OF REFERENCES

- Congress. (2008). *National Defense Authorization Act of 2008*. Washington, D.C.: United States Government Printing Office.
- Davis, J. R., Kimble, T. H., & Hattiangadi, A. U. (2007). *USMC reserve endstrength model*. Alexandria, VA: Center for Naval Analyses.
- Davis, J. R., Kimble, T. H., Hattiangadi, A. U. (2007). *USMC reserve endstrength model: User's guide*. Alexandria, VA: Center for Naval Analyses.
- Hawes, E. A. (1990). *An application of survival analysis methods to the study of Marine Corps enlisted attrition*. Monterey, CA: Naval Postgraduate School.
- Hogan, D. L. (1984). *The use of exponential smoothing to produce yearly updates of loss rate estimates in Marine Corps manpower models*. Monterey, CA: Naval Postgraduate School.
- Orrick, S. C. (2008). *Forecasting Marine Corps enlisted losses*. Monterey, CA: Naval Postgraduate School.
- Schumacher, J. F. (2005). *Forecasting retention in the United States Marine Corps Reserve*. Monterey, CA: Naval Postgraduate School.

THIS PAGE INTENTIONALLY LEFT BLANK

## INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center  
Fort Belvoir, Virginia
2. Dudley Knox Library  
Naval Postgraduate School  
Monterey, California
3. Marine Corps Representative  
Naval Postgraduate School  
Monterey, California
4. Director, Training and Education, MCCDC, Code C46  
Quantico, Virginia
5. Director, Marine Corps Research Center, MCCDC, Code C40RC  
Quantico, Virginia
6. Marine Corps Tactical Systems Support Activity (Attn: Operations Officer)  
Camp Pendleton, California
7. William Hatch  
Naval Postgraduate School  
Monterey, California
8. Samuel Buttrey  
Naval Postgraduate School  
Monterey, California
9. Wayne Wagner  
Strategic Affairs Office, N1Z  
Arlington Annex, Washington, District of Columbia
10. Commandant of the Marine Corps  
Manpower & Reserve Affairs  
Headquarters Marine Corps  
Quantico, Virginia
11. Reserve Affairs Division  
Manpower & Reserve Affairs  
Headquarters Marine Corps  
Quantico, Virginia

12. Reserve Manpower Planner  
Reserve Affairs Division  
Manpower & Reserve Affairs  
Headquarters Marine Corps  
Quantico, Virginia
13. Michelle Dolfini-Reed  
Center for Naval Analyses  
Alexandria, Virginia
14. Cheryle Fitzgerald  
Programs & Resources Division  
Manpower & Reserve Affairs  
Headquarters Marine Corps  
Quantico, Virginia
15. Nathan Emery  
Fredericksburg, Virginia