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Allocating Promotions to Year of Service (YOS) Cells in a Marine Corps Inventory Projection Model

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This report describes the development of a preliminary method for allocating pay grade promotions to year of service (YOS) cells at the all Marine Corps (ALMAR) level in the prototype inventory projection model (IPM). For FY81 through FY86, historical promotion data by pay grade and YOS at the end of each fiscal year were used for the analysis. The analysis showed that for all pay grades, the distribution of promotions across YOS has changed. Two techniques were used to produce a promotion allocation table to be used in the IPM. In a comparison with the actual YOS distribution of ALMAR promotions in FY87, the naive method out performed the IPM promotion allocation table. Further research is needed to explore a method that does not solely rely on the historical distributions.

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FOREWORD

This report describes the method used in the prototype Inventory Projection Model to allocate promotions to year of service cells by pay grade. The Inventory Projection Model is one of the components of the Enlisted Planning System (EPS). This work was conducted under program element 0603732M (Marine Corps Advanced Manpower Training Systems), work unit number C0073-03.05 (Human Resources Management and Forecasting), sponsored by the Deputy Chief of Staff for Manpower and Reserves Affairs (MISC). Appreciation is expressed to Maj. J. Villarta (MPP-20) for providing information on enlisted promotions.

MURRAY ROWE
Director, Manpower Systems Department

SUMMARY

This report describes the development of a preliminary method for allocating pay grade promotions to year of service (YOS) cells at the all Marine Corps (ALMAR) level in the prototype IPM. Historical promotion data by pay grade and YOS at the end of each fiscal year was used for the analysis. For FY81 through FY86, a single table, showing the distribution of promotions across YOS within a pay grade, was created. The six fiscal year tables were then combined to form one data set. This combined table was used to assess the existence of trends in the distribution of promotions by YOS.

The analysis of historical promotion data showed that for all pay grades, the distribution of promotions across YOS has changed during FY81-FY86. Two techniques were used to produce a promotion allocation table for the prototype IPM. For each pay grade/YOS cell, if the data appeared to exhibit a trend over time (FY81-FY86), the percent from the most recently computed year (FY86) was used. If the data did not appear to exhibit a trend over FY81-FY86, the average of the distribution percentages for all 6 years was used.

In a comparison with the actual YOS distribution of ALMAR promotions in FY87, the naive method out performed the IPM promotion allocation table, as measured by WMAPE. The results of these analyses suggest that a means of forecasting policy impacts on the YOS distribution of promotions is needed that does not rely solely on the historical YOS distributions of promotions.

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INTRODUCTION

Problem

The prototype Inventory Projection Model (IPM) of the USMC's new EPS simulates annual personnel flows (e.g., losses, gains, promotions), applies the flows to a begin fiscal year inventory, and produces an end fiscal year inventory arrayed by pay grade and year of service (YOS). This cycle is repeated seven times yielding inventory and flow forecasts for 7 future fiscal years.

The promotion module in the IPM determines the number of promotions at each pay grade needed to achieve the authorized strength, or Grade Adjust Recapitulation (GAR). It accomplishes this by comparing the inventory at each pay grade, after subtracting losses and adding gains, to the GAR. The IPM must then distribute the total promotions in each pay grade across YOS. Because the GAR does not have a YOS dimension, the IPM must include a methodology for allocating promotions to YOS cells. The purpose of this study was to analyze historical promotion data and to use the results to develop a preliminary method for allocating promotions to YOS cells in the prototype IPM.

Approach

The yearly version of the Enlisted Personnel Data Base covering FY81-FY86 was used to analyze historical promotion behavior.[1] The data base contains a single record for each Marine who was on active duty anytime during a fiscal year. The record contains the number and type of pay grade changes (e.g., regular promotion, punitive reduction) a Marine had during the fiscal year. The analysis included both regular and meritorious promotions and was conducted at the all Marine Corps (ALMAR) level. Promotion distributions by YOS at the end of the fiscal year in which a promotion occurred were constructed and analyzed. For FY81 through FY86, a single table, showing the distribution of promotions across YOS within a pay grade, was created. The six fiscal year tables were then combined to form one data set. Each pay grade/YOS cell in the new table contained a maximum of six entries, one for each fiscal year. The combined table was used to assess the existence of trends in the distribution of promotions by YOS.

Background: The Marine Corps Enlisted Promotion System

The USMC enlisted personnel system provides two ways for Marines to advance through the pay grade hierarchy, regular promotion and meritorious promotion. A Marine is eligible for a regular promotion once he/she meets the minimum time in service (TIS) and time in grade (TIG) requirements. Table 1, taken from the *U.S. Marine Corps Enlisted Promotion Handbook*, outlines the minimum TIS and TIG requirements for promotion. These minimums have remained unchanged during FY81-86. For example, to be eligible for regular promotion to E-3, a Marine must have 8 months TIG as an E-2 and 9 months total TIS. Marines must also have the recommendation of their commanding officer. Additional requirements include meeting or

[1] FY87 data were withheld for use in validation of methods developed during the analysis.

exceeding the respective cutoff score[2] established for E-4 and E-5 and being chosen by a HQMC selection board for promotion to E-6 and above.

Table 1

Minimum Time in Service and Time in Grade Requirements for Regular Promotion and Meritorious Promotion

	Regular		Meritorious	
Promotion To	TIG[a]	TIS	TIG	TIS
E-2	6 months	6 months	none	none
E-3	8 months	9 months	none	none
E-4	8 months	1 year	none	6 months
E-5	1 year	2 years	none	18 months
E-6	27 months	4 years	none	4 years
E-7	3 years	6 years	none	6 years
E-8	4 years	8 years		
E-9	3 years	10 years		

[a]TIG refers to time in previous pay grade.

Based on outstanding performance, a Marine can be meritoriously promoted up to E-7. TIG minimums are waived and the TIS requirement is waived or reduced, depending on the pay grade. Table 1 shows the TIS minimums for meritorious promotion.

The Marine Corps maintains maximum TIS limits for pay grade E-3 through E-9. This informal "Up or Out" policy dictates that a Marine must reach E-3 by the sixth year of service or he/she will not be eligible to reenlist. Table 2 displays the old TIS limits and the current limits which became effective on 1 October 1988. The Marine Corps has not rigidly enforced the "Up or Out" policy. Instead, the case of each Marine reaching the maximum TIS limit is reviewed individually.

[2]The score is a composite measure of a Marine's professional performance, length of service, and physical fitness.

Table 2

Maximum TIS Limits by Pay Grade

Pay Grade	Old	Current
E-1--E-3	6 years	6 years
E-4	8 years	8 years
E-5	12 years	13 years
E-6	20 years	20 years
E-7	25 years	22 years
E-8	27 years	27 years
E-9	30 years	30 years

Data Analysis

E-2

Figure 1 shows that during the period FY81-FY86, nearly 95 percent of all promotions to E-2 occurred in YOS 1 and YOS 2. The proportion of promotions in YOS 1 rose steadily through FY84 and then leveled off in the latter 2 years. In both FY85 and FY86, 63 percent of promotions to E-2 were in YOS 1 and 32 percent of promotions were in YOS 2. The remaining 5 percent was spread across YOS 3-YOS 8.

E-3

The YOS distribution of promotions to E-3 between FY81-FY86 is shown in Figure 2. Over 90 percent of all promotions occurred in YOS 1-3. At the same time, the proportion of E-3 promotions in YOS 1 has increased from 5 percent in FY81 to over 17 percent in FY86. The expansion of the Quality Enlistment Program (QEP) contributed to the increase in E-2 and E-3 promotions from YOS 1. The program attracted individuals in upper mental categories to join the Marine Corps by promising them accelerated promotions. Despite the maximum TIS limit of 6 years, the analysis uncovered cases in each fiscal year of Marines being promoted to E-2 with 8 years of service at the end of the fiscal year and to E-3 with 8, 9, and 10 years of service.

E-4

Figure 3 displays the historical YOS promotion data for E-4. The analysis of these data produced three notable findings. First, between FY81 and FY86, over 90 percent of all promotions to E-4 came from YOS 2-5. While this aggregate percent remained relatively stable across time, the relative contributions from YOS 2-3 and 5 have shifted significantly. For example, during FY83, 44 percent of promotions to E-3 occurred in YOS 3. By FY86, only 26 percent of the promotions were from YOS 3. The decline in YOS 3's proportion has been offset by increases in the proportion of promotions from YOS 2, 4, and 5. These results suggest that in recent years Marines are waiting longer to get promoted to E-4.

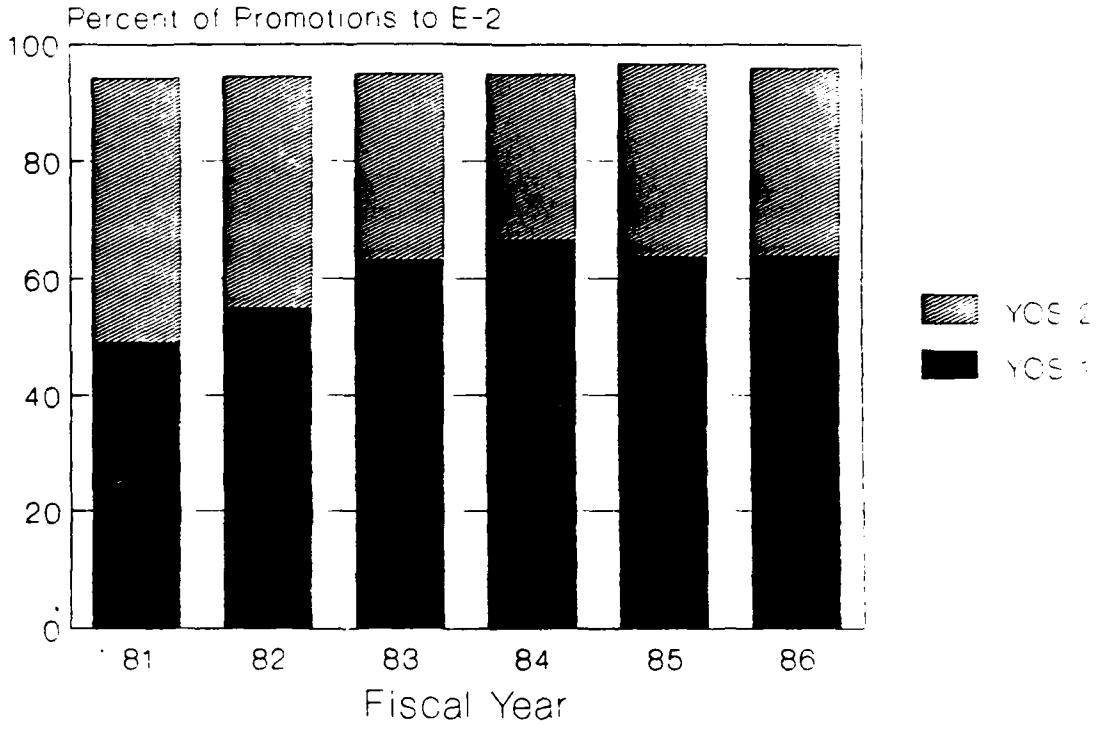

Figure 1. Distribution of promotions to E-2 by YOS, FY81-FY86.

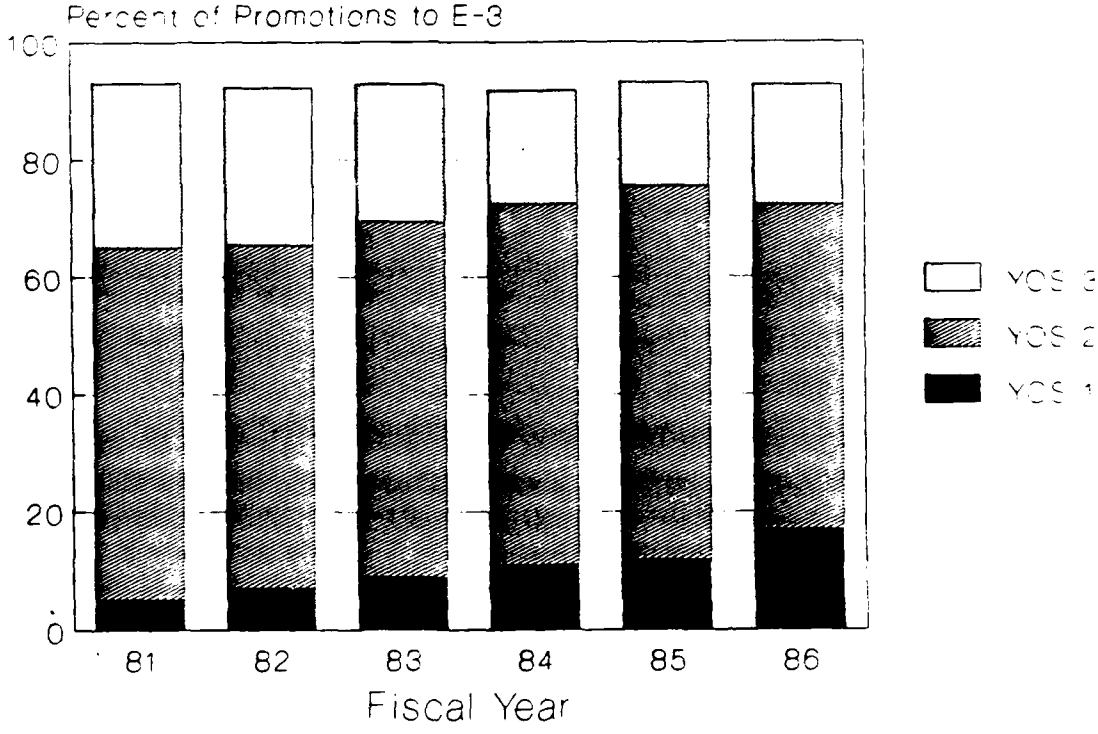

Figure 2. Distribution of promotions to E-3 by YOS, FY81-FY86.

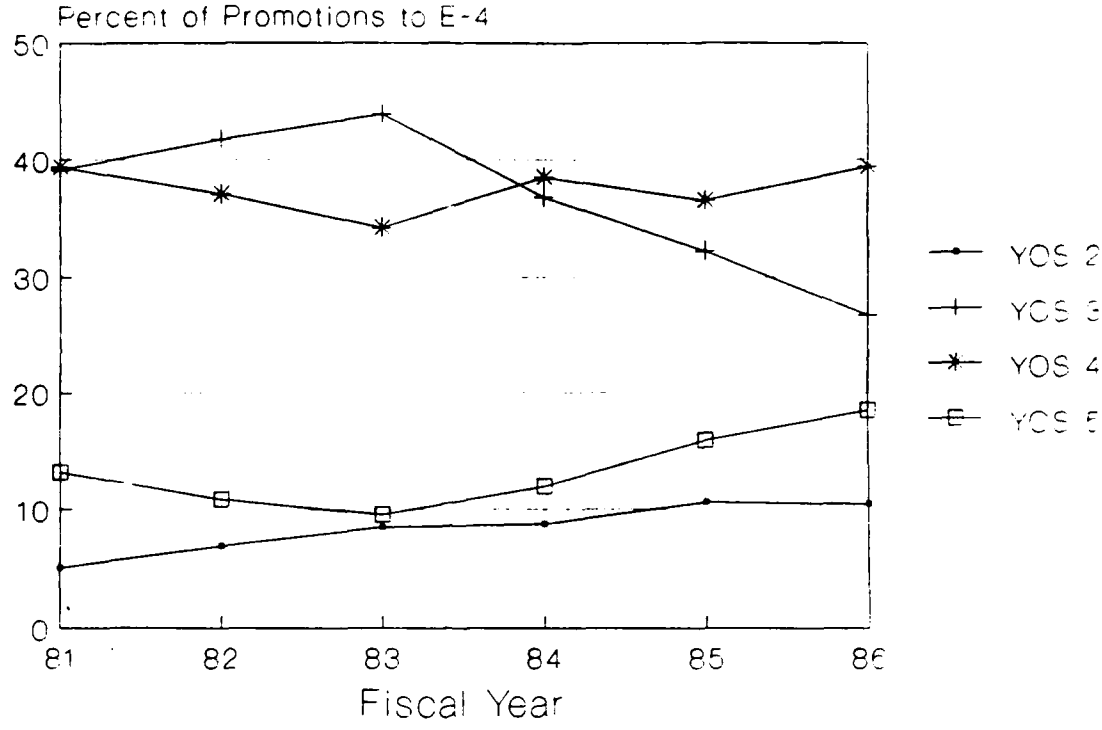

Figure 3. Distribution of promotions to E-4 by YOS, FY81-FY86.

Second, Marines were promoted to E-4 despite their YOS exceeding the limit imposed in the "Up or Out" policy (i.e., 8 years of service). In each fiscal year observed, Marines were promoted to E-4 with 10, 11, or 12 years of service. E-2-E-4 were the only pay grades where exceptions to the "Up or Out" policy were found consistently. Finally, less than 1 percent of promotions to E-4 occurred in YOS 1. These are meritorious promotions where the TIG requirement is waived and the TIS requirement is only 6 months.

E-5

Figure 4 shows YOS distribution of promotions to E-5. Over 90 percent of all E-5 promotions were in YOS 4-7. While this aggregate percent remained relatively stable over time, the distribution within the range has changed. For example, nearly 42 percent of promotions to E-5 in FY81 were in YOS 5. By FY86, only 23 percent came from YOS 5. In contrast, only 5 percent of E-5 promotions in FY81 were in YOS 7. However, by FY86, nearly 20 percent of E-5 promotions occurred in YOS 7. The increase in YOS 6's and YOS 7's proportions has been offset by a similar decline in the proportions of promotions from YOS 4 and YOS 5.

This shift in the YOS distribution of promotions is due, in part, to stagnation at E-6, in the early 1980s. At that time, reenlistments were high, and losses were low. Few vacancies existed at E-6, which resulted in a limited number of E-5s being promoted. The E-5 vacancies were filled by the more senior E-4s.

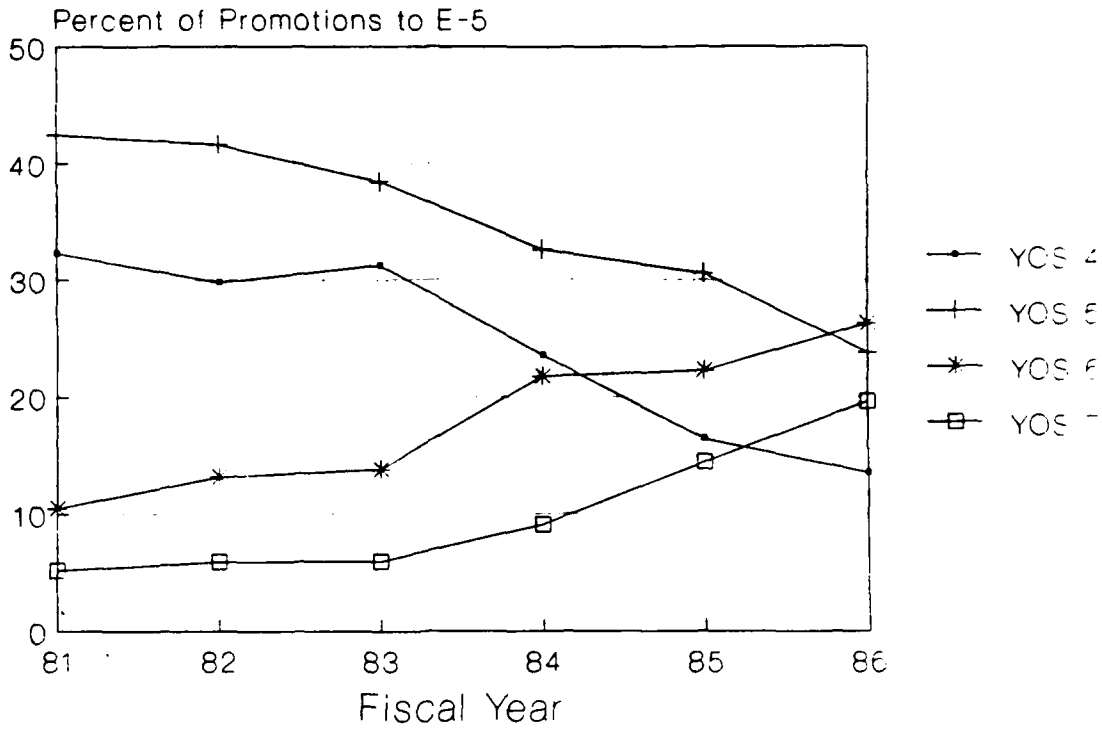

Figure 4. Distribution of promotions to E-5 by YOS, FY81-FY86.

E-6

Historical promotion behavior at E-6 exhibited trends similar to those observed for E-5. Figure 5 shows that over 80 percent of E-6 promotions occurred in YOS 7-10. While the overall percent has remained stable, proportions from individual years of service have changed. Both YOS 7 and YOS 8 have experienced a declining share of promotions since FY83 while the proportion of promotions in YOS 9 and 10 increased sharply. For example, by FY86, only 5 percent of E-6 promotions occurred in YOS 7, down from over 25 percent in FY83. In contrast, the proportion of promotions in YOS 10 grew from 7 percent in FY83 to over 21 percent by FY86. As mentioned above, this shift is due to a limited number of vacancies resulting from a large number of reenlistments and few losses.

E-7, E-8, and E-9

More than 70 percent of all E-7 promotions occurred in YOS 11-15. Figure 6 indicates that between FY81 and FY86, the proportion of E-7 promotions in YOS 11 dropped from 17.51 percent to 6.02 percent and the proportion in YOS 12 dropped from 25.37 percent to 19.03 percent. Over the same time frame, the proportions in YOS 14 and 15 increased.

No consistent trends were observed in either E-8 or E-9 historical promotion data. The distributions for both pay grades were erratic with the majority of E-8 promotions occurring in YOS 16-22. The majority of promotions to E-9 occurred in YOS 20-27.

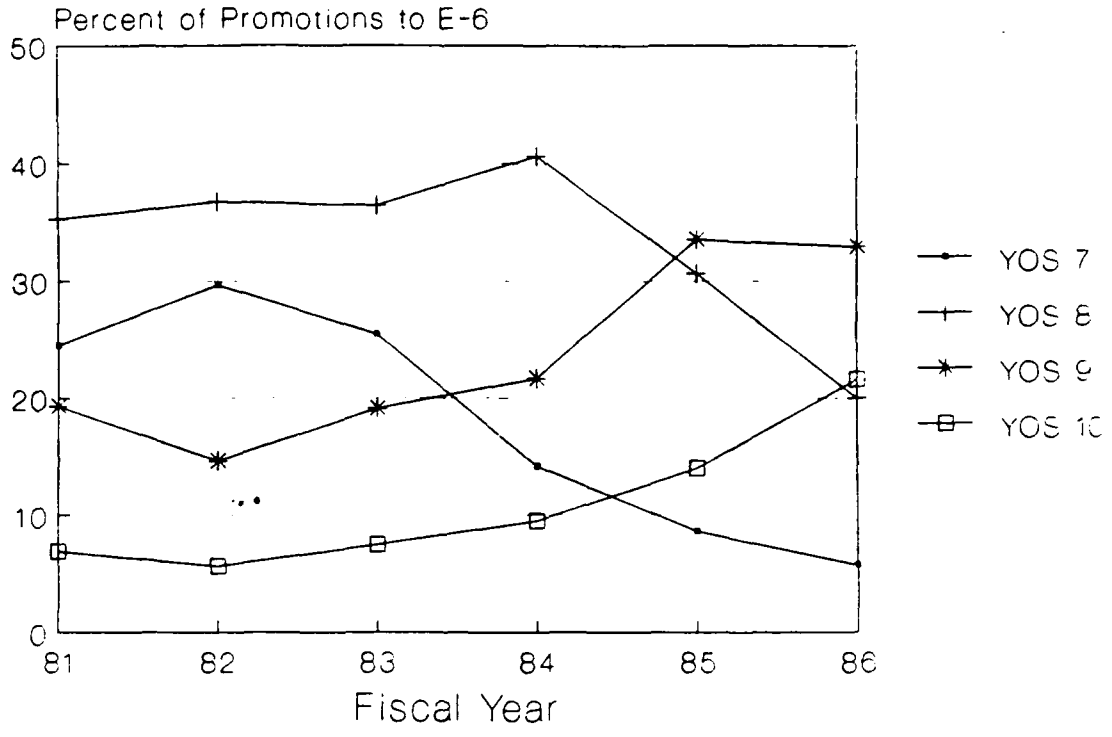

Figure 5. Distribution of promotions to E-6 by YOS, FY81-FY86.

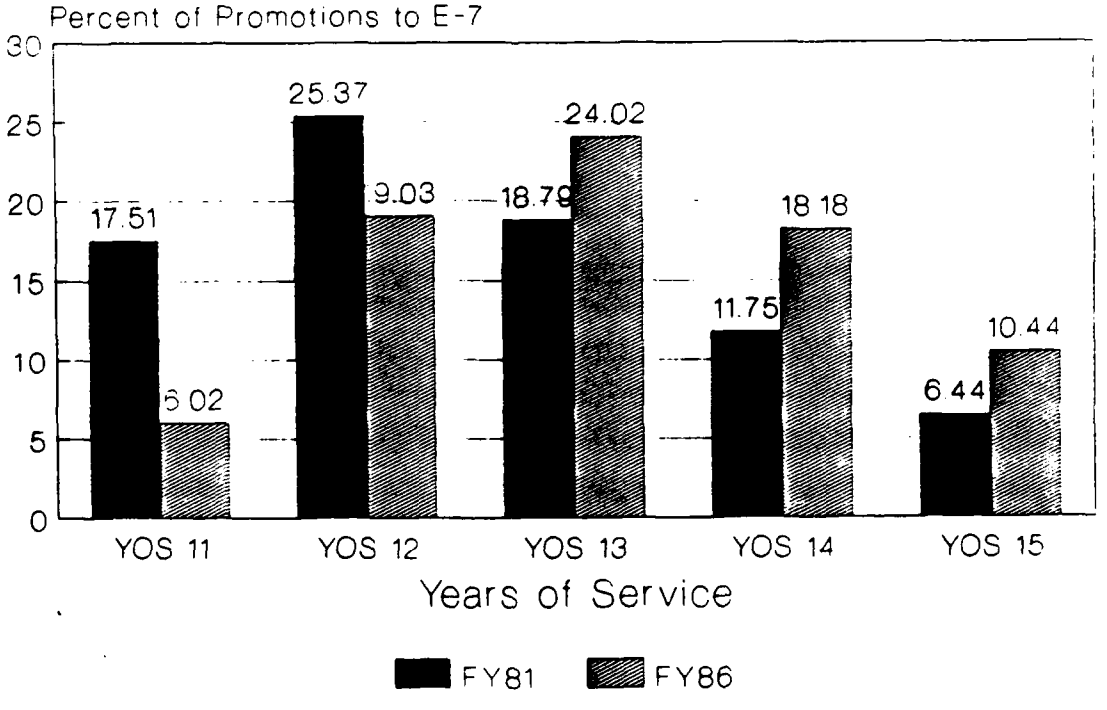

Figure 6. Distribution of promotions to E-7 at YOS 11-15, FY81-FY86.

PROMOTION ALLOCATION TECHNIQUES

The analysis of historical promotion data showed that for all pay grades, the distribution of promotions across years of service has changed during FY81-FY86, exhibiting several kinds of trends. This finding suggested that more than one technique might be necessary to represent the future YOS allocation of promotions within each pay grade. Two techniques were chosen to distribute promotions across YOS cells in the prototype IPM: a simple, unweighted average of the distribution percentage for all 6 years and the distribution percentage of the most recent year (FY86).

The choice of which percentage to use in each PG and YOS cell was based on a rule developed from the analysis of the historical data. If the data appeared to exhibit a trend over time (FY81-86)[3], the percent from the most recently computed year (FY86) was used. If the data did not appear to exhibit a trend over FY81-86, a simple average of the percents from all 6 years was used. The former case is exemplified by historical promotions to E-5 from YOS 5 (see Table 3). In this case, the FY86 percent, 23.79 was used. The latter case is exemplified by historical promotions to E-3 from YOS 2 (see Table 4). Since the data exhibited no trend, the simple average of all six percentages, 59.74, was used. Analysis of the data suggested that 34 cells revealed a trend and 70 cells did not.

Table 3

Distribution of E-5 Promotions at YOS 5

Fiscal Year	Percentage
81	42.46
82	41.65
83	38.48
84	32.62
85	30.58
86	23.79

[3]A series showing steady increases or decreases over FY81-86 was said to exhibit a trend.

Table 4

Distribution of E-3 Promotions at YOS 2

Fiscal Year	Percentage
81	59.73
82	58.28
83	60.35
84	61.37
85	63.48
86	55.26

The rule described above was used to create a promotion allocation table by YOS. Two adjustments to the resulting table were applied to ensure that (1) percentages across YOS cells within each pay grade summed to 100 percent and that (2) no promotions are allocated to YOS cells below the minimum TIS (see Table 1) or above the maximum TIS plus one year (see Table 2).[4]

Table 5 displays the YOS promotion allocation table that results from the decision rule and subsequent adjustments described above. An evaluation of the effectiveness of this allocation table was then conducted.

[4]Violations to the minimum/maximum TIS were alowed in cells where historical data showed Marines consistently being promoted beyond the TIS limits (E-2, YOS 8; E-3, YOS 8-10; E-4, YOS 10-12).

Table 5

Allocation of Promotions to YOS Based on YOS at the End of Promotion Year (Percent of Total Pay Grade Promotions)

	Pay Grade							
YOS	E-2	E-3	E-4	E-5	E-6	E-7	E-8	E-9
1	62.40	16.01	0.53					
2	33.52	57.75	11.48	0.73				
3	2.24	18.88	28.24	5.26				
4	0.99	4.57	40.11	13.51				
5	0.52	2.01	15.16	23.46	0.84			
6	0.14	0.38	2.72	25.90	1.58			
7	0.12	0.20	0.93	19.61	5.72	0.32		
8	0.07	0.11	0.53	7.65	30.08	0.88		
9		0.06	0.21	2.55	29.77	2.36		
10		0.03	0.06	0.83	18.59	4.09		
11			0.02	0.26	8.53	6.02		
12			0.01	0.19	2.62	22.28	0.24	
13				0.05	1.26	21.74	0.64	
14					0.51	18.18	1.42	
15					0.21	8.46	3.00	
16					0.13	6.82	6.47	
17					0.09	4.36	11.92	0.47
18					0.04	2.12	24.50	2.07
19					0.03	1.10	24.96	4.03
20						0.78	13.15	6.96
21						0.29	5.22	11.34
22						0.20	4.67	7.87
23							1.37	13.41
24							1.09	14.12
25							0.57	12.98
26							0.42	12.14
27							0.19	7.67
28							0.17	4.46
29								1.64
30								0.84

VALIDATION OF THE ALLOCATION TECHNIQUES

Actual FY87 promotion data were used to assess the accuracy of the allocation table presented in Table 5. In each YOS x PG cell, the projected number of promotions was calculated using both the naive method (the most recent year's distribution percent) and the decision rule (Table 5) multiplied by the number of promotions to a pay grade in the actual FY87 data. Then the weighted mean absolute percent error (WMAPE) was computed for each method across all YOS cells within a pay grade and then, across all pay grades (see Appendix A). The method with a smaller WMAPE is considered more accurate, in an average sense. The resulting WMAPE for each pay grade and across all pay grades are provided in Table 6. All PG x YOS cell naive and IPM forecasts for FY87 are provided in Appendix B, as are the FY87 actual promotions for each PG x YOS cell.

Table 6

Accuracy of Naive Forecasts and IPM Forecasts of FY87 Promotions by YOS

Pay Grade	WMAPE Naive	WMAPE IPM
E-2	1.17	3.80
E-3	9.57	8.95
E-4	20.83	24.16
E-5	25.01	25.26
E-6	41.71	54.57
E-7	22.42	26.87
E-8	23.89	22.59
E-9	29.87	22.40
Total	14.50	16.29

The interpretation of these results is as follows (using E-2 as an example): the total absolute error across YOS cells of naive forecasts of E-2 promotions is 1.17 percent of actual total E-2 promotions. The analogous IPM WMAPE is 3.80 percent. Table 6 shows that the IPM forecasts YOS promotion allocations more accurately, as indicated by lower WMAPE, in E-3, E-8 and E-9, and the naive method forecasts more accurately in the other five pay grades. Across all PG x YOS cells the naive forecasts slightly out performed the IPM forecasts (14.5% WMAPE vs. 16.29% WMAPE). This result means that the IPM's forecasts misallocated 1.79 percent more promotions than did the naive method's forecasts. Given a total of 61,869 promotions, the IPM method allocated 1,107 more promotions to the wrong YOS cell than did the naive method.

SUMMARY AND CONCLUSIONS

Historical promotion data by pay grade and YOS were analyzed. The analysis showed that the distribution of promotions across years of service has changed during the period FY81-FY86. Two techniques were used to produce a promotion allocation table for the prototype IPM. In a comparison with the actual YOS distribution of ALMAR promotions in FY87, the naive method out performed the IPM promotion allocation table, as measured by WMAPE. The results of these analyses suggest that a means of forecasting policy impacts on YOS distribution of promotions is needed that does not rely solely on historical YOS distributions of promotions.

As the Marine Corps carries out the Career Force Control policies, promotion patterns are expected to change even more. Changing YOS promotion patterns resulting from these policies and other management actions must be reflected in the promotion allocation method used by the IPM.

APPENDIX A

WEIGHTED MEAN ABSOLUTE PERCENT ERROR (WMAPE)

WEIGHTED MEAN ABSOLUTE PERCENT ERROR (WMAPE)

WMAPE for pay grade i is calculated as

$$WMAPE_i = \sum_j \left| \frac{(actual_{ij} - projected_{ij})}{actual_{ij}} \right| * \frac{actual_{ij}}{\sum_j actual_{ij}} * 100$$

where j is the index of the YOS cell within a pay grade and i is the index of the pay grade.

WMAPE across all pay grades is calculated as

$$WMAPE = \sum_{i=1}^{9} \left[\sum_j \left| \frac{actual_{ij} - projected_{ij}}{actual_{ij}} \right| * \frac{actual_{ij}}{\sum_j actual_{ij}} * 100 \right] \frac{\sum_j actual_{ij}}{\sum_i \sum_j actual_{ij}}$$

APPENDIX B

VALIDATION RESULTS BY PAY GRADE

YOS	FY87 Actuals	Naive	IPM
	E-2 Promotion Forecasts and Actuals by YOS		
1	7903	7869	7683
2	3972	3954	4124
3	223	275	275
4	136	122	122
5	59	70	64
6	12	6	17
7	2	9	15
8	1	3	8
Total	12308	12308	12308
	E-3 Promotion Forecasts and Actuals by YOS		
1	4269	3629	3416
2	12018	11788	12321
3	3380	4357	4028
4	1003	907	975
5	450	492	429
6	134	94	81
7	43	34	43
8	23	17	23
9	9	10	12
10	5	6	6
Total	21334	21334	21334
	E-4 Promotion Forecasts and Actuals by YOS		
1	33	58	85
2	2265	1717	1874
3	2706	4362	4607
4	6759	6432	6544
5	3652	3015	2474
6	575	444	444
7	195	152	152
8	71	86	86
9	31	34	34
10	19	10	10
11	7	3	3
12	2	2	2
Total	16315	16315	16315

YOS	FY87 Actuals	Naive	IPM
	E-5 Promotion Forecasts and Actuals by YOS		
2	24	31	48
3	135	301	349
4	687	898	898
5	1281	1585	1560
6	1614	1754	1722
7	1651	1306	1311
8	861	509	508
9	279	169	169
10	77	55	55
11	30	29	17
12	8	12	12
13	5	3	3
Total	6652	6652	6652
	E-6 Promotion Forecasts and Actuals by YOS		
5	10	16	21
6	24	41	41
7	85	149	149
8	266	539	785
9	675	860	777
10	866	564	494
11	373	222	222
12	195	132	68
13	68	55	32
14	22	21	13
15	15	8	5
16	8	3	3
17	4	2	2
18	2	1	1
Total	2613	2613	2613

YOS	FY87 Actuals	Naive	IPM
	E-7 Promotion Forecasts and Actuals by YOS		
7	2	1	4
8	6	9	11
9	15	19	31
10	31	55	55
11	102	90	90
12	183	256	300
13	276	323	292
14	250	244	244
15	192	140	113
16	110	91	91
17	63	58	58
18	41	28	28
19	39	24	14
20	23	5	10
21	13	4	4
22	1	0	2
Total	1347	1347	1347
	E-8 Promotion Forecasts and Actuals by YOS		
12	2	2	2
13	4	5	5
14	14	9	13
15	20	27	27
16	38	52	59
17	144	134	110
18	216	253	226
19	194	240	230
20	179	106	128
21	70	48	48
22	24	21	43
23	9	12	12
24	6	6	10
25	0	5	5
26	3	3	3
27	2	2	2
28	0	0	2
Total	925	925	925

YOS	FY87 Actuals	Naive	IPM
	E-9 Promotion Forecasts and Actuals by YOS		
17	2	0	2
18	3	5	7
19	16	18	15
20	22	34	26
21	34	38	42
22	69	29	35
23	39	43	50
24	52	57	52
25	44	39	48
26	40	50	45
27	33	46	28
28	18	9	16
29	1	2	6
30	2	5	3
Total	375	375	375

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Manpower and Personnel Division (AFHRL/MO)
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