Risk Assessment of Retention and Accession Tradeoffs

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Executive summary

Analytical question

The current slowdown in the U.S. economy has led to higher reenlistment rates. To avoid overmanning, Navy communities may need to either reduce accessions or find a way to lower the number of reenlistments. Both of these policy responses, however, involve long-term manpower and personnel (M&P) risks.

To help the Navy address these risks, OPNAV N-14 asked CNA to study the M&P consequences of changing reenlistment and accession (R&A) policy in response to external forces, such as changes in the U.S. economy, that influence retention rates. Specifically, we were asked to assess the risk associated with reducing accessions in a Navy enlisted rating community. Risk assessment in this context involves analyzing the future manning and potential readiness consequences that follow today's decision regarding changes in R&A policy.

Several specific manpower concerns were raised. Attempts to reduce reenlistments during a slow economy could involve involuntary separations, which involve costly separation payments, could lead to possible increases in future reenlistment costs if servicemembers perceive that a military career is less certain, and could have adverse effects on morale. Conversely, reducing accessions results in small junior cohorts, which remain small when they become mid-level cohorts. Some hold that, when the economy returns to normal, vacancies will be too high, and personnel can fall short of requirements. Others, however, suggest that the manpower system is flexible enough in its promotion rules to adjust to changes and maintain an appropriately experienced force.

Approach and methodology

We take a three-step approach to address these issues. First, we conduct a statistical analysis, in which we use 27 years of personnel data to study the relationships between U.S. economic conditions and other variables and reenlistment rates.

Second, using the data, the results from the statistical analysis, and the Navy's reenlistment and advancement rules, we construct a model that simulates the dynamic flows of personnel into, through, and out of the Navy at each year of service and paygrade. This model allows us to study the long-term manning effects of changes in the Navy's R&A policy in response to external forces, such as the state of the U.S. economy.

Finally, we conduct a community-level risk assessment, in which we apply the simulation model in a set of three scenarios for one Navy community, the Advanced Electronics and Computer Field and Submarine Electronics and Computer Field (AECF/SECF). We use the results of the simulation scenarios to assess the effects of reducing accessions on future manning readiness.

Scenarios and risk assessment

In the first scenario, we simulate the effect of a slow economy using the parameters from the statistical model on the AECF/SECF rating community. We find that, even though the economy has a statistically significant effect on reenlistments, the effect is small—around a 3.8-percent rise in reenlistments following a transition from a normal to a slow economy. This effect, while not trivial, is not a potential threat to future manning.

To more rigorously test the Navy's enlisted manpower system, we used the model to simulate a deep recession, one in which the effect was nearly 8 times the statistical effect of an average slow economy. This simulated deep recession resulted in a 30-percent increase in reenlistments, necessitating about a 15-percent reduction in accessions. We found that, while our simulated future personnel advancement profiles and inventory profiles did change substantially, there was no time in which requirements could not be met or the enlisted community became dangerously junior.

In fact, in this scenario, our model showed how flexible the manpower system is. We first see that the rate and number of promotions fell during the simulated recession. Thus, in the short term, average seniority levels at each paygrade increased. When the simulated economy returned to normal, the promotions returned to their normal rate and numbers. However, there was no need to promote an overly junior force because pent-up demand for promotions countered the small cohort reaching eligibility.

In a final scenario, we pushed the model to the limit to determine whether and where there is an accession floor—an accession rate so low that the manpower system would break. In this scenario, we simulated an increase in reenlistments by 50 percent and a reduction in accessions by one-third. Here, the system was challenged beyond its limits. Within about 6 to 12 simulated years, practically all enlisted personnel in the AECF/SECF community needed to be promoted to E4 in their first year of service, to E5 in their third year of service, and to E6 in their seventh year of service.

Interpretation and conclusions

In a period of high reenlistments, the balance between reenlistments and accessions will rely on the effects of the Navy's R&A policy on future manning. Specifically, if reenlistment rates are high in the short run, the Navy might want to increase reenlistments and reduce accessions to compensate.

The problem is that decreasing accessions results in small cohorts. At some time, the economy will improve and reenlistment rates will return to normal. By then, it is at least theoretically possible that those accession cohorts will be too small to fill available vacancies without promoting a large number of inexperienced servicemembers.

As we see from the results of our simulation scenarios, however, reducing accessions during this period of slow economic conditions and high retention will challenge—but not break—the M&P system.

The M&P system's requirements and advancement rules have built flexibility into the system, which allow it to adjust to reasonable reductions in accessions. There is, of course, a limit to how low accessions can go, but a 15-percent cut in accessions does not reach that limit.

This study is just a foundation for this method of modeling community-level manning risk assessments. It has the capability of answering many other questions and concerns regarding R&A tradeoffs. We suggest that further use of the analytical method and modeling technique would be useful in the following areas:

- Estimating the changes in direct costs of reenlistments and accessions, such change in bonuses, military wages, recruiting costs, and training costs
- Conducting risk assessments for any or all other Navy communities
- Helping Navy communities to focus on the methods and approaches to selecting break points, those points at which the profile of personnel is so young as to jeopardize readiness
- Developing and conducting a range of possible scenarios to assist communities in making policy decisions about the balance of R&A. We could consider scenarios such as changes in endstrength requirements or events that cause reenlistment rates to fall (rather than rise).

Introduction

OPNAV N-14 asked CNA to study the tradeoffs that occur when the Navy changes reenlistment and accession (R&A) policy in response to changes in the U.S. economy—changes that are currently raising retention rates. Navy communities can accept higher reenlistments and reduce accessions to compensate, or they can incentivize separations to return reenlistment rates to prior rates and keep accessions level, or some combination of both. Any kind of response entails costs, both financial and in terms of their effects on future manning. N-14 specifically asked us to provide an assessment of the future manning risks associated with reducing accessions in a Navy rating community.

Attempts to reduce reenlistments during a slow economy, to return retention rates to their pre-recession rates, could involve involuntary separations, which can mean costly separation payments, future costs of retention if this action reduces the expected likelihood of reaching retirement eligibility, and adverse effects on Sailor morale. Conversely, reducing accessions results in small junior cohorts, which remain small when they become mid-level cohorts. Some believe that vacancies will be too high when the economy returns to normal, but others suggest that the manpower system is flexible enough in its promotion rules to adjust to changes and maintain an appropriately experienced force.

Our methodology and the results of this study will help Navy M&P balance the ratio of retention and accessions to meet manpower requirements and maintain a sustainable mix of senior and junior personnel. We conduct a steady-state analysis, which is a common method of looking at these tradeoffs [1, 2, 3, 4, 5]. Steady-state analysis is a helpful tool in the analysis of R&A policy. It is an analytical concept that begins with an ideal state, in which external conditions, such as the U.S. economy, are normal and stable. A change in external conditions moves the Navy away from the steady state, and analysis of the effects of that change can help guide the Navy's response.

Steady-state analysis yields an annual accession goal, which becomes a year-to-year objective. As long as national economic conditions and/or national attitudes about military service remain constant, steady-state analysis would advise the Navy to seek to maintain this constant year-to-year number of accessions. That does not mean, however, that Navy M&P should continue to maintain that number when conditions change. A properly designed steady-state analysis would advise how the Navy might change the reenlistment-accession balance to save short-run costs and still maintain a balanced mix of senior and junior personnel.

Objective of the study

The purpose of the study is to analyze the effects of changes to the Navy's R&A policy and discover the effect of various policy decisions on future manning. To do this, we've conducted a risk analysis at the rating community level—using the Advanced Electronics and Computer Field and Submarine Electronics and Computer Field (AECF/SECF) community—to determine if changes in retention and accession policy would have deleterious effects on the community's ability to sustain manpower requirements in the long run.

A catalyst for this study is the current state of the U.S. economy, which is characterized by high unemployment nationwide and has resulted in high retention rates. A first big response by the Navy was to reduce reenlistment bonuses, many of them to zero [6]. Even then, however, reenlistment rates remained high.

This raises questions about how the Navy in general and Navy communities should further respond. The Navy has a range of policy options available. On one hand, it could take additional steps to encourage more Sailors to leave the Navy with the goal of returning reenlistment rates to their pre-recession levels. This might appear at first glance as a safe strategy by keeping future manning stable, but it could involve separation costs and other negative consequences. On the other hand, the Navy could accept higher reenlistment rates and reduce accessions to compensate. This, however, risks creating an accession cohort that is too small to fill senior ranks in later years, thereby jeopardizing future manning readiness.

Each policy choice, then, has its potential risks and costs. As a framework for our analysis, we outline these issues by asking, "What are the consequences of the R&A policy choices on future Navy readiness as defined by the Navy's ability to meet manpower requirements with appropriately experienced personnel?"

Methodology and approach

We employ a threefold approach in studying these issues and addressing the foregoing analytical questions:

1. *Statistical analysis:* We use historical data to estimate reenlistment probabilities and personnel profiles with statistical models.
2. *Simulation model:* We use the results from the statistical analysis along with the Navy's reenlistment and advancement rules to build a simulation model. This model allows us to study the effects of changes in external conditions, such as the economy, and the Navy's retention and accession responses to those changes on future manning readiness.
3. *Risk assessment:* Applying the simulation model to the AECF/SECF community, we assess possible risks in future manning readiness that can occur as a result of changes in retention and accession rates and the Navy's response to them. We find that inherent flexibility in the Navy's advancement policy provides some reasonable flexibility in retention and accession policy.

Next, we discuss each of these steps in more detail.

Statistical analysis

First, we use detailed data on military personnel and on civilian workers from 1983 through 2009. We employ traditional Logit regression models to estimate the determinants of reenlistment rates for individual Sailors [7, 8, 9].[1] We use the parameters from the Logit models to estimate reenlistment probabilities by paygrade and years of service

1. Other linear econometric models, such as Probit estimation, are used as often as Logit [7, 10, 11]. Either method provides similar results [12].

(YOS) for three different states of the U.S. economy (slow, normal, and good). We also use these data to estimate expected attrition rates, paygrade advancement rates, and manning requirements for use in the simulation model.

We perform these statistical analyses for personnel Navy wide and for servicemembers in the AECF/SECF community, specifically the Electronic Technicians (ETs), Fire Control Technicians (FCs for surface ships and FTs for subs), and Sonar Technicians–Submarine (STSs). These estimates of reenlistment probabilities, and other parameters from the model, form the basis of our manning simulation model.

Simulation model

We've developed a simulation model that (a) uses our statistical estimates of reenlistment rates, attrition rates, paygrade (PG) advancement rates, and manning requirements and (b) combines them with specific reenlistment, PG, and advancement rules to allow the model to calculate steady-state personnel profiles by PG and YOS. The simulation model also uses these results to calculate the number of annual reenlistments and accessions needed to maintain these steady-state personnel profiles when all external conditions remain constant.

Establishing a steady state in the model, however, is only a means to an end—a starting point for the analysis. Our model must be able to achieve a steady-state level of R&A so we can focus our analysis on how the manpower world will move away from the steady state when an external condition, such as the condition of the U.S. economy, changes. With that knowledge, the Navy can decide how it wants to respond to the changes in external conditions.

Risk assessment

Risk assessment specifically targets the issue of how changes in reenlistments and accessions caused by changes in external conditions can affect future manning readiness. We give a brief explanation and provide more detail in a later section. Essentially, reducing the number of accessions in any given year results in a small cohort that will remain small throughout the Navy careers of its members. The only way the

Navy gets senior personnel is by growing junior personnel, so a small accession cohort can result in a small future senior cohort.

We developed the model using personnel data for the entire Navy. This exercise helped us to develop and test the simulation model itself. However, the entire Navy is too broad to provide a complete and accurate assessment of the risks of changing reenlistments and accessions on future manning readiness. This is because advancements are vacancy driven, and vacancies are mostly specific to the individual rating community.

So, using the simulation model, we assess one specific set of Navy communities—the Advanced Electronics and Computer Field and Submarine Electronics and Computer Field.[2] We begin by simulating specific scenarios that resemble a change to an external condition, such as a change in the U.S. economy. We then simulate a Navy response to this external change, and finally we simulate the effect on the future profiles of personnel by PG and YOS.

Specifically, we simulate a situation in which the national economy has slowed considerably for a number of years. Under these circumstances, reenlistment rates will increase and the Navy AECF/SECF community managers must reduce reenlistments, reduce accessions, reduce some combination of both, or face overmanning.

The objective is to determine whether and how manpower readiness will be negatively affected by the policy choice. In the case of a negative effect, we want to know when it occurs and what the magnitude of the effect is.

2. The AECF/SECF community includes members of the following ratings: ET, FT, FC, and STG. We exclude those members of the communities who are, or are training to be, nuclear-power specialists.

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Model of the retention-accession world

Introduction

To answer the questions posed by N14, we developed a dynamic, deterministic simulation model of the personnel planning world. The simulator is a collection of statistical parameters, reenlistment and advancement rules, and historical profiles of attrition rates, advancement rates, and U.S. national economic conditions. It allows us to model the conditions and events that influence the retention and accession decisions for the entire Navy, or for a single Navy community.

The model is *dynamic* in the sense that it is forward looking. After introducing a disruption to the steady-state condition, the simulator will model its effects on costs and personnel as far into the future as necessary to ascertain whether the Navy, or an individual Navy community, can sustain its manning requirements under the new conditions, and/or what changes might be necessary to return to a more sustainable manning state.

The fact that the model is *deterministic* means that the probability parameters driving losses and reenlistments are fixed for a particular set of conditions. For example, servicemembers at a given YOS and PG, and in a given state of the U.S. national economy, display a certain probability of staying in the military at the end of their enlistment contract. As long as these conditions hold, these servicemembers will continue to reenlist at the same rate. This is what we call a "steady state"—an analytical concept that allows us to focus on the effects of specific changes in R&A policy. We will discuss the pros and cons of steady-state analysis in more detail in a later section.

As complex as it may sound, this simulator is nonetheless a simplified model of the world of retention and accession policy. Embedded in it, as with any model, are assumptions that both simplify the analysis and leave open the question of how the model differs from the actual M&P world. Its purpose is to facilitate a special focus on the important characteristics of the world and to assess how a few critical outcomes would adjust if one or two of these characteristics were to change.

We assume, for example, that for a given set of national economic conditions, such as a "good economy" with high growth in national income and low unemployment, the probability of reenlistment will be the same for all servicemembers within a Navy community, PG, and YOS. This is a key feature of the model's ability to model a steady state. Even further, we could model a change in economic conditions, to a "slow economy," in which the probabilities change, and then a return to a "normal economy," in which the retention probabilities revert to the pre-recession steady-state rates.

To illustrate, consider that our data show that, on average, E4s with 5 years of service in a normal economy have a 46-percent probability of reenlisting. The probability of staying increases to roughly 50 percent during a slow economy; however, when the economy returns to normal, E4s with 5 years of service will again have a 46-percent probability of staying.

One could argue that this is unrealistic since other conditions can change during the interim period. It’s possible that the Navy's decisions during the slow economy could influence the behavior even after the economy returns to normal. For example, whether the Navy's policy during the slow economy is seen as "keeping faith with Navy senior personnel" may influence Sailors’ stay decisions when the normal economy returns.

At this juncture, modeling those kinds of secondary effects would add complexity to the analysis, without necessarily adding value, since it could lead to ambiguous and possibly nonquantifiable debate as to what changed the pre-recession parameters and what the direction and magnitude of the secondary effects are.

How does the analysis work?

Analysis begins at steady state

The analysis begins when our modeled world of Navy enlisted personnel is in a steady-state condition. We describe this condition in more detail later in this section, but, in general, we use the term to mean two things.

First, steady state is an analytical concept which describes a conditionally ideal state. In our model, we define the ideal state where personnel profiles at the PG level are roughly the same as manpower requirements (billets authorized), and YOS profiles within each paygrade are roughly the same as that which derives from 27 years of historical data (1983 through 2009).

Second, as long as all external conditions remain stable and constant, personnel reenlistment and attrition parameters will also remain constant.[3] By design, our steady-state personnel profiles match the Navy's manpower requirements by paygrade for the entire Navy or for the AECF/SECF community.

What is steady state?

In reality, however, external conditions do not remain constant. For example, such external conditions as the U.S. economy and endstrength requirements change frequently. A forgivable misconception about steady state is that reenlistments and accessions should be constant each year. But that would be correct only if circumstances were identical from year to year, which is rarely the case.

In the subsections that follow, we explore what it means for Navy personnel to be in a steady state, how an external shock (i.e., a change in the national economy) affects the steady state, and what consequences result from the various choices the Navy can make in response.

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3. Other external rules and conditions are Navy endstrength requirements, Navy retention and accession policies (by which we mean rules governing reenlistment and advancement eligibility), and national economic conditions, which are defined by unemployment and GDP growth rates.

Retention and accession policy

Conceptually, when we say that policy-makers change R&A policy, we mean that they seek to change the relationship between the number of reenlistments and the number of new recruits in a given year. Referred to as "balancing" reenlistments and accessions, this relationship begins with the necessary condition that total accessions must equal total losses in any given year. Total losses consist of servicemembers who are at the end of their active service obligation (EAOS) and leave the Navy and servicemembers who are not at the end of their service obligation and choose or are asked to leave anyway (ATTRITES).

So, as a (hypothetical) numerical example, suppose that in a steady-state year the number of enlisted servicemembers who face the end of their contractual obligation is roughly 500 and that, at the steady state, 50 percent (or 250) stay and 50 percent leave. Further suppose that the Navy also loses 100 for other reasons (attrition, high-year tenure). Total losses are now 350, and the Navy must recruit 350 new servicemembers to replace those losses. The Navy will have reenlisted 250 and accessed 350, and will have achieved balance.

But suppose the Navy chooses to change the R&A policy by increasing reenlistments. In this example, the Navy chooses to influence a higher stay rate by 5 percentage points, from 50 to 55 percent of EAOS servicemembers, resulting in a 10-percent increase in reenlistments. Now reenlistments are 275 rather than 250, and total losses will be 225 + 100 = 325 rather than 350. In this scenario, the Navy will need to access 325 new recruits. Balance will have been achieved with a new policy in which 275 EAOS servicemembers are incentivized to stay (R = 275) and the Navy actively recruits 325 new servicemembers (A = 325).

Thus, the R&A policy change is that the Navy *influences* an increase in reenlistments and then *chooses* the number of accessions needed to replace total losses.

Relationship of R&A is also influenced by external conditions

Bear in mind that external conditions as well as Navy policy-makers can influence this relationship. Consider what happens to the preceding example in a year in which a slow national economy (represented by high unemployment rates, for example) results in raising the stay rate by 10 percentage points, from 50 to 60 percent of EAOS servicemembers. As a result, we have 50 of the EAOS servicemembers who, under normal economic conditions, would have left but, in the slow economy, prefer to stay. Unchecked, reenlistments will be 300 (vice 250), and losses will be 300 (vice 350). This is an example of an external shock to the steady state.

Navy response to change in external conditions

Under these circumstances, the Navy must respond. However, there is a wide range of possible responses. At one extreme, the Navy could take no action on reenlistments, allowing them to rise by 10 percent, and reducing accessions by 50.

If the Navy chooses to allow reenlistments to rise and reduces accessions, the look of the enlisted force would change in the following ways. First, for one period, the Navy would have fewer people in training (relative to the number of trainees in the steady state). This implies that, for a short time, the number of servicemembers available to fill operational billets (distributable strength) would rise. This could have the effect of increasing readiness, at least temporarily.

The small accession cohort, however, would result in a small cohort of junior personnel ready for advancement to senior positions in the future. This raises the question, "How much can the Navy reduce accessions and still have a cohort that can fill the senior ranks in the future?"

If the cohort were small enough, the result could be that either the Navy or the Navy community would not be able to meet manning requirements or that, in order to meet manning requirements, it would need to promote very junior servicemembers and end up with an inexperienced force.

On the other hand, the Navy could choose to incentivize reenlistments back in the direction of the steady-state rate and maintain accessions at their steady-state rate. This method might appear to be a safe response since the objective is to return reenlistments and accessions to the former steady-state rate. However, this response entails costs and consequences that need to be considered.

Under these circumstances the Navy could reduce the Selective Reenlistment Bonus (SRB) in an attempt to restore the pre-recession retention rates. Of course, once the SRB goes to zero, no further reduction of SRB is possible. If the pre-recession retention rates were not restored by the zero SRB, the Navy would need to either resort to involuntary separations or decrease accessions to avoid overmanning, (i.e., exceeding endstrength requirements). Involuntary separations can be costly, with high separation payments and possible negative effects on future retention. Conversely, overmanning in any one community can incur high wage costs and require undermanning in other communities to meet endstrength requirements.

Ideally, the actual response will result from a careful analysis of short- and long-term costs of reenlistments and accessions, including an assessment of the potential consequences of each choice on future manning.

The simulation model

Concept

To address these issues, we have developed a simulation model that uses the results of our statistical analysis of reenlistment rates, attrition rates, PG advancement rates, and manning requirements, combined with specific reenlistment and advancement rules.[4]

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4. We would like to thank Dr. Jerry Cox (CNA) for his ideas and advice on the construction of this simulation model. He and Mr. Robert Shuford had developed the original concept and programming for what ultimately became this simulation model [13 and 14].

The first objective of the simulation model is to estimate a steady-state personnel profile by paygrade and YOS that resembles that of billet requirements. The model simulates the dynamic flows of personnel through the M&P system, using estimates of statistical reenlistment parameters averaged over the 1983–2009 period, which represents an assortment of economic and endstrength conditions.

The model is properly described as a dynamic model because it simulates the annual flow of personnel aging (moving from one YOS to the next), leaving and entering the Navy, and advancing from one PG to the next. Our overall objective here is for the model to simulate the natural flows of personnel that occur over time.

We begin the simulation with a personnel profile by PG and YOS. We've constructed this profile with 2009 data on authorized billets by PG and with historical data from 1983 to 2009 on the personnel profiles by YOS within paygrades. Parameters from our statistical model describing reenlistment rates are included here, as are historical attrition rates and advancement profiles, all by PG and YOS.

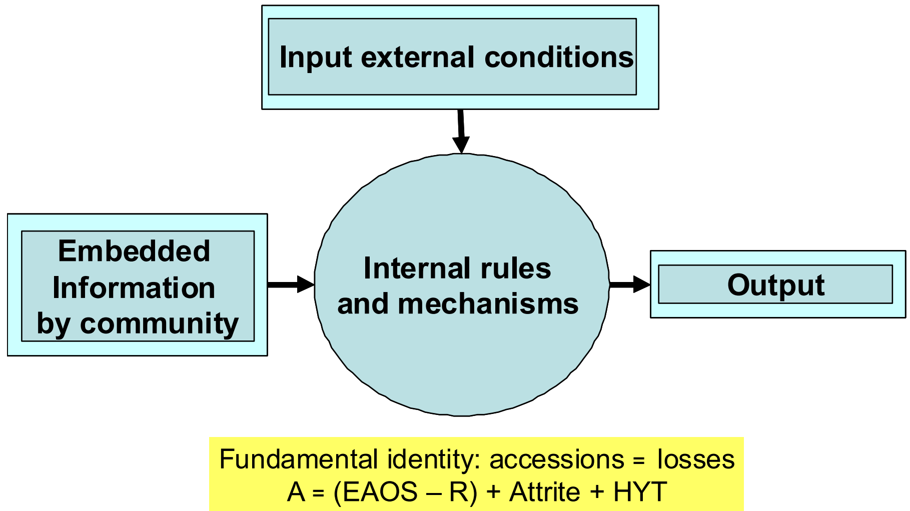
Inflow, throughflow, and outflow of personnel

In this subsection, we describe the flow of personnel, starting with the basic inflow through accessions, their internal throughflow from YOS to YOS and from PG to PG, and the final outflow of personnel who leave the Navy for the reasons we describe next. Figure 1 depicts how we model these flows.

Recruitment is the only method the Navy has to bring in servicemembers.[5] Outward flow of personnel from the Navy occurs for one of three reasons. First, personnel leave if they are at 30 YOS or have reached high-year tenure. Second, some proportion of personnel reach their EAOS, and some proportion of those will leave the Navy. As we'll see, these proportions are influenced by YOS, PG, and other factors. Finally, some percentage of personnel leave for various reasons, even when they are not at the end of an active-duty contract.

5. For modeling purposes, we have no prior-service accessions—that is, personnel who leave the Navy and come back after a lengthy period. They would show up in our model as reenlistments instead.

Figure 1. The simulation flow model



Before we move on, and for ease of communication, it will be useful to define some terms. Those who are at their EAOS and stay are called REENLISTMENTS. Those who are at their EAOS and leave are known as EAOS LOSSES. We refer to personnel who are not at the end of their enlistment contract but leave anyway as ATTRITES. Some leave the Navy because of high-year tenure (HYT). HYT LOSSES are personnel who have reached a YOS milestone but not a sufficiently high paygrade to be allowed to stay in the Navy. Some HYT losses are at the end of their EAOS and are a subgroup of all EAOS losses. Some are not at the end of their EAOS and are a subset of attrite losses. However, we look at HYT losses separately because we expect that they will be directly influenced by the Navy's R&A decisions, whereas other attrite losses will not.

Each year the number of accessions is, by design, equal to the total number of personnel who leave the Navy:

$$\mathit{ACCESSIONS} == \mathit{EAOS\ LOSSES} + \mathit{ATTRITE\ LOSSES} + \mathit{HYT\ LOSSES} \qquad (1)$$

Thus, our model simulates R&A policy adjustments whereby the Navy *influences* reenlistments by adjusting policy such that the probability of stay rises or falls, for example, by changing SRBs. And then the

Navy *chooses* the number of accessions to be equal to the resulting number of losses.[6]

As long as Navy R&A policy and national economic conditions remain constant, the number of reenlistees and accessions remains constant in our model. If the Navy changes R&A policy to increase retention, the model will automatically reduce accessions to maintain end-strength.

An ADVANCEMENT is a rise in paygrade. We will discuss how the advancement mechanism works later in this section, but note that advancements only occur to fill vacancies, which themselves come from separations from the Navy.

Components

Recall that we define steady state by the outcomes in a world in which external conditions are constant. In this state, retention rates will be constant, and the Navy will want to hold accessions constant. The outcomes we care about are the personnel profiles by PG and YOS that ultimately lead the Navy to make its R&A decisions.

Main parts

The four main components of the model follow:

1. Parameters and personnel profiles from the statistical models
2. Primary external conditions (those over which the Navy has no control)
3. Internal rules of reenlistment and advancement
4. Output.

We describe each component here.

6. In the simulation model, we can impose a change directly to the retention probabilities. But we implicitly treat this as either a change in SRB or a change in the state of the national economy.

Parameters and personnel profiles estimated from statistical models

EAOS personnel are at the end of their enlistment contract, at each YOS and PG. These are the servicemembers we consider in our reenlistment model. We model these as proportions of servicemembers at each PG and YOS.

Reenlistment probabilities describe the likelihood that servicemembers of a given PG and YOS will stay in the Navy, given they are EAOS personnel. Conceptually, these probabilities are a function of the differences in servicemembers' military and civilian opportunities, which will vary from member to member, depending on skill sets and relative taste for military service. We find they don't vary much from year to year for servicemembers, except in response to changes in the U.S. economy.

Attrition rates are the proportions of servicemembers, by YOS and PG, who are not at the end of an enlistment contract and yet leave the Navy anyway. Attrition rates do not appear to be influenced much by the state of the national economy, and we assume they are roughly constant.

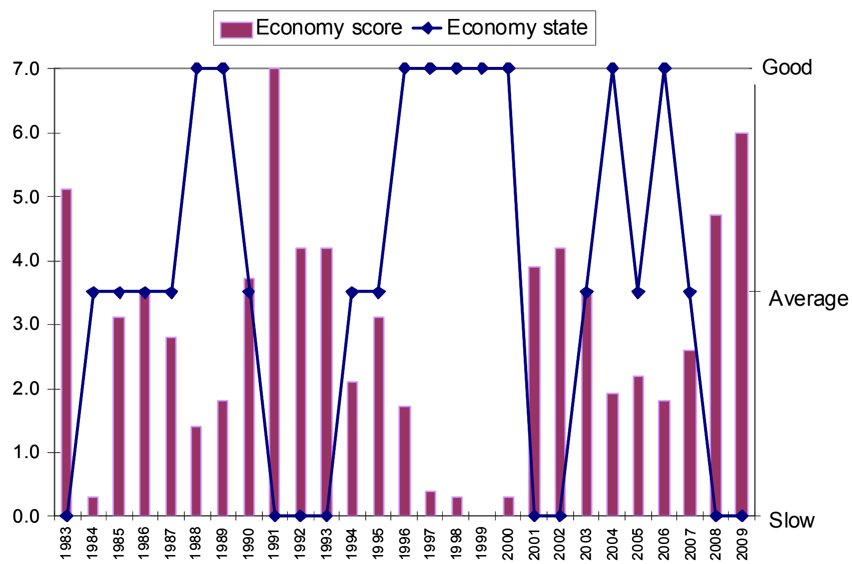
Manpower requirements are defined by the proportions of personnel in each paygrade Navy wide or within a rating community. These profiles are fixed by billet requirements.

Primary external conditions

One external parameter is the state of the U.S. economy—specifically, whether the economy is good, normal, or slow, as defined by a simple scoring function of two traditional measures. We subtract the rate of growth of the U.S. gross domestic product (GDP) from the U.S. unemployment rate. From these scores, we develop three indicator variables: one for a good economy, one for an average economy, and one for a slow economy. (See figure 2 for an illustration of the economy scores and indicator values.)

Endstrength requirements are also an external condition in the model. While certainly the Navy has some influence over endstrength, it is generally determined by external political decisions. In the case of an individual Navy rating community, endstrength can also change in response to changes in the state of technology or because the Navy chooses to increase or decrease functions that require that rating community. Note that, while the model has the capability of looking at changes in endstrength requirements, for this analysis, we assume that endstrength is given.

Figure 2. The three potential states of the U.S. economy from 1983 to 2009

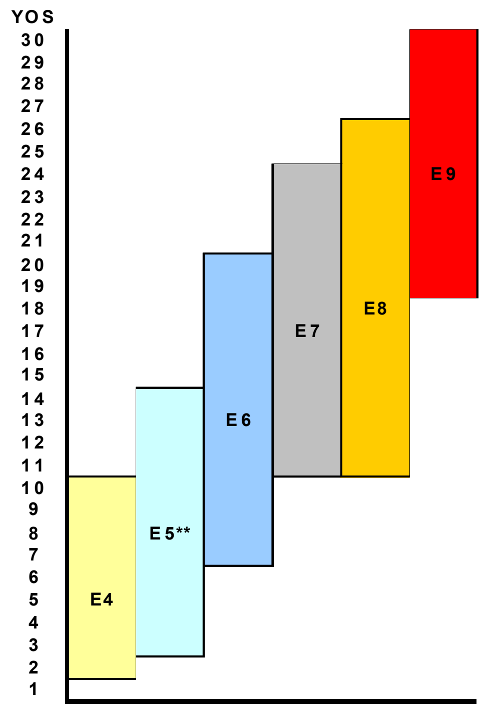


Internal rules

Embedded in the model, are fixed rules regarding advancement, reenlistment eligibility, and manpower requirements.

HYT rules for reenlistment are described by a set of maximum YOS for each PG. Once a servicemember reaches the maximum YOS in PG, he or she is no longer eligible to reenlist. Figure 3 presents the advancement and reenlistment rules for the Navy.

Figure 3. Rules governing high-year tenure and minimum YOS for advancement for U.S. Navy



Output

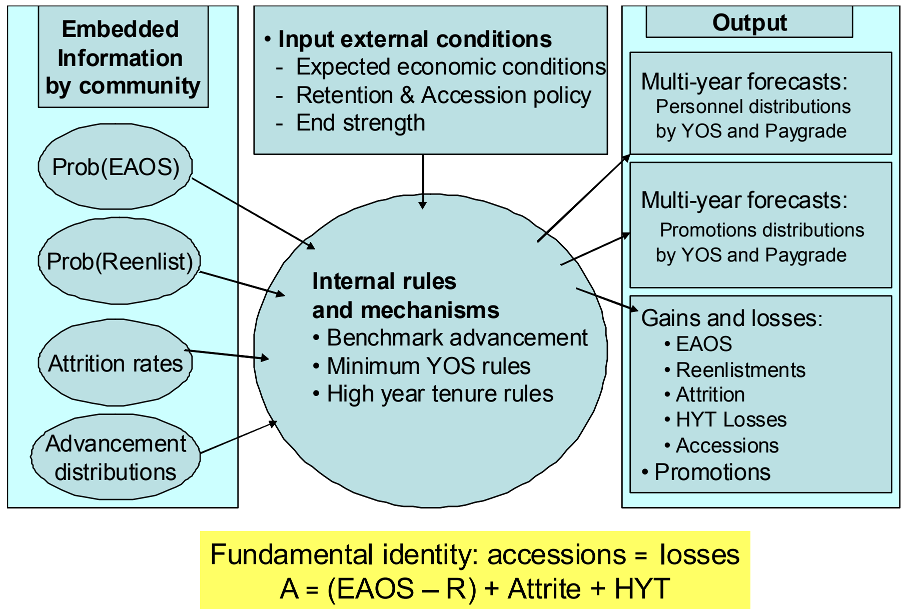
There are two types of output. First, personnel profiles by PG and YOS for future years, and personnel advancement profiles by PG and YOS, will tell us if the Navy has the personnel to achieve manpower requirements and whether they are, on average, experienced enough to maintain readiness.

Second, the model gives us tables that provide us with the numbers of reenlistments, accessions, personnel who are at the end of contract, HYT losses, and attrition losses.

How these components fit together into the simulation model

We combine the foregoing data sets in a series of flow models, described and illustrated in figure 4.

Figure 4. The simulation flow model in detail



Reading from top to bottom, and from left to right in the flowchart, the left column shows the first component, which consists of the parameters and personnel profiles from the statistical models for the entire Navy and for the individual Navy community. These parameters are estimated. The results are fed into the model and become embedded in the simulation.

Shown at the top and middle of the diagram, we feed into the model our expectations about the national economy, and/or the Navy's response in terms of R&A policy. We input the number of years to look into the future, keeping in mind that, the farther into the future we look, the less likely it is that predictions will be accurate. We also input endstrength requirements, which, even though they are dictated by Congress and DOD and not the Navy, we can change in the model if we expect them to change.

Inside the model, we have the reenlistment, HYT, and advancement rules, along with the mechanisms that simulate aging of the force and advancement to vacancies.

Finally, after running the model, it provides us with two types of output. The first is information about personnel profiles and personnel advancement profiles by PG and YOS for future years. These tell us if the Navy has the personnel to achieve manpower requirements and allows us to ascertain whether the force has the experience levels to maintain proper levels of readiness.

The second type of output is tabled information about the numbers of reenlistments, accessions, personnel who are at the end of contract, HYT losses, and attrition losses.

Other mechanisms within the simulation model

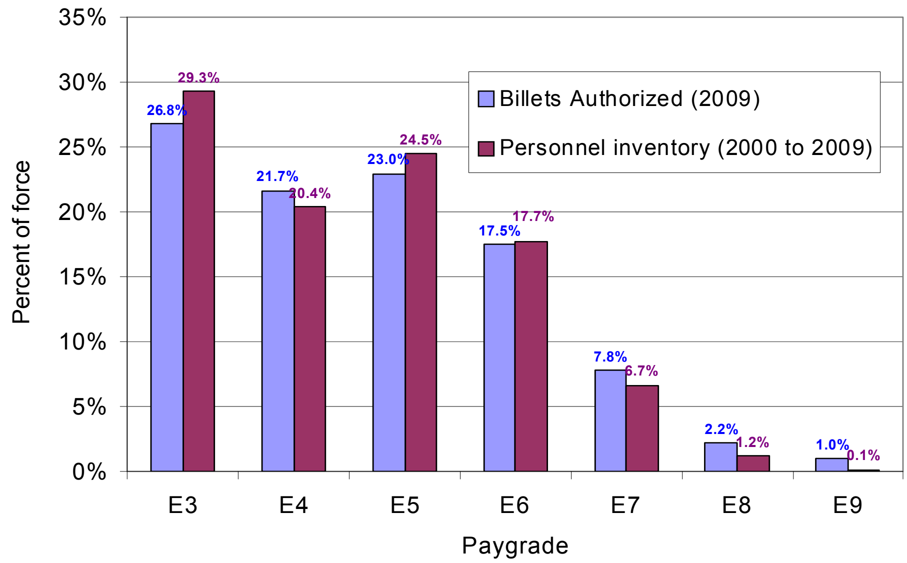
Paygrade and advancement function

In addition to simulating the inflows and outflows of personnel, we also simulated the flow of personnel in the Navy through the ranks. Personnel movement through years of service is predetermined; in other words, each year members move up one year of service. However, only a portion of servicemembers advance to the next higher PG. Thus, advancements are a combination of YOS and some level of uncertainty since not all servicemembers who are eligible for a promotion receive one. Moreover, there are limits to how long a servicemember can stay in the Navy without advancing. These limits are called HYT rules, and they result in some number of personnel losses each year.

Advancements are determined by vacancies, which are themselves determined by separations. The advancement function serves two purposes. Most critically, manpower requirements are set to paygrade both within a rating community and Navy wide. It is by changes in the personnel profiles by paygrade that we can determine if changes to R&A policy have damaged the M&P system in some way.

Thus, an internal objective of our model is that the personnel profile by PG is constant and set to manpower requirements. That means that, regardless of the Navy's R&A policy and/or economic conditions, the total number of personnel in each paygrade should be roughly equal to requirements (see figure 5). If a change in R&A policy results in a shortage of personnel to fill vacancies, the personnel profiles by paygrade in the model will not meet requirements, and we will consider the system broken by that criterion.

Figure 5. Distribution of Navy-wide paygrade requirements, described by billets authorized

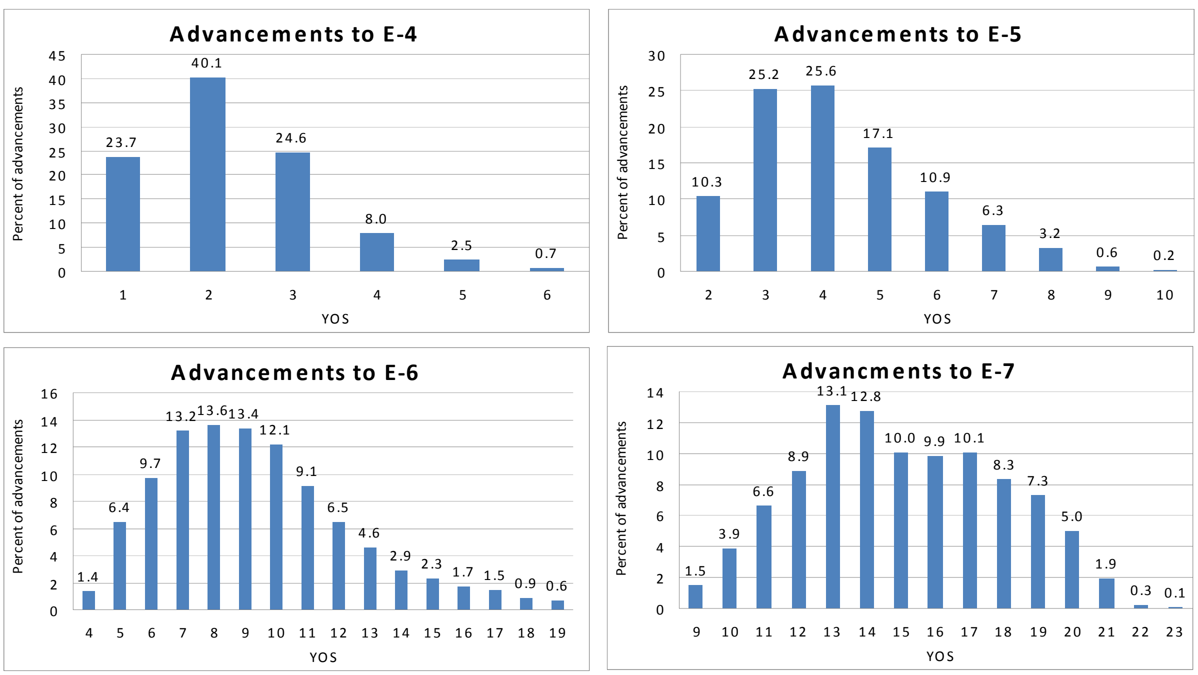


Since not of all those eligible for promotion are advanced, we needed to devise a mechanism by which simulated personnel are chosen to fill the vacancies. We had several choices of mechanisms for producing advancements by YOS. For example, we might have had the most senior within a paygrade advanced (a first-in/first out method). We might have simulated a uniform advancement by YOS, meaning that all YOS in the paygrade have an equal chance to advance.

Looking at the advancement profile data (figure 6), however, we found that advancements tended to form a bell-shaped curve around some central YOS. In figure 6, we see that the curve is skewed to the right at the lower paygrades (E4 and E5) but relatively symmetrical at E6 and E7. In all cases, there appears to be a YOS (or group of YOS) within a paygrade that is central. We call that a benchmark YOS, and the mechanism we use for advancements is a benchmark method.

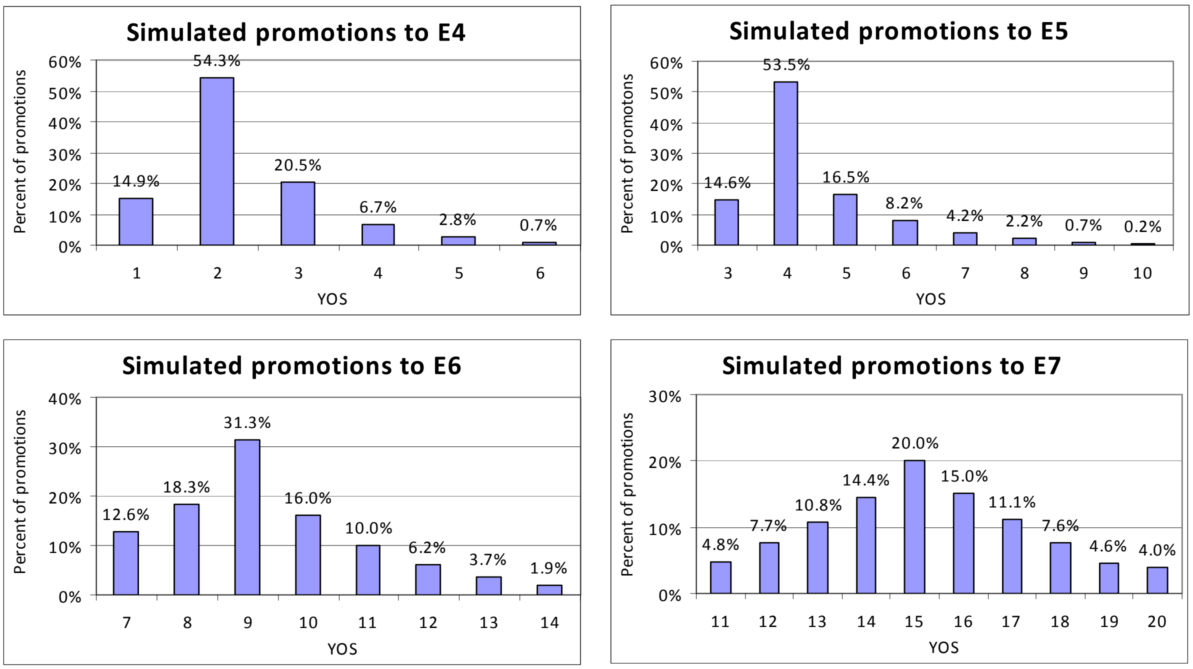
In the benchmark method for simulating advancements, the simulated ordering of advancements within a paygrade begins with the median YOS for advancements within a paygrade. Some predetermined proportion of vacancies in a paygrade are filled with members from a lower paygrade. To fill the vacancies, the model begins the process by advancing a proportion of those in the benchmark YOS within the paygrade. The advancement function continues to the next YOS up and advances some of them, then the next YOS down from the benchmark, then two YOS up and two YOS down, and so forth, repeating the process until all vacancies are filled or the system runs out of eligible people to advance (figure 7). While the simulated advancement profiles do not have the smooth look of historical results, they do maintain the bell shape profile that will give us reasonable results for this type of steady-state analysis.

Figure 6. Distribution of Navy-wide advancements by paygrade from 2000-2009 data



Our objective is to simulate an advancement schedule that resembles the historical profiles. Of course, we can't just force these profiles. If we did that, we wouldn't be able to simulate the effect that changes in retention and accession have on these profiles. This mechanism produces the profiles in the steady state but allows the downstream advancement profiles to adjust when external conditions change reenlistment rates and/or when the Navy changes R&A policy.

Figure 7. Simulated advancement distributions from our benchmark method



We care about this because there are two signs that changes in R&A have broken the system: (1) a downstream shortage in some paygrade or (2) personnel advancement and/or inventory profiles by paygrade that are clearly too junior.

The data

The model uses a set of estimated statistical parameters and historical personnel profiles, military wages, SRBs, and demographic data that come from the Navy's Enlisted Master Records (EMR) for 1983 through 2009. Manpower requirements for 2009 are authorized billets data and come from the Navy's Total Force Manpower Management Systems (TFMMS). Historical data on the U.S. economy for 1983 through 2009 are from the U.S. Bureau of Labor Statistics (BLS).

Included in the EMR are data on reenlistments, attrition, the dates at which servicemembers arrive at end of enlistment contracts, and an assortment of information about servicemembers' YOS and PG, family size, deployments, income, eligibility for reenlistment bonuses, and end of enlistment contracts.

Regression analysis and inputs to the model

Using the personnel data described earlier, we ran Logit models of the probability of reenlistment for servicemembers who were at the end of their enlistment contracts in the defined years. Our primary focus was to estimate the effect of the U.S. national economy on reenlistment probabilities, holding all other external conditions constant.

From the results of the Logit model, we collected the predicted reenlistment probabilities for each PG and YOS, and under each of the three economic conditions.

The Logit regression model is:

$$Pr(STAY|EAOS) = \beta_0 + \beta_1 EC + \beta_2 SRB + \beta_3 ES + \beta_4 W + \beta_5 M + \beta_6 X + u \qquad (2)$$

where:

Pr(STAY|EAOS) is our estimate of the model's outcome for each servicemember, the probability that he or she stays in the Navy, given that he or she is at the end of an enlistment contract. It is the focus on servicemembers at the end of an enlistment contract that makes this a reenlistment model rather than a continuation model.

STAY is the indicator of whether the servicemember continued in the Navy from one fiscal year to the next. STAY equals 1 if he or she continued, and equals 0 if not.

EAOS is the indicator that the servicemember was at the end of his or her enlistment contract within the fiscal year. EAOS equals 1 if the servicemember was at the end of contract and equals 0 if not.

EC is a set of indicators that tells us the state of the U.S. economy. There are three indicators:

- One that is equal to 1 if the economy was good
- Another that is equal to 1 if the economy was normal, or average
- One that is equal to 1 if the economy was slow.

The state of the economy was defined by a simple scoring function, in which the value of the growth in the U.S. GDP is subtracted from the value of the U.S. unemployment rate. These scores were ordered and placed in one of the three categories. (See figure 2 for economy scores and the values of the indicator variables. Of the three indicators, the indicator for the slow economy is the excluded variable in the regression model.)

SRB is an indicator that equals 1 if the servicemember was eligible for an SRB.

ES is a variable indicating whether the Navy was increasing or decreasing in endstrength in that fiscal year. *ES = 1* if endstrength grew that year; *ES = 0* if not. These values control for the Navy's growth period of the 1980s, the drawdown of the 1990s, the stable endstrength period of the early 2000s, and the minor downsizing of the later 2000s.

W is our estimate of the military/civilian wage ratio by YOS and year. The expected civilian wage comes from data in the BLS Current Population Surveys from 1983 through 2009.

M represents military career variables—specifically, paygrade, years of active service, and months in paygrade.

X refers to demographic variables: gender, married, children, and an indicator of whether the recruit was considered high quality as measured by Armed Forces Qualification Test (AFQT) score and whether he or she had a high school diploma.

We ran essentially the same model on servicemembers in the whole Navy and for servicemembers in the AECF/SECF community.

Discussion and analysis of estimates of regression models

In table 1, we show the coefficients of primary interest from both the Navy-wide and the AECF/SECF models. More detailed tables of coefficients for the models are in appendix A. The parameters in this table tell us the marginal probabilities (dy/dx)—the percentage-point change in the probability for a discrete change in the indicator variable from 0 to 1.

As we expected, reenlistment probabilities are strongly influenced by the state of the U.S. economy. So, for example, the marginal probability for a slow economy—relative to a normal economy (the excluded indicator variable)—in the Navy-wide model is 0.026. This means that a discrete change to a slow economy is associated with a 2.6-percentage-point increase in the probability of reenlistment.

Table 1. Logit regression, retention model, marginal effects—All Navy and ET/FC community

Variable	All Navy		ET/FC community	
	dy/dx[a]	z	dy/dx[a]	z
Bad Economy	0.026	24.67	0.022	4.53
Good Economy	-0.007	-7.72	-0.018	-4.41
Months in PG	-0.009	-10.62	-0.055	-13.5
SRB Indicator (1/0)	-0.071	-80.84	-0.034	-7.28
Endstrength Growth	0.045	51.99	0.031	7.84
Mil-Civ Wage Ratio	0.015	15.02	-0.007	-1.57
High-Quality Recruit	-0.082	-106.8	-0.027	-2.34
Married	-0.002	-1.07	-0.001	0.12
Children	0.085	48.98	0.092	10.5
Female	0.018	16.01	0.014	1.66
Number of observations	2,200,911		114,658	
Pseudo R2	0.172		0.178	
Dependent variable	Reenlist		Reenlist	

a. dy/dx represents a change in the probability for discrete change of dummy variable from 0 to 1.

Results from Navy-wide steady state

We've run a simulation of a Navy enlisted force with endstrength at 270,000 personnel.[7] Here we present the results in the following ways:

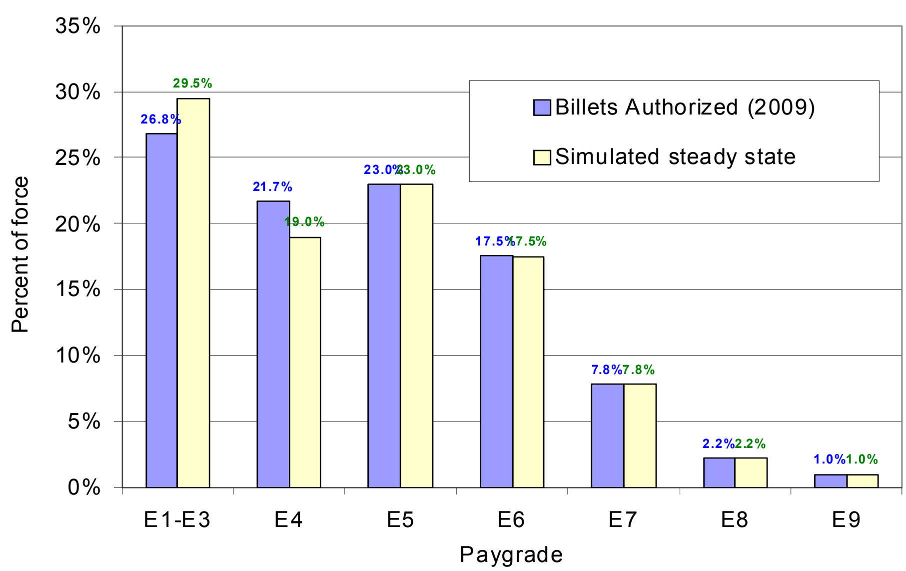
7. Navy enlisted endstrength has varied from roughly 310,000 in 2000 to 268,000 in 2010 (source: Navy Recruiting Command website: http://www.cnrc.navy.mil/PAO/facts_stats.htm).

- First and most important are personnel profiles by paygrade relative to manpower requirements. This gives us the first indication that the simulation model is working as we expect.
- Second, we show the numbers of reenlistments, accessions, EAOS losses, HYT losses, and promotions for the entire Navy enlisted force at the steady state.
- Finally, we run a simulation of a scenario in which the economy slows down and reenlistments rise. The results show what happens to reenlistments, accessions, and promotions. They also show the effect on personnel profiles relative to manpower requirements.

The Navy-wide results are a test of the model. The goal here is to determine that the model provides results that align with historical outcomes. In the next section, we describe the critical piece in this study—that is, the manpower risk assessment at the Navy community level.

Figure 8 shows the steady-state personnel profiles by paygrade. We showed in figure 5 the billet requirements. The objective of our model is to simulate these profiles and compare them with historical averages. We see in figure 8 that the model simulates historical personnel profiles relatively closely.

Figure 8. Steady-state personnel distribution, by paygrade, Navy wide



The results from our steady-state run of the simulation model suggest that, at endstrength 270,000, the Navy would retain roughly 30,630 and access about 39,012 every year. Recall that these numbers are a result of parameters drawn from a statistical model of retention over 27 years (1983 through 2009). As such, they will represent an average of retention and accession, holding many other variables constant.

Recall also that the concept of steady state assumes that all outside conditions stay the same over time. Thus, it is an important starting point for analysis, but steady state isn't the interesting result. That comes from analysis of the consequences of changing conditions that influence the steady state and, thus, influence retention and accession policy.

Risk assessment of R&A for Navy communities

Introduction

To this point, we've been discussing steady-state conditions and R&A policy as if the entire Navy operated as a single community. That was a useful path for developing, testing, and presenting the model. As a model of the manning world, however, it could produce misleading results because, in a model of the entire Navy treated as one community, there are no constraints on how vacancies are filled. In the model, if there is a promotion vacancy anywhere in the Navy at a paygrade, and there is a Sailor anywhere in the Navy who is eligible for promotion, the two could be matched. In reality, vacancies are not a function of paygrade only, but of paygrade within a rating community.

Because of this, the usefulness of this type of model comes from a community-level risk assessment. Here, we focus on one community with three scenarios that simulate the effects of changes in national economic conditions and consequent changes in R&A policy on the future manning of this community. Community-level risk can occur if today's R&A policy affects tomorrow's M&P in a way that diminishes readiness. This risk assessment is the primary focus of this section, and we'll describe it in more detail as we proceed.

In the subsections that follow, we first describe the community we simulate, and how we modeled retention and attrition rates for this community using historical data and the regression models we described previously. We detail the differences between modeling the entire Navy and modeling a community. We describe the concept of risk assessment and how it relates to the Navy's R&A decisions. We provide details of our methodology of assessing these risks using our simulation model.

We then describe our two scenarios, what conditions they simulate, and the consequences of R&A policy decisions. We define the M&P

system as having been "broken" by a change in R&A policy if (1) the result is a downstream (future) shortage in one of the paygrades or (2) the future personnel profiles of YOS within paygrades become too junior.

In a final scenario, we push the policy change to the limit to determine the conditions that may cause the system to break.

Community-level analysis

We had specific objectives in the choice of which community to study. We wanted it to be a relatively large community to avoid statistical issues associated with small numbers. We wanted the training programs within the community to be relatively homogeneous so that we could use the same parameters to simulate the entire community, although we exclude the Nuclear Field (NF) members within the community for this reason. Finally, we preferred the community to be relatively well recognized in terms of its purpose in the Navy and the training required.

We chose to analyze the combination of the Advanced Electronics and Computer Field (AECF) and Submarine Electronics and Computer Field (SECF) rating communities, which include Electronics Technician (ET), Fire Control Technician (FC), Fire Control Technician–Submarine (FT), and Sonar Technician–Submarine (STS). As before, we use the retention, attrition, and advancement parameters and personnel profiles from the EMR. We put these parameters and personnel profiles into the simulation model and analyze the effects of changes in external conditions that influence retention rates, and changes due to the Navy's response to those.

R&A decision following a change from the steady state

When M&P is in a steady state, Navy communities can hold accessions constant since, by the definition of steady state, external conditions (such as the U.S. economy) are stable. Under these conditions, retention, attrition, and high-year tenure loss will also be stable.

But what happens when external conditions change? How should community managers respond? For example, since about 2007, the

U.S. economy has been characterized by high unemployment and slow income growth. As a result, reenlistments are high because servicemembers want to stay in higher numbers. Should community managers respond by mitigating high retention rates and continuing to access in the same numbers as before? Or should they allow retention to rise as it will and reduce accessions?

The tradeoffs are as follows. On one hand, if Navy communities continue to access in the same numbers, they will need to mitigate high reenlistments. If they don't, the communities will become overmanned and the Navy will exceed endstrength. If the Navy decides to keep retention rates at previous levels, they might need to resort to "involuntary separations," meaning that otherwise eligible servicemembers would be asked to leave. This could entail costly separation payments, higher future reenlistment costs if it is regarded by servicemembers as reducing the long term probability of reaching retirement, and perhaps some adverse affect on “morale” and/or loss of "loyalty" between the Navy and senior personnel.[8]

On the other hand, if Navy communities decide to allow retention to rise, they would need to cut accessions (to prevent overmanning). While they could save costs on accessions, there is some danger that, if they cut too much, the size of the cohort(s) could cause downstream problems in manning senior billets. Communities whose paygrade structure is top heavy (i.e., their senior proportion is large) could be especially vulnerable to this problem.

Thus, part of the policy decision would entail comparing the risk-benefit tradeoff between the two choices: (1) allowing reenlistment rates to rise as they will and reducing accessions or (2) mitigating high reenlistments and holding accessions constant.

What is risk assessment?

What do we mean by "assessing the risk of an R&A policy choice"? Essentially, risk assessment involves taking into consideration the

8. See appendix C for information regarding voluntary and involuntary separation pay requirements and other costs of involuntary separations.

future manning and readiness consequences that follow today's decision regarding changes in R&A policy.

These consequences follow from the fact that the Navy (like all military services) gets its senior personnel only from the junior ranks and does not laterally hire senior members from the private sector. It means that members of a cohort of personnel grow together in their military careers—that today's recruits become tomorrow's E4s, E5s, and so on. The military has strategic and practical reasons for using this method of growing senior personnel. A consequence of this practice, however, is that, when a change in R&A policy results in a change in the size of a cohort, that change stays with the military and passes up the ranks for years to come.

Thus, community managers may be reluctant to change the number of accessions, even if doing so might be a cost-saving measure in the short run.[9] A decision today to reduce the number of accessions could create a small cohort of junior servicemembers, who, when they become eligible for promotion to E4, could result in a small cohort of E4s, then a small cohort of E5s, and so forth.

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9. Because this a manning-risk study, we do not specifically address direct costs of reenlistments and accessions. Reference [1], however, found that training costs in the AECF/SECF program were roughly $20,000 for each trainee. In this study, we found that involuntary separation costs for mid-level personnel were roughly $20,000 each (see appendix C). Offsetting these costs, we estimate that increasing reenlistments in the AECF/SECF community by 20 percent and would raise the average cost of military wages by only about 0.6 to 1.5 percent, resulting in a marginal seniority cost of $12,000 to $16,000 per additional reenlistee.

   With these estimates, reducing accessions by 450 would save $9 million in training costs. If this prevented the involuntary separation of 200 mid-level servicemembers (Zones B and C only), that would save an additional $4 million for a total savings of $13 million. Balanced against that are the costs of increased reenlistment of 450 servicemembers, which increases average seniority, and which we estimate would increase the cost of wages by roughly $6 million to $16 million.

   We suggest that it is currently not clear that reducing reenlistments versus reducing accessions is cost saving, and we recommend that further study be done on the direct costs of reenlistments and accessions.

Navy advancement rules are flexible enough to accommodate this to some extent. The Navy can promote a higher (or lower) proportion of eligible servicemembers as necessary to meet manpower requirements. In fact, this flexibility is an important tool for the Navy to adjust to changes in R&A policy that arise from changes in external conditions that influence reenlistment rates.

There are constraints to this flexibility, however, in the minimum YOS rules and in the tests that servicemembers take and other criteria for promotion. Further, if the cohort were very small, the Navy might need to promote very junior members within a paygrade, potentially resulting in a relatively inexperienced force, even when the force appeared to meet billet requirements by paygrade.

The potential "risk" in this type of analysis then, is whether and to what extent today's R&A policy decision will allow for an appropriately experienced force that meets manpower requirements in the future.

Methodology for our risk assessment

Our simulation model will allow long-term risk assessment by simulating the effects that today's changes in R&A would have on future manning. Recall that the two objectives of the simulation analysis are (1) to test whether the Navy community can adjust accessions and reenlistments and still meet future billet requirements and (2) to determine whether that force is sufficiently experienced. The risk being considered in our analysis is that changes will result in failure to meet one of these objectives, with the consequent reduction in readiness.

In our test scenarios, we simulate increases in retention and a consequent decrease in accessions in the AECF/SECF communities as if the economy is slow for some number of years; then we simulate a return to a normal economy for the following years. We follow our simulated set of small cohorts a number of years into the future, observing the changes in the personnel profiles by YOS, paygrade, and advancement, until there is a return to a new steady state.

If, at any point, either manpower requirements are not met or the personnel profiles by YOS within paygrade become overly junior, we'll consider that as having "broken" the system.

Estimating community-level parameters

Before moving on to the community-level simulations, we describe a couple of parameters that are conceptually different at the community level from the analogous parameters Navy wide. For example, to determine an accession goal, we need to estimate the rate at which accessions will drop out of the system before they reach full duty (i.e., the early attrition rate).

At the Navy-wide level, an attrite is any accession who leaves the Navy before the end of his or her service obligation. At the rating community level, however, the measurement of attrition is more complex since some servicemembers who are recruited into the community's training program will fail or otherwise leave that program during one of the training phases. While this will resemble an attrite from the community's point of view, it isn't necessarily seen as an attrite by the Navy.

Conversely, while most recruits are accessed directly into the community's training program, some are accessed into some other program such as another training program or as unrated Seamen (SN), Firemen (FN), or Airmen (AN). Some of these Sailors can then reclassify into a community's training program.

Thus, reclassification both in and out of the community training program, and regular attrition out of the Navy, are parameters we consider in the model. Consequently, attrition for the Navy refers to those who leave the Navy before the end of their enlistment contract, whereas an attrite for a community, can be anyone who leaves the program, even if he or she doesn't leave the Navy.

Adding to the complexity is that new servicemembers aren't technically considered part of a ratings community until they've completed part of the training program. For example, servicemembers who intend to join the AECF/SECF community are considered enrolled in the AECF or the SECF training program, but they don't officially join the community for about a year. Nonetheless, for planning purposes, AECF/SECF accessions begin when new recruits enter recruit training.[10]

The Navy's accession needs for the AECF/SECF communities

The Navy's Production Management Office (PMO) Tracking System provides information about the accession and attrition plans for all Navy ratings. The plan for 2010 for the AECF/SECF communities was to access 2,356 recruits into the AECF training program, and 1,235 into the SECF program, for a total of 3,591 accessions.

Within those programs, however, for servicemembers who are slated for the Nuclear Field, the training program is quite different in both length and intensity. As a result, we exclude NF from our analysis. From the Navy Recruiting Center's (NRC's) Personalized Recruiting for Immediate and Delayed Enlistment (PRIDE) data, we estimate that 9.7 percent (about 227) of AECF accessions and 14.5 percent (about 180) SECF accessions will be in the NF program. Subtracting these 407 accessions from the above total gives us 3,184.

The PMO further plans that, of these, it will lose about 1 percent before boot camp, roughly 17 percent in boot camp, and another 15 percent before they reach full duty. After having about 5 or 6 servicemembers reclassified in from another training program, 1,446 will reach full-duty status as a non-NF AECF ET or FC, and 761 will reach full-duty status as a non-NF SECF ET, FT, or STS. In general, then, the AECF community plans for a 32-percent loss rate from its accession target, and the SECF community plans for a 27-percent loss.

Since the simulation model estimates annual rates, and the AECF/SECF programs last longer than a year, we use a combination of the typical program lengths and EMR data on attrition rates to estimate first-year losses to the AECF/SECF communities at roughly 26 percent. This is the first-year attrition rate we use in the simulation model.

10. Production Management Officer (PMO) Tracker FY10.

Analyzing the steady state for the AECF/SECF communities

As we've discussed, the starting point for analysis is the steady state. We will show first what a steady state looks like for the AECF/SECF communities. Then we'll look at what happens when conditions change.

The 2009 Authorized Billet file calls for a total manpower requirement for the AECF/SECF communities of 23,572, including operational and student billets, as well as billets for Transients, Patients, Prisoners, and Holdees (TPPH). We estimate that roughly 10.9 percent (or 2,570) are NF, leaving 21,002 non-NF billets. Our model calculates steady-state accession requirements of 2,878 personnel. This is within 10 percent of the PMO's planning estimates discussed earlier. Table 2 lists annual retention, accessions, promotions, and HYT losses at the steady state. Also, table 2 shows the advancement profiles by paygrade and YOS. These numbers are the starting point for our analysis and provide the basis for analysis of the changes to the steady state.

Table 2. Estimates of results from our steady state runs for the entire Navy and the AECF/SECF communities

	Navy-wide	AECF/SECF communities
Accessions	39,012	2,878
Reenlistments	30,630	1,439
Attrition losses	16,956	1,596
High-year tenure losses	338	17
Promotions	55,230	5,175

Comparing results of the steady state with personnel data

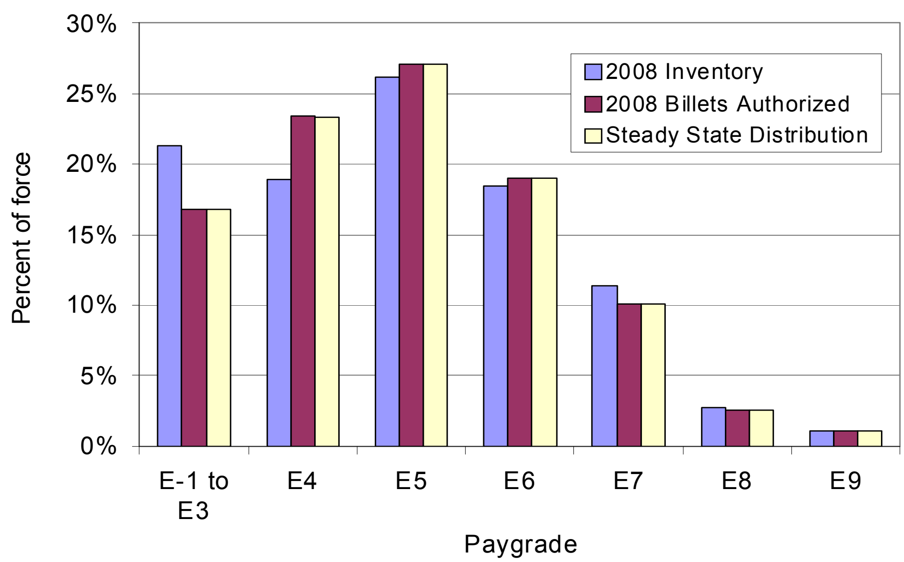
To test the robustness of our simulation model, we compare the steady-state outcomes of the model with other forms of data. Specifically, we compare the model's steady-state personnel profiles with historical averages from the Navy's personnel data and its authorized billet data.

There are differences in the way the historical data and the model's outcomes evolve. Historical personnel profiles follow from manpower requirements, but they evolve from various changes in recruiting and retention environments, in advancement rules, and in compensation-driven incentives. Personnel profiles predicted by our simulation model evolve from statistical estimates of retention and attrition rates, and from specific and unyielding rules regarding promotion and eligibility for reenlistment.

In spite of these differences between personnel data and predictions from the simulation, we still expect that the observed profiles should be close. In figure 9, we show the personnel profiles by paygrade from all three data sets: billets, bodies, and simulation results. We see that the simulation results closely match the billet requirements.

Throughout this presentation, keep in mind that the steady-state position is the starting point, not the objective. We then simulate a change in external conditions that affects reenlistments, necessitating an R&A policy decision by the Navy.

Figure 9. Distributions by paygrade for AECF/SECF communities



Future manning risk for the AECF/SECF communities when external conditions change

Review

As we've described, the steady state exists only as long as external conditions remain the same. Because these external conditions change regularly, we asked the analytical question, “How much can a rating community lower accession rates before it risks having a cohort so small it can't adequately fill future senior billet requirements?” The problem occurs when a change in accessions results in an accession cohort that is too small to adequately fill advancement vacancies when they come open.

Flexibility in advancements

An important key to mitigating the manning effects of changes in external conditions is the inherent flexibility in the Navy's enlisted requirements and promotion rules.

First, most billets allow for one-up or one-down, meaning that a billet could be filled, at least temporarily, by someone who is one paygrade higher or one paygrade lower than the requirement itself. Normally, this is used to allow a billet to be filled by someone who is about to be promoted or who is promoted during his or her tenure in the billet. But this can also be used to man billets during times of changing reenlistment and accession policy. We don't model this because the one-up/one-down decision in any given billet would require a subjective determination and would depend on additional information that is not in the data about the person who would fill the billet.

Second, and critical for our analysis, paygrade advancement rules also bring flexibility to personnel policy. When events (such as a slow national economy) lead to changes in reenlistment rates and Navy accession strategies, advancement rates can be slowed or speeded so that overall personnel profiles by paygrade can be kept stable. For example, when a slow economy raises reenlistments, increasing the number of senior people who stay and reducing vacancies, the Navy can promote fewer of them and keep personnel inventory within billet requirements.

This would require some caution because changes in advancement rates can themselves lead to secondary retention effects if they become too large. Slower advancements can lead to reduced retention rates in the future, as the perceived benefit of a military career declines. We capture a portion of these secondary effects because we include paygrade in our reenlistment model. Sailors who fail to advance reenlist at lower rates because they are at lower paygrades.[11]

Next, we explore two scenarios: first, we simulate a slowing of the economy; second, we simulate a deep recession.

Scenario one: slow economy, reenlistments rise, Navy reduces accessions, economy returns to normal after 4 years

The regression model shows that, all else equal, slow economic conditions—characterized by high unemployment rates and low GDP growth—increase reenlistments. However, because the regression model is based on data from 1983 to 2009, it measures the effects of a “slow economy” rather then the effects of a deep recession. This results in roughly a 3.8-percent increase in reenlistments (about 55 people) the first year after the change in the economy. It also implies that, all else equal, the community could reduce accessions by about 55 people (approximately 1.9 percent) and meet short-run requirements. In this simulation, reenlistments would continue to rise slowly from this high level for 4 years and then return to its steady-state level. Accessions would stay low for the 4 years of the simulated deep recession, then rise by over 60 people in the fifth year—a small overshoot of the steady state rate—before returning to steady-state levels around the eighth year.

While these changes are not trivial, they are clearly not a rigorous test of the M&P system. During the years of the economic slowdown, there are small reductions in promotion rates. There is no substantial change in paygrade profiles any year. At the end of the economic slowdown, just a small readjustment in R&A (i.e., an accession rate just over the previous steady-state number for a couple of years) would quickly bring the system back to the pre-recession steady state.

11. Note that these secondary effects mitigate the increased retention from the slow economy.

Scenario two: deep recession

To really test the manpower system, we need to set up a scenario in which reenlistment rates rise by a relatively large rate. Here we simulate a deep recession. As a result, reenlistments increase considerably, necessitating a large reduction in accessions. We run this scenario for 4 simulated years, at which time everything returns to normal.

In scenario two, we mechanically increase reenlistment rates in the simulation model by 20 percentage points for a simulated 4 years in a row. This rate of change is around 8 times the statistical marginal effect on reenlistments that we find in the statistical regression model, which measures a slow economy, not a deep recession. Our objective is to see if and when changes in external conditions and consequent R&A policy response cause the M&P system to reach a breaking point.

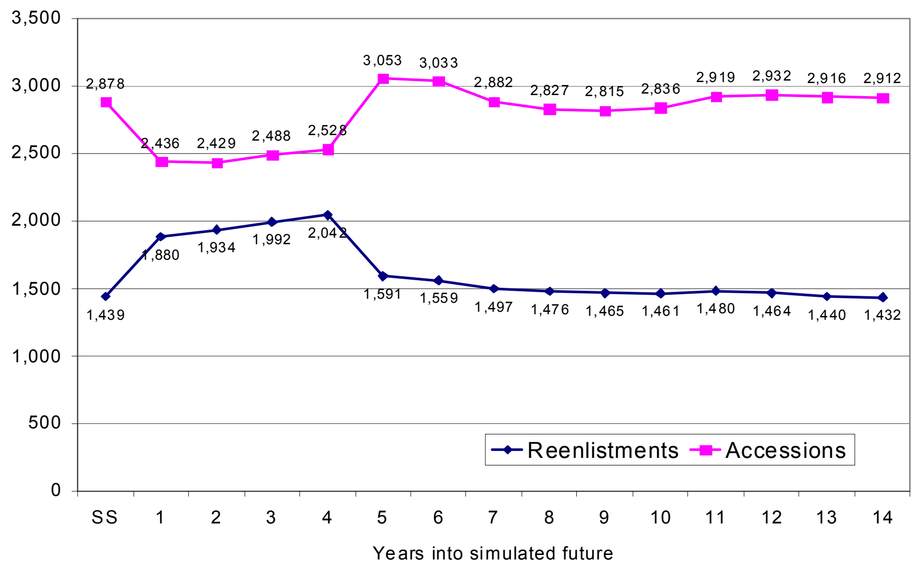
We show the changes in reenlistments and accessions in figure 10. In this scenario, reenlistments increase in the first year by about 30 percent, from the steady state of 1,440 to about 1,880. To stay at the 21,000-person endstrength at the higher reenlistment rate, the Navy would need to reduce accessions in the first year from 2,878 to 2,436, a nearly 17-percent reduction from the steady state rate. In the second year of these conditions, reenlistments increase by another 6 percent to about 1,995, although subsequent accessions stay roughly at the same low rate of about 2,430. These are stark changes, but we mean to challenge the system by simulating big changes and following the effects on future manning.

We ran this simulated slow economy for 4 years and then returned the economy to normal in the fifth year. By the fifth year, simulated reenlistments, at 1,591, are returning to the steady state. In this year, since reenlistments dropped, the Navy would need to access 3,053, roughly 6 percent more than the pre-recession steady-state number, to meet requirements in the fifth year.

Small cohort moving through time

In table 3, we illustrate how reduced accessions create a small cohort whose members remain and age in their Navy careers through time. The yellow cells that begin at YOS 0 in the steady-state year (SS) and travel diagonally from YOS 0 in YEAR SS to YOS 14 in YEAR 14 (in this table) are the last steady-state cohort before the change. The next year (YEAR 1), the Navy reduces accessions from 2,878 to 2,436 and creates the cohort in the blue cells that travels diagonally from YOS 0 in YEAR 1, to YOS 13 in YEAR 14. The next cohort, shaded in orange, begins at YOS 0 in YEAR 2, and so forth.

Figure 10. Reenlistments and accessions at steady state and after the deep recession for the AECF/SECF community



The table demonstrates clearly the small cohort that results from reducing accessions and illustrates why communities are cautious before making the decision to do this. A further look, however, will show that the flexibility in the promotion system really does reduce future manning risk from the small cohort effect.

Meeting manpower requirements

So, after the deep recession, does the Navy still meet future manning requirements? And do the promotion and personnel profiles remain reasonably senior (representing relatively experienced personnel) despite the small accession cohorts during the deep recession?

Table 3. Following a small cohort through time: AECF/SECF community at steady state and after deep recession

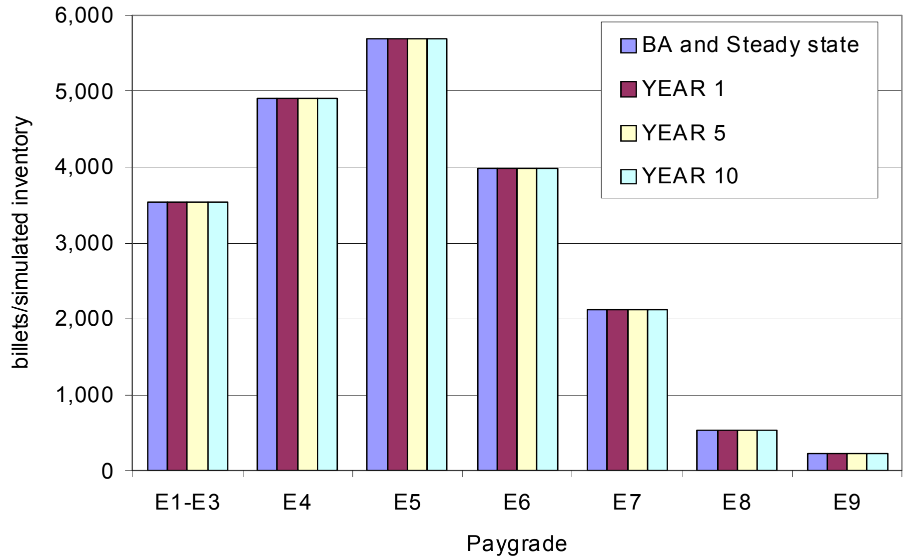
	Years into simulated future														
YOS	SS	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Accessions	2878	2436	2429	2488	2528	3053	3033	2882	2827	2815	2836	2919	2932	2916	2912
1	2129	2130	1803	1797	1841	1871	2259	2244	2132	2091	2082	2098	2159	2169	2157
2	2016	2017	1985	1677	1674	1718	1784	2148	2125	2016	1976	1969	1990	2048	2057
3	1868	1873	1873	1826	1541	1534	1576	1661	1995	1969	1865	1828	1822	1845	1900
4	1727	1746	1734	1731	1685	1407	1407	1455	1541	1849	1819	1720	1688	1686	1710
5	1579	1600	1615	1587	1582	1517	1279	1282	1329	1409	1691	1661	1570	1542	1542
6	1054	1209	1224	1232	1193	1017	985	850	856	888	941	1129	1109	1049	1030
7	936	961	1102	1116	1123	1055	900	874	754	760	788	836	1003	985	931
8	818	848	868	994	1005	975	916	782	760	657	663	688	730	876	861
9	707	741	765	779	888	853	828	779	667	649	564	571	595	633	758
10	591	637	667	688	697	732	701	681	642	551	537	469	476	497	530
11	536	554	597	625	644	630	661	633	614	580	498	486	425	431	451
12	498	514	530	572	599	596	584	612	586	569	537	462	451	394	400
13	470	482	497	514	554	564	562	550	576	552	536	506	435	425	372
14	447	456	468	483	499	526	536	534	523	548	524	509	481	414	405
15	431	437	445	456	471	479	506	515	513	503	526	503	489	462	399
16	415	421	427	435	446	452	459	485	494	492	482	504	482	469	444
17	402	405	412	417	425	431	437	444	469	477	476	466	487	466	453
18	392	394	398	404	409	415	421	426	433	457	465	464	454	474	454
19	382	384	386	389	396	398	404	409	415	421	444	452	451	441	461
20	211	242	243	244	245	216	217	218	220	222	224	234	237	236	232
21	147	147	167	167	168	168	149	150	151	152	153	153	159	161	161
22	106	106	106	119	119	120	120	107	108	108	109	110	110	114	115
23	80	80	80	80	89	89	89	90	81	81	81	82	82	83	85
24	54	54	54	54	54	59	59	59	59	54	54	55	55	55	55
25	40	40	40	40	40	40	43	43	43	43	40	40	40	41	41
26	26	26	26	26	26	26	26	28	27	27	28	26	26	26	26
27	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
28	15	15	15	15	15	15	15	15	15	16	16	16	16	15	15
29	12	12	12	12	12	12	12	12	12	12	13	13	13	13	12
Total	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000

In every year after the simulated slowing of the economy, the AECF/SECF community was able to meet its manpower requirements, as we see in figure 11, which compares billets with simulated inventory for the AECF/SECF community.

Effects on promotions and promotion profiles

As a result of the deep recession, we have a few years of small accession cohorts. What happens when the economy returns to normal and reenlistment rates fall back to their pre-recession rate? A major concern is that the higher number of vacancies in the post-recession years will need to be filled by inexperienced personnel from the small accession cohorts. We analyze this concern in the subsections that follow.

Figure 11. Distribution of personnel by paygrade: Billets authorized, simulated steady state, and years following deep recession

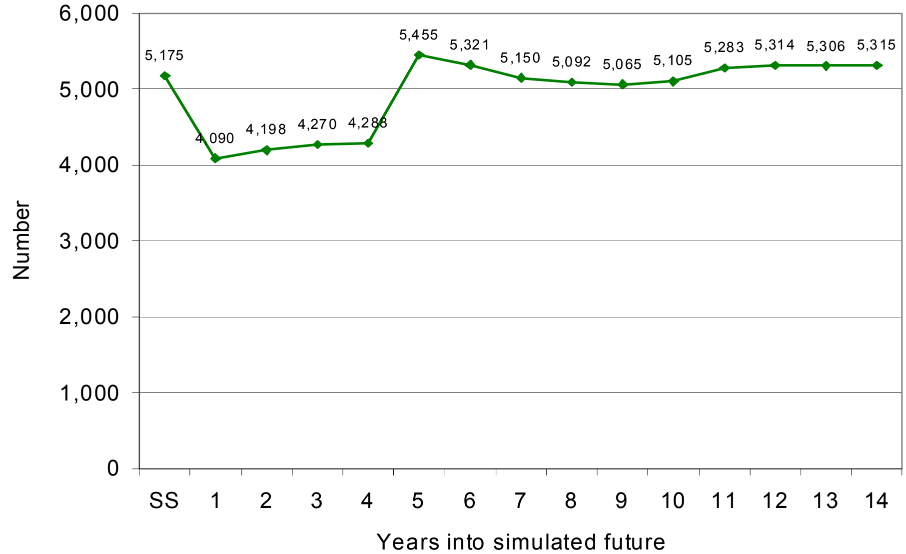


Effects on the number of promotions. Because of the deep recession, high reenlistment rates will initially increase the number of servicemembers eligible for promotion. And yet, the number of actual promotions will fall, as an increase in the number of personnel who stay reduces the number of available vacancies. After the recession ends, lower reenlistment rates will increase the number of vacancies, but by then many promotions will come from the small cohorts from the recession years.

Figure 12 demonstrates this trend in the number of promotions. We see that in the first year of the simulated deep recession, promotions fell by a little over 20 percent, from 5,175 to 4,090. Promotions remain under 4,300 each year for the next 3 years, until the economy returns to normal. Then, because reenlistments fall and accessions rise that year, promotions rise to about 5,455.

Effects on promotion profiles. We look at the profiles of these promotions over time to see if there is an indication that the Navy needs to promote relatively inexperienced personnel in order to fill vacancies after reenlistment rates fall back to normal again. We provide two methods for making this assessment.

Figure 12. Total number of simulated AECF/SECF promotions by year of the simulation, versus the steady state

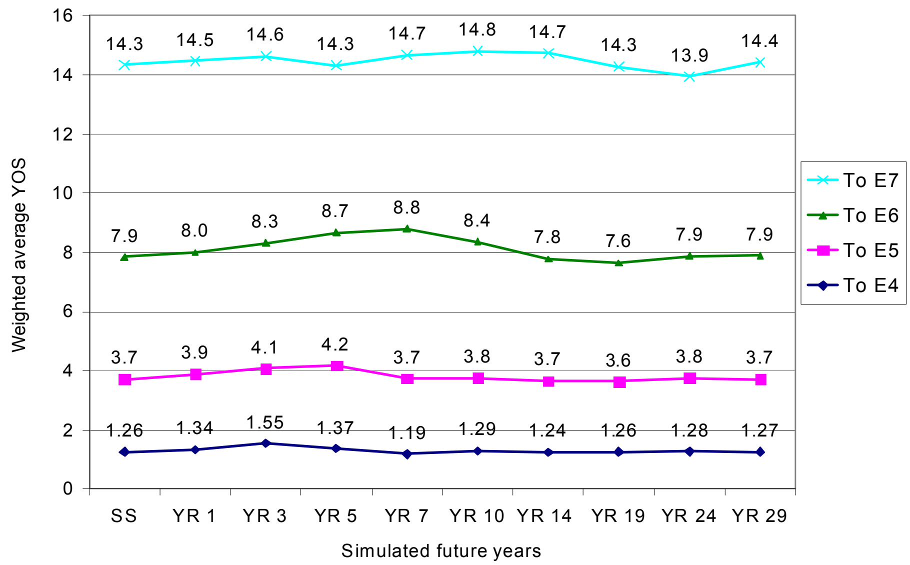


First, in figure 13, we provide the average YOS at promotion for each paygrade (E4 through E7) for the simulated future years from the beginning of the recession out to year 30. Average YOS will show us when a major change in the promotion profile occurs. The definition of "major" change is somewhat subjective and should vary by paygrade. However, we begin the discussion by suggesting that a reduction in average YOS at promotion by, for example, 10 percent from the steady-state level, would be significant.

We see in figure 13, that, for the first few years during and after the simulated deep recession, seniority rises at all paygrades because reenlistment rates have risen. It is no surprise that seniority rises, but the fact that it rises by as much as 20 percent for promotions to E4, and by over 10 percent for promotions to E5 and E6, is of interest.

What we want to see, however, is what happens to seniority levels as the small accession cohorts reach eligibility for promotions far into the future. We see here that, in the seventh year, average YOS for promotions to E4 drop to 1.19, which is about 0.07 percentage point, or around 6 percent, below the steady-state average of 1.26. This does not meet our criterion of a 10-percent reduction from the steady-state level to be considered significant. None of the other paygrades experience this magnitude of change.

Figure 13. Average YOS at promotion: scenario two



For a more comprehensive analysis of this topic, we look at the full promotion profiles by YOS for each paygrade. We provide the profiles in figures 14 through 16. This method allows us to see the proportionate change in the number of promotions at each YOS for members within a paygrade.

Looking first at promotions from E3 to E4 in figure 14, we see that, in the third year after reducing accessions (shown, for example, by the yellow bar in each YOS), the proportion of Sailors promoted to E4 that were in YOS 1 fall from roughly 78 percent (in the steady state) to about 55 percent in the third year. Conversely, the proportion in YOS 2 was higher in the third year than in steady state (32 percent versus 17 percent). This confirms our previous finding that average YOS for promotions from E3 to E4 rose after the beginning of the simulated deep recession. This continued until the seventh year (represented by the dark purple bar in each YOS), when the proportion of promotions that were YOS 1 rose to well over 80 percent, while the proportion that were YOS 2 fell to around 13 percent. These are not huge changes, but they are notable and confirm a small drop in average YOS for promotions from E3 to E4 by the seventh year.

Figure 14. Promotions to E4 by YOS

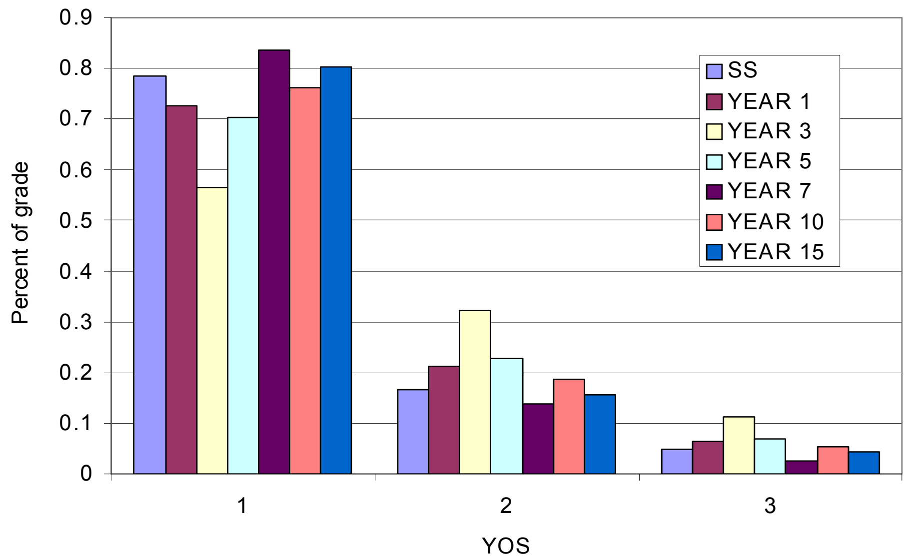


Figure 15. Promotions to E5 by YOS

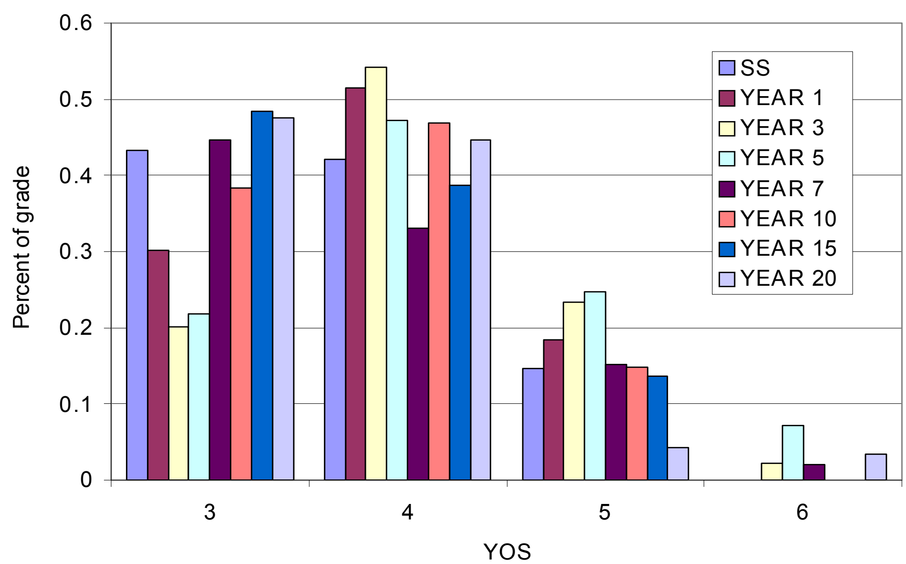


Figure 16. Promotions to E6 by YOS

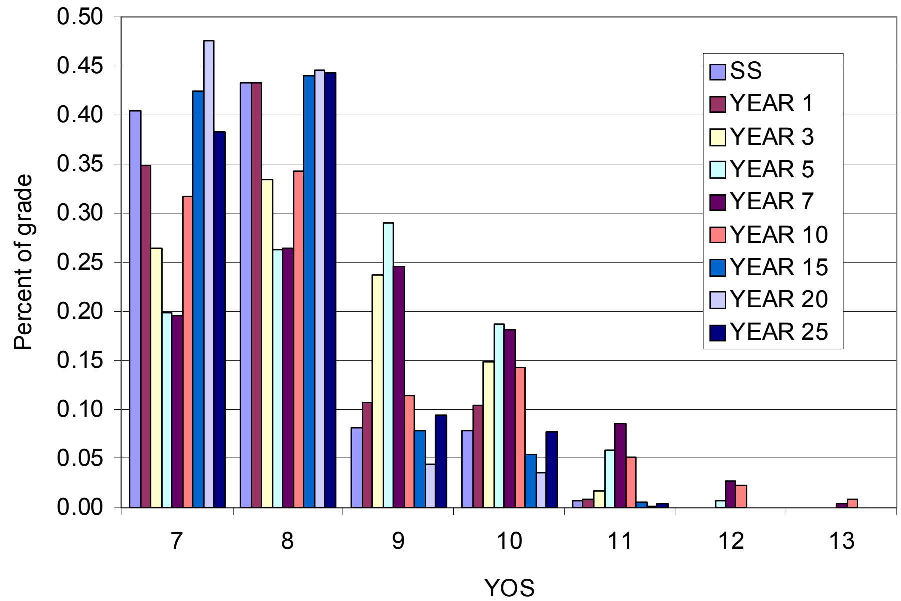
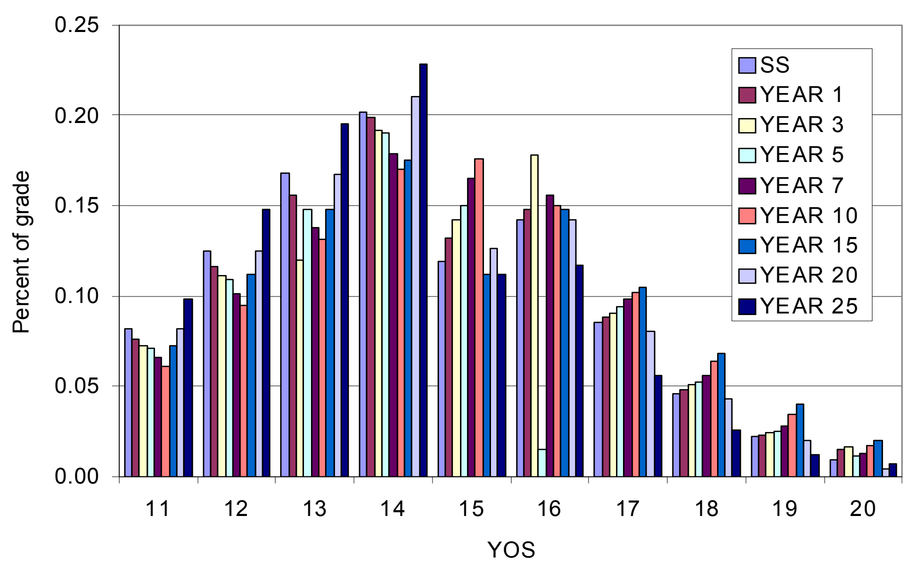


Figure 17. Promotions to E7 by YOS



Similar paths follow for promotions to E5 (figure 15), E6 (figure 16), and E7 (figure 17). For the first few years, proportionately fewer promotions go to personnel who are junior YOS, and more promotions go to those who are more senior. When the economy and reenlistment rates return to normal, the process reverses; more promotions go to junior personnel and fewer to senior personnel. Yet the advancement profile is only slightly more junior on average than the steady-state profile. By the time the small accession cohorts work through the system, it goes back to the steady-state rates.

So, from this simulation, it does not appear that promotions would need to go to an unsustainably young cohort any time after the deep recession. To further study this issue, however, we look at the experience levels of the actual future force to see if the recession would result in an unsustainably young personnel profile.

Effects on personnel profiles—by YOS and paygrade

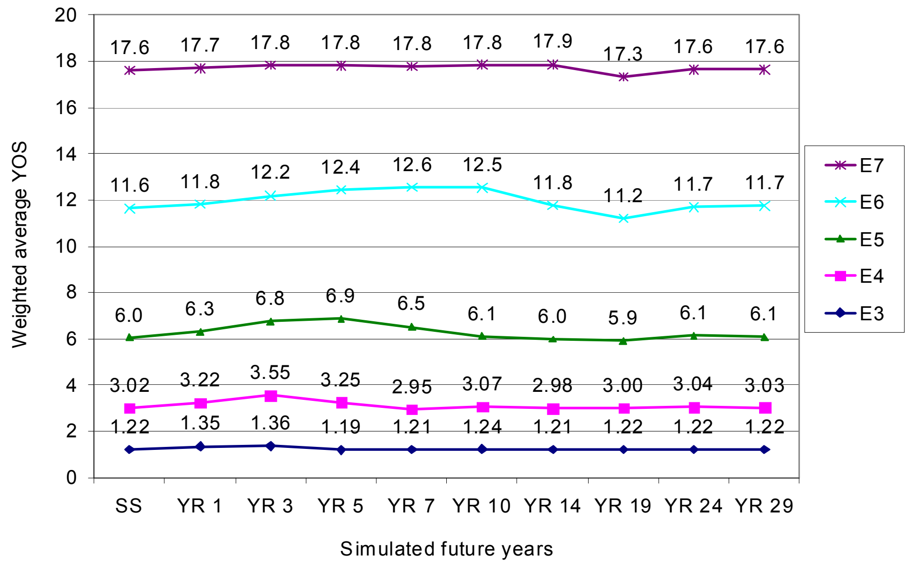
Recall that a key to the flexibility of manpower requirements comes from the ability of the Navy to speed or slow promotion rates to fill vacancies and meet manpower requirements. And, as we saw, it doesn't appear to result in the Navy *promoting* an overly young future cohort.

Yet promotions present the *flow* of people into a paygrade. A personnel inventory profile presents experience levels of the entire *stock* of people in that paygrade. We examine these profiles by experience levels (YOS) of the force in each paygrade far into the simulated future. Again, we provide two different perspectives of the effect: (1) with average YOS by paygrade and (2) with full detailed YOS profile at each PG.

Consider the changes in average YOS by paygrade in figure 18. In the first few years that follow the beginning of the simulated deep recession, we see a substantial increase in average YOS for all paygrades. For personnel in the Seaman paygrades (E1 to E3), average YOS rose by year 3 from 1.22 to 1.36, roughly a 10-percent increase.[12]

12. Average YOS is a weighted average of the YOS within a paygrade. So for example, at the steady state, 81.5 of percent of Seamen are in their first YOS (YOS 1), 14.9 percent are in their second, and 3.7 percent are in their third. The weighted average YOS for this group is 1.22.

Figure 18. Average YOS by paygrade: scenario two



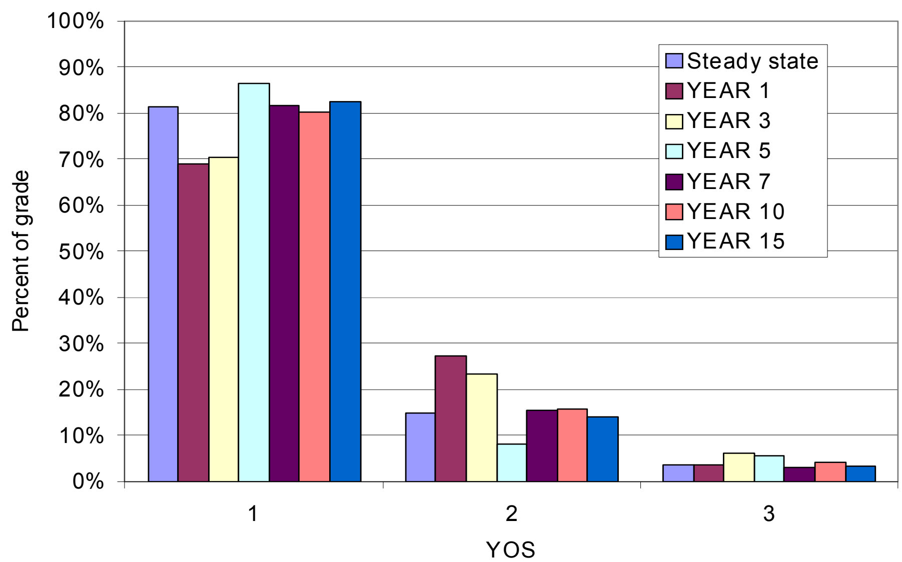
For servicemembers in paygrade E4, average YOS rose from 3.22 to 3.55, a roughly 17.5-percent rise in three simulated years. Similarly, average YOS for E5 and E6 rise by nearly a full year from 6 to 6.9 and from 11.6 to 12.6, respectively. Both are remarkable increases in average seniority and suggest that, at least in the years just following this deep recession, readiness could possibly get stronger.

After our simulated recession ends and reenlistment rates return to normal, we see the effects of the large rise in accessions in that average YOS falls a little for the Seamen (E1 to E3) personnel. The average YOS is only slightly below steady state, however, falling to 1.19 compared with 1.22 in the steady state.

Similarly, in the subsequent years, as the compensating rise in promotions takes effect, average YOS falls to about 2.95 in year 7 for E4, about 2.5 percent lower than steady state. Average YOS falls for E5s, E6s, and E7s by year 19 but only slightly, in the range of 1 to 3.5 percent below steady state. Thus, there is no evidence here that the community ever becomes too junior, or that readiness is ever at risk, as a result of the low accession rates during the simulated deep recession.

We show another type of analysis of the effects of the R&A policy changes on personnel profiles in figures 19 through 23. Here we look at the profiles—or distributions—of personnel by YOS at various years into the simulated future. Confirming our previous findings, in the 5 years following the beginning of the deep recession, we see a fall in the proportionate number of personnel at lower YOS, and the simultaneous rise in the number of personnel in higher YOS within each paygrade.

Figure 19. Distribution of E3 by YOS and YEAR



After the fifth year, when reenlistment rates return to normal and the community needs to access more personnel, we see that the YOS distribution of personnel becomes a little more junior, but not seriously so. We see this with the rise of personnel in the lower YOS and the fall in the higher YOS in each paygrade. Note, however, that it doesn't look much more junior than the steady-state profiles. Shortly thereafter, it returns roughly to the steady-state levels.

Figure 20. Distribution of E4 by YOS and YEAR

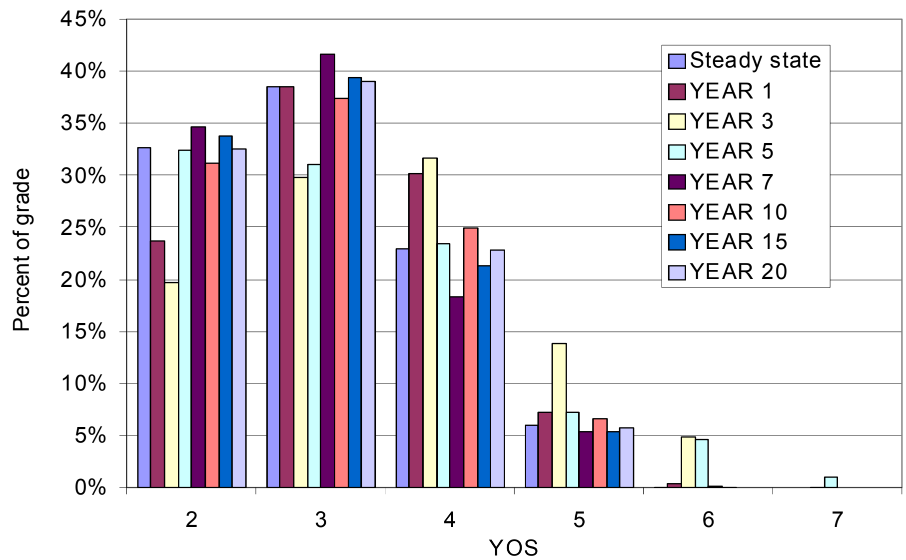


Figure 21. Distribution of E5 by YOS and YEAR

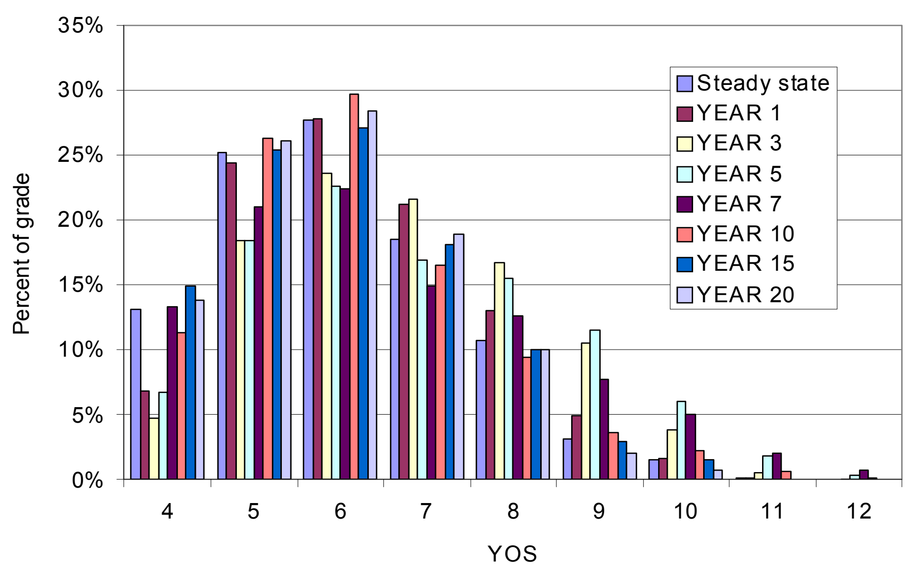


Figure 22. Distribution of E6 by YOS and YEAR

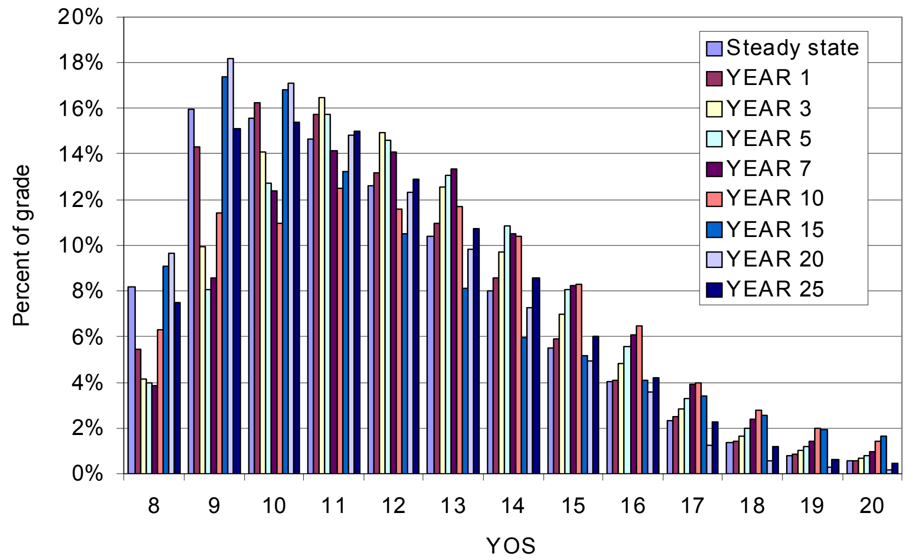
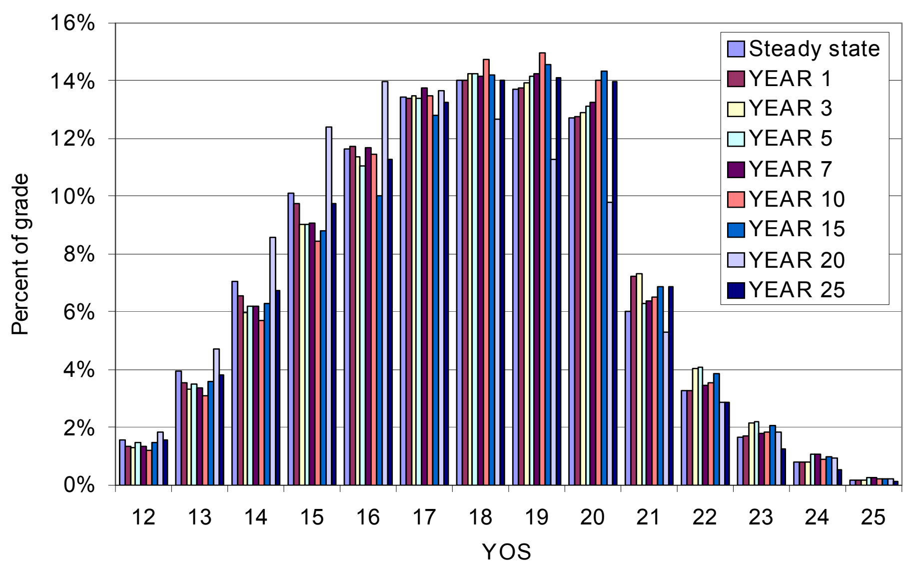


Figure 23. Distribution of E7 by YOS and YEAR



We find that, countering the small accession cohorts in the first years of the recession, the community also gains a more senior force (on average) from which to draw its promotions in the years following the recession. This pent-up demand for promotions lends additional flexibility to the M&P system, allowing it to more easily recover from the years of the recession.

Is there an accession floor?

Another way to phrase this question would be, "Could the Navy reduce accession rates enough that eventually the system would not be able to meet requirements with a sufficiently experienced force?"

As a final check, we simulated a scenario in which accessions are reduced by about 40 percent—from 2,878 (at the steady state) to 1,735. Here, the system was challenged beyond its limits, by our criteria. In the fifth year, the number of E3s and E4s deviates from manpower requirements. Specifically, the number of E3s goes 5 percent over billet requirements and the number of E4s falls the same number (though about 3.5 percent) below E4 billet requirements.

The reasons this happens are, first, in the prior four years, accession cohorts were so small that they promoted quickly through the ranks. By the fifth year, there were many vacancies in E4 and E5, and the fifth-year accession cohort wasn't large enough to fill them, leaving the E4 billets undermanned. At the same time, the fifth-year accession requirement was large because the economy had recovered and losses had risen, resulting in overmanning of the E3 billets.

In addition to billet requirements not being met, in that year, over 93 percent of promotions to E4 went to E3s in their first year of service. This compares with 74 percent in the steady state. By year 11, over 74 percent of promotions to E5 were by servicemembers in their third year of service, which is their first year of eligibility. This compares with just over 43 percent at the steady state. Promotions to the higher paygrades (E6 and E7) also went to servicemembers who were more junior, but not as seriously different from the steady state as E4s and E5s.

To be sure, we do not believe that the community would reduce accessions by that level. Our goal, however, was to simulate a reduction so severe that it seems to place a theoretical floor on the number of accessions required.

Distributable endstrength

Another factor the Navy could consider is that, if the Navy increases retention and decreases accessions (to maintain endstrength), there will be fewer personnel in training in the short run and, thus, a higher "distributable endstrength," meaning more people to fill operational billets.

What effect, if any, would this have on overall community-level productivity? Measuring productivity and readiness is outside the scope of this project. But we could postulate one of several outcomes. First, it's possible that the proportional increase in the average seniority levels could increase readiness. Second, there would be more servicemembers actually producing, and fewer in training, which could in itself increase productivity and readiness.

This would be especially evident to the extent that billets are gapped—that is, the billets exist in requirements but are not actually filled by people. If billet requirements are binding, which means that all billets really need to be filled in order to achieve readiness goals, and if some billets are gapped, increasing the number of people available to fill operational billets would increase production and readiness beyond the current level.

Finally, going the other way, making the force more junior by increasing accessions would probably reduce readiness by decreasing distributable strength and decreasing average seniority levels.

Summary and conclusions

Finding the right balance between reenlistments and accessions will depend on the effects of the Navy's R&A policy on future manning. Specifically, in a recessionary period, the Navy might want to increase reenlistments and reduce accessions in the short run to take advantage of the high retention climate.

The problem is that decreasing accessions will result in small cohorts. At some time, the economy will improve and reenlistment rates will return to normal. By then, it is possible that those accession cohorts will be too small to fill available vacancies without promoting a large number of inexperienced servicemembers. The results of our analysis reveal, however, that the built-in flexibility in the M&P system and in the advancement rules will allow the Navy to adjust to reasonable reductions in accessions.

Results of simulation scenarios

To review, using 27 years of Navy personnel data, the results from the statistical analysis of those data, and the Navy's reenlistment and advancement rules, we constructed a model that simulates the dynamic flows of personnel into, through, and out of the Navy at each year of service and paygrade. After defining a set of R&A policy scenarios, we used the simulation model to conduct a community-level risk assessment of the Navy AECF/SECF community. With the results of these simulations, we assessed the long-term M&P consequences of reducing accessions.

In our test of the Navy's enlisted M&P system, we used our model to simulate a very serious recession. This deep recession resulted in a 30-percent increase in AECF/SECF community reenlistments, from the steady state of 1,439 to 1,880, and necessitated about a 15-percent reduction in accessions, from 2,878 to 2,436.

We found that the simulated future profile of promotions and personnel YOS did change substantially. In the first years, servicemembers became more senior, on average, as a result of high reenlistment and low accessions. At the end of our simulated recession, reenlistment rates fell and vacancies rose to be filled by the small cohorts. Shortly after that, the paygrades started becoming more junior because promotions went to personnel with lower YOS.

Throughout this 20-year simulated period, however, there was no time in which requirements could not be met or in which the enlisted paygrades became dangerously junior. In fact, our model showed how flexible the M&P system is. In our simulated recession, we see that the rate and number of promotions fell during the simulated recession, from the steady state of 5,175 annual promotions to about 4,080. Promotions stayed low for the simulated recession years, rose again to a high of 5,455, and then returned to the steady-state rate by about the seventh year.

Thus, in the short term, average seniority levels at each paygrade increased. When the simulated economy returned to normal, the promotions essentially returned to their normal rates and numbers. There was never a need for the AECF/SECF community to promote an overly junior force because pent-up demand for promotions, which had resulted from the previous period's high reenlistment rates, countered the effect of the small cohort reaching eligibility.

In a final scenario, to determine whether and where there is an accession floor—an accession rate so low that the M&P system would eventually break—we simulated an increase in reenlistments by about 50 percent, from 1,439 to 2,158, and a reduction in accessions by one-third, from 2,878 to 1,922. Here, the system was challenged beyond its limits. Promotions fell by nearly 45 percent, from 5,455 to 2,881, and within 6 to 12 simulated years, practically all enlisted personnel in the AECF/SECF community needed to be promoted to E4 in their first year of service, to E5 in their third year of service, and to E6 in their seventh year of service.

Bottom line

The model suggests that the manpower system is flexible and will adjust to relatively large changes in reenlistments and accessions. Up to a reasonable limit, reducing accessions today will not result in Navy communities failing to meet future manpower requirements.

This study is just a foundation for this method of modeling community-level manning risk assessments. It has the capability of answering many other questions and concerns regarding R&A tradeoffs. We list four possible areas of further study in which this analytical method and modeling technique would be useful.

Direct costs of R&A

For example, this study focused on future manning risk as the important consideration in the balance between reenlistments and accession. But also important are the list of direct costs associated with each. Such costs as recruitment, training, incentive bonuses, and military wages are all influenced by the same types of conditions that create manning risks. It would be possible to study these costs and include them in the model.

Risk assessments for other Navy communities

The methods we employ and the mechanisms in this model are capable of conducting similar assessments of the manning risks of balancing R&A for any Navy community. Each community has its own concerns and procedures regarding recruitment, training, attrition, and continuation. With careful discussion and planning, these can be integrated into the model and provide answers to the R&A balancing question.

Selection of break points

Our method has raised some fundamental questions about which events are considered risky and at what point the manning system is really broken. In this study, we asserted that, if billet requirements weren't exactly met, the system was broken. There are reasons to do so in this type of modeling. For example, how would one justify a softening of this hard break point? How far from billet requirements could we go? Also, we chose a somewhat arbitrary break point for when promotions and personnel were too junior (i.e., when the average YOS within a paygrade fell by 10 percent of the steady-state average). That may be reasonable in this context, but it could vary by community, by type of billets within a community, or even at different times.

Range of possible scenarios

The conclusions in this analysis are based on scenarios in which high retention and reduced accessions were of a specific size and length of time. So, in our main scenario (number two) we increased reenlistment rates by 20 percentage points and decreased accessions by about a third for 4 years, when they returned to their pre-recession rates. A natural follow-on with this model would be to conduct a wide range of scenarios, exploring many different topics that community managers face. For example, what happens if the entire Navy needs to reduce accessions by some large number (e.g., 50 percent) but for only for a short time? Or, what if endstrength requirements were cut? What if they were raised? What are the R&A choices available for dealing with these events? And what are the potential costs and risks for each of the various choices?

Appendix A: Results from reenlistment model

Table 4. Logit regression, retention model, All Navy marginal effects (all variables)

Variable	dy/dx[a]	z	P>|z|	95% conf. int.	
Bad Economy	0.026	24.67	0	0.024	0.028
Normal Economy	-0.007	-7.72	0	-0.009	-0.005
Months in PG	-0.009	-10.62	0	-0.011	-0.008
SRB Indicator (1/0)	-0.071	-80.84	0	-0.073	-0.069
Endstrength growth	0.045	51.99	0	0.043	0.047
Mil-civ wage ratio	0.015	15.02	0	0.013	0.017
High quality recruit	-0.082	-106.79	0	-0.083	-0.080
Married	-0.002	-1.07	0.286	-0.005	0.001
Children	0.085	48.98	0	0.081	0.088
Female	0.018	16.01	0	0.016	0.021
E4	0.130	107.59	0	0.128	0.133
E5	0.189	127.84	0	0.186	0.192
E6	0.226	120.94	0	0.222	0.230
E7	0.358	273.32	0	0.356	0.361
E8	0.374	449.83	0	0.372	0.375
E9	0.384	603.89	0	0.383	0.385
YOS2	0.038	2.21	0.027	0.004	0.071
YOS3	0.137	9.38	0	0.108	0.166
YOS4	0.150	9.53	0	0.119	0.181
YOS5	0.202	15.80	0	0.177	0.227
YOS6	0.137	9.21	0	0.107	0.166
YOS7	0.231	20.88	0	0.209	0.252
YOS8	0.222	19.00	0	0.199	0.245
YOS9	0.242	22.78	0	0.221	0.263
YOS10	0.259	25.82	0	0.240	0.279
YOS11	0.289	36.00	0	0.274	0.305
YOS12	0.320	49.97	0	0.307	0.332
YOS13	0.340	65.35	0	0.330	0.350
YOS14	0.356	81.81	0	0.348	0.365
YOS15	0.360	88.68	0	0.352	0.368

Table 4. Logit regression, retention model, All Navy marginal effects (all variables) (continued)

YOS16	0.360	84.83	0	0.352	0.369
YOS17	0.367	101.12	0	0.360	0.374
YOS18	0.370	114.30	0	0.363	0.376
YOS19	0.361	96.38	0	0.354	0.368
YOS20	-0.373	-26.43	0	-0.400	-0.345
YOS21	-0.284	-17.29	0	-0.316	-0.252
YOS22	-0.294	-18.08	0	-0.325	-0.262
YOS23	-0.281	-16.84	0	-0.314	-0.248
YOS24	-0.405	-32.99	0	-0.430	-0.381
YOS25	-0.287	-16.79	0	-0.320	-0.253
YOS26	-0.459	-46.82	0	-0.478	-0.440
YOS27	-0.379	-26.50	0	-0.407	-0.351
YOS28	-0.406	-30.19	0	-0.432	-0.380
YOS29	-0.385	-25.66	0	-0.415	-0.356
Number of observations			2,200,911		
Pseudo R2			0.171		
Dependent variable			Reenlist		

a. dy/dx represents a change in the probability for discrete change of dummy variable from 0 to 1.

Table 5. Logit regression, marginal effects, retention model, AECF/SECF community (all variables)

Variable	dy/dx[a]	z	P>|z|	95% conf. int.	
Bad Economy	0.022	4.53	0	0.013	0.032
Normal Economy	-0.018	-4.41	0	-0.026	-0.010
Months in PG	-0.055	13.47	0	-0.063	-0.047
SRB Indicator (1/0)	-0.034	-7.28	0	-0.043	-0.025
Endstrength growth	0.031	7.84	0	0.023	0.039
Mil-civ wage ratio	-0.007	-1.57	0.117	-0.016	0.002
High quality recruit	-0.037	-6.69	0	-0.048	-0.026
Married	0.001	0.12	0.904	-0.016	0.018
Children	0.093	10.49	0	0.075	0.110
Female	0.014	1.66	0.097	-0.003	0.030
E4	0.171	13.16	0	0.146	0.197
E5	0.168	12.02	0	0.141	0.195
E6	0.152	10.08	0	0.122	0.181

Table 5. Logit regression, marginal effects, retention model, AECF/SECF community (all variables) (continued)

E7	0.328	25.34	0	0.302	0.353
E8	0.405	47.07	0	0.388	0.422
E9	0.439	71.79	0	0.427	0.451
YOS2	0.221	1.41	0.158	-0.085	0.527
YOS3	0.092	0.54	0.587	-0.240	0.424
YOS4	0.303	2.61	0.009	0.075	0.531
YOS5	0.130	0.79	0.427	-0.191	0.450
YOS6	0.037	0.21	0.834	-0.307	0.380
YOS7	0.116	0.70	0.485	-0.209	0.441
YOS8	0.180	1.16	0.244	-0.123	0.483
YOS9	0.184	1.20	0.232	-0.118	0.487
YOS10	0.269	2.00	0.045	0.006	0.532
YOS11	0.265	2.08	0.038	0.015	0.515
YOS12	0.359	4.02	0	0.184	0.534
YOS13	0.396	5.66	0	0.259	0.533
YOS14	0.440	9.13	0	0.345	0.534
YOS15	0.450	11.00	0	0.370	0.530
YOS16	0.466	11.73	0	0.388	0.543
YOS17	0.468	13.95	0	0.403	0.534
YOS18	0.467	16.50	0	0.412	0.523
YOS19	0.472	17.67	0	0.419	0.524
YOS20	-0.233	-1.57	0.116	-0.523	0.057
YOS21	-0.171	-1.08	0.282	-0.483	0.141
YOS22	-0.190	-1.23	0.221	-0.493	0.114
YOS23	-0.156	-0.96	0.337	-0.474	0.162
YOS24	-0.276	-2.15	0.032	-0.527	-0.024
YOS25	-0.174	-1.09	0.275	-0.485	0.138
YOS26	-0.331	-3.13	0.002	-0.538	-0.124
YOS27	-0.209	-1.38	0.167	-0.506	0.088
YOS28	-0.245	-1.73	0.083	-0.521	0.032
YOS29	-0.239	-1.66	0.098	-0.521	0.044
Number of observations			114,658		
Pseudo R2			0.178		
Dependent variable			Reenlist		

a. dy/dx represents a change in the probability for discrete change of dummy variable from 0 to 1.

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Appendix B: Tables of estimated reenlistment probabilities

Table 6. Estimated reenlistment probabilities: slow economy, AECF/SECF community

	Paygrade (percentage)						
YOS	E3	E4	E5	E6	E7	E8	E9
2	2.7						
3	5.4	0.3					
4	2.5	3.5	3.7				
5	13.6	2.2	2.6				
6	4.7	20.9	18.2				
7		5.6	4.3				
8		9.3	7.3	8.9			
9		10.2	10.3	10.9			
10		28.9	20.4	20.0			
11		17.5	10.7	9.5			
12			14.4	12.2	10.0		
13			13.9	12.4	10.1		
14			18.9	14.9	13.1		
15			18.5	15.0	12.6	7.9	
16				22.4	19.9	13.5	
17				18.8	17.0	12.7	
18				11.9	12.6	8.9	
19				15.8	12.8	10.7	
20				10.4	12.9	14.1	12.1
21				8.3	12.8	14.7	13.5
22					11.5	14.2	16.1
23					14.8	16.8	14.2
24					15.3	10.7	11.9
25					14.7	13.4	15.0
26						18.1	10.2
27						16.2	13.1
28							12.2
29							14.3

Table 7. Estimated reenlistment probabilities: normal economy, AECF/SECF Community

	Paygrade (percentage)						
YOS	E3	E4	E5	E6	E7	E8	E9
2	2.5						
3	5.3	0.3					
4	2.4	3.5	3.7				
5	12.9	2.1	2.5				
6	4.7	20.2	17.6				
7		5.6	4.2				
8		9.2	7.0	8.8			
9		10.2	10.0	10.9			
10		27.7	20.0	19.8			
11		17.1	10.6	9.4			
12			14.3	12.0	10.0		
13			13.7	12.3	10.1		
14			18.6	14.8	13.1		
15			18.4	15.0	12.5	7.9	
16				22.3	19.9	13.5	
17				18.7	17.0	12.7	
18				11.9	12.5	8.9	
19				15.7	12.8	10.7	
20				9.8	12.3	13.5	11.8
21				8.4	12.4	14.2	13.5
22					11.0	13.5	15.9
23					14.3	16.5	14.2
24					14.6	10.5	11.7
25					14.2	13.3	14.8
26						17.6	9.9
27						15.8	12.8
28							11.7
29							14.4

Table 8. Estimated reenlistment probabilities: good economy, AECF/SECF Community

	Paygrade (percentage)						
YOS	E3	E4	E5	E6	E7	E8	E9
2	2.4						
3	5.0	0.2					
4	2.2	3.4	3.6				
5	11.9	2.0	2.4				
6	4.6	19.3	16.9				
7		5.3	4.0				
8		8.8	6.7	8.6			
9		9.7	9.7	10.4			
10		26.3	19.3	19.2			
11		17.2	10.2	9.1			
12			13.8	11.8	9.9		
13			13.4	12.1	10.1		
14			18.4	14.6	13.0		
15			18.1	14.8	12.5	7.9	
16				22.0	19.8	13.5	
17				18.6	16.9	12.7	
18				11.8	12.5	8.9	
19				15.6	12.7	10.7	
20				9.1	11.6	12.9	11.5
21				7.6	11.6	13.7	13.1
22					10.4	13.0	15.4
23					13.3	15.8	13.7
24					13.7	9.9	11.2
25					13.9	12.6	14.6
26						16.5	9.4
27						15.6	12.5
28							11.8
29							13.9

Table 9. Estimated reenlistment probabilities: good economy, Navy-wide

	Paygrade (percentage)						
YOS	E3	E4	E5	E6	E7	E8	E9
2	0.7						
3	6.2	4.5					
4	22.6	25.7	17.6				
5	15.5	14.1	10.4				
6	11.4	13.7	15.9				
7	12.1	13.7	11.3				
8		19.4	17.1	18.2			
9		18.9	16.9	17.1			
10		42.1	23.1	20.7			
11		26.1	18.6	15.1			
12			20.2	18.6	15.4		
13			21.0	19.7	18.4		
14			23.5	22.7	20.6		
15			24.7	22.4	19.5	13.2	
16				25.6	24.7	20.9	
17				22.2	22.2	17.3	
18				18.1	17.3	14.2	
19				18.7	16.1	14.1	
20				9.3	13.3	16.2	17.9
21				9.5	15.3	18.1	17.3
22					15.0	18.4	19.9
23					15.5	17.9	17.9
24					14.8	13.0	15.2
25					14.3	15.2	16.2
26						16.4	13.3
27						14.1	15.9
28							11.8
29							15.1

Table 10. Estimated reenlistment probabilities: normal economy, Navy-wide

	Paygrade (percentage)						
YOS	E3	E4	E5	E6	E7	E8	E9
2	0.7						
3	3.4	2.7					
4	21.9	23.6	16.6				
5	18.3	15.9	12.0				
6	13.2	14.7	14.9				
7	14.0	15.0	11.0				
8		21.7	17.1	16.3			
9		19.9	16.8	16.5			
10		39.3	22.8	21.6			
11		26.5	18.2	15.1			
12			19.7	17.1	13.3		
13			19.0	16.9	14.4		
14			22.4	20.2	17.2		
15			22.3	20.1	16.4	9.1	
16				24.1	23.9	18.9	
17				21.8	21.4	15.1	
18				17.6	17.4	14.2	
19				18.8	16.5	12.9	
20				10.8	15.5	17.6	17.5
21				11.2	16.8	19.1	19.8
22					17.1	19.3	19.7
23					17.6	19.6	18.8
24					18.8	15.4	15.4
25					16.5	18.6	17.4
26						20.2	14.6
27						17.9	16.7
28							13.5
29							15.7

Table 11. Estimated reenlistment probabilities: slow economy, Navy-wide

	Paygrade (percentage)						
YOS	E3	E4	E5	E6	E7	E8	E9
2	0.9						
3	3.8	2.2					
4	23.0	24.1	15.8				
5	19.1	17.4	13.0				
6	14.2	15.5	16.6				
7	15.2	16.6	11.9				
8		28.6	18.7	14.5			
9		21.5	17.6	16.6			
10		40.1	24.1	23.0			
11		28.7	19.1	14.8			
12			20.1	16.3	11.0		
13			20.4	17.4	12.9		
14			24.1	20.6	16.5		
15			22.6	20.5	16.6	12.6	
16				25.0	23.1	17.5	
17				21.9	20.5	14.3	
18				17.6	16.7	13.3	
19				20.1	16.7	13.1	
20				12.4	16.9	17.9	16.6
21				10.8	17.2	20.0	19.2
22					17.3	19.7	19.4
23					19.3	20.9	19.6
24					22.4	16.6	16.8
25					19.3	20.3	17.8
26						22.9	15.5
27						20.3	16.1
28							15.0
29							17.1

Appendix C: Voluntary and involuntary separation pay

Involuntary separation pay

According to U.S. Code, Title 10, Sub A, Part II, Ch. 59, sec. 1174(d.1), the one-time, lump-sum amount of involuntary separation pay is 10 percent of annual basic bay (BP) times the servicemember's YOS.

To illustrate, consider an E5 with 7 years of service, whose annual BP is about $31,000 and who is involuntarily separated. His or her separation pay would be about $18,605.

Voluntary separation pay

According to U.S. Code, Title 10, Sub A, Part II, Ch. 59, sec. 1175(e.1), the amount a separating Sailor would receive would be 2.5 percent of annual BP times the servicemember's YOS, and would be paid every year for 2 times the member's YOS.

In our example above, if the Sailor were to be eligible and accept a voluntary separation, he or she would receive $4,650 annually for 14 years. The sum of the annuity payments will be $4,650 *14 = $65,100. However, since most of the payments will be in the future, their value will be discounted. So, for example, the present value of this annuity would be only PV = $34,255 if discounted at d = 10 percent.

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References

[1] James E. Grefer, with Michael J. Moskowitz. *Evaluating Retention and Accessions Cost Tradeoffs for Navy Enlisted Personnel,* Oct 2009 (CNA Research Memorandum D0021294)

[2] Diana S. Lien. *Review of Steady-State Accession Requirements Literature,* May 2006 (CNA Memorandum D0014203)

[3] Michael L. Hansen. *Steady-State Accession Requirements and National Call to Service Recruits,* Dec 2006 (CNA Memorandum D0013427)

[4] Michael L. Hansen, with David Gregory and Henry S.Griffis. *Junior Work Requirements and the Steady-State Accession Mission,* Nov 2004 (CNA Research Memorandum D0010608)

[5] Michael L. Hansen, Henry S. Griffis, and Deena Ackerman. *Steady-State Accession Requirements,* Mar 2003 (CNA Research Memorandum D0007675)

[6] Chief of Naval Operations. *Selective Reenlistment Bonus,* Aug 2009 (NAVADMIN 250/09)

[7] Matthew S. Goldberg. *A Survey of Enlisted Retention: Models and Findings,* Nov 2001 (CNA Research Memorandum D000085)

[8] Bradley M. Gray and James E. Grefer. "Career Earnings and Retention of Military Physicians." *Defence and Peace Economics* (forthcoming)

[9] Beth J. Asch and James R. Hosek. "New Economics of Manpower in the Post Cold War Era." In *Handbook of Defense Economics* (Vol. 2). Amsterdam: Elsevier B. V., 2007 (pp. 1076-1133)

[10] Thomas Daula and Robert Moffitt. “Estimating Dynamic Models of Quit Behavior: The Case of Military Reenlistment.” *Journal of Labor Economics,* Vol. 13, No. 3, pp 499-523, Jul 1995

[11] John T. Warner and Matthew Goldberg. “The Influence of Non-Pecuniary Factors on Labor Supply: The Case of Navy Enlisted Personnel.” *The Review of Economics and Statistics,* Vol. 66, No. 1, pp 26-35, Feb 1984

[12] Jeff Gill. “Generalized Linear Models: A Unified Approach,” 2001 (Sage University Paper, Thousand Oaks, CA)

[13] Gerald E. Cox, with Kletus S. Lawler, David L. Reese, and Robert L. Shuford. *Manning the Expanded Fleet,* Jun 2009 (CNA Research Memorandum D0020174)

[14] Robert Shuford. *User Manual for Personnel Inventory Aging and Promotion Model,* Jun 2009 (CNA Information Memorandum D0020718)

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