Support for the Enlisted Women in Submarines Task Force (EWSTF)

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Abstract

The Enlisted Women in Submarines Task Force (EWSTF) originated in May 2013 to produce a plan for integrating enlisted female sailors into submarine crews. The Director of Military Personnel Plans and Policy (N13) asked CNA to provide analytic support to the EWSTF. One goal of the integration plans was to achieve a sustainable female submariner population—meaning that, over time, female accessions should be able to produce female representation across the paygrades in integrated submarine crews indefinitely. We built a discrete-event model to simulate the flow of enlisted women from accession through their submarine careers. We found that several of the proposed plans could produce a sustainable female submariner population. We estimate that the effects on the gender mix in the rest of the Navy will be modest to moderate, depending on which female sailors will be allowed to convert to the submarine community until sustainability is achieved.

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Executive Summary

In May 2013, the Commander, Naval Submarine Forces (COMSUBFOR) stood up the Enlisted Women in Submarines Task Force (EWSTF) to deliver a "viable and actionable" plan for the integration of enlisted women in submarines. For the last year, the EWSTF has been headed by the Commander, Submarine Group Two and has had representation from stakeholders across the Navy. N13, the Director of Military Personnel Plans and Policy, sponsored this study so that CNA could provide analytic support to the EWSTF and consider the effect of the integration of women in submarines on the rest of the Navy.

A viable and actionable integration plan should include the development of a sustainable population of female submariners. Sustainability means that, over time, female accessions should be able to produce female representation across the paygrades in integrated submarine crews indefinitely. The female submariner population cannot reach sustainability for some time because it takes 12 or more years to produce female chiefs from accessions. To ensure female representation across paygrades in integrated crews until sustainability is reached, experienced female sailors will need to convert to the submarine community from the rest of the Navy. These female conversions will affect the gender mix in the rest of the Navy, and the size of the effect will depend of the number of conversions needed, the time it takes for the female submariner population to achieve sustainability, and the enlisted management communities (EMCs) from which female sailors will convert.

Our support for the EWSTF under the direction of N13 focused on two main tasks:

1. To build a model that could determine the timeline to sustainability of a proposed integration plan

2. To determine the effect of the integration plan on the gender mix in the rest of the Navy

We built a discrete-event simulation model of the female integration plan. The model simulated the flow of women in the submarine community from accession to assignment in the fleet, through sea and shore rotations and paygrade advancements, to leaving submarine service. Our assumptions for female enlisted retention behavior and advancement were derived from data on women in the

surface fleet and were also informed by data on male submariner retention and advancement.

We analyzed several integration plans that the EWSTF considered, including one that it has endorsed. Phase one of the endorsed plan is the integration of 14 Ohio-class crews to be phased in over a period of 5 years beginning in FY 2016. Each newly integrated crew will have 12 female E3-E4 accessions and 15 female E4-E6 conversion sailors, along with 2 female E7 conversion sailors.

We found the accession plan that achieves the desired accession/conversion mix for each newly integrated crew, and we also found the smallest accession plan that achieves a sustainable female submariner population in the steady state (long term). Using this smallest steady-state accession plan, we estimate that the endorsed integration plan will take just over 10 years to achieve E4-E6 sustainability and will require about 645 female E4-E6 conversion sailors from the rest of the Navy. If we assume that the most likely candidates for conversion are female sailors with adequate experience in ratings that have high sea manning, the number of E4-E6 conversions is approximately 1 to 2 percent of the eligible female population per year. The range depends on the need for conversions in each of the 10 years until sustainability is reached. The annual effects could be cumulative over the 10 years that conversions are needed; this would result in an approximately 10 to 12 percent decrease in the eligible female population until sustainability is reached.

If, in addition, the submarine community requires that minimum scores be achieved on various subtests of the Armed Services Vocational Aptitude Battery (ASVAB) by sailors desiring to convert to the submarine community, the cumulative number of E4-E6 conversions needed over the 10 years until sustainability is reached is approximately 11 to 14 percent of the eligible female population. Using the most restrictive eligibility criteria to estimate the number of likely candidates for conversion (i.e., eligibility criteria for conversion includes ratings with high sea manning, paygrade, years of service, and test score restrictions), the cumulative number of E4-E6 conversions needed is approximately 20 percent of the eligible female population. These estimated effects can be mitigated by lowering the restrictions for conversion to the submarine community.

We also found that the endorsed plan would require about 60 female E7 conversion sailors over about 8 years to achieve E7 sustainability. This amounts to about 1 to 3 percent of the female sailor population that we estimated to have the potential to convert. E7 conversion candidates are those in ratings with high sea manning and who have a rate counterpart in a submarine crew (E7 Yeoman (YN), Logistics Specialist (LS), Culinary Specialist (CS), etc.).

For comparison, we also analyzed another plan that called for a larger number of accessions with fewer conversion sailors in each newly integrated crew. The larger number of accessions assigned to each newly integrated crew means that the average experience level of the female sailors is lower. This plan would require about 375 E4-E6 conversion sailors over about an 11-year period, so its effect on the gender mix in the rest of the Navy is about 40 percent less than that for the endorsed plan. The number of E7 conversions needed to achieve E7 sustainability was 75 over an 8-year period.

Two goals must be balanced with limited resources: (1) providing adequate female representation at higher paygrades in integrated submarine crews until a sustainable female submariner population is achieved and (2) maintaining sufficient gender representation at all paygrades in the rest of the Navy. We leave it to Navy leadership to determine which integration plan is acceptable to both the submarine community and the rest of the Navy.

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Glossary

ABE	Aviation Boatswain's Mate – Launch/Recovery
ABF	Aviation Boatswain's Mate – Fuels
ABH	Aviation Boatswain's Mate – Aircraft Handler
AC	Air Traffic Controller
AD	Aviation Machinist's Mate
AE	Aviation Electrician's Mate
AECF	Advanced electronics and computer field (a collection of EMCs promised at enlistment that includes ETSW and FC)
AG	Aerographer's Mate
AM	Aviation Structural Mechanic
AME	Aviation Structural Mechanic – Equipment
AO	Aviation Ordnanceman
AR	Arithmetic Reasoning subtest of the ASVAB
AS	Aviation Support Equipment Technician
ASVAB	Armed Services Vocational Aptitude Battery
AT	Aviation Electronics Technician
AWF	Aircrewman (Mechanical)
AWO	Aircrewman (Operator)
AWR	Aircrewman – Tactical Helicopter
AWS	Aviation Warfare Systems Operator
AWV	Aircrewman (Avionics)
AZ	Aviation Maintenance Administration
BA	Billets Authorized
BU	Builder
CE	Construction Electrician
CM	Construction Mechanic
COMSUBFOR	Commander, Naval Submarine Forces
CS	Culinary Specialist (Surface)
CSS	Culinary Specialist (Submarine)
CTI ARA	Cryptologic Technician Interpretive (Arabic)
CTI CHI	Cryptologic Technician Interpretive (Chinese)
CTI KOR	Cryptologic Technician Interpretive (Korean)
CTI PER	Cryptologic Technician Interpretive (Persian)
CTI SPA	Cryptologic Technician Interpretive (Spanish)
CTM	Cryptologic Technician Maintenance

CTN	Cryptologic Technician Networks
CTR	Cryptologic Technician Collection
CTT	Cryptologic Technician Technical
DTHYG	Dental Hygienist (now HM with a unique NEC)
DTLABB	Dental Laboratory Technician, Basic (now HM with a unique NEC)
EA	Engineering Aide
EI	Electronics Information subtest of the ASVAB
EMC	Enlisted Management Community
EM NUC	Electrician's Mate, Nuclear (Surface or Submarine)
EMSW	Electrician's Mate (Surface)
ENSWMN	Engineman Auxiliary Systems Maintainer
EO	Equipment Operator
EOY	End of Year
ET COMM	Electronics Technician, Communication (Submarine)
ET NAV	Electronics Technician, Navigation (Submarine)
ET NUC	Electronics Technician, Nuclear (Surface or Submarine)
ETSW	Electronics Technician, Surface Warfare
EWSTF	Enlisted Women in Submarines Task Force
FC	Fire Controlman (Surface)
FC Aegis	Fire Controlman, Aegis (Surface)
FT	Fire Control Technician (Submarine)
GM	Gunner's Mate
GS	General Science subtest of the ASVAB
GSE	Gas Turbine System Technician Electrical
HM	Hospital Corpsman
HMAVMED	Aerospace Medical Technician (now HM with a unique NEC)
HMDASST	Dental Assistant (now HM with a unique NEC)
HMFLDMED	Field Medical Service Technician
HMGEN	Hospital Corpsman General
HM IDC	Hospital Corpsman Independent Duty Corpsman (Surface)
HMLABA	Medical Laboratory Technician Advanced
HMOPT	Optician
HMPMT	Preventative Medical Technician
HMRADHLT	Radiation Health Technician
HMRT	Respiratory Therapy Technician
HMS	Hospital Corpsman (Submarine)
HMSURG	Operating Room Technician
HT	Hull Technician (HT)
IDC	Independent Duty Corpsman
IS	Intelligence Specialist

ITS	Information Systems Technician (Submarine)
ITSW	Information Systems Technician (Surface)
LS	Logistics Specialist (Surface)
LSS	Logistics Specialist (Submarine)
MC (ASVAB)	Mechanical Comprehension subtest of the ASVAB
MC (EMC)	Mass Communication Specialist
MK	Mathematics Knowledge subtest of the ASVAB
MMA	Machinist's Mate (Auxiliary) (Submarine)
MM NUC	Machinist's Mate, Nuclear (Surface or Submarine)
MMSW	Machinist's Mate (Surface)
MMW	Machinist Mate (Weapons) (Submarine)
MR	Machinery Repairmen
MT	Missile Technician (Submarine)
MU	Musician
NEC	Navy Enlisted Classification
NUC	Nuclear Subspecialty
OS	Operations Specialist (Surface)
PFA	Physical Fitness Assessment
PR	Aircrew Survival Equipmentman (Parachute Rigger)
PRD	Projected Rotation Date
PS	Personnel Specialist
PST	Prescribed Sea Tour
QMSW	Quartermaster (Surface)
SH	Ship's Serviceman
STG	Sonar Technician (Surface)
STS	Sonar Technician (Submarine)
SW	Steelworker
UT	Utilitiesman
VE	Sum of the scores earned on Word Knowledge (WK) and Paragraph Comprehension (PC) subtests of the ASVAB
YN	Yeoman (Surface)
YNS	Yeoman (Submarine)
YOS	Years of Service

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Introduction

The integration of women into the submarine community began in 2010 when the first female officers were accessed and assigned to submarine officer training. At present, there are female officers assigned to 14 Ohio-class crews, and the first of four Virginia-class officer crews will be integrated in FY 2015. Until June 2014, there had been no detailed plan to integrate enlisted women in submarine crews put forth publicly.

In a memorandum dated May 10, 2013, the Commander, Naval Submarine Forces (COMSUBFOR) directed the Commander, Submarine Group Two to "stand up and lead the Enlisted Women in Submarines Task Force [(EWSTF)]." The memorandum states that "the ultimate deliverable is a viable and actionable road map to female enlisted integration" [1].

CNA was asked to provide analytical support to the EWSTF as it developed enlisted integration plans. N13, the Director of Military Personnel Plans and Policy, sponsored this study to provide that support.

COMSUBFOR's memorandum provided some guidance for enlisted integration plan development. For example, only crews that currently have or are scheduled to have female officers in the future are eligible for enlisted integration. It also specifies that plans must be both *viable* and *actionable*. Although not explicitly stated in the memorandum, a feature of a viable and actionable plan is that the female submariner population is sustainable in the long term. That is, when the integration has matured, there should be representation of female enlisted submariners at all paygrades that is produced solely by female submariner accessions and can be replicated indefinitely. The EWSTF embraced sustainability as a tenet of its integration plan development.

Sustainability is a long-term concept. It takes, on average, about 12 years to grow a sailor from accession to chief (paygrade E7). If there is a desire to have female representation in the middle- and senior-level paygrades in submarine crews early in the integration, experienced female sailors from the rest of the Navy must convert (i.e., transfer) to the submarine community to fill those more senior positions. Moreover, female conversions will have to be used until female submariner accessions grow to senior-level paygrades and do so sustainably.

Female conversion sailors may provide experience and a presence in all paygrades in integrated submarine crews, but their conversion may negatively affect the gender mix in rest of the Navy. Thus, a female submariner population may achieve sustainability, but the integration plan as a whole may come at an unacceptably high cost to the rest of the Navy. A sustainable female submariner population may be a necessary condition for a viable and actionable integration plan, but it is not a sufficient one.

To clarify, we offer a two-part definition of sustainability. The first concerns the sustainability of the female enlisted submariner population. This population is sustainable if there is an accession plan that produces the desired total number of female sailors and the desired number of female chiefs (sailors in paygrades E7-E9) in each integrated crew in the steady state (i.e., in the long term). A sustainable female submariner population requires no conversion sailors.

The second part of the definition of sustainability concerns the effect of the integration plan on the rest of the Navy. A submarine community integration plan is sustainable under the following two conditions:

- The female submariner population is sustainable.
- The effect on the rest of the Navy (e.g., the effect of conversions on the gender mix in the rest of the Navy and an increased female recruiting mission) is acceptable.

In this study, we intentionally do not define the term *acceptable.* We leave it to Navy leadership and policy-makers to determine which plans are acceptable, but we provide analytic support for that determination.

The two main tasks in the study align directly with analyzing the sustainability of proposed EWSTF integration plans. The first task directs us to develop a simulation model that can test the long-term sustainability of the female submariner population under the various proposed integration plans. The second task directs us to estimate the effect of the various integration plans on the female accession mission and the gender mix in rest of the Navy.

Background

In 2011, CNA completed a study on the integration of enlisted women in submarines under the sponsorship of COMSUBFOR [2]. In that study, we found that there was a female accession plan that could sustain about 28-29 female E3-E6 sailors and 2 female chiefs in integrated Ohio-class crews in the steady state, even when using conservative estimates of female retention and career progression.

On the broader question of sustainability of the entire integration plan, we found that a relatively small plan was likely to be sustainable in the steady state, perhaps one that included from 8 to 18 crews. A sustainable female submariner population was still achievable with a larger number of integrated crews, but the estimated effect on the female enlisted recruiting mission and on the female E7 population required to convert to the submarine community became quite pronounced. It was not clear if larger plans would have been acceptable throughout the Navy.

In the 2011 study, we focused on the steady state and provided limited analysis on the effect of female E7 conversions on the rest of the Navy. We did not explicitly model the phase-in period of the integration and did not consider the effect of converting E4-E6 female sailors on the rest of the Navy. Modeling the phase-in period is critical for estimating the full effect of submarine enlisted integration. A plan for the phase-in period describes how many newly integrated crews will be added each year, the desired number of women to be assigned to each newly integrated crew, and the desired mix of accessions and conversions. All of these details directly affect how many additional female recruits must be accessed and how many female conversion sailors will be needed from the rest of the Navy.

An integration plan must provide enough female enlisted submariners to fill the female complement of submarine crews at a high rate while ensuring that waiting times for crew assignment are not onerous (i.e., waiting times should allow for appropriate career progression.) The model developed in this study maximizes female berthing utilization (i.e., it is programmed to keep the total number of women assigned to each crew at the desired maximum level), simulates the phase-in period, monitors waiting times for assignment to a crew, and determines how long it takes to reach sustainability. It also provides the key inputs to estimating the effect of the integration plan on the rest of the Navy—a female submariner accession plan that achieves population sustainability, the number of conversion sailors needed, and timing of the assignment of conversion sailors to crews.

Methodology

Our first task was to build a model to determine if proposed integration plans would result in a sustainable female submariner population. Four main items are needed:

1. Number of crews to be integrated and integration phase-in plan[1]
2. Desired number and paygrade/enlisted management community (EMC) composition of female sailors in each newly integrated crew
3. Assumptions of how female submariners will retain and advance
4. A model that simulates assignment of women to crews, their flow through sea-shore rotations, and their advancement and loss to the community. (The model begins with the phase-in and continues monthly for the next 35 years.)

Members of the EWSTF provided items 1 and 2; we produced items 3 and 4.

Number of crews and integration phase-in

Two factors helped determine the number of crews to be integrated and the timeline for integration. First, only crews that currently have or are scheduled to have female submarine officers are eligible for integrating female enlisted crewmembers. Second, it is efficient to perform berthing and other modifications necessary for integration when a submarine is already scheduled to be away from fleet operations. Therefore, the current submarine maintenance schedules helped to set the integration phase-in. Using those factors, the EWSTF proposed that the first phase of the enlisted integration plan include 14 Ohio-class crews (7 submarines with 2 crews each) and that phase-in be complete in 5 years. Table 1 shows the timeline.[2]

[1] Integration phase-in time is not the same as the timeline for sustainability. An integration plan may call for integrating 14 crews over 5 years (i.e., 1 or 2 crews per year). Sustainability may not be achieved for years after phase-in (if ever) and depends heavily on items 2 and 3.

[2] The phase-in plan may shift slightly to the left or the right, although it is expected that all 14 crews will be integrated in a span of about 5 years with approximately a 2-4-2-4-2 pattern of new integrated crews across the 5 years.

Table 1. Timing and number of crews in the phase-in of the integration

Year	Number of: Ohio-class submarines with newly integrated crews[a]	Number of: Newly integrated Ohio-class crews	Cumulative number of: Ohio-class submarines with integrated crews	Cumulative number of: Integrated Ohio-class crews
1	1	2	1	2
2	2	4	3	6
3	1	2	4	8
4	2	4	6	12
5	1	2	7	14

[a] Each SSGN and SSBN has a blue crew and a gold crew that rotate manning the submarine. Four SSGNs (eight crews) and three SSBNs (six crews) are scheduled to be integrated. The SSGN crew integrations are scheduled for years 1, 2, and 3. SSBN crew integrations are scheduled for years 4 and 5.

Our model follows this phase-in plan. In the future, the model can be adapted to integrate a larger number of crews, different types of crews (e.g., those for Virginia-class submarines), or a different phase-in timeline.

Number of women and the accession/ conversion mix in the phase-in

To ensure female representation at the seniormost enlisted level, the EWSTF recommends that each integrated Ohio-class crew have two female chiefs (paygrades E7-E9). The submarine community must use female E7 conversion sailors until it can produce its own.[3]

Currently, there is separate berthing on submarines for sailors in paygrades E3 through E6 and for those in paygrades E7 through E9. Berthing for female sailors will follow this convention, and women and men will have separate berthing areas. The current plans for berthing modifications will allow for 27 female E3-E6 sailors and 2 female E7-E9 sailors. (Note: The berthing plan does not necessarily limit the number

[3] E7 conversions are expected to come from five EMCs that have associated submarine EMCs: LS, CS, YN, HM, and ITSW. They were chosen because, of all the non-NUC E7 billets in an Ohio-class submarine crew, they have the most directly applicable skill set. These EMCs combined have only one E8 billet (ITS) and no E9 billets in submarine crews. Thus, an E8 or E9 sailor in these EMCs could in theory convert to fill an E7 submarine billet.

of women who can be assigned to a submarine. The number can be increased or decreased by using a male berthing area for women or vice versa. Due to the layout of the berthing areas, this is most easily done in multiples of 9, such as changing the number of female E3-E6s from 27 to 36 or 18.)

There are many ways to combine E3-E4 accessions and E4-E6 conversions to form the E3-E6 female complement of each integrated crew. The EWSTF hoped to achieve some female representation at each paygrade (or in each paygrade band) and across submarine divisions and departments. It also considered the overall seniority of the female complement compared with the rest of the crew. To that end, the EWSTF proposed a relatively low number of female accessions and a relatively high number of female conversions for each newly integrated crew. Each crew has 12 E3-E4 accessions and 15 E4-E6 conversions. Table 2 shows the desired distribution of female sailors across EMCs and paygrade for this low-accession/high-conversion mix.

Table 2. Low-accession/high-conversion mix by paygrade and EMC

Department	Division (EMC)[a]	E3[b]	E4[b]	E5[b]	E6[b]	E7[b]	Female total	Division (EMC) total
Executive	HM					1	1	1
	YNS			1		1	2	3
Weapons	STS	2		1			3	15
	FT	1		1			2	11
	MMW		1		1		2	5
	MT						0	15
Navigation	ITS		1		1		2	5
	ET-NAV	2					2	7
	ET-COM	1		2			3	8
Supply	LSS				1		1	3
	CSS			1	1		2	7
Engineering	EMN		1	1			2	14
	MMN		1	1			2	14
	ETN		1				1	11
	ELT		1				1	5
	MMA		1	1	1		3	15
	Total	6	7	9	5	2	29	139

Source: EWSTF.

a. See the glossary for EMC definitions.

b. All E3s and E4/E5 NUCs are accessions. Non-NUC E4s and E5-E7s are conversions.

The female crew complement described in Table 2 is notional. There are many variations of paygrade/EMC combinations that also produce 12 female accessions and 15 female conversion sailors for each newly integrated crew, thus holding the experience level of the female complement of the crew constant. According to the EWSTF, the factors to consider in assigning women to the crew in order of importance are paygrade, department, and division.[4]

There are also combinations of accessions and conversions that would assign 27 female E3-E6 sailors to each newly integrated crew but do not hold constant the experience level. For example, an alternative formation is the high accession/low conversion mix. Under this plan, a larger portion of the female complement is accessions—19 of the 27 E3-E6s. Table 3 displays this high-accession/low-conversion mix across EMCs and paygrade.

Table 3. High-accession/low-conversion mix by EMC and paygrade

Department	Division (EMC)[a]	E3[b]	E4[b]	E5[b]	E6[b]	E7[b]	Female total	Division (EMC) total
Executive	HM					1	1	1
	YNS	1			1		2	3
Weapons	STS	1	1		1		3	15
	FT	1		1			2	11
	MMW	1		1			2	5
	MT						0	15
Navigation	ITS		1			1	2	5
	ET-NAV	1	1		1		3	7
	ET-COM	1			1		2	8
Supply	LSS		1	1			2	3
	CSS	1			1		2	7
Engineering	EMN		2				2	14
	MMN		2				2	14
	ETN		1				1	11
	ELT		1				1	5
	MMA	1					2	15
	Total	9	10	3	5	2	29	139

[a] See the glossary for EMC definitions.

[b] All E3s and E4s are accessions. All E5-E7s are conversions.

Table 4 summarizes the female seniority distributions under the accession/ conversion mixes shown in tables 2 and 3 and compares them with the male seniority distribution in an integrated crew.

[4] The exception is the NUC EMCs. In newly integrated crews, the plan is for 6 female E4/E5 NUC accessions, regardless of the rest of the accession/conversion mix choice.

Table 4. Crew seniority distributions in newly integrated crews

Paygrade	Total enlisted billets	Low-accession/ high-conversion mix		High-accession/ low-conversion mix	
	All	Female	Male	Female	Male
E3	11	6	5	9	2
E4	43	7	36	10	33
E5	45	9	36	3	42
E6	29	5	24	5	24
E7	13	2	11	2	11
E8	5	0	5	0	5
E9	2	0	2	0	2
Total	148	29	119	29	119
Total E3-E4	54	13	41	19	35
Total E5-E6	74	14	60	8	66
Total E7-E9	20	2	18	2	18
E3-E4 to E5-E6 ratio	0.7:1	0.9:1	0.7:1	2.4:1	0.5:1
E3 share of E3-E6	9%	22%	5%	33%	2%

The key difference in the two accession/conversion mixes is the experience level of the women in newly integrated crews. The low-accession/high-conversion mix has the more experienced female complement, but this experience is taken from the rest of the Navy in the form of conversion sailors. The female complement with the high-accession/low-conversion mix has lower overall experience (note, for example, that female accessions would fill 9 of the 11 E3 billets on board) but requires less support from the rest of the Navy.

Retention and other career progression assumptions

Modeling the flow of women through a submarine career depends heavily on assumptions made about how they will retain and advance in the community. We assume that enlisted female submariners will retain at rates that we observe for women in similar EMCs in the surface fleet. For example, we assume that women in the submarine NUC EMCs will retain at the same rates as their surface NUC counterparts. Likewise, we assume that female ET NAV and ET COMM sailors will retain at the same rate as female ETSW sailors.

To estimate retention from the beginning of bootcamp to reaching the fleet with full duty status, we used CNA's enlisted street-to-fleet database. We classify women by the rating (or EMC) that they were promised at enlistment and the fiscal year that they accessed. We follow them through the training pipeline until one of three outcomes occurs: (1) they reach the fleet in their promised ratings/EMCs, (2) they reach the fleet in other EMCs, or (3) they leave the Navy. Only those who reach the fleet in their promised EMCs are considered to have retained through the training pipeline.[5] We use the FY 2008 to FY 2010 average training pipeline retention rate as our estimate of prefleet retention for EMCs with average training length of more than one year, and we use the FY 2010 to FY 2012 average rate for EMCs with average training length of a year or less. Table 5 shows the training retention rates.

Table 5. Training pipeline retention rates

Entry program/rating (EMC)	Submarine EMC comparison	Female training retention rate (percentage)	Male surface retention rate (percentage)	Male submarine training retention rate (percentage)
Nuclear Field	All NUC	53	67	67
MMSW	MMA and MMW	75	78	75
AECF (FC, ETSW)	ET COMM, ET NAV, FT, MT	66	72	68
ITSW	ITS	72	78	78
STG	STS	70	74	67
LS	LSS	84	86	63
CS	CSS	80	82	64
YN	YNS	81	87	65

Source: CNA Street-to-fleet database.

We then calculate the 2010-2012 average one-year retention rates for each year of service (YOS) in the fleet. For EMCs with average training pipelines of about a year or less, we calculate the one-year rates for YOS 1-29. For EMCs with average training pipelines of about 2 years, we calculate the one-year rates for YOS 2-29.

When there are no female retention rates to observe (e.g., retention rates for YOS 20-29 in surface EMCs that were still closed to women 20 or more years ago), we use either men's surface retention rates or women's rates in another similar surface EMC for which we can observe retention. In several cases, we use men's submariner retention rates because they differ substantially from rates in similar non-submarine EMCs for both men and women. These include the CSS, LSS, and YNS EMCs.

[5] A fourth group has the potential to complete a submarine EMC training pipeline—women who start in a non-submarine EMC training pipeline but transfer to and complete a submarine EMC training pipeline. This group is likely to be small, but our estimate of the number of sailors completing the various submarine EMC training pipelines could be understated.

We combine prefleet and fleet retention rates as our estimate of female submariner retention from accession through YOS 30. To summarize our estimated female retention behavior, we compute the YOS 0-7 cumulative continuation rates (CCRs), the product of the one-year retention rates from accession through YOS 7. We also report in Table 6 the male YOS 0-7 CCRs in similar surface and submarine EMCs.

Table 6. YOS 0-7 CCRs

Surface EMC[a]	Submarine EMC alignment with surface EMC[a]	CCR (percentage)		
		Female surface	Male surface	Male submarine
All NUC	All NUC	15.7	27.4	33.7
MMSW	MMS (A)	15.9	16.7	31.6
MMSW	MMS (W)	15.9	16.7	35.2
FC/FC Aegis	FT	23.3	34.6	30.0
ETSW	ET COMM	28.7	38.7	36.7
ETSW	ET NAV	28.7	38.7	31.4
ITSW	ITS	34.2	39.6	39.6[b]
FC/FC Aegis	MT	23.3	34.6	37.2
STG	STS	21.0	27.0	35.3
LS	LSS	26.0	34.3	31.2
CS	CSS	23.7	32.0	22.4
YN	YNS	25.0	36.3	38.1

a. See the glossary for definitions of the EMCs.

b. Male ITSW rates are shown here because of insufficient data on male ITS rates.

To summarize our estimate of female retention to the point where some sailors will advance to paygrade E7, we compute the CCR for YOS 0-12 (see Table 7).

Table 7. YOS 0-12 CCRs

Surface EMC[a]	Submarine EMC alignment with surface EMC[a]	CCR (percentage)		
		Female surface	Male surface	Male submarine
All NUC	All NUC	2.3	9.1	12.7
MMSW	MMS (A)	3.2	5.2	17.2
MMSW	MMS (W)	3.2	5.2	21.2
FC/FC Aegis	FT	8.5	18.1	13.7
ETSW	ET COMM	8.1	16.1	21.4
ETSW	ET NAV	8.1	16.1	18.5
ITSW[b]	ITS	18.3	22.1	22.1
FC/FC Aegis	MT	8.5	18.1	20.9
STG	STS	6.6	9.7	19.5
LS	LSS	13.4	19.9	18.2
CS	CSS	11.0	18.8	13.8
YN	YNS	14.2	20.9	22.9

a. See the glossary for definitions of the EMCs.

b. Male ITSW rates are shown here because of insufficient data on male ITS rates.

Female sailors will also advance through the paygrades at varying rates as they accumulate time in the Navy. We assume that they will advance at the average of the FY 2009 to FY 2012 advancement rates for each EMC in the submarine community. Note that the rates we use are not necessarily calculated in the same way that others may calculate advancement rates. In the Navy enlisted master files, we cannot observe all sailors who attempt to advance in a given period; we can only observe those who do advance. To estimate an advancement rate, we selected all of the sailors who were in the same EMC and paygrade at the beginning of a fiscal year. We eliminated those who had not yet reached the minimum time in grade to advance and those who were about to reach high-year tenure. We then observed the status of the sailors at the end of the year and calculated the rate of advancement to the next paygrade.[6] Table 8 shows the advancement rates.

Table 8. Advancement rates

	Advancement rates (percentage) by paygrade					
EMC	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**
EMN		66.1	67.7	10.3	8.6	32.7
ETN		83.6	81.4	17.1	10.7	40.9
MMN		84.0	72.7	8.8	17.1	26.1
MMA	75.7	53.5	23.3	12.4	20.6	11.3
MMW	90.4	57.4	31.8	25.4	6.3	24.2
ET COMM	88.5	81.9	40.5	15.7	13.1	7.0
ET NAV	66.6	69.5	31.3	15.7	8.6	12.2
ITS[a]	77.8	53.0	22.2	10.4	9.6	15.6
FT	57.4	69.6	38.6	15.1	6.2	20.3
MT		37.6	30.6	20.2	27.3	11.3
STS	79.0	40.3	23.7	10.8	25.7	7.2
LSS	58.4	49.4	25.5	26.6	11.8	7.7
CSS	76.8	36.7	36.7	25.8	6.0	12.0
YNS	90.4	62.2	27.9	20.4	4.8	4.2

a. FY 2009 to FY 2012 average advancement rates for ITS do not exist. We use male ITSW average advancement rates.

Another key input to modeling the progression of women through their submarine careers is the sea/shore flow. The sea/shore flow describes the sea and shore tour lengths that sailors follow throughout their Navy careers. The sea/shore flow varies by EMC. Table 9 contains the most recent sea/shore flows for submarine EMCs.

[6] The denominator of the advancement rate includes those men who leave the Navy in that year. We model the advancement rates for women in the same way.

Table 9. Sea/shore flow enlisted career paths

	Sea and shore tour lengths in months									
EMC[a]	Sea tour 1	Shore tour 1	Sea tour 2	Shore tour 2	Sea tour 3	Shore tour 3	Sea tour 4	Shore tour 4	Sea tour 5 +	Shore tour 5 +
ALL NUC	54	36	60	36	36	36	36	36	36	36
MMA	51	36	54	36	48	36	42	36	36	36
MMW	51	36	54	36	48	36	36	36	36	36
ET COMM	48	36	48	36	36	36	36	36	36	36
ET NAV	48	36	48	36	48	36	48	36	36	36
ITS	48	36	48	36	36	36	36	36	36	36
FT	54	36	54	36	48	36	42	36	36	36
STS	48	36	48	36	42	36	42	36	36	36
MT	48	36	48	36	36	36	36	36	36	36
LSS	48	36	42	36	36	36	36	36	36	36
CSS	52	36	54	36	48	36	36	36	36	36
YNS	36	36	36	36	36	36	36	36	36	36

Source: NAVADMIN 361/Dec. 12, 2012.

a. There is no proposed sea/shore flow for HMs. We assume that all HM sea and shore tours are 36 months.

The last inputs to the model concern career pauses, particularly as they affect sea duty. These are for sailors who are placed in limited duty (LIMDU) status due to a temporary physical limitation (e.g., recovery from an injury) and for pregnancy. We use 4 percent for the annualized at-sea LIMDU rate. We assume that the average time spent in LIMDU is 6 months.[7]

We use 5 percent for the annualized at-sea pregnancy rate, which we base on information from a presentation of the 2010 Navy Pregnancy and Parenthood Survey [3]. The model randomly assigns sailors to pregnancy status; they are then moved to shore when they are assumed to be 4 months into their pregnancy. Under current Navy policy, they will remain on shore duty for the remaining 5 months of pregnancy and for 12 months postpartum. Thus, a sailor for whom pregnancy interrupts sea duty will be ineligible for sea duty for the next 17 months. If a sailor was within 12 months of completing her sea tour when she was moved to shore, the model treats

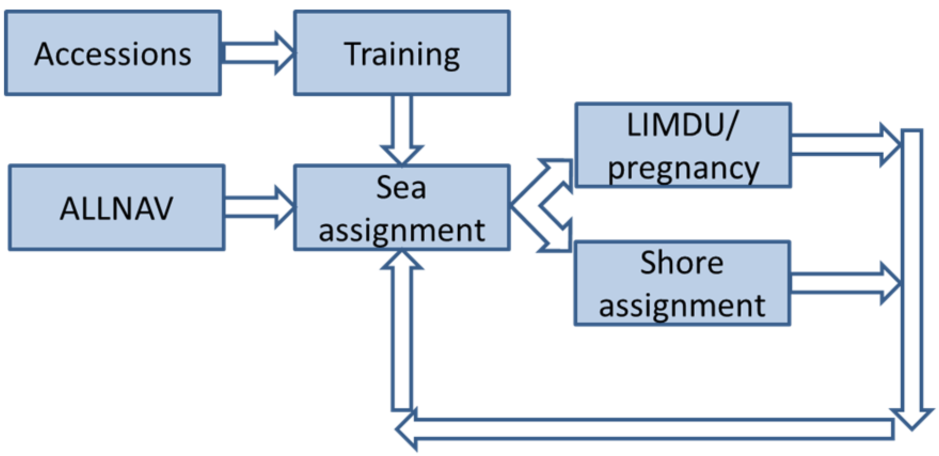
[7] We tested a number of different assumptions about pregnancy and LIMDU rates while assigned to sea duty. The results suggest that for a range of reasonable assumptions about pregnancy and LIMDU rates, none has much effect on the number of accessions needed or berthing utilization. Also, if the submarine community chose to remove sailors from crews earlier than 4 months into a pregnancy, this would have little effect on the numbers of accessions needed or berthing utilization.

the sailor as if she completed that sea tour. Otherwise, when the sailor completes the 17-month pregnancy leave, she must return to sea to finish her tour. We do not explicitly model pregnancy leave or LIMDU status that occurs while assigned to shore duty.

The model

The EWSTF model is a discrete-event simulation that was built using Version 9 of the ExtendSim software [4]. The objective of the model is to maximize berthing utilization in submarines modified to berth 27 female E3-E6s and 2 female E7s.[8] Crews are integrated according to the phase-in plan, and female sailors are assigned to newly integrated crews according to the desired accession/conversion mix. Figure 1 shows the overview of the model.

Figure 1. Overview of the simulation model



The model follows every female sailor assigned to an integrated submarine crew monthly from accession through the next 35 years. The model is programmed so that women follow career paths according to the estimated annual retention rates, advancement rates, and sea/shore flows for the EMCs to which they are assigned. The model randomly chooses which sailors leave the community, advance, and rotate

[8] Maximizing berthing utilization based on 27 E3-E6 and 2 E7 racks does not imply that the number of women assigned to each crew cannot be increased or decreased. It does follow the integration plan put forth by the EWSTF, however.

to shore because of pregnancy or LIMDU status each year according to the probability of those events occurring.

Each submarine follows a 36-month cycle that includes an initial 6-month maintenance period followed by consecutive 2-month deployments, which are carried out by alternating blue and gold crews. While on deployment, we assume that a crew can remove or take on new personnel every two months, excluding emergencies.

Women can be assigned to crews from several queues. A queue is part of the model that represents a group of sailors waiting to receive orders. A queue operates on a first-come/first-served basis and does not give any preference to an individual sailor. The queues from which women can be assigned follow:

- The accession queue contains the accessions who successfully complete their initial prefleet training pipeline.
- The "rollers-to-sea" queues (one queue for E4-E6s and one queue for E7s) contain female submariners who have completed a shore tour and are ready to be assigned to sea duty again.
- The "ALLNAV" queue contains qualified E4-E7 female sailors from the rest of the Navy who volunteer and are selected for conversion to the submarine community.

When a woman leaves a crew to rotate to shore or to separate from the Navy, a signal is sent to indicate that a new female crewmember is needed. If the opening is for a female E3-E6 sailor, the model is programmed to compare the waiting times of the assignable sailors in the accession queue and the E4-E6 rollers-to-sea queue and to choose the sailor with the longest waiting time. If those queues are empty, the model selects a conversion sailor from the ALLNAV queue.

Likewise, the response to a signal for a female E7 sailor is to look first in the E7 rollers-to-sea queue. If none is available, the model selects an E7 conversion sailor from the ALLNAV queue.

The accession queue is supplied by the accession plan for each EMC (with historical prefleet training retention rates applied). The rollers-to-sea queue is supplied by women completing their shore tours, so it is dependent on the sea/shore flow, retention rates, and advancement rates for each EMC. The ALLNAV queue is assumed to have unlimited numbers of female conversion E4-E7s ready to be assigned to a crew.[9] Early in the integration, there are no sailors in the rollers-to-sea queue, so the female complement of each crew is composed of accessions and conversions only.

The desired accession/conversion mix for women is applied only for the initial integration of each crew. After that, the model fills signals for female sailors in the two paygrade bands for berthing (E3-E6 or E7 and above) without regard to EMC. Thus, there is no guarantee that a female sailor will be replaced by one with the same rate.

The model is programmed to monitor minimum time in grade and high-year tenure. It applies the annual advancement rate for each paygrade to the pool of sailors expected to be eligible for advancement.

We programmed the model to determine a projected rotation date (PRD) for each sailor in each time period. The PRD is a function of the prescribed sea tour (PST) length (as shown in Table 9). Three events may occur with respect to PRD: (1) normal rotation to shore (PRD = PST), (2) attrition, and (3) LIMDU and pregnancy. We randomly generate the probability of these events and adjust PRD to be lower than PST in events 2 and 3. Sailors on shore duty may be subject to events 1 and 2 but not 3 (pregnancy and LIMDU).

To determine whether the female population was sustainable in the steady state for a particular run of the model, we collected as output data the number of sailors assigned to crews from the ALLNAV queue and the time period in which they were assigned.

We also collected output on average berthing utilization rates and the average composition of each crew (by paygrade and EMC) over various time periods. While less critical for determining sustainability, these latter two data outputs helped indicate if the model was working as intended (i.e., that berthing utilization was maximized) and if crew composition became heavily skewed toward certain paygrades or EMCs (in general, it did not).

[9] Clearly, this is a simplifying assumption. There is uncertainty about the number of women who would be willing and available to convert to the submarine community. The EWSTF surveyed women in the fleet about their interest in serving in the submarine community. Although there appears to be substantial interest, it is not clear how many women would actually convert to the submarine community.

Results

Once the number of crews, the phase-in timeline, and the accession/conversion mix for the initial integration of crews have been determined and estimates of female sailor retention and career progression have been made, we can test for sustainability of various integration plans using our simulation model. This begins with identifying an accession plan that produces a sustainable female submariner population.

The phase-in and steady-state accession plans

The accession plan has two periods. The first is the phase-in period, which begins when women are accessed to integrate the first crew and ends when the last crew is integrated. This is 7 years in the EWSTF endorsed plan. The phase-in accession plan has to be tailored to deliver just the desired number of women from the accession queue to each newly integrated crew. Then, the remaining portion of the female complement is filled by experienced conversion sailors from the ALLNAV queue. The phase-in accession plan is derived from the desired number of accessions per crew by EMC and the training retention rates for those EMCs.

The second period of the accession plan is the steady state. The steady-state accession plan will be larger than the phase-in accession plan because it is not intended to be supplemented with conversion sailors. From a modeling perspective, the steady-state accession plan achieves female submariner population sustainability when the model no longer selects conversion sailors from the ALLNAV queue. There are two sustainability milestones: one for E4-E6 conversions and one for E7 conversions. We find the steady-state accession plan that achieves a sustainable population by iteration.

Table 10 shows the phase-in accession plan for a low-accession/high-conversion mix of women in each newly integrated crew. The accession plan for the phase-in period is shown in the columns labeled Year (-1) through Year (5). Table 10 also displays several steady-state accession plans. The second-to-last column in Table 10 shows the lowest possible (i.e., lower bound) steady-state accession plan that achieves female submariner population sustainability.

Table 10. Accession plans with a low-accession/high-conversion phase-in

EMC	Year (-1)	Year 0	Year 1[a]	Year 2	Year 3	Year 4	Year 5	Sustainable steady state: Lower bound plan year 6 and after	Sustainable steady state: Plan with a larger friction allowance
ALL NUC	25	50	25	50	50	50	25	58	72
MMA	0	0	0	0	0	0	0	14	17
MMW	0	0	0	0	0	0	0	8	10
ET COMM	3	7	3	7	7	7	3	9	11
ET NAV	6	12	6	12	12	12	6	16	20
ITS	0	0	0	0	0	0	0	9	11
FT	3	6	3	6	6	6	3	9	11
MT	0	0	0	0	0	0	0	16	20
STS	6	12	6	12	12	12	6	15	19
LS	0	0	0	0	0	0	0	9	11
CS	0	0	0	0	0	0	0	9	11
YN	0	0	0	0	0	0	0	13	16
Total	44	88	44	88	88	88	44	185	230

[a] Year 1 represents the first year that women reach the fleet to join a crew. Year (-1) represents the year of accession for women who will reach the fleet in year 1 and who are in EMCs that have the longest training pipelines (between 1 and 2 years). Year 0 represents the year of accession for women who will reach the fleet in year 1 and who are in EMCs that have shorter training pipelines (1 year or less). Some EMCs have no female accessions during the phase-in period because they are not among the desired accessions in the accession/conversion mix. However, all EMCs must eventually have accessions if the plan is to achieve sustainability (see the steady-state accession plans in the last two columns).

Although this lower bound steady-state accession plan achieves sustainability, the model shows that it is so low that there is no waiting time in the accession queue or the E4-E6 rollers-to-sea queue. This means that sustainability is achieved because we have assumed that there is very little friction in the submariner personnel system. However, some sailors may be in transit, may have a temporary medical hold, or may otherwise be temporarily unable to join their crew.[10] To account for a more realistic amount of friction in the personnel system, we increased the steady-state accession plan, but only to the extent that waiting times in queues remained reasonable. That plan—230 total accessions— is displayed in the last column of Table 10.

In the 2011 CNA study, the steady-state accession estimate for integrating 14 Ohio-class crews was about 300. The higher accession estimate in the earlier study is due to differences in assumptions. We assumed lower continuation rates (i.e., the average

[10] In both the lower bound and the higher steady-state plans, pregnancy and LIMDU are explicitly accounted for in the model.

2007-2009 CCRs), and we assumed that every E7 served only one sea tour (i.e., no E7 sea re-tours). We also allowed a greater number of women in the system to account for friction, but we did not calculate assignment waiting times. When we run the EWSTF model using the 2007-2009 CCRs and limit E7 sea re-tours, the steady-state accession plan is in the 280-300 range. Thus, an accession plan of 185 may be considered a lower bound and an accession plan of 300 may be considered an upper bound. A steady-state accession plan in the 230-250 range may balance the risks of having insufficient numbers of assignable women and of having extended waiting times in queues.

If the number of female recruits for the rest of the Navy is to be maintained, the accession plan needed to achieve female submariner population sustainability determines the increase in the female recruiting mission. At present, the Commander Navy Recruiting Command (CNRC) has indicated that an increase in the current female enlisted recruiting mission by 185 female accessions for the submarine EMCs is achievable. Submarine accessions must achieve among the highest scores on the Armed Services Vocational Aptitude Battery (ASVAB). In Appendix A, we provide some data on the number of women currently in the Navy who achieved scores that would have met the standards for selection to the submarine community.

Female submariner population sustainability

Figure 2 displays the number of E4-E6 conversion sailors needed each year to achieve a low-accession/high-conversion mix in each newly integrated crew during the phase-in and to maintain the E3-E6 female complement of each crew at 27 until population sustainability is achieved.[11] We estimate that it will take about 10 years (123 months) to reach sustainability and that about 645 E4-E6 conversion sailors will be needed in total during that time.

The darker circles in Figure 2 represent the number of E4-E6 conversion sailors assigned to crews just as they are newly integrated. The pattern of the darker circles over the years represents the 15 conversion sailors assigned to each newly integrated crew with the 2-4-2-4-2 new crew phase-in pattern. The lighter circles in Figure 2 represent E4-E6 conversion sailors who are assigned to crews to replace female sailors who attrite, rotate to shore, or promote to E7.

[11] These results are for the lower bound steady-state accession plan of 185.

Figure 2. E4-E6 conversions under the lower bound steady-state accession plan with a low-accession/high-conversion mix during phase-in

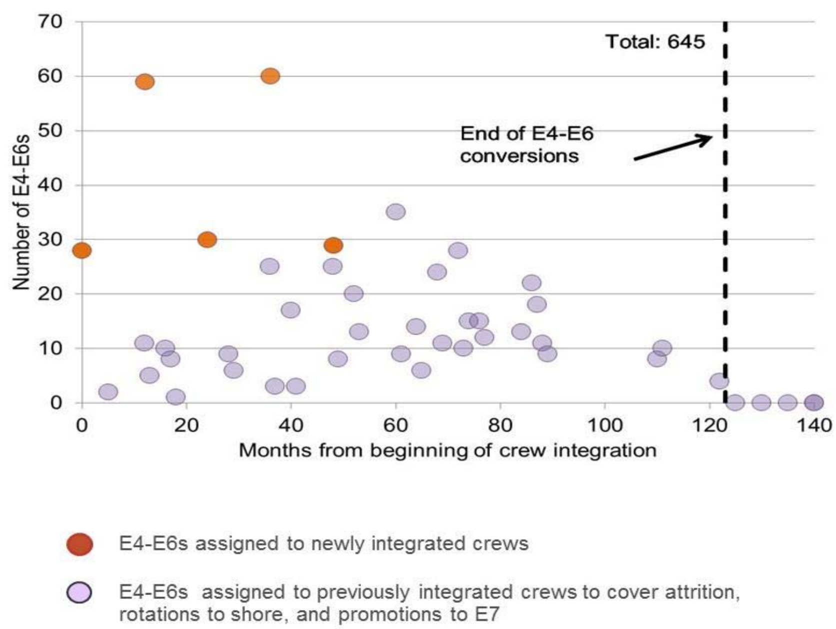


Figure 3 shows the number of E7 conversion sailors needed to provide every integrated crew with 2 female chiefs until sustainability is reached. We estimate that it will take about 8 years (100 months) to achieve E7 sustainability with a low-accession/high-conversion mix for each newly integrated crew and the lower bound steady-state accession plan of 185. We estimate that E7 sustainability will be reached in about 8 years and that about 60 E7 conversions will be needed.

We assume that E4-E6 conversions remain with the submarine community for the rest of their time in the Navy. As a result, they become the first female E7s produced in the community (albeit not from accession). Thus, E7 sustainability is achieved more quickly than E4-E6 sustainability.

Sustainability may be achieved with fewer conversions and/or in a shorter amount of time by using different accession/conversion mixes in the phase-in and different steady-state accession plans. The top panel of Table 11 summarizes the model results on the number of conversions needed and the time to sustainability using the lowest steady-state accession plan that achieves sustainability (185 accessions). The bottom panel of Table 11 shows the results on conversions using a larger accession plan that allows for more friction in the system (230 accessions). It also shows the results for the low-accession/high-conversion mix compared with a high-accession/low-conversion mix.

Figure 3. E7 conversions under the lower bound steady-state accession plan with a low-accession/high-conversion mix during phase-in

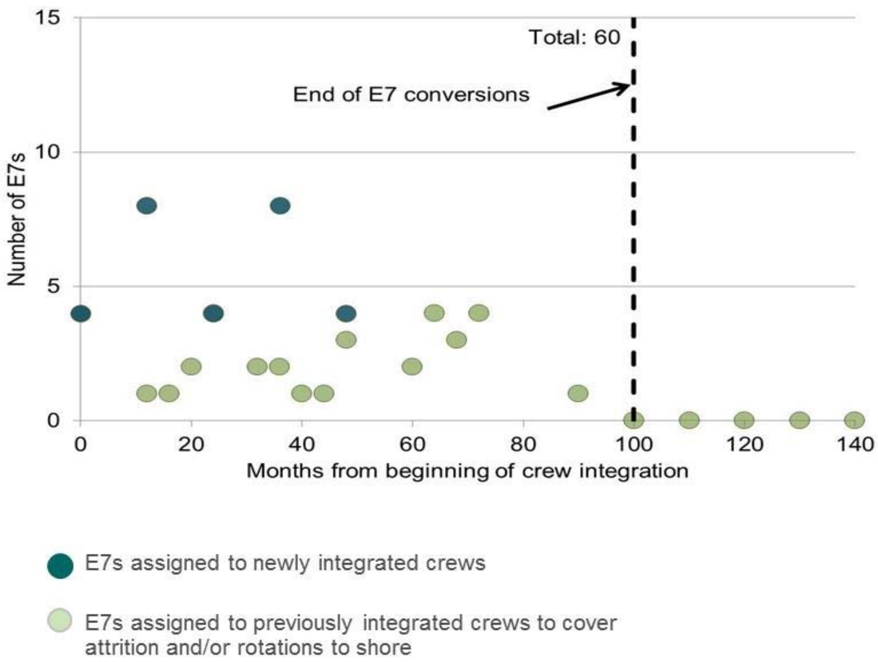


Table 11. Estimated number of conversions and time to sustainability

Number of conversions and time to sustainability	Low-accession/ high-conversion mix		High-accession/ low-conversion mix	
	Number	Time (months)	Number	Time (months)
Accession plan = 185				
E4-E6	645	123	375	130
E7	60	100	75	95
Accession plan = 230				
E4-E6	605	95	365	95
E7	60	100	75	90

The time to achieve E4-E6 sustainability changes modestly with the choice of accession/conversion mix but more substantially with the steady-state accession plan. Using either accession/conversion mix with the lower bound steady-state accession plan (185), E4-E6 sustainability is reached within a few months of 10.5

years (123 to 130 months). The time to E4-E6 sustainability decreases to about 8 years (95 months) if the steady-state accession plan is increased to 230.

By contrast, the number of E4-E6 conversions needed changes substantially with the choice of accession/conversion mix and more modestly with the choice of steady-state accession plan. With 185 steady-state accessions, the number of E4-E6 conversions needed for the low-accession/high-conversion mix is about 645. The high-accession/low-conversion mix needs approximately 375 conversions, which results in a 40-percent decrease in the effect on the rest of the Navy. With 230 accessions, the conversions needed decrease to about 605 and 365 for the two accession/conversion mixes, respectively.

The time to E7 sustainability does not change with the choice of steady-state accession plan or the accession/conversion mix; it takes about 8 years (90 to 100 months) to reach sustainability using any combination of steady-state accession plan and accession/conversion mix.

Although the number of E7 conversions is insensitive to the choice of steady-state accession plan, it does change somewhat with the choice of accession/conversion mix. The number of E7 conversions needed is about 60 for the low-accession/high-conversion mix and about 75 for the high-accession/low-conversion mix.

Table 11 helps illustrate the trade-offs in choosing among accession/conversion mixes and steady-state accession plans. The choice of accession/conversion mix has the biggest implications for the gender mix in the rest the Navy. Although the low-accession/high-conversion mix provides a more experienced female complement and a larger female presence across all paygrades, it requires many more conversion sailors. This will impose a cost on the rest of the Navy.

The choice of steady-state accession plan has more modest implications for the gender mix in the rest of the Navy. The time to E4-E6 sustainability is improved with the larger accession plan, but the number of E4-E6 conversions needed decreases by less than 10 percent. Thus, the effect on the gender mix in the rest of the Navy is improved by only a small margin by choosing the larger accession plan. Note, however, that the larger accession plan does require a larger female accession mission.

The model helped identify another issue with the low-accession/high-conversion mix. When the 185 steady-state accession plan is used, about 60 percent of the 645 conversion sailors convert to the submarine community in the first 5 years of integration, and 95 percent convert in the first 8 years of integration. The model shows that the amount and speed of E4-E6 conversions has an unintended effect. From about the 9th to the 15th year of integration, the low-accession/high-conversion mix may produce more E7s than are needed. The model results show that the waiting time in the E7 rollers-to-sea queue begins to increase during this time. On average, the number of E7s in the rollers-to sea queue during the 9th to 15th years reaches a peak of about 25 with an average waiting time for assignment of 5-8 months. The temporary overproduction of female submariner E7s goes away in the long term.

The EWSTF endorsed the low-accession/high-conversion mix phase-in plan.

Effect of conversions on the rest of the Navy

Our modeling efforts identified the accession plans that achieve female population sustainability and the estimated number of conversion sailors needed until sustainability was reached. These outcomes are used to determine the effect of the submarine integration plan on the gender mix in the rest of the Navy and on the longer term female recruiting mission.

E4-E6 conversions

To determine the effect of E4-E6 conversions on the gender mix in the rest of the Navy, we first estimated the potential population of female conversion sailors based on EMC sea manning and sailor experience only. Conversion sailors will be allowed to convert to 9 submarine EMCs: ET COMM, ET NAV, MMA, MMW, ITS, STS, CSS, LSS, and YNS. The submarine community will accept the best and fully qualified sailors who volunteer to convert and who will be allowed to leave their current EMC. The submarine community will take conversion sailors from anywhere in the Navy. The additional training that they will need to serve on a submarine will depend on the sailor's current training and experience.

For the E4-E6 population, we consider the population of female sailors who have sufficient experience to convert to the submarine community and who are in non-submarine EMCs that may be least affected by the conversions. To identify this population, we first determined which EMCs would be least affected by having *any* conversions from its ranks. That is, we identified EMCs that had relatively high manning at sea in paygrades E4-E6. EMCs were selected as potentially able to provide conversions if the average FY 2010-2013 end-of-year (EOY) counts of sea full-duty inventory to billets authorized (BA) was at least 95 percent.

We then focused on the female sailor population in these EMCs. We limited the pool of potential female conversions to those with sufficient experience to convert to the submarine community but eliminated those close to reaching high-year tenure. For example, we limited the E4 sailors to those with YOS 3-6. E5 sailors were limited to those with YOS 3-9, and E6 sailors were limited to those with YOS 6-14. We averaged the counts of potential female conversions across the 2010-2013 September snapshots. We then decreased the counts of potential female conversions by

7 percent to ensure that the population also holds U.S. citizenship, holds a security clearance, and has no more than one physical fitness assessment (PFA) failure (all important criteria for conversion to the submarine community).

Table 12 shows the size of the E4-E6 female population that meets the EMC, paygrade, and YOS criteria for conversion to the submarine community just described.

Table 12. Estimated E4-E6 female conversion pool meeting the EMC, paygrade, and YOS criteria

EMC group[a]	Surface Ops	Cryp-tology	Surface Engnrg.	Admin/ Supply	Avia-tion	CB/ Diver	Intel	Med-ical	Total
E4s	470	100	372	546	865	220	100	17	2,688
E5-E6s	738	361	175	35	779	N/A	264	1,117	3,468
Total	1,207	460	547	581	1,643	220	364	1,135	6,156

a. See Table 19 in appendix B for the EMCs in these EMC groups that meet the 95-percent sea manning condition.

Table 13 shows the estimated effect of conversions in a low-accession/high-conversion mix on the estimated female conversion pool (defined by the EMC, paygrade, and YOS criteria) in each of the 11 years until sustainability is reached.[12] About 1 to 2 percent of the estimated female conversion pool per year would need to convert to the submarine community to ensure that 27 female E3-E6s would be assigned to each crew. The variation in the percentage each year is due to the variation in the need for conversion sailors each year until sustainability is reached.

If the flow of female sailors into the estimated conversion pool is constant over time, the cumulative effect of conversions on the estimated conversion pool is roughly the sum of the annual effects. Thus, over the 11 years needed to achieve sustainability, these EMCs could experience a 10- to 12-percentage-point decrease in the number of E4-E6 female sailors in the selected YOS groups.

The submarine community may also require potential E4-E6 conversion sailors to achieve a minimum score on certain ASVAB subtests. Appendix C contains the subtests and scores that may determine qualification for conversion to the various submarine EMCs. The use of test scores as a criterion for conversion defines a different estimated conversion pool. The use of test scores in conjunction with the other possible conversion criteria (e.g., EMC, paygrade, and YOS) defines still another estimated conversion pools.

[12] The model results show that sustainability is reached 3 months into the 11th year of integration.

Table 13. E4-E6 conversions as a percentage of the estimated conversion pool (defined by EMC, paygrade, and YOS criteria)

Years since first crew integration	E4-E6 conversions needed with the low-accession/ high-conversion mix during phase-in	Percentage of estimated female conversion pool[a]
Year 1	30	1
Year 2	93	2
Year 3	46	1
Year 4	105	2
Year 5	98	2
Year 6	99	2
Year 7	80	1
Year 8	73	1
Year 9	0	0
Year 10	17	0[b]
Year 11	4	0[b]
Total	645	11

a. Rounded to the nearest whole percent.

b. The result is positive but less than 0.5 percent.

There is an additional step to consider when test scores are introduced as a conversion pool criterion. Support EMCs on a submarine (CSS, LSS, and YNS) require the lowest minimum test scores for eligibility. However, only a portion of E4-E6 billets to which sailors can convert are in the support EMCs (23 percent). Thus, the pool of potential conversions to support EMCs is likely to be large, but the number of available billets is relatively small. By contrast, the most technical of the EMCs to which sailors can convert (ETSNV, ETSRV, ITS, and STS) require the highest minimum test scores but comprise 36 percent of the E4-E6 conversion billets. The remaining EMCs to which sailors may convert are the MM EMCs. They require minimum test scores greater than those required for support EMCs but less than those required for the most technical EMCs, and they comprise 41 percent of the conversion billets.

We identified the pool of female sailors who met the test score criteria for each EMC category (i.e., support, most technical (with ITS calculated separately), and MMA/MMW). We weighed each of those separate pools by the percentage of the conversion billets that the category comprises. The result is a weighted pool of potential conversion sailors. We then determined the percentage of the weighted pool of potential conversion sailors that is needed each year under the integration plan. Table 14 shows the results.

Table 14. E4-E6 conversions as a percentage of estimated conversion pools (defined by various criteria)

Years since first crew integration	E4-E6 conversions needed with the low-accession/ high-conversion mix during phase-in	Percentage of estimated female conversion pool[a]			
		Criteria = paygrade and test scores	Criteria = paygrade, YOS, and EMC[b]	Criteria = paygrade, YOS, and test scores	Criteria = paygrade, YOS, EMC, and test scores
Year 1	30	0[c]	1	1	1
Year 2	93	1	2	2	3
Year 3	46	0[c]	1	1	1
Year 4	105	1	2	2	3
Year 5	98	1	2	2	3
Year 6	99	1	2	2	3
Year 7	80	1	1	2	3
Year 8	73	1	1	2	2
Year 9	0	0	0	0	0
Year 10	17	0[c]	0[c]	0[c]	1
Year 11	4	0[c]	0[c]	0[c]	0[c]
Total	645	5	11	14	20

[a.] Rounded to the nearest whole percent. Total may not equal the sum of the year effects due to rounding.

[b.] This is the result presented in Table 13.

[c.] The result is positive but less than 0.5 percent.

Table 14 shows that the conversions needed to support the endorsed integration plan will have the smallest effect on the estimated female conversion pool if the pool is determined by applying the paygrade (E4-E6) and test score criteria only. In this case, we estimate that the sum of the year effects is about 5 percent of the pool. Conversions have the greatest effect on the estimated conversion pool if the pool is determined by applying *all* of the criteria we have described—paygrade, YOS, EMC, and test scores. In this case, we estimate that the sum of the year effects is about 20 percent of the pool. Two intermediate cases are when the pool is determined by paygrade, YOS, and EMC (sum of year effects is 11 percent of the pool), or by paygrade, YOS and test scores (sum of year effects is 14 percent of the pool).

The sum of the year effects may be mitigated. For example, for the EMC criteria, we include EMCs for which sea full-duty inventory to billets authorized (BA) is at least 95 percent. This is an assumption. The criteria could be set to something less than 95 percent, and more EMCs could be included to increase the number of women in the potential conversion pool. Indeed, any of the criteria used to determine the conversion pool could be made less rigid. Also, the number of enlisted women is increasing across the Navy. The flow of women into the potential conversion pool—no matter how the pool is defined—is likely to grow over time.

E7 conversions

Female E7s must convert from the ITSW, LS, CS, YN, and HM EMCs to fill the submarine equivalents of those occupations. Among those EMCs, we selected those that were potentially able to provide conversions by applying the condition that the average FY 2010-2013 EOY counts of E7-E9 sea full-duty inventory to BA had to be at least 95 percent. This eliminated CS from the list.[13]

For HMs, several subspecialty EMCs meet the eligibility criteria and had women in the E7 inventory, including Hospital Corpsman, General; Medical Laboratory Technician, Advanced; Pharmacy Technician; X-Ray Technician, Advanced; Surface Force Independent Duty Corpsman; Biomedical Equipment Repair Technician; and Preventive Medicine Technician.[14] Of these, sailors in the Surface Force Independent Duty Corpsman EMC (IDC) appear to have the most relevant skills and experience for conversion, and, on average over the last 3 years, there were 47 women in the EMC. (If we include all E7 women whose specialty in the HM community meets the 95-percent criterion, the average number increases to 242). Table 15 shows the estimated E7 female conversion pool with the more restrictive inclusion criterion for HMs.

Table 15. Estimated E7 female conversion pool

	Estimated E7 female conversion pool					
EMC	ITSW	CS	LS	YN	HM	Total
E7s	155	n/a	146	160	47	508

Table 16 shows the number of E7 conversions required in each year until sustainability is achieved; it also shows the effect on the estimated E7 female conversion pool. The low-accession/high-conversion plan would require, on average, about 7 to 8 E7 conversions per year for about 8 years. This represents about 1 to 3 percent of the estimated E7 female conversion pool depending on the year.

[13] The CS rating would be included if we did not average earlier years into the calculation. The E7-E9 EOY inventory-to-BA ratio was below 95 percent for each FY in 2010-2012 but was well above it for FY 2013. However, to be consistent in our measurements, we exclude female CSs from our estimated conversion pool.

[14] These specialties were separate EMCs until very recently. They are all now under the General Hospital Corpsman EMC, and the specialties are indicated by Navy Enlisted Classification (NEC) codes. In either case, it is not clear how relevant their specialty training is for service as an HM IDC on a submarine, with the exception of the surface force HM IDC.

Table 16. E7 conversions as a percentage of the estimated conversion pool

Years since first crew integration	E7 conversions needed in low-accession/ high-conversion mix during phase-in	Percentage of estimated E7 conversion pool[a]
Year 1	4	1
Year 2	10	2
Year 3	10	2
Year 4	13	3
Year 5	8	2
Year 6	9	2
Year 7	4	1
Year 8	2	0[b]
Total	60	12

a. Rounded to the nearest whole percent.

b. The result is positive but less than 0.5 percent.

If the flow of female sailors into the estimated E7 conversion pool is constant over time, the cumulative 8-year effect of conversions on the estimated female conversion pool is about 12 percent.

As already noted, there are factors that could make the conversion pool expand. The first is that the number of enlisted women in the Navy is growing across ratings and across paygrades. The second is that the number of EMCs with EOY inventory-to-BA ratios of 95 percent or greater could increase. Thus, the flow of female sailors into the conversion pools may actually increase and offset the cumulative effects of the conversions to the submarine community.

Summary and Conclusions

The EWSTF was tasked with delivering a viable and actionable plan for integrating enlisted women in the submarine community. N13 sponsored this study so that CNA could support the EWSTF in its development of the integration plan.

A female enlisted submariner population is sustainable if female accessions can grow to produce female representation at all paygrades in integrated crews in the long term. A sustainable population is one that produces sailors at all paygrades in the steady state and does not rely on experienced female conversion sailors.

It takes years to produce a female chief from an accession cohort, so sustainability cannot be achieved for some time. It there is a desire to have female representation at all paygrades in the initial stages of the integration, experienced sailors from the rest of the Navy must convert to the submarine community to fill the more senior positions. Thus, enlisted integration in the submarine community has the potential to negatively affect the gender mix in the rest of the Navy until a sustainable female submariner population is achieved.

N13 tasked us to build a model that could simulate the flow of female submariners through their careers based on various proposed integration plans. The point of the modeling effort was twofold: to determine if and when an integration plan would achieve a sustainable female submariner population and to estimate the effects of the integration plan on the gender mix in the rest of the Navy.

Phase one of the integration plan endorsed by the EWSTF is to integrate 14 Ohio-class crews over 5 years beginning in FY 2016. Enlisted women will be assigned only to crews with female officers. The berthing modifications planned for the 7 submarines whose crews will be integrated are designed to accommodate 27 female E3-E6 sailors and 2 female E7 sailors. The plan places 12 E3-E4 accessions and 15 E4-E6 conversion sailors in each newly integrated crew. Two E7 sailors will also convert from the rest of the fleet for assignment to each newly integrated crew.

Using ExtendSim software, we built a model that simulated the flow of women through their submarine careers based on this integration plan. We found several accession plans that achieve female submariner population sustainability. If the female representation among accessions in the rest of the Navy is to remain constant, the female accession mission would have to increase by about 185 to 230 accessions.

We also determined the number of female E4-E6 sailors that must convert to the submarine community to achieve the desired mix of accessions and conversions in the integration phase-in and to ensure female representation and experience across the paygrades until sustainability is reached. Using the lower bound accession plan, we estimate that E4-E6 sustainability will be reached in just over 10 years and that about 645 E4-E6 female conversion sailors will be needed. This represents annually about 1 to 2 percent of the female population in the rest of the Navy that we estimate may be qualified and allowed to convert. This is determined by membership in EMCs with sufficiently high sea manning levels and by experience. The annual effects could be cumulative over the 10 years that conversions are needed, potentially resulting in an approximately 10 to 12 percent decrease in the eligible female population until sustainability is reached.

The submarine community may require that minimum scores be achieved on various subtests of the Armed Services Vocational Aptitude Battery (ASVAB) by sailors willing to convert to the submarine community. If test score, paygrade, and YOS restrictions are used to determine the potential pool of conversion sailors, the cumulative number of E4-E6 conversions over the 10 years until sustainability is reached is approximately 11 to 14 percent of the eligible female population. If the most restrictive eligibility criteria are used to estimate the potential conversion pool (i.e., eligibility criteria for conversion includes EMC, paygrade, YOS, and test score restrictions), the cumulative number of E4-E6 conversions needed is approximately 20 percent of the eligible female population. These estimated effects can be mitigated by reducing the restrictions for conversion to the submarine community.

We estimate that E7 sustainability can be reached in about 8 years and would require about 60 E7 conversions. This represents about 1 to 2 percent of the E7 population that we estimate may be qualified to convert.

An integration plan that calls for a different accession/conversion mix during the phase-in (i.e., a higher number of accessions and a lower number of conversions in each newly integrated crew) will require only about 375 E4-E6 female conversion sailors. There is a commensurate decrease in the portion of the female population in the rest of the Navy that would convert to the submarine community.

The trade-off is clear. The more the female complement in newly integrated crews is required to have previous Navy experience, the more the female representation in key areas of the Navy may be affected. None of the effects is estimated to be especially large when considered annually, but there should be a careful review by EMC to ensure that the goals of the submarine integration plan and maintenance of female representation in other parts of the Navy are balanced.

Appendix A: Effect on the Female Accession Mission

In FY 2013, the Navy accessed about 9,500 female recruits. We estimate that a steady-state accession plan that achieves female submariner population sustainability can range from 185 to 230 accessions. If the number of women accessed to fill positions in the rest of the Navy is maintained, the steady-state accession plans represent a 2- to 2.5-percent increase in the current number of female accessions.

Accessions to the submarine community will differ from the average female accession. They must have higher than average scores on certain subtests of the ASVAB (particularly to serve in the NUC EMCs), and they must volunteer to serve in the submarine force. Table 17 shows the number of women with ASVAB subtest scores that would likely qualify them for acceptance into the submarine community, either in a NUC subspecialty (subtest scores greater than 240) or in a non-NUC technical specialty (subtest scores between 215 and 240).[15] Note that the subtest scores are only one condition for service in the submarine force. The recruits must volunteer to serve, must be U.S. citizens, must be high school graduates, and typically must have very few if any recruiting waivers.

The steady-state accession plan for submarine integration would require about an 8- to 10-percent increase in the number of very high scoring female recruits (those with subtest scores at or above 240). (Note, however, that the level increase (approximately 58 to 72) is below 100 additional recruits.) The steady-state accession plan also calls for about a 3- to 4-percent increase in female recruits whose scores fall between the minimum score for service in the non-NUC technical ratings on submarines and below the minimum for NUC EMCs. The percentage increase in female recruits needed for submarine support ratings (minimum score is about 195) is negligible.[16]

[15] Recruits who score above 240 can access to a non-NUC technical submarine EMC, so the percentages presented in Table 17 are an upper bound estimate of the effect.

[16] We use slightly lower minimum standards on test scores here than are presented in appendix C to reflect actual minimum test scores achieved by accessions across these EMCs over the last decade.

Table 17. Increase in female accessions due to integration by test scores

	Percentage increase from current	
	Number with ASVAB subtest scores >= 240[a]	Number with ASVAB subtest 215 <= scores < 240[a]
Current for rest of the Navy (average 2009-2012)	720	3100
Steady-state accession plan = 185	58 (8%)	96 (3%)
Steady-state accession plan = 230	72 (10%)	120 (4%)

[a.] The score is the sum of Arithmetic Reasoning (AR), Mathematics Knowledge (MK), Mechanical Comprehension (MC) and Word Knowledge and Paragraph Comprehension (VE) subtest scores or the sum of AR, MK, Electronics Information (EI), and General Science (GS) subtest scores on the ASVAB. A score of 240 is approximately the lower bound cutoff for NUC accessions. Using Enlisted Master File data, we found that a score of 215 is approximately the lower bound cutoff (10th percentile of scores for those reaching the fleet over the last decade for the non-NUC technical submarine ratings). The lower bound cutoff for submarine support ratings is approximately 195 over the last decade.

Alternatively, we can look at the number of female accessions that were promised to be trained in certain surface EMCs and consider the increase in female recruits needed to achieve the steady-state accession plan. This is a more conservative approach to calculating the impact of the additional female accessions needed to achieve the steady-state accession plan because it requires minimum test scores to be met and also demonstration of an interest in EMCs that are similar to those found on submarines.

Table 18 shows that, in recent years, about 230 female recruits were promised to be trained in a nuclear subspecialty. (If they successfully complete training, these women will serve in the surface NUC force.) The steady-state accession plan would increase this number by 25 to 30 percent (58 to 72 additional accessions).

About 1,050 female recruits were promised to be trained in surface EMCs that compare with non-NUC technical EMCs on submarines. The steady-state accession plan would increase that number by about 10 percent (96 to 120 additional accessions). Finally, about 500 female recruits were promised to be trained in surface EMCs that compare with support EMCs on submarines. The steady state accession plan would increase that number by about 6 to 8 percent (31 to 38 additional accessions).

Table 18. Increase in female accessions due to integration by EMC promised

	Percentage increase from current		
	Number of NUC accessions	**Number of non-NUC technical accessions[a]**	**Number of support accessions[b]**
Current for rest of the Navy (average 2010-2013)	230	1050	500
Steady-state accession plan = 185	58 (25%)	96 (9%)	31 (6%)
Steady-state accession plan = 230	72 (31%)	120 (11%)	38 (8%)

a. Current non-NUC technical accessions for the rest of the Navy include recruits with promised ratings of Advanced Electronics and Computer Field (ETSW, FC, and FC Aegis), IT, MMSW, and STG.

b. Support accessions for the rest of the Navy include recruits with promised ratings of CS, LS, and YN.

Appendix B: EMCs With Estimated Female Populations for Conversion

Table 19 displays the EMCs in each EMC group that meet the criteria of a 95-percent ratio of sea full-duty inventory to BA (average of September inventories and BA for FY 2011 to FY 2013).

Table 19. EMCs with eligible female populations for conversion

EMC group[a]	Sur-face Ops	Cryp-tology	Surface Engrng.	Admin/ Supply	Aviation	CB/ Diver	Intel	Medical
E4	ETSW, OS, QMSW	CTI ARA, CTI PER, CTI KOR, CTN, CTT	ENSWMN, GSE, MMSW, HT, MR	MC, PS, SH, LS, YN	AD, AM, AME, AE, AT, AC AG, AS, AZ, PR, AWR, AWV	BU, CE, CM, EA, EO, SW, UT	IS	HMAVMED, HMFLDMED, HMOPT,
E5-E6	FC, FC Aegis, GM, ETSW, QMSW	CTI CHI, CTI SPA, CTM, CTR	ENSWMN, EMSW	MU	ABE, ABF, ABH, AC, AO, AWR, AWS, AWO, AWF	ND	IS	HMGEN, HMFLDMED, HMSURG, HMLABA, HMPHARM, HMXRAYA, HMRT, HMPMT, HMRADHLT, DTLABB, DTHYG, HMDASST

Source: CNA calculations from Enlisted Master Files and Total Force Manpower Management System (TFMMS).

a. Definitions for the EMC abbreviations can be found in the glossary.

Appendix C: Minimum ASVAB Subtest Scores

Table 20 shows the minimum qualifying ASVAB subtest scores for entry into the non-NUC submarine ratings.

Table 20. Minimum qualifying ASVAB subtest scores for entry into the non-NUC submarine ratings

Conversion to EMC	Minimum subtest scores for entry[a]
ET COMM, ET NAV, STS	GS + AR + MK + EI >= 222 or AR + MK + MC + VE >= 222
ITS	GS + AR + MK + EI >= 222 or GS + AR + 2MK >= 222
MMA, MMW	AR + MK + MC + VE >= 210
CSS, LSS, YNS	GS + AR + MK + EI >= 200 or AR + MK + MC + VE >= 200

Source: Navy Selection and Classification Office

[a.] Definitions for the ASVAB subtest abbreviations can be found in the glossary.

References

[1] Commander, Naval Submarine Forces. May 10, 2013. Memorandum for RDML Kenneth Perry, USN. Subject: Enlisted Women in Submarines Task Force.

[2] Parcell, A., A. Kraus, and M. Farnsworth-Riche. 2011. *Integration of Women in Submarines*. CNA Corporation. CRM D0026057.A2/Final.

[3] Uriell, Zannette A. 2011. "Results of the 2010 Pregnancy and Parenthood Survey." Briefing to LCDR Jean Marie Sullivan, N134W, Washington, DC, Jan. 27, 2011.

[4] Imagine That, Inc. 2013. *ExtendSim 9 User's Guide*.

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