

A SIMPLIFIED PROCEDURE FOR IDENTIFICATION OF OPTIMAL TEST SCORE
CUT-OFF POINTS FOR NON-RATED SUBMARINER CANDIDATES

by

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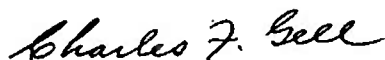
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NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY
REPORT NUMBER 797

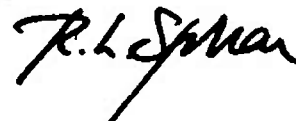
Bureau of Medicine and Surgery, Navy Department
Research Work Unit MF51.524.022-0004.01

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SUMMARY PAGE

THE PROBLEM

To delineate selected test score cut-off points which effectively identify those non-rated submariner volunteers with a high likelihood of failing the Basic Submarine School.

FINDINGS

Based upon the Basic Test Battery distributions obtained from a sample of 955 non-rated submariner candidates, attainment of a high-school diploma was a most crucial selection standard. Within the high-school drop-outs (42% of the input), an ECOP (Experimental Cut-off Point) either at $GCT=50$ or $GCT+Mech=100$, would reduce the false positive rate (proportion screened out who would have passed) from 51% to 40%. By extrapolation, it was estimated that a $GCT=33$ identifies an ECOP below which 100% attrition within the high-school drop group would occur.

APPLICATIONS

This paper presents a simplified method for pinpointing maximally effective test score levels that identify non-rated men with high and low odds of graduating from Basic Submarine School, thus providing a means by which significant amounts of training funds may be saved.

ADMINISTRATIVE INFORMATION

This investigation was conducted as part of Bureau of Medicine and Surgery Research Unit MF51.524.022-0004 - Environmental Factors during Extended Missions. The present report is Number 1 on this work unit. It was submitted for review on 16 December 1974, approved for publication on 18 December 1974 and designated as NavSubMedRschLab Report No. 797.

This study was requested by the Commanding Officer, Naval Submarine School, and was partially funded by the Chief of Naval Education and Training.

PUBLISHED BY THE NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY

ABSTRACT

The goals of this study were to identify the most effective cut-off points on the distributions of selected Basic Test Battery (BTB) score combinations obtained from a sample of non-rated volunteers for Basic Submarine School. Based upon the disparities in the cumulative percentage BTB score distributions obtained from 955 non-rated submariner candidates, optimal ECOP's (Experimental Cut-off Points) were delineated for GCT, GCT+MECH, GCT+MECH+SP, ARI+MECH+SP and for SP (Shop Practices) test alone. Capable of being applied by a middle-level clerk, the analytical techniques provided estimates of the maximum COPV (Coefficient of Practical Validity), an index of selection efficiency, as well as an estimate of the False Positive (FP) and false negative losses for several ECOP's for each test score or score combination. Taking into account the 90% requisite selection ratio imposed at this time, some of the major findings were: (1) Level of formal education is a crucial moderator variable, the most effective ECOP being high school graduate versus dropout; (2) the attrition rate (AR) was 49% for H.S. drop-outs as compared to 21% for H.S. graduates; (3) the data argue that there are no usefully effective ECOP's for the 58% with a high school diploma as accepting all of this education group yields an AR=20%; (4) for the H.S. drops, GCT=50, or GCT+MECH=100 are equally effective but both yield an FP=40% which compares to 51% within all H.S. drop-outs. A brief dictionary of relevant selection terminology is included as an appendix.

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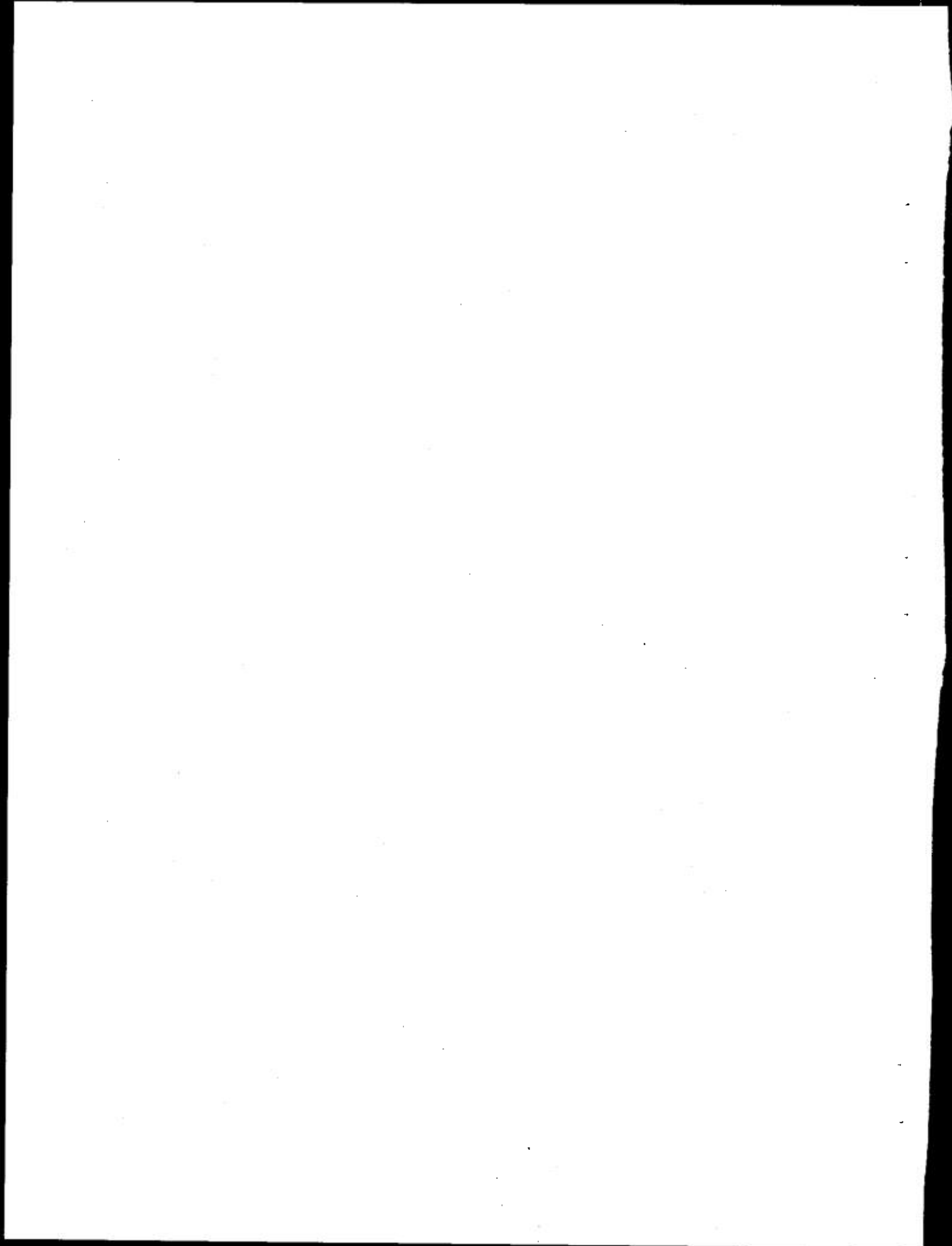
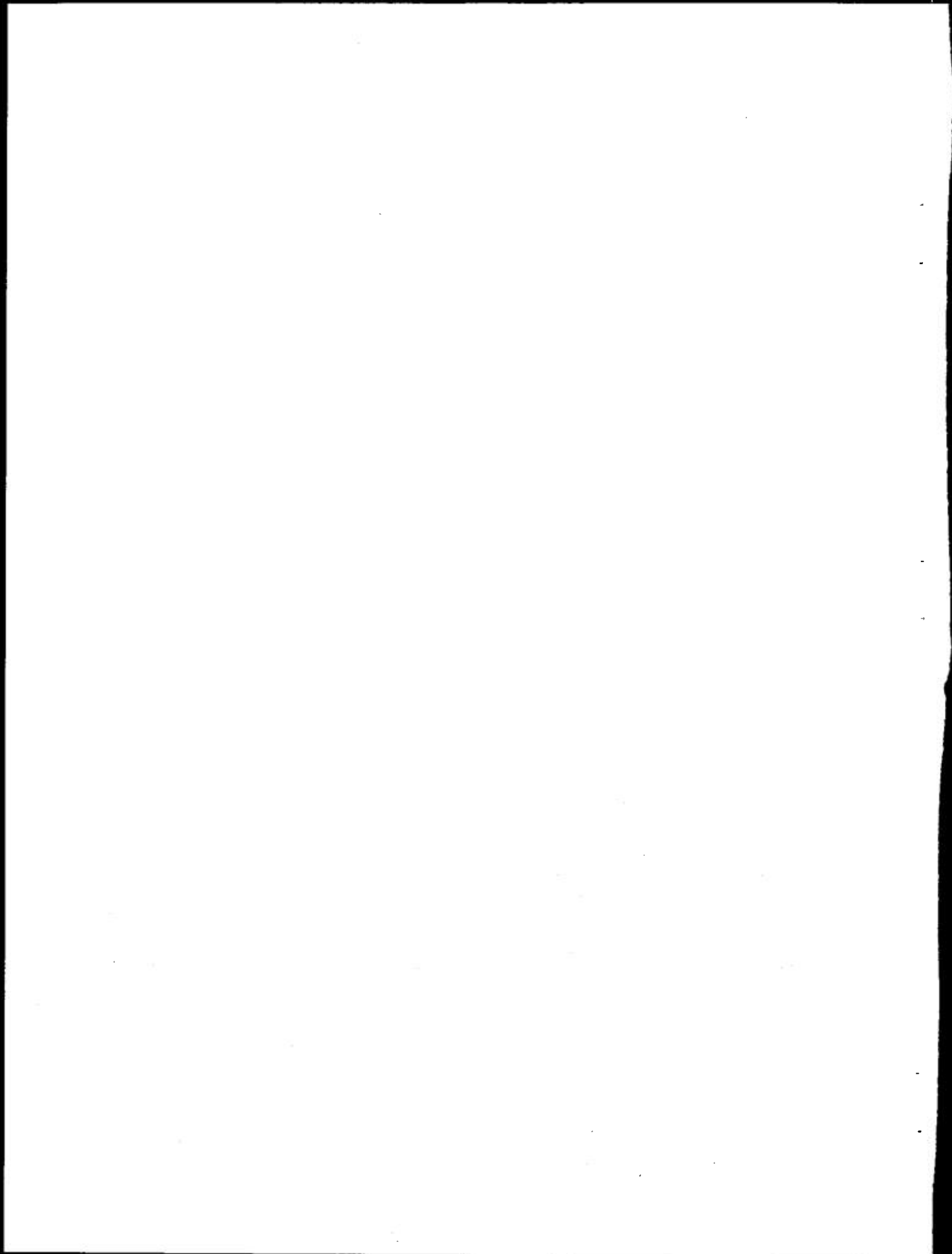


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A SIMPLIFIED PROCEDURE FOR IDENTIFICATION OF OPTIMAL TEST SCORE CUT-OFF POINTS FOR NON-RATED SUBMARINER CANDIDATES

INTRODUCTION

The problem to which this study is addressed originated in a conference held on 30 November 1973 at the Bureau of Naval Personnel, the broad objective of this conference having been a delineation of the problems related to the current shortages and desirable "quality mixes" of non-rated, non-designated candidates for the Submarine Force. Stated in an official letter from CHNAVPER¹, one outcome of this conference was the recommendation that the selection efficiency of the GCT, MECH, ARI and SP as well as selected combinations of these tests be determined for the non-rated input to Basic Enlisted Submarine School. Further, a letter dated 15 January from the Commanding Officer of the Naval Submarine School to the Commanding Officer of the Naval Submarine Medical Center² requested that "the NAVSUBMEDCEN conduct a study to determine if a minimum floor on GCT should be established, and what it should be, as well as investigating the validity of the Shop Practice criteria (9-point waiver allowed)", *op. cit.*, p. 3. Upon receipt of Project Order PO4-005 providing funding from Chief of Naval Education and Training Support on 17 April 1974, the study was organized and data collection begun.

METHODS AND PROCEDURE

The necessary first step in the determination of the efficacy of any personnel selection program is to ascertain

empirically the combinations of biographical information, test scores and other observational data which will maximize the predictive efficiency (validity) in terms of the available evaluative standards (criteria). There are two general statistical approaches to identification of the most useful predictor variable combination: First, the Multiple Correlation Technique most often involving the computational procedure commonly called the Wherry-Doolittle Technique³ and second, the Multiple Cutting-Score (M C-S) method of which there are several computational modes^{4,5,6}. Since for more than three decades both of these approaches have been periodically applied to the submariner selection situation and since the statistical techniques used in the present study are a variation of the M C-S method, some brief statements regarding the pros and cons of each will be presented.

Prior to the advent of the computer, the Multiple Correlation Technique (MCT), since it requires first the computation of a square matrix of correlation coefficients (matrix size equal to the number of predictor variables, "n") and then the solution of "n" simultaneous linear equations, resulted in prohibitive amounts of computational labor, particularly so if more than 4-6 variables were included. The outcome however provided so-called Beta weights, usually nonintegers, as coefficients for each predictor variable indicating its relative importance for predicting individual differences in the

so-called criterion variable, in the present study, graduation or failing Basic Submarine School. Hence each person may be classified in terms of a composite score from which can be obtained estimates of his success probability. One Navy researcher labels this index, Odds for Effectiveness.⁷ However, the MCT can only be useful in personnel situations wherein (1) the test and criteria are linearly related throughout their full range; (2) no trait is so essential (for example GCT as an index of reading ability) that it cannot be compensated by high scores on other traits; and (3) the distribution for each test or measure has a sizeable range if, indeed it is to contribute anything to the overall predictive efficiency of the selection procedure.

Unlike the MCT which involves a series of quite sophisticated statistical computations, the Multiple Cutting-Score (M C-S) Technique can easily be applied by an average clerk since only averages and percentage calculations are ordinarily required. Rather simply the M C-S technique involves the determination for each test in the battery a critical score variously defined as the score point on every test above which the selectees are accepted and below which they are rejected, or, for some selection situations, the scale position which provides maximum discrimination between "good" and "poor" personnel. While at least one federal department, the United States Employment Office, has abandoned the use of the MCT methodology in favor of the M C-S procedure,⁸ the literature argues that both methods are approximately equivalent in terms of the efficacy of the test battery compiled

for use in most personnel selection programs.¹⁹

As stated earlier, both MCT and M C-S methods have been used for the past 20 years to assemble predictive test score batteries for a variety of Naval selection situations including the submarine service.^{9,10,16} The single and multiple test combinations under investigation in the present study were based upon the results of these studies. However, as stated earlier, the purpose of this study was to analyze the available test score data in order to identify the point or points on each of the test score distributions which may be effectly employed in the selection of the non-rated segment of the input to Basic Enlisted Submarine School.

Analytical Techniques - Some Assumptions and Definitions.

As discussed in several places in the selection literature^{10,11,12} the usefulness (validity) of any selection technique including tests used for submariner selection is directly proportional to the Success Ratio (SUR)* in an unselected population and inversely related to the Selection Ratio (SER)** of necessity imposed by the personnel requirements of the situation. Thus, any recommended methodology for identifying effective test score cut-off points (ECOP, Exper-

* SUR = for the present situation, the percentage of an unscreened population of enlisted submariner candidates for Submarine School (SubSchl) who succeed i.e. graduate from SubSchl, qualify S/S etc.

** SER = Selection Ratio is the ratio of number of selectees required to the number available (usually presented in percentage terms). In a sense, this index is analogous to the econometric demand/supply ratio.

imental Cut-off Points) should somehow take into account the prevailing SUR/SER situation. Accordingly, the modified cutting-score technique used in this study includes an estimate of the seriousness for the selection program of both types of incorrect decisions (ICD) i.e., the percent of false positives (FP) and false negatives (FN) for each ECOP. Since the notion of FP and FN are central to the analytical approaches used in this study, a simplified description of the methodology of choice follows (see also Appendix A).*

It is seen in Fig. 1 that FP (Quadrant A) represents those candidates rejected by ECOP_I but who would have graduated from Submarine School.

* Others have previously used essentially the same reasoning as a means of determining the effectiveness of a given personnel selection system.^{11,20}

Conversely, FN (D) are those men accepted by ECOP_I but, in fact, "drop" out (fail) SubSchl. $FN + FP = I.C.D.$ (incorrect decisions), Quadrant "B" are those accepted by ECOP_I and do in fact graduate summed with those rejected by the same trial cut-off who fail. Thus $B+C = C.D.$ (correct decisions) and $A+B+C+D = N = I.C.D. + C.D. = \text{total personnel decisions to be made by the selection process}.$

As implied earlier, the most meaningful ECOP on the predictor(s) score distribution must of necessity take into consideration the requisite SER at the time the selection decisions are to be made. Thus, if the number of optimal quality men is in short supply and if the numbers and quality mixes of men required is accelerating (the present situation in the submarine service), then

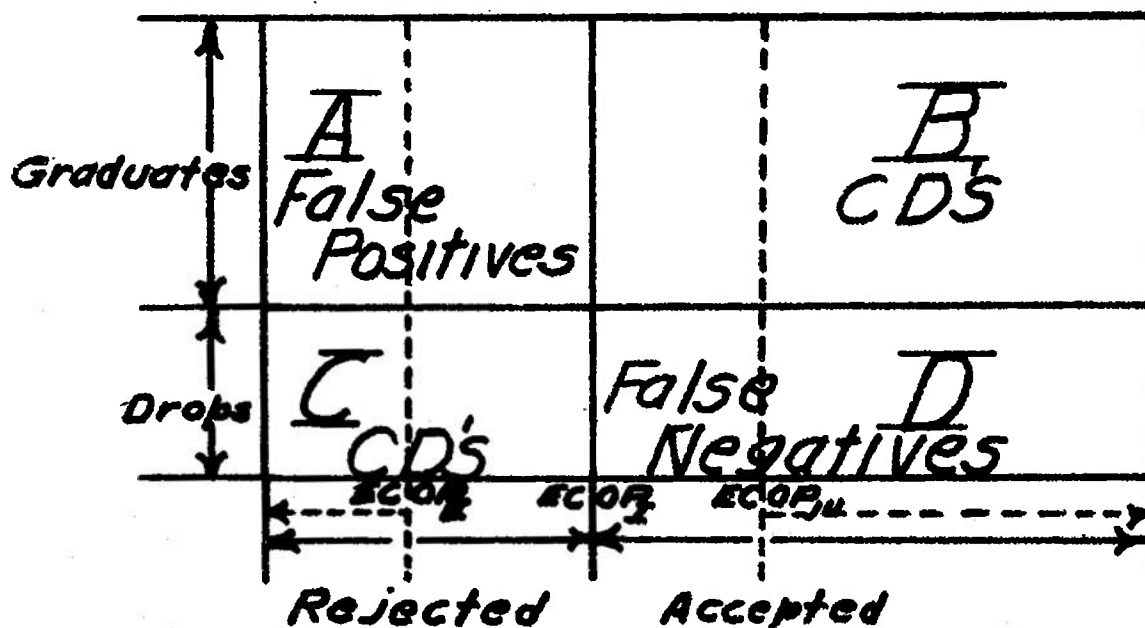


Fig. 1. Procedural diagram depicting the methodology employed in this study.

SER must be as near 100% as possible. Stated simply, if SER approaches 100%, an ECOP should be low enough (ECOP_{II} in Fig. 1) to reject as few of the input as possible. In particular, FP should approach "O" i.e., ECOP_{II} cannot afford to reject many (ideally, any) candidates who would succeed. Conversely, in circumstances wherein the supply of quality candidates is high in proportion to the personnel requirements i.e., SER is low, the ECOP can be raised up the score scale to, for example, ECOP_{III} (Fig. 1) with little concern about FP*, but with much concern about reducing FN** particularly if the training costs are exorbitant, for example, nuclear power submariner training.

With the foregoing selection concepts in mind, the procedure for pinpointing the most efficacious ECOP for each selection test or combination of tests shown by earlier studies to have significant predictive validity^{9,10} was simply to plot the FN and FP for ascending score intervals. Several other indices were also calculated and plotted for each ECOP or score interval.

These are defined below:

CD - Correct Decisions, i.e., the percentage of total accepted/rejected correct decisions for each ECOP. In Fig. 1 C.D. = $[B+C/N] \cdot 100$.

* This is so, however, only if the resource cost (personnel and test materials) is low. Otherwise, the dollar cost to fail a candidate may be prohibitive.¹³

** Another way of expressing this selection objective is to maximize SUR (Success Ratio) represented by quadrant "B" in Fig. 1 since $SUR = (100 - FN)$.

COPV - Coefficient of Practical Validity, that is the difference between correct decisions (CD) and I.C.D. (Incorrect Decisions), calculated as $[B+C] - [A+D]/N$ changed to percent. High positive COPV indices correlate with the overall efficiency of the selection program. Conversely, a negative COPV suggests an inefficient system.

RL - Relative Losses, that is, the difference between the proportion of the men who would fail that would be rejected by the ECOP and the proportion of men who would succeed also lost by the ECOP. $R.L. = [C/C+D] - [A/A+B] \cdot 100^*$.

One necessary assumption made in implementing this rather simple cut-off score technique was that there were no rigidly applied cut-off scores in effect at the time these data were collected. This assumption is necessary since the question posed by this research viz., can a meaningful ECOP be identified for single or composite score distributions, would be "begged" if a cut-off point were in fact being applied during the time frame** during which the data used in this study had accumulated. Thus, in spite of the fact that theoretical BTB

* The reader is referred to the dictionary of terms for expanded definitions of these and other concepts involved in this methodological approach (app. A).

** The data for this study were based upon the non-rated input to Basic Enlisted Submarine School during the calendar year 1973. The total input was 2100 of which the non-rated segment (N=990) amounted to 47%.

(Basic Test Battery) eligibility standards for submariner candidates have been in existence for more than a decade, for example, $GCT+Ari \geq 100$ (6 point waiver), $GCT+Mech \geq 100$ and/or $GCT+Mech+SP = 150$ (9-point waiver), it was assumed that because of the elevated selection ratio necessitated by the ever accelerating requirements for quality personnel in short supply, that no strict cut-off test scores were being adhered to in 1973.

Subjects.

The initial sample of SR's, SA's (FA's) and SN's entering Submarine School between Jan. 1, 1973 and Dec. 31, 1973 numbered 990. However, 35 of these men had been set back from their initially assigned Submarine School classes as medical or other "holds". Since their names may have appeared on more than one class roster, they were eliminated, the remaining sample being 955. The median age was 18.4 years with a range of 17 to 30 years. Sixty-four percent of the sample were SR's, 20 percent were SA/FA's and the remainder SN's.

Data Processing Techniques.

Selected items of biographical information, the BTB score combinations, and Submarine School criteria* were coded and IBM key punched by the ADP Branch of the Laboratory**. Besides

* A 20-30 column punched card field was left blank so that a battery of personality test scores could be punched to be analyzed at a later date.

** Appreciation is extended to Mrs. Betty Megos, Head of the ADP Branch and her staff for punching and verifying the cards and for performing the numerous card sorting operations required to produce the accumulative percentage distributions basic to the study.

the key punch and verifier, the only ADP hardware used in this study was the IBM 026 sorter with pocket counter attachment by means of which the rank-ordered frequency distributions for each of the test score combinations were obtained. The accumulative percentage distributions and the five score cut-off indices were derived for each score combination (See Appendix A) from these rank order distributions by means of a desk calculator. The total computation time for each test score or score combination was approximately three man-hours.

RESULTS

As implied in the introductory section of this paper, the present study is an extension or updating of past research aimed at delineating the most effective predictors of Submarine School success. Based upon research extending over more than two decades^{9,10,15,16} the relative predictive effectiveness of all possible combinations of BTB scores and other measures has been repeatedly calculated on independent samples of enlisted candidates for the submarine service. The present study extends these earlier validation studies in two ways: First, past studies have focussed only upon samples of total input, both rated and non-rated, to the Submarine School. In contrast, the population sample for the present study included only non-rated personnel who had volunteered for submarine training. Secondly, based upon the assumption that optimal test score combinations had been delineated by past studies over the years, the present study submits these test score distributions to an analysis designed to identify for each distribution

a cut-off point which, if applied, will maximize the efficiency of the submariner selection system for the SER and SUR (See Appendix A) existing at a given time.

The Search for Moderator Variables.

Previous studies¹⁷ designed to examine the interactional effects of BTB scores and personality test scores have demonstrated the necessity of exploiting the occurrence of moderator factors in a personnel selection situation (See Appendix A for clarification of the moderator concept).

Educational Achievement and SubSchool Attrition. The significant moderator effect of EA (Educational Achievement) for prediction of Submarine School Performance has been known for almost twenty years (See Table 3 in reference No. 15). Thus, in the mid-fifties it was known, for example, that submariner candidates who had graduated from high school had 2-1/2 times the probability to graduate from SubSchl as did high school dropouts (op. cit., p. 4). The relationship between EA and SubSchl attrition is depicted for the sample of 955 non-rated submariner candidates in Table I.

Table I. Distributions of Education Achievement of Non-rated Enlisted Sample (N= 955)

SubSchool Status	Educational Achievement (EA)							
	9 years or less		10 - 11 years		12 years		More than 12 years	
	<u>f</u>	<u>%</u>	<u>f</u>	<u>%</u>	<u>f</u>	<u>%</u>	<u>f</u>	<u>%</u>
Drops	45	53.6	151	47.9	110	22.0	5	8.9
Graduates	39	46.4	164	52.1	390	78.0	51	91.1
Totals	84	100	315	100	500	100	56	100
% of Total in each EA Group		8.8		33.0		52.3		5.9

With $df=3$, p of $X^2 < 0.01$

At the outset, clarification of the term Submarine School (SubSchl) "drop" as used in Table I is required. Eighty-two percent of the 311 "drops" were labelled "academic" indicating that the major cause of the failure had to do with the inability to acquire sufficient knowledge and skills to meet the "passing" standards required by the SubSchl. The remaining 56 men (18%) were the so-called "administrative" drops, men disqualified for insufficient obligated time, and for disciplinary, psychological, and other reasons.*

Overall, the attrition rate (AR) was 33% in this sample. It is immediately apparent from the data in Table I that the "betting odds" are 49% to fail in SubSchl if a candidate's EA is less than 12 years. This compares to a probability to fail of 21% if he has completed high school ($EA \geq 12$).** Stated another way, 63% of the SubSchl drops in this sample were also high school dropouts, while only 31% of the SubSchl graduates had an EA less than 12. Finally, there is no statistically significant (5% confidence level, by χ^2) in the odds to fail in SubSchl of those with $EA=9$ and those with $EA=10-11$ years, the odds being about 50/50.*** Thus from Table I, if an EA of 12 or more were required for qualification of non-rated men for submarine training, 41.8 of the

non-rated volunteers in the present sample ($N=955$) would have been rejected. However, of those high school graduates accepted 79% (556 men) would graduate. Perhaps noteworthy is the fact that this hypothetical SubSchl output of 441 graduates is 31% less than the output of 644 (67% of total) in the present sample. The question becomes however, if the requirement of $EA=12$ be imposed upon submariner candidates, can the existing personnel situation withstand the 51% false positive (FP, see Appendix A) loss.

For purposes of comparison of the effectiveness of the various ECOP's (Experimental Cut-off Points) to be identified for the test score distributions later on in this paper, the same indices were calculated for a hypothetical $ECOP/EA < 12$ the plausibility of which is suggested by the data in Table I. Following the rationale expressed in the discussion of Fig. 1, the following indices* were calculated for $ECOP/EA < 12$: $CD=66.7\%$, $COPV=33.4\%$, $RL=31\%$, $FP=51\%$, and $FN=21\%$. Thus this simple procedure would hypothetically result in a rather efficient selection system resulting in a SUR (Success Ratio) of $100-FN=79\%$. However, the price paid for imposition of this procedure is reflected by the statistic $RL=31\%$ resulting from rejecting 63% of the potential "Drops" but at the same time losing 32% of those men who would graduate from Submarine School. It remains to be proven whether any procedure involving test score ECOP's will significantly improve this simple EA cut-off procedure. At any rate, it is

* The relatively few candidates disqualified for the submarine service for medical reasons prior to the onset of the basic submarine course were not included in the "drop" group.

** The 1.5% (14 men) who had obtained a high school diploma by means of the G.E.D. equivalency examination were included in the high school drop ($EA < 12$) group.

*** A Sample of SubSchl enlisted men obtained in 1956 showed exactly the same odds for high school dropouts to graduate from SubSchl, namely, 50%. 15

* See Appendix A and the discussion of Fig. 1 for an explanation of these indices of selection efficiency.

obvious from the data in Table I and the above discussion that submariner candidates who are and are not high school graduates show significant differences in terms of the present criterion of concern, drop/graduate from SubSchl. Thus, EA appears without question to be a significant moderator variable, necessitating the identification of effective ECOP's for each of the selection

tests separately for the segments of the non-rated population with and without a high school diploma.

Age and SubSchl Attrition. Another variable of concern is the relationship of age of the non-rated candidate to SubSchl attrition. Table II presents these data in crossbreak form.*

Table II. Age Distributions for Submarine School Graduate and Drop Sample (N= 955)

SubSchool Status	AGE							
	17		18-19		20-22		23+	
	<u>f</u>	<u>%</u>	<u>f</u>	<u>%</u>	<u>f</u>	<u>%</u>	<u>f</u>	<u>%</u>
Drops	99	49.3	164	29.3	44	26.2	4	15.4
Graduates	102	50.7	396	70.7	124	73.8	22	84.6
Totals	201	100	560	100	168	100	26	100
% of Total in each age group		21.0		58.6		17.6		2.7

With $df=2$, p of $X^2 < 0.01$

It is immediately obvious that the 21% of the non-rated input to Submarine School under 17 years of age are a high risk group (AR=49), which is significantly different from the 18 and older candidates for which an AR=28% is found. Thus, imposing a minimum age requirement of 18 for non-rated volunteers would bring about the elimination of a poor risk group resulting in the loss of 32% of those who would eventu-

ally drop but at a "cost" of 16% of those who would graduate thus yielding an RL (Relative Loss) of 16% (See Appendix A). In light of the discussion of the SER concept in the methods and procedure section, application of this age cut-off

* A crossbreak or contingency table is a method of presenting numerical data, usually in frequency or percentage form, in which variables or factors are juxtaposed in such a manner that their interrelationships can be examined.

point can be recommended only if an SER of 79% or less for the non-rated segment of the input to SubSchl is feasible (79%=the complement of the 21% loss of the 17 year olds caused by the ECOP being set at age 17).

Age and Educational Achievement Interaction. Since the mean age of

high school graduates is 18 years, the likelihood that the SubSchl attrition data in Tables I and II actually "tell the same story", namely that the high risk candidate group whose EA is less than 12 is mainly composed of 17 year olds, also showing an elevated AR. Table III presents this three-way crossbreak.

Table III. Age and Educational Achievement Interactional Relationship with Attrition Rate (AR) in Submarine School (N= 950^c)

Educational Achievement (EA)	Age						
	<u>17</u> <u>Drops^a</u> <u>Grads^a</u>		<u>18-19</u> <u>Drops</u> <u>Grads</u>		<u>20+</u> <u>Drops</u> <u>Grads</u>		<u>%</u> <u>in each</u> <u>EA Group</u>
9 years or less	25	25	13	11	6	3	8.7
	AR=50%		AR=54%		AR=66%		
10-11 years	66	67	73	82	12	15	33.0
	AR=50%		AR=47%		AR=44%		
12 years or more	8	10	73	303	30	128	58.2
	AR=44%		AR=20%		AR=19%		
Totals	99	102	159	396	48	146	
% Total in each Age Group	20.1		58.4		21.5		
With df=2, p of X ²	n.s. ^b		.001		<.001		

^aSubmarine School Drops and Graduates

^bn.s. - nonsignificant, i.e., null probability >5%

^cIncomplete data on 5 cases.

As expected, 92% of the 17 year old submariner volunteers are high school dropouts who have about 50% probability to graduate from SubSchl irrespective of EA (See column 1 in Table III).^{*} Further, an examination of the AR's for age groups "18-19" and "20+" (columns 2 and 3) reveals that an AR less than 20% would result from accepting non-rated volunteers who are at least 18 and are high school graduates.

The question as to whether the imposition of an age/EA interactional cut-off would significantly improve the selection situation for the non-rated input to SubSchl was raised. Accordingly, the indices calculated from Table III for an ECOP EA<12 & Age<18 were: COPV=33.5%, CD=67%, FP=51%, FN=19.3% and RL=33.2 (drop loss 66.3, graduate loss 33.1). Thus, including the age 17 criterion with the EA<12 cut-off based upon Table I would result in only a very slight improvement, namely 2% increase in RL and a drop of about the same proportion in FN. However, as before, the permissible SER for the non-rated component of the submariner volunteer pool must be of the order of 50%^{**} for this age/EA cut-off group to be practical.

Paygrade and EA Interaction. Since paygrade is obviously correlated with

time-on-active-duty, the possibility that the more adequately indoctrinated SN's and SA's would be better risks for SubSchl was examined next. Table IV contains data bearing on this point and analyzed separately for the high school graduate and high school dropout component of the sample.

Again as expected, E-1's are a high risk group (AR=39% overall) but much more for high school dropouts (AR=48.7%) than for high school graduates (AR=29.4%). With increase in paygrade the AR situation improves significantly but only for high school graduates again providing support for the treatment of the EA as a moderator variable in search for effective ECOP's for the test score distributions to follow.

Gross Descriptive Statistics for each Test or Test Score Combination.

As stated earlier, the purpose of this study was to search the distributions of selected tests and test score combinations obtained from a sample of non-rated submariner volunteers to ascertain whether meaningful cut-off points could be identified. Before initiating the cut-off score analysis however, it was necessary to compare the score distributions for the tests and test combinations taking into account the major moderator variable, Educational Achievement (EA). Table V contains gross descriptive statistics estimated from the accumulative frequency and percentage distributions derived by a card sorter and desk calculator for each test score or combination.

^{*} Thirty-two percent of the 18-19 y/o and 37% of the 20+ age were high school dropouts in the present sample of non-rated SubSchl candidates.

^{**} This statistic was calculated by first summing the total losses of men resulting from this EA/Age cut-off, i.e., A+C+D in Fig. 1. The complement of this sum changed to % of total is the percentage of this group who would finally graduate from Submarine School.

Table IV. Interactional Effects of Paygrade and Educational Achievement upon
Submarine School Attrition Rate (AR) (N=955)

Educational Achievement	PAYGRADE							
	E-1		E-2		E-3			
	Subschl Grads f %	SubSchl Drops f %	SubSchl Grads f %	SubSchl Drops f %	SubSchl Grads f %	SubSchl Drops f %	% in each EA Group ^a	
12 + Years AR ^a = 20.8%	218 70.6	91 29.4	95 84.1	18 15.8	128 95	7 5	58.3	
<12 Years AR ^a = 50.0%	157 51.3	149 48.7	40 48.8	42 51.2	6 60	4 40	41.7	
% in each Paygrade	64.4		20.4		15.2			
AR within Paygrade	39.0%		30.8%		7.6%			

^a Attrition rate within EA group across all paygrades.

Table V. Gross Descriptive Statistics for the Distributions of Each Test or Test Score Combination

Test(s) ^a	E.A. Grouping	S/S Status	Sample size	Median (50 p.c.)	16 p.c.	84 p.c.	Approximate ^c S.D.	Symmetry ^d
GCT	<12	S/S Grads	203	53.3	46.4	59.9	6.7	Symmetrical
		S/S Drops	195	50.3	45.7	56.9	5.6	Slight +
	≥12	S/S Grads	441	57.6	49.8	65.3	7.8	Symmetrical
		S/S Drops	116	50.9	46.1	56.8	5.3	Slight +
GCT + MECH	<12	S/S Grads	203	103.4	96.0	113.3	8.6	Slight +
		S/S Drops	163	99.7	91.9	105.7	6.9	Slight -
	≥12	S/S Grads	441	108.4	98.4	121.2	11.4	Slight +
		S/S Drops	92	97.5	90.0	106.5	8.2	Slight +
GCT + MECH + SP	<12	S/S Grads	182	154.1	142.7	171.5	14.4	Mod. +
		S/S Drops	149	149.2	140.9	161.9	10.5	Mod. +
	≥12	S/S Grads	424	162.3	146.8	180.1	16.6	Symmetrical
		S/S Drops	102	146.1	136.5	163.8	13.6	Sharp +
ARI + MECH + SP	<12	S/S Grads	182	150.2	138.9	165.7	13.4	Slight +
		S/S Drops	150	147.1	136.1	158.3	11.1	Symmetrical
	≥12	S/S Grads	423	158.5	143.7	175.1	15.6	Symmetrical
		S/S Drops	103	145.6	131.9	155.4	11.7	Slight -
SP		S/S Grads	605	53.1	44.5	60.2	7.8	Symmetrical
		S/S Drops	210	48.9	42.9	55.4	6.2	Symmetrical

^aGCT = General Classification Test; MECH = Mechanical Aptitude Test; SP = Shop Practice Test.

^bE.A. = Educational Achievement

^cS.D. = Standard Deviation approximated from mean score range between 84 p.c. and 16 p.c.

^dSkewness estimated from relative difference between the score distance from 50 p.c. to 16 p.c. and from 50 p.c. to 84 p.c.

At the outset, it is obvious that the differences between the EA groupings (high school drops versus high school graduates)* in terms of the score distributions are in most cases sizeable, thus providing further support for treating EA as a moderator variable throughout the score cutoff analysis to follow. Another related observation of some considerable significance, is that the score distributions for the EA<12 groups are very similar for Submarine School Drops as compared to graduates. This was not true, however, for the score distributions obtained from the high school graduate segment, as large distribution differences between SubSchl graduates and drops appeared for each test combination for this EA subgroup. The upshot of this finding, apart from providing further justification for the EA moderator, is that the high school dropout component of the SubSchl input is rather homogeneous insofar as the presently used test battery is concerned. It follows therefore that the identification of optimal cut-off scores should be much more difficult for the high school dropouts than for the high school graduate subsample.

Optimal Experimental Test Score Cut-off Points.

As stated in the procedural section, the data analysis for each of the distributions of test or test score combinations was identical. Defined in Appendix A, five interrelated indices (CD, FN, FP, COPV and RL) were derived for each ECOP, which were in all

* Preliminary examination of the distributions of the SP (Shop Practice) test scores indicated that partitioning the data for different EA levels was not necessary.

cases separated by a 5-point score interval.

GCT. The line graphs* for each of these 5 indices are presented for GCT distributions obtained for the high school drop group in Fig. 2A and for the high school graduate group in Fig. 2B.

Looking first at Fig. 2A, GCT=50 is sharply delineated as the ECOP where the screening system is most efficient as indicated by a maximum COPV of 20%. But, the personnel losses would be high at that point, namely, 43% (A + C/N in Fig. 1). Further, the FP index is 40% at GCT=50 i.e., 40% of those rejected by the ECOP=50 would have been graduated had they have been accepted. Equally troublesome is the FN=40% at ECOP=50 i.e., 40% of those accepted (B + D in Fig. 1) will drop in SubSchl, a statistic that is slightly lower than the expected attrition of high school dropout candidates for the submarine service irrespective of their GCT scores. In sum, with both FP and FN about 40% the imposition of an ECOP=50 would result in an SUR of about 60%. In other words, the attrition rate for the non-rated, EA<12, group would be reduced from the existing 49% (Table I) to 40% with the imposition of ECOP=GCT/50.**

* The reader should realize that line graphs are used merely for convenience since the abscissae of all the figures to follow are discrete rather than continuous scales consisting of ascending ECOP's separated by 5-point score intervals. The interconnecting data points were not calculated.

** A caveat is necessary at this point, namely, that all of the statistical indices used in this study (COPV, FN, RL, etc.), like all statistics, have sampling errors. Accordingly, computed on a different subject sample, these indices may be quite different, resulting in different ECOP's, each with correlated selection indices.

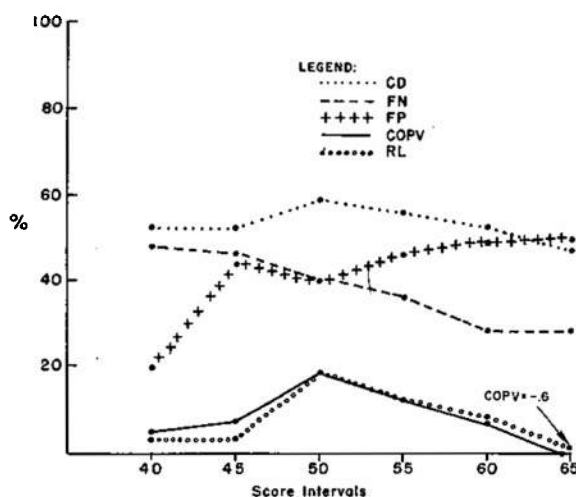


Fig. 2A. Experimental cut-off points for GCT (SS Grads., N=203; S/S Drops N=195; E.A. < 12)

Turning to the line graphs in Fig. 2B, as might be expected from the elevated GCT distributions for high school graduates (Table V), the present selection system for this higher EA group is slightly more efficient at ECOP's GCT/40-55. This is so because the AR in this group overall is only 21% (Table I) and decreases to 8% at GCT=55. The fact that FP "climbs" from 62% at ECOP GCT/45 to 72% at GCT=60 would seem to argue against the application of any ECOP based on GCT scores for this group, especially when a high SER is necessitated by the extant personnel situation.

One final comment regarding the possibility of locating a minimal ECOP on the GCT scale below which a submariner candidate would absolutely be disqualified presumably on the basis

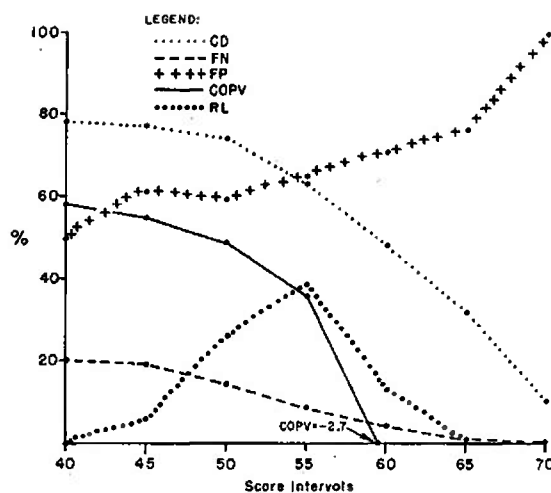


Fig. 2B. Experimental cut-off points for GCT (SS Grads., N=441; S/S Drops, N=116; E.A. ≥ 12)

of illiteracy or limited literacy. In terms of the indices of selection efficiency used in this study this hypothetical point on the GCT distribution would coincide with the ECOP at which FP=0 i.e., all candidates rejected would have failed. Looking at Fig. 2B first, with FP=50 at ECOP GCT/40, it is obvious that such a "bottom-out" score is non-existent for the EA ≥ 12 input to SubSchl. However, this may not be true for the EA < 12 subgroup. Accordingly, if we extrapolate the FP line in Fig. 2A from GCT/45 through GCT/40 backward it crosses the GCT score scale exactly at GCT/33. Keeping in mind that only 2.5% of the present sample (10 men) had GCT scores below 40, nonetheless, hypothetically at least, this minimal score may be at or near GCT=33 for similar non-rated samples.

GCT + MECH.* The same type of analysis was completed for the combined T-Score distributions for the combined GCT and Mech scores obtained from the present sample of non-rated submariner candidates, again treating the data separately for high school dropouts and for high school graduates. Figs. 3A and 3B contain the results of this analysis.

For those men with less than 12 years formal education, the plots in Fig. 3A suggest that an $ECOP = GCT + MECH/100$ is more efficient than $ECOP = GCT/50$ for the same group ($COPV = 25\%$ as compared to 19%). Yet the AR for this ECOP would still be about 33% at that point. Moreover, 48%

* *ARI + MECH score distributions were not analyzed on the basis that the correlation of this composite score with SubSchl criteria has been shown¹⁰ to be approximately equivalent with the same statistic calculated for GCT + MECH (Figs. 3A and 3B) and therefore the test score cut-off potentiality would similarly be expected to be comparable.*

of the total input in this group would be rejected by this ECOP (A + C in Fig. 1) of which 43% (about 21% of the total input) would have graduated had they been accepted.

A slightly more effective ECOP for the GCT + Mech distributions for non-high school graduates can be pinpointed in Fig. 3A viz., $ECOP = GCT + MECH/95$. At this point, AR (FN) would increase to 39% but 9% fewer "good" candidates would be rejected as indicated by the drop of 9% in FP between these two ECOP's.

As for a possible ECOP for the GCT + MECH distributions for the high school graduate component of the non-rated input to the submarine, the data in Fig. 3B, suggest that an AR of less than 20% would result from accepting all of this group irrespective of their combined GCT + MECH scores.

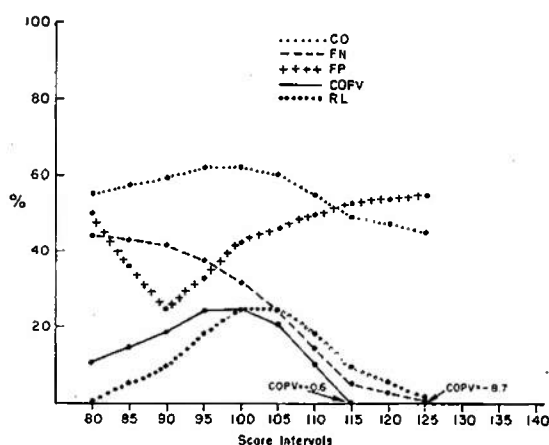


Fig. 3A. Experimental cut-off points GCT + MECH (SubSchool Drops N=163, Grads. N=203, E.A. < 12)

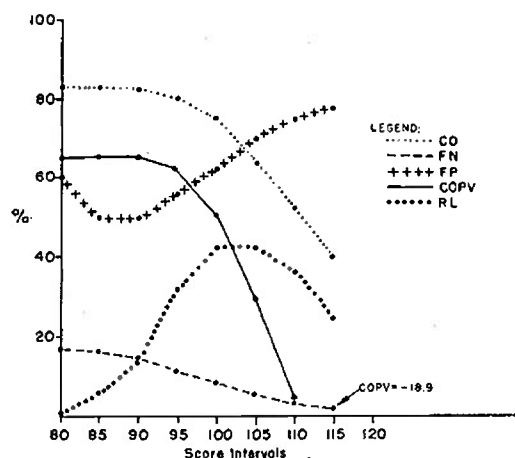


Fig. 3B. Experimental cut-off points GCT + MECH (S/S Grads., N=441, Drops N=92, E.A. ≥ 12)

However, an ECOP GCT + Mech/90 would minimize FP*, which may be desirable when SER must be high.

GCT + MECH + SP. The line graphs for the distributions of summed standard scores for GCT, MECH and SP are presented in Figs. 4A and 4B.

Whereas it cannot be directly estimated from Figs. 4A and 4B, it should be noted that for the EA<12 group (Fig. 4A), about 17% (N=331) were below the hypothetical cut-off of 141 (150 less the allowable 9-point waiver). The equivalent proportion for the EA>12 group (Fig. 4B) was of the order of 7%. Overall, the selection efficiency of this score combination is not high as estimated by COPV of 18% as a maximum at ECOP/150 with a coincident CD only

* The number of cases upon which this FP calculation was based was small, i.e., N=32 or 6% of the total.

of 59% (chance probability=50%). For the EA<12 group, this combination appears approximately equivalent to GCT alone (Fig. 2A); however, with AR 36-44% none of the test scores singly or in combination appear to offer much promise as a selection system for this EA group.

An examination of the same graphs obtained from the higher EA group (Fig. 4B) as before, suggests that acceptance of candidates regardless of their summed test would yield less than a 20% attrition rate. However, if a low SER were ever feasible (say 60% or less), judging from the CD and COPV graphs, an ECOP in the 145-155 might be useful in the sense that an AR of 9-13% would be realized. This hypothetical situation is feasible because with a low SER, the number of capable men rejected (high FP) is not of great concern. However, with the requisite Selection Ratio high (90% or so)

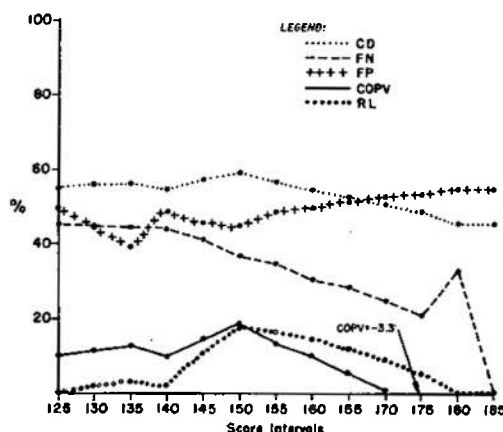


Fig. 4A. Experimental cut-off points for GCT + MECH + SP (SS Grads. N=182; SS Drops N=149; E.A. < 12)

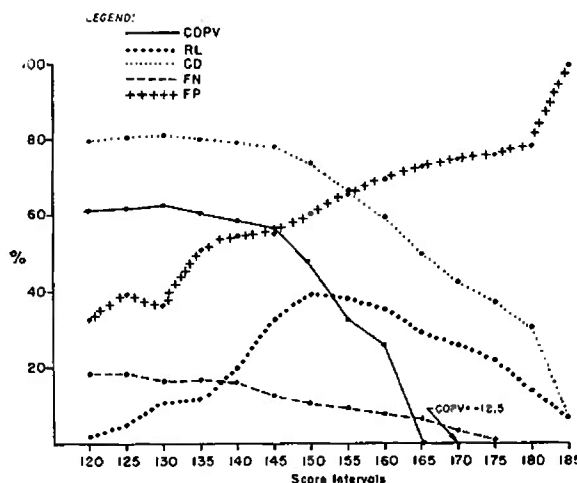


Fig. 4B. Experimental cut-off points for GCT + MECH + SP (SS Grads. N=424; SS Drops N=102; E.A. ≥ 12)

no GCT + MECH + SP ECOP is indicated for this EA group.

ARI + MECH + SP. Whereas past research has shown the combination of ARI + MECH and GCT + MECH to be approximately equivalent in the sense of predictive capability in terms of Submarine School performance criteria,¹⁰ nonetheless it seemed desirable to evaluate both combinations with SP. Figures 5A and 5B contain the graphs for these two distributions.

It is immediately obvious from the COPV plot in Fig. 5A which is 13% or less at all ECOP's, and from the CD line only slightly above chance (maximum 57%) that this score combination is not practically useful with this lower EA group. This is certainly true for scores up to 145 as more than 40% of those selected would fail (FN>40%) and at the same time almost half of those

men rejected by ECOP's in that range would have succeeded (FP=50%).

As for the practicality of any identifiable ECOP for the higher EA segment of the enlisted sample, the graphs in Fig. 5B are very similar to those resulting from the GCT/MECH/SP analysis depicted in Fig. 4B showing fairly efficient ECOP's in the lower score range with COPV peaking at ECOP 135, dropping rapidly because of a rapidly rising FP. But as in all of the previous test score analyses involving only the high school graduate portion of the present sample, irrespective of a candidate's combined ARI/MECH/SP score the betting odds are more than 80% to graduate from Submarine School. Interestingly, if the personnel requirements were such that only half of the EA_{≥12} volunteer group were needed (i.e. SER=50%), an ECOP of 155 would result in a 94% Success Ratio, while

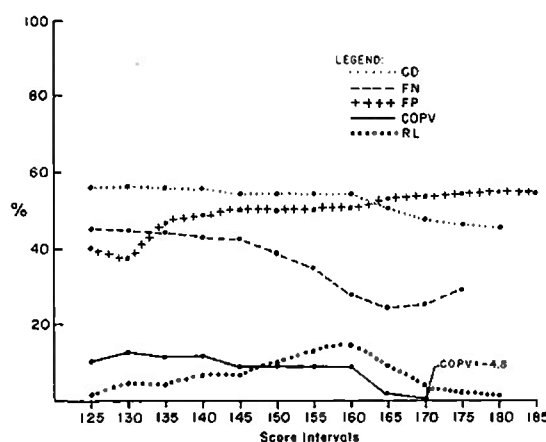


Fig. 5A. Experimental cut-off points for ARI + MECH + SP (E.A. < 12; SubSchl Grads. N=182, SubSchl Drops N=150)

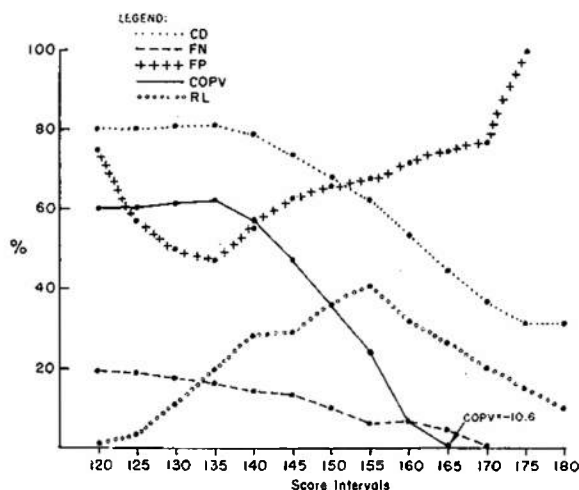


Fig. 5B. Experimental cut-off points for ARI + MECH + SP (E.A. ≥ 12; SubSchl Grads. N=423; SubSchl Drops N=103)

rejecting 84% of potential failures at a "cost" of rejecting 43% of the potential "successes", i.e., R.L.=41%.

SP. Finally, since the Shop Practice (SP) test was a relatively recent entry to the U.S. Navy selection test battery, the same analysis was completed for the SP distribution, without this time, controlling for individual differences in Educational Achievement. The resulting graphs are contained in Fig. 6.

A comparison of the descriptive statistics for the SP scores obtained from the Submarine School graduates (N=605) with those from the drop group (N=210)* indicates rather similar distribution (Table V), although the difference between the medians was significant (1% confidence level, t-test). While the COPV index is highest on the low score end of the SP score scale, FP in that score range is 60% or higher making the

* Forty men in the sample did not have SP scores.

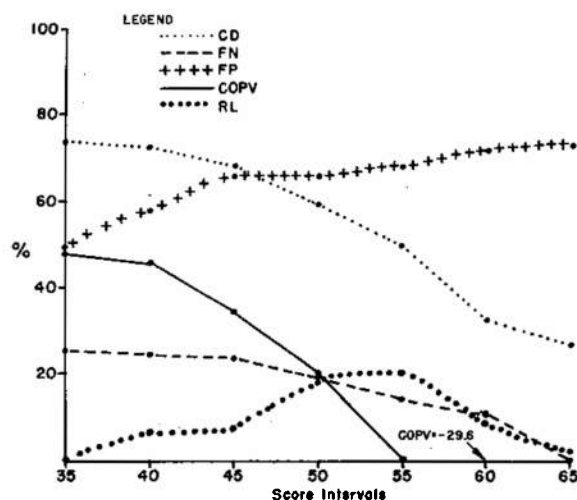


Fig. 6. Experimental cut-off points for SP (SS Grads. N=605; S/S Drops N=210)

selection "cost" of losing capable submariner candidates prohibitively high during a high SER era. Too, the non-feasibility of employing any ECOP on the SP score scale is indicated by the fact that CD (Correct Selection Decisions) approaches 50% in the maximum frequency density range, i.e. the 50-60 percentile area.

SUMMARIZING STATEMENTS

Several limitations of the rather simple methodology used in this study to identify possibly useful ECOP's for several moderator variables and test score combinations have already been mentioned. Thus, the question of the reliability of the indices of selection efficiency (COPV, CD, RL, FN, FP) was raised earlier. An extension of this sampling problem is that these indices, calculated for ECOP's at various levels of the score scale are differentially reliable as a result of varying frequency density. An extreme example of this characteristic of the test score distributions may be seen in Fig. 6 at ECOP SP/35, where FP=50% computed on the basis of 2 out of a total of 4 cases below this ECOP. Calculations in the 15 to 85 p.c. ranges are of course based upon much more copious subject samples. Another limitation related to the reliability problem is the fluctuation of the pass/fail level of success criteria, for example, difficulty level of achievement tests in Submarine School from time to time.

Finally, one criticism often stated by the proponents of the MCT (Multiple Correlation Techniques) applies to the several exploratory analyses involving summed test scores (in standard score

form) each with unitary "weight" rather than with precisely determined Beta weights capable of being derived by the proper application of MCT to this multiple prediction problem. Justification for the unitary weighting derivation of the multiple-score distributions analyzed in this study (Figs. 3A, 3B, 4A, 4B, 5A and B5) comes from several studies in the literature showing that combining tests with a variety of weights, such as Beta weights, 1/standard deviation, summed standard scores, or even simple addition of raw scores results in almost identical predictive relationships with most criteria.^{21,22,23}

With these limitations in mind, the task of integrating the data from the numerous graphs and tables presented in the body of this paper was undertaken first by compiling a summary table (Table VI) including comparable items of data from each display.

It should be noted at the outset that the major assumptions basic for the decisions as to which data points to include in Table VI was that the most meaningful selection system would involve an ECOP at which the margin of correct selection decisions (CD's) over incorrect decisions (ICD's), defined by the COPV percentage, was maximum. The remaining indices were either calculated from the tables or taken directly from the graphs indicated in the far right column in Table VI. The following statements are indicated:

1. First of all, for the $EA \geq 12$ group (58.2%) all of the tests singly (except SP) or in combinations, provide 2-5 times the selection efficiency as they

do for the lesser educated segment of the sample of 955 non-rated candidates for the submarine service. Thus accepting all non-rated volunteers with at least a high school education, irrespective of any test scores would result in a success ratio (SUR) of about 79% (4th from bottom row in Table VI). This SUR could be raised to 85% by accepting high school graduates with $GCT+MECH \geq 90$ (100-FN in row 4 in Table VI). Further, it is seen in the second row from the bottom of Table VI that an $ECOP\ EA < 12$, $Age < 18$ would yield an 81% SUR and an $RL = 33\%$, that is 66% of those who would drop would be rejected at a "cost" of losing 33% of the SubSchl graduates ($RL = 66-33$).

However, in an era when presumably as many as possible of the available men of acceptable quality are needed for submarine service at this time (i.e., a high SER), the question as to whether FP's in the 50% range can be tolerated need to be weighed prior to the imposition of any ECOP's for this higher EA group.

2. With an overall AR of about 49%, identification of a useful ECOP for the 42% who are in the $EA < 12$ group is difficult. Considering all the indices, an $ECOP\ GCT+MECH/100$ may be helpful. At least FP could be reduced to 42% with an attrition rate reduced from 49% to 33% (row 3 Table VI).

3. Assuming the present requirement of a SER approaching 90-100%, the most effective ECOP resulting in a minimal FP (25-35%) would be an $ECOP\ ARI+MECH/90-95$ for $EA\ group < 12$ years, (Fig. 3A).

Table VI. Comparative Selection Efficiency Indices for Five Test Scores and Four Moderator Factors

Variables	E.A.	Maximum COPV %	CD	ECOP at that point %	RL	FN/AR ^a %	FP %	From Fig. or Table
<u>Tests</u>								
GCT	< 12	19	59	50	18	40	40	2A
	≥ 12	58	79	40	01	21	50	2B
GCT+MECH	< 12	25	62	100	25	33	42	3A
	≥ 12	67	83	90	15	15	50	3B
GCT+MECH+SP	< 12	18	59	150	17	37	45	4A
	≥ 12	63	81	130	11	16	36	4B
ARI+MECH+SP	< 12	13	57	130	5	42	37	5A
	≥ 12	62	81	135	20	16	47	5B
SP	^b —	40 ^c	73	35	6	24	58	6
<u>Moderator Factors</u>								
<u>EA</u>	—	33	67	< $\frac{5}{12/12}$	31	21	51	T-I
Age	—	34	67	17/ $\frac{5}{18}$	13	28	51	T-II
EA/Age	—	34	67	EA<12 Age<18	33	19	51	T-III
Paygrade/EA<12 E-1	—	33	67	E-1/ EA<12	24	25	51	T-IV

^a FN=AR; see Appendix A for definition of terms.

^b EA, Educational Achievement not controlled in this analysis.

^c Maximum COPV was at ECOP SP/35 but only based upon N=4.

4. At least a partial answer to the question "Should a floor for combined scores or for one or more individual scores (especially GCT) be established" emerged from the results of this study. For high-school graduates, there does not appear to be any single or multiple score points that would significantly improve the selection efficiency for this EA group. For the high-school drop group on the other hand, an ECOP at $GCT+MECH=90$ may be useful (Fig. 3A). An approximately equivalent ECOP for this EA group would be $ECOP_{GCT}=50$ (Fig. 2A). Adding SP either to $GCT+MECH$ (Figs. 4A, 4B) or to $ARI+MECH$ (Figs. 5A, 5B) doesn't appear to significantly improve the situation.

5. Should SP and/or $ARI+MECH+SP$ scores be deleted as one of the eligibility criteria options? Figure 6 presents the graphs bearing on the first part of this question, namely, the use of SP scores as criteria. As seen in Table VI, 5th row from the bottom, SP is most efficient in the 40-45 score range (COPV 46-37%), but FP is about 60% in this range signifying that 60% of those rejected by an ECOP in that range would have graduated from SubSchl. Too, taken together with the fact that $RL=6\%$ in that range (i.e., only 6% more of potential failures than potential graduates would be eliminated by an ECOP in this score range) it appears that the SP score alone has little potentiality with the non-rated segment of the SubSchl input.

6. As for the summed score, $ARI+MECH+SP$ within the $EA \leq 12$ segment, as with other test scores and test score combinations for this EA group, does

not demonstrate any fruitful ECOP possibilities since SUR is over 80% regardless of these combined scores. For the $EA < 12$ group however, looking at Fig. 5A within the score range 145-165, AR drops from 43 to 24% while FP holds at about 50% in this range. This means, for example, that with an ECOP at $ARI/MECH/SP=155$, and assuming that the personnel situation allows for acceptance of only the $1/3$ above $ECOP/155$, the attrition rate would be only 35% which is 14 percentage points below the existing AR of 49% across the total group of high school drops (Table I).

7. Another question pertains to the usefulness of the $GCT+MECH+SP$ within the hypothetical ECOP 141-150 range (combined score=150 with 9 point waiver allowed). Looking first at Table VI row 6 and Fig. 4B, any ECOP's are impractical in a high SER situation, since for all points above $ECOP/135$, FP is greater than 50% meaning of course that the majority of those rejected would have graduated. However, turning to Fig. 4A and row 5 in Table VI, the selection efficiency peaks at $ECOP/150$ and declines within the 9-point waiverable range. Translated to outcomes, if a rigid ECOP at $GCT+MECH+SP=150$ were to be adopted for the $EA < 12$ segment of the non-rated input, the following approximate consequences would be expected: (1) Forty-five percent would be rejected ($A+C$ in Fig. 1); (2) of these, 45% (FP) or 20% of total input would have graduated; (3) of the 55% accepted 37% would drop in SubSchl (about 20% of total input); and, finally (4) this results in a success ratio (SUR) of about 35% as compared to 51% (Table I) for the high school drop

group as a whole irrespective of test scores.

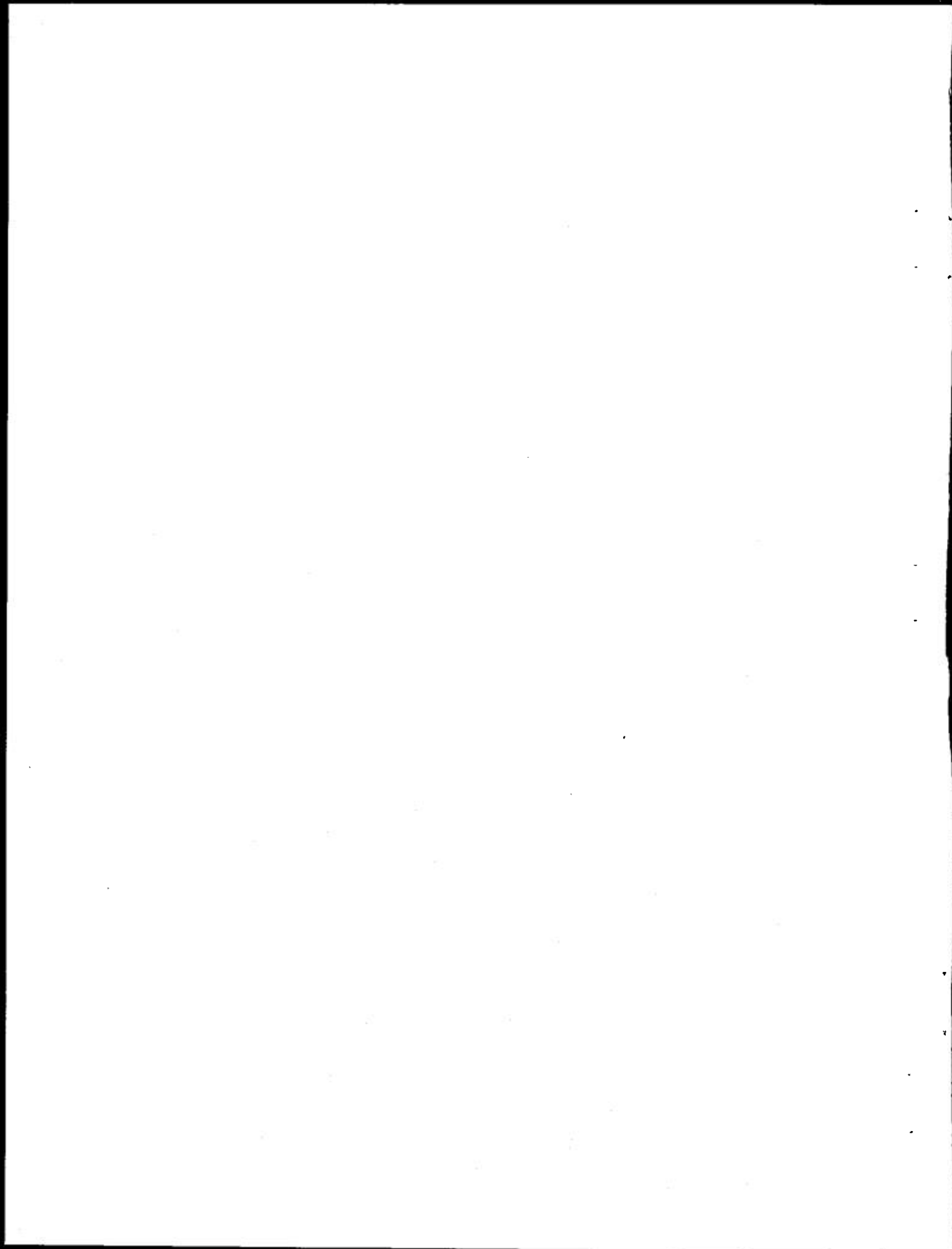
8. Overall, the most useful ECOP for the EA<12 group appears to be ECOP GCT+MECH/95 (See Fig. 3A). Thus, imposing this ECOP would reject about 21%, of which 34% (FP=34%) (7% of total input) would have graduated. Further, of the 79% accepted, 61% should graduate. In sum, a SUR of 48% would be realized. While this is only 3% less than the present overall SUR of this EA group (51%) the resource cost of processing the 21% rejected by this ECOP would be avoided.

9. Finally, the question of a possible "bottom-out" GCT score presumably indicative of limited literacy on the part of the candidate has been mentioned in the context of the discussion of Fig. 2A. Apparently, a useful ECOP for the GCT distribution obtained from the segment of the non-rated input whose EA is ≥ 12 years cannot be meaningfully identified since the attrition rate of this group is about 21%. However, by means of a backward extrapolation of the FP curve in Fig. 2A, something of the order of GCT=33 appears to approximate that "bottom" point for non-rated men without a high school diploma. However, with approximately 2.5% of the EA<12 input segment having GCT scores ≥ 40 and an expected failure rate of 70-80% (i.e., FP=20-30%), a more realistic cut-off point might be GCT=40.

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APPENDIX A

- AR - Attrition Rate or failure rate in a given personnel endeavor, e.g., Submarine School drop rate for those accepted by a given ECOP (see below). $[AR = D/(B+D)] \cdot 100^*$. $AR = FN$.
- CD - Percent of Correct Decisions, calculated as follows: $CD = [B + C/N] \cdot 100$.
- COPV - Coefficient of Practical Validity is the difference between CD's and ICD's changed to percent of the total selection decisions (N). Thus (Fig. 1) $COPV = [B + C] - [A + D]/N \cdot 100$. This index is essentially equivalent to the index of Selection Efficiency (S) proposed by Jenkins (Ref. No. 20). In a selection system with SER 30-70%, COPV apparently approximates numerically the coefficient of correlation (op. cit.).
- EA - Educational Achievement, the number of years of formal education (not including USN Technical Schools) completed. Ordinarily completion of high school results in $EA = 12$ and receipt of a bachelors degree, $EA = 16$, etc.
- ECOP - Experimental Cut-off Point, a hypothetical point on a selection test score distribution, which is used as a basis for the acceptance/rejection decisions required by the personnel situation.
- FN - False Negatives, those candidates accepted by a given ECOP who subsequently fail e.g. drop in SubSchl, quadrant D in Fig. 1. $FN = [D/(B+D)] \cdot 100$. FN is equivalent to AR.
- FP - False Positives, those candidates rejected by a given ECOP who would have succeeded e.g. graduated from SubSchl (Quadrant A). $FP = [A/(A+C)] \cdot 100$.
- ICD - Incorrect Decisions resulting from the application of a given ECOP. $ICD = FP + FN = A + D$.
- Moderator Variable - A psychometric term defined as a variable used as a basis for identifying subgroups within a given population sample, the assumption being that different predictive relationships exist within the subgroups so delineated.¹⁴
- RL - Relative Losses, that is the difference between the percent of those who would fail that would be rejected by an ECOP and the percent of those who would succeed that would also be rejected by the same cut-off. $RL = [(C/(C+D)) - (A/(A+B))] \cdot 100$.
- SER - Selection Ratio is the ratio of number of selectees required to the number available (usually presented in percentage terms). In a sense, this index
- * Most of these terms are operationally defined with reference to the schematic in Fig. 1, p. 3a.

is analogous to the econometric demand/supply ratio $SER = (B/N) \cdot 100$.

Skewness - Degree of departure from symmetry of a frequency distribution. Positive skewness indicates reduced frequency density at the high end of the scale; negative skewness means low density on the opposite end.

SUR - Success Ratio, that is the percentage of those accepted $(B+D)$ who succeed. $SUR = [B/(B+D)] \cdot 100$. Also SUR is the complement of FN. $SUR = 100 - FN$.

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Security Classification

DOCUMENT CONTROL DATA - R & D		
<i>(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)</i>		
1. ORIGINATING ACTIVITY (Corporate author) NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY		2a. REPORT SECURITY CLASSIFICATION Unclassified
		2b. GROUP
3. REPORT TITLE A SIMPLIFIED PROCEDURE FOR IDENTIFICATION OF OPTIMAL TEST SCORE CUT-OFF POINTS FOR NON-RATED SUBMARINER CANDIDATES		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Interim report		
5. AUTHOR(S) (First name, middle initial, last name) Benjamin B. WEYBREW and Ernest M. NODDIN		
6. REPORT DATE 18 December 1974	7a. TOTAL NO. OF PAGES 23 + an Appendix (2PP)	7b. NO. OF REFS 23
8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) NavSubMedRschLab Report No. 797	
b. PROJECT NO. MF51.524.022-0004		
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
d.		
10. DISTRIBUTION STATEMENT Approved for public release; distribution unlimited.		
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY Naval Submarine Medical Research Lab. Box 900 Naval Submarine Base Groton, Connecticut 06340
13. ABSTRACT The goals of this study were to identify the most effective cut-off points on the distributions of selected Basic Test Battery (BTB) score combinations obtained from a sample of non-rated volunteers for Basic Submarine School. Based on the disparities in the cumulative percentage BTB score distributions obtained from 955 non-rated submariner candidates, optimal ECOP's (Experimental Cut-Off Points) were delineated for GCT, GCT+MECH, GCT+MECH+SP, ARI+MECH+SP (Shop Practices), and for SP test alone. Capable of being applied by a middle-level clerk, the analytical techniques provided estimates of the maximum COPV (Coefficient of Practical Validity), an index of selection efficiency, as well as an estimate of the False Positive (FP) and false negative losses for several ECOP's for each test score or score combination. Taking into account the 90% requisite selection ratio imposed at this time, some of the major findings were: (1) level of formal education is a crucial moderator variable, the most effective ECOP being high-school graduate versus drop-out; (2) the attrition rate (AR) was 49% for H.S. drop-outs, as compared to 21% for H.S. graduates; (3) the data argue that there are no usefully effective ECOP's for the 58% with a high-school diploma, since accepting all of this education group yields an AR=20%; (4) for the H.S. drops, GCT=50, or GCT+MECH=100 are equally effective, but both yield an FP=40%, which compares to 51% within all H.S. drop-outs. A brief glossary of relevant selection terminology is included as an appendix.		

DD FORM 1473 (PAGE 1)

S/N 0102-014-6600

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