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PORT PLANNING FOR SEAGOING BUOY TENDER (WLB) ATTRITION

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PREFACE

This study of home ports for existing WLB's (seagoing buoy tenders servicing aids to navigation) was performed by the Transportation Systems Center (TSC) for the United States Coast Guard, Office of Navigation Safety and Waterway Services. It is delivered as part of Project Plan Agreement CG-875 to the Short Range Aids Division (G-NSR-2). The Coast Guard project manager has been LCDR A. R. Stiles Jr. The extensive knowledge, data, and guidance provided by LCDR Stiles are an integral part of this report. The author gratefully acknowledges his many contributions. All computer model runs needed for this study were energetically executed by Kathleen Murphy of System Resources Corporation.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Coast Guard operates a diverse complement of servicing vessels to service aids to navigation. Of these, the fleet of 28 WLB's (seagoing buoy tenders) is the largest and oldest. Over 40 years old, these vessels are well beyond the end of their economic service life. The replacement process is complex and new vessels will not start to come into service until the mid 1990's. Fourteen of the WLB's underwent a major renovation to prolong their service life. A Service LIfe Extension Project (SLEP) was begun to prolong the service life of the remainder of the fleet. Four vessels have completed the SLEP and two more are in process. However, a recent decision by the Coast Guard to limit the SLEP to a total of nine vessels has resulted in a projected fleet reduction to 23 vessels. This analysis determines the most effective home ports for this remaining WLB fleet. The most effective ports comprise those from which WLB's can service the entire current workload with a minimum of increased resource time dedicated by the fleet.

The analysis uses the Service Force Mix (SFM) model, developed at the Transportation Systems Center. The SFM model is a computer simulation of vessels servicing aids to navigation. Given a list of navigation aids assigned to servicing vessels, the model simulates the servicing of those aids and reports the resulting vessel performance. By simulating the elimination of each of the current WLB ports, the port with the least impact may be determined. Sequentially following this procedure for each reduction allows the best set of remaining ports to be determined.

The analysis results are summarized here by listing, in order of importance, the ports to be eliminated.

DISTRICT	HOME PORT	VESSEL
7	San Juan, PR	Sagebrush
17	Kodiak, AK	Ironwood
9	Port Huron, MI	Bramble
9	Grand Haven, MI	Acacia
5	Atlantic Beach, NC	Gentian

Because of the distance to San Juan, the concept of operations was changed for the two ports reassigned its workload. Kodiak was, in fact, not eliminated as a port; the two vessels assigned there were reduced to one. The choice of Atlantic Beach was from among four equally rated candidates. Other valid substitute selections include New York, Cape May, and Portsmouth. Either because they were too far from others or because they were at regional endpoints, ten of the 28 WLB home ports were not candidates for elimination.

1. INTRODUCTION

One mission of the United States Coast Guard is to provide and service short range aids to navigation. These are the buoys, lights and other devices used by mariners for navigating the waterways. The Coast Guard is currently responsible for about 49,000 short range aids. These aids cover a wide geographical territory which, in addition to the continental United States, extends into the Caribbean, Alaska, Hawaii, and as far west as the Philippines. Each of these aids to navigation receives a routine inspection and servicing annually. In addition to this scheduled service, the Coast Guard responds to reports of outages, called discrepancies. To accomplish its inspection, servicing, and discrepancy response responsibilities, the Coast Guard maintains and staffs a diverse complement of servicing vessels.

Of these, the WLB (seagoing buoy tender) class is the largest and oldest. A typical WLB is 180 feet long and maintains a crew of approximately 48. As of April 1988, there were 28 WLB's in service throughout the Coast Guard. Built in the 1940's, they have undergone various refurbishments over the years. Improvements notwithstanding, the vessels are well beyond the end of their economic service life and the capability they provide requires replacement. Accordingly, the Coast Guard has begun the acquisition process prescribed by The Office of Management and Budget (in Circular A-109). This process, however, which includes cycles of design, review, approval, contracting, and construction, could result in significant delay before replacement vessels are actually employed into service.

The current WLB reconditioning effort is called the Service Life Extension Program (SLEP). This allows for refurbishing two vessels at a time, each vessel requiring 16 months of renovation. Meanwhile the unimproved vessels are experiencing major failures which incur significant down time and expense. For example, a recent estimate for repair of one vessel exceeded two million dollars. With an ever tighter budget, funds for these unplanned remedial repairs compete with those planned for new vessel acquisitions. Thus, although 14 vessels were originally planned for SLEP, only 9 will now receive these improvements. The five unimproved vessels will be decommissioned as they fail, reducing SLEP competition with the vessel replacement program. Other WLB's not in the SLEP will receive new engines to improve reliability and then be repositioned as needed. The net result is to reduce the WLB fleet to 23 from 28 vessels. This analysis seeks to determine the most effective home ports for the 23 remaining vessels.

2. SERVICE FORCE MIX MODEL (SFM) DESCRIPTION

The Service Force Mix (SFM) Model is a computer implemented simulation which presents an overview of the annual vessel activities in servicing aids to navigation. Given a list of navigation aids which are assigned to any number of servicing vessels, the model simulates the servicing of those aids and reports the resulting vessel performance. By running the model for several alternatives and comparing the results, the effectiveness of several differing aid assignments may be evaluated. This chapter provides a brief description of the SFM model operation. The following sections will describe the data structure, model logic, and reports of results.

2.1. Data structure

2.1.1. Data files. To operate correctly, the SFM model requires three separate files of data. One to describe the aids to navigation, one for the servicing vessels, and one to describe the district level environment of operation. Figure 2-1 shows these three file structures and enumerates their more important elements.

2.1.1.1. Aids file. The AIDS file is used to describe each aid to navigation to be serviced. There is one entry in the file for each aid to be serviced. In special cases where aids are routinely visited by the servicing vessel more than once in a servicing cycle, the aid is shown in the file more than once. Seasonal aids, which are placed in the spring and removed before winter, typify aids having two entries in the file. Others include the Mississippi River aids in the Eighth District which are visited as a group during a trip up the river as many as ten times a year. The fifteen specific characteristics used by the SFM model include: identifying data (number, name, type, authorized hull), location data (waterway, latitude, longitude, depth, exposed or protected environment), servicing vessel, and servicing schedule (next inspection, mooring check, recharge, relief, and any special service).

The order of placement of aids within the file is important. The model acts as a sequential list processor. That is, it will service aids for any particular vessel in the order of placement within the file. Thus, the entries need to be somewhat geographically contiguous. District aid files are often ordered in this way and are entered either by waterway, which is a small geographic area, or by light list order, which essentially follows a coastline. If aids within a file are scattered, then the file must be sorted by an appropriate combination of latitude, longitude and waterway.

data (discrepancy policy, probability of aids becoming discrepant), hourly cost, and availability (total operational hours, other mission time, additional discrepancy time).

2.1.1.3. District file. In addition to the files describing aids and vessels, there is one which provides a description of miscellaneous district data required to run the model. There are three important categories of district level data required. These are home port descriptions, aid service times, and vessel-buoy environment compatibility.

Each home port is described by a name, a latitude and longitude, and a latitude and longitude of a waypoint. The home port name is matched with the port given in the vessel file for each vessel. This file provides the port location so that travel may be simulated. When ever a vessel leaves its home port, the SFM model requires that it travel to a waypoint before going to the first aid to service. This is because all travel within the model is with straight lines between two points. The provision of a waypoint allows simulation of navigation through a channel before reaching open waters. If no waypoint is necessary, the waypoint location is set equal to the port location.

A prior TSC study [2] examined the service records for ten percent of the aids to navigation in the First Coast Guard District (Boston) dating back through the past ten years for factors which might determine aid service times. Factors examined included, servicing vessel type, year of service, buoy type, buoy exposure, water depth, buoy diameter, and type of service. The only factors shown to be significant in affecting service times were type of service, and exposed vs. non-exposed environment. Accordingly, the SFM model requires separate service times by the categories of service and exposure. A separate TSC examination of the same data[3] provided the service times used in this study. They are given below in figure 2-2.

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[2] <u>Factors Affecting Aid Service Times in the First Coast Guard District</u>, Report Number DOT-TSC-CG-569-TM3, Transportation Systems Center, January 11, 1985

[3] <u>Service Times for Short Range Aids to Navigation in the First Coast Guard District</u>, Report Number TSC-CG-569-TM-5, Transportation Systems Center, June 5, 1985.

2.2. Model logic

The Service Force Mix Model is an event oriented, deterministic, computer simulation of vessels servicing aids to navigation. It is written in Pascal and consists of approximately 6,000 lines of code. The code is divided into six major modules: executive, text editor, aid file processor, vessel file processor, calculation and display processor, and random access file processor. These modules are compiled separately and then linked together to operate on the Coast Guard Standard Terminal microcomputer.

The model is menu driven. It can be operated with no specific knowledge of the internal workings of the program. Rather, a person knowledgeable in servicing aids to navigation can operate the model by making several simple menu selections offered to him or her on several successive computer screens. In addition to running the simulation, the operator can edit the vessel and district files, and can change the assignment of aids to vessels in a variety of ways. The data for the model, described above, are provided in the form of text files which are read and converted by the model in appropriate formats for SFM model consumption.

The model logic is centered on the operation of a single vessel. Aids from the ordered assignment list are provided to the vessel one at a time for servicing. The vessel's operations are simulated and its performance is recorded. Each vessel is processed until the district's operations are complete. Since the aids on the list are serviced annually by the vessel, the simulation represents the annual vessel activities. The primary measure resulting from the simulation is a vessel use percentage which is a measure of the time each vessel is used compared with its adjusted available time.

The vessel activities represented include steaming from home port to an aid through a waypoint, servicing that aid, steaming to the next aid, and servicing it. The process is repeated until the day is done. Then, depending upon the vessel parameters, the vessel will either set anchor and rest overnight, or return to home port and begin the next and successive days, until all of its aids are serviced. Associated with each vessel are some additional parameters which allow for a more realistic simulation of its activities. For example, the effects of bad weather are represented by indicating the percentage of aids for which the servicing vessel must return to home port before completing the sortie (aid servicing trip).

Also associated with each vessel is a discrepancy percentage and servicing policy. The discrepancy percentage represents the percent of aids which must be visited a second time. The discrepancy aid list is generated by selecting the appropriate

LOGIC

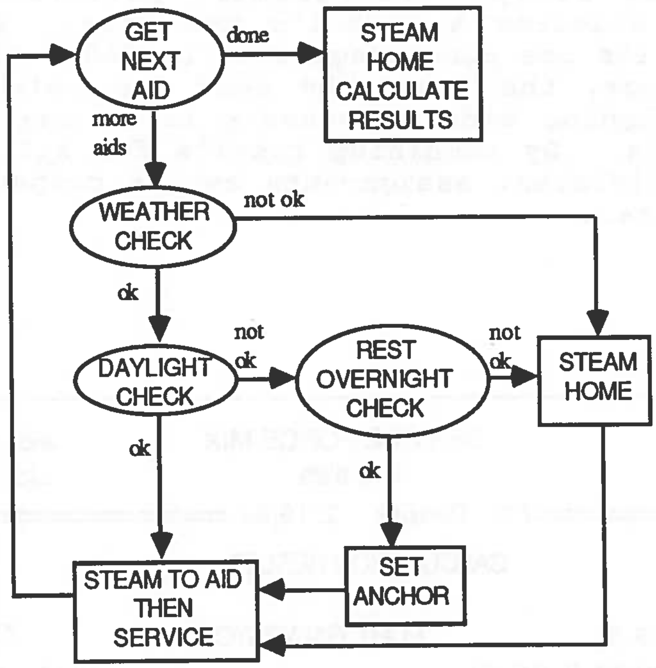

FIGURE 2-3 SFM MODEL LOGIC DIAGRAM

2.3. Model output

The Service Force Mix Model provides the results of its calculation on a single screen. This screen may also be printed. Each output screen may represent either a single vessel, a class of vessel (such as seagoing or coastal), or may summarize results for the entire district. Figure 2-4 shows a sample output screen from the model.

The results are divided horizontally into three sections. The first is a header section which identifies the conditions, dates, files, and district of the run. The middle section describes the input vessel parameters of the run. The last section shows the resultant model calculations. The portion marked "AIDS" shows the number of scheduled aids and discrepancies which were serviced. If an aid is outside of the radius of service (as measured from the vessel's home port), then it is skipped. The "TIME" section shows hours spent within each

3. STUDY STRUCTURE

3.1. Objective

Through extensive use of the Service Force Mix (SFM) simulation, this study seeks to determine the most desirable 23 of the current 28 WLB home ports. This will allow attrition planning for decommissioning the five vessels requiring the most renovation in this aging fleet over the next several years. The most desirable ports comprise those which can service the current WLB aids to navigation workload with the minimum adverse impact on the surviving vessels. Impact is measured by changes in total hours spent servicing aids to navigation. To accommodate this increased workload, the remaining 23 vessels will require a more focussed mission. That is, a higher percentage of their time must be devoted to the aids to navigation mission.

3.2. Approach

This is a study of ports and not vessels. The goal is to determine the most desirable 23 of the existing 28 WLB ports. Ports not now berthing a WLB were not considered. The plan is to retire rather than repair the first five WLB's (with austere renovations) requiring major repairs. In any event, five will be retired by 1992. Since we do not know which vessels will fail, we expect several vessel reassignments will be necessary to accomplish the final port configuration. Starting with the full 28 ports, the effects of eliminating each port is assessed. The one with the least impact is selected for elimination. The remaining 27 ports are then reexamined and the process repeats until the list is pared down to the preferred 23 ports.

Prior to conducting the analysis, initial model runs were made for the aid and vessel data to verify both the model operation and the existing data. The runs reasonably replicated existing conditions with existing data.

To facilitate the analysis, zones of influence were established. The elimination of a port within any zone was considered to affect only ports within the zone. Once a port was selected for elimination, ports within the zone are recalculated to identify the next best selection within the zone. This would then be compared to the best selection from within the other zones. The zones included: the eastern seaboard, the Gulf of Mexico, the Great Lakes, the western seaboard, the Alaskan coast, and 14th District (Hawaii and the Pacific). Because of the particular aid densities and port spacings, the analysis identified zones where no cuts were acceptable. These essential areas included: the Gulf of Mexico, the western seaboard, and the energies[4], and the facility to return a vessel to port early due to weather is disabled. The two locations where this reduced concept of operations is employed include the 14th District (Hawaii), where typical servicing trips are of many weeks duration, and the ports which were reassigned San Juan's aids, since they are located a great distance away.

3.4. Vessel parameters

Vessel parameters are the assumptions the SFM model requires to calculate performance. They describe the vessel's speed, availability, discrepancy rates and response policies, etc. This is a study of ports and not of individual vessels. Since unplanned vessel failures will determine which vessels remain, vessels will, most likely, need to be reassigned to achieve the final port configuration. All WLB's in this study, therefore, will be assigned the same operating parameters. These parameters are:

- -9 knot average speed
- -14 hour work day
- -average trip length of 5 days
- -moderate discrepancy response policy[5]
- -annual vessel employment of 140 days[6]
- -focussed aids to navigation mission[7]

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[4] We presume in these cases that another local vessel or aids to navigation team (ANT) will respond to discrepancies and temporarily remedy the situation until the WLB can return to the remote location.

[5] This is described in section 2.2 as policy "B".

[6] This is down from the standard of 170 days. It allows for the current condition of the aging fleet which often requires unscheduled maintenance.

[7] Since 23 vessels will be asked to do the work of 28, less of their time will be available for other than aids to navigation (AtoN) missions. For this study, 75% of the available resource hours are assumed devoted to the AtoN mission. This is up from the 58% which WLB's now devote to AtoN according to an examination of recent data from the abstract of operations.

4. RESULTS

4.1. Overview

The end result of this study is the determination of the 23 most essential ports of the 28 existing WLB home ports. These resulting ports, along with their assigned vessels, are given below in figure 4-2. The ports are shown grouped in order of importance. Group 1 ports are the most essential in the sense that they are required even if no cuts are to be made. These include the 14th district, the western seaboard and the gulf coast which were essential due to aid density and port spacing. Thus, they are not candidates for cutting, or elimination. Group 2 ports are next in order of importance in that they become essential after the first cut is made. Here, essential means that all aids currently assigned to WLB's could not be serviced with the other remaining vessels and ports. The successive groups represent ports which become essential with each additional eliminated port. The group 7 ports, the last two on the list, are not essential but remain in the list of retained ports.

Conversely, the analysis results are succinctly given by listing, in order of importance, the ports determined by the analysis to be eliminated by WLB attrition. These are given below in figure 4-1. San Juan, then, would be the first to be cut, and Atlantic Beach the last.

DISTRICT	HOME PORT	VESSEL
7	San Juan, PR	Sagebrush[8]
17	Kodiak, AK	Ironwood[9]
9	Port Huron, MI	Bramble
9	Grand Haven, MI	Acacia
5	Atlantic Beach, NC	Gentian[10]

FIGURE 4-1 PORTS SELECTED FOR ATTRITION

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[8] Because the distance from San Juan to other ports was so great, the concept of operations was eased for servicing its aids. Refer to the text for further discussion.

[9] In fact, the port is retained; the two vessels currently assigned there are reduced to one.

[10] The choice of Atlantic Beach was from among four equally rated candidates. Other valid substitute selections include New York, Cape May, and Portsmouth.

4.2. Details

Determination of ports to cut were made one at a time, in rounds. At each round of cut, each port was separately evaluated first, to determine if it were essential and then, to determine the impact on the remaining fleet if it were eliminated. If, during a round, a port was considered non-essential, it was considered a viable candidate for cutting during that round. Thus, as the cutting rounds progress, the number of viable candidates dwindles substantially.

Figures 4-3 through 4-12 display the detailed results for the first through the fifth round of cuts. Two figures display each round of cut. One is in tabular form; the other shows a map. Also figures 4-13 through 4-15 display the final configuration for each of the equivalent eastern seaboard options.

Each of the tabular figures shows the viable ports for that round. Each port is assigned a letter rating from A through E indicating the effect of eliminating that port on overall time needed for traveling to and servicing all WLB aids to navigation (AtoN). A port found at an extreme end of its rating range is assigned a "+" or "-" to distinguish it from the others. Viable ports were assigned ratings as follows:

RATING	EFFECT ON AtoN HOURS
A	save more than 200 hours
B	save 200 to lose 100 hours
C	lose 101 to 400 hours
D	lose 401 to 700 hours
E	lose more than 700 hours

The rating for the selected port in each round is bracketed by "{ }" marks. Dashed lines in the figures separate groups of ports within the same zone of influence for cuts. That is, the remaining vessels within a zone are expected to absorb the servicing requirements of the aids previously assigned to the cut vessel. Following each of the detailed results figures is a graphic figure displaying all remaining ports and the use percentage for the vessels. The use percentage represents the portion of available time a vessel is employed.

Figures 4-3 and 4-4 show the results for the first round of cuts. Notice that only 18 of current 28 ports are listed as initially viable candidates. The other 10 ports, shown as group 1 in figure 4-2, are essential. That is, if any of these were cut, the remaining fleet could not absorb its aid servicing requirements. One of several conditions distinguish the

WLB PORTS AND VESSEL USE PERCENTAGES

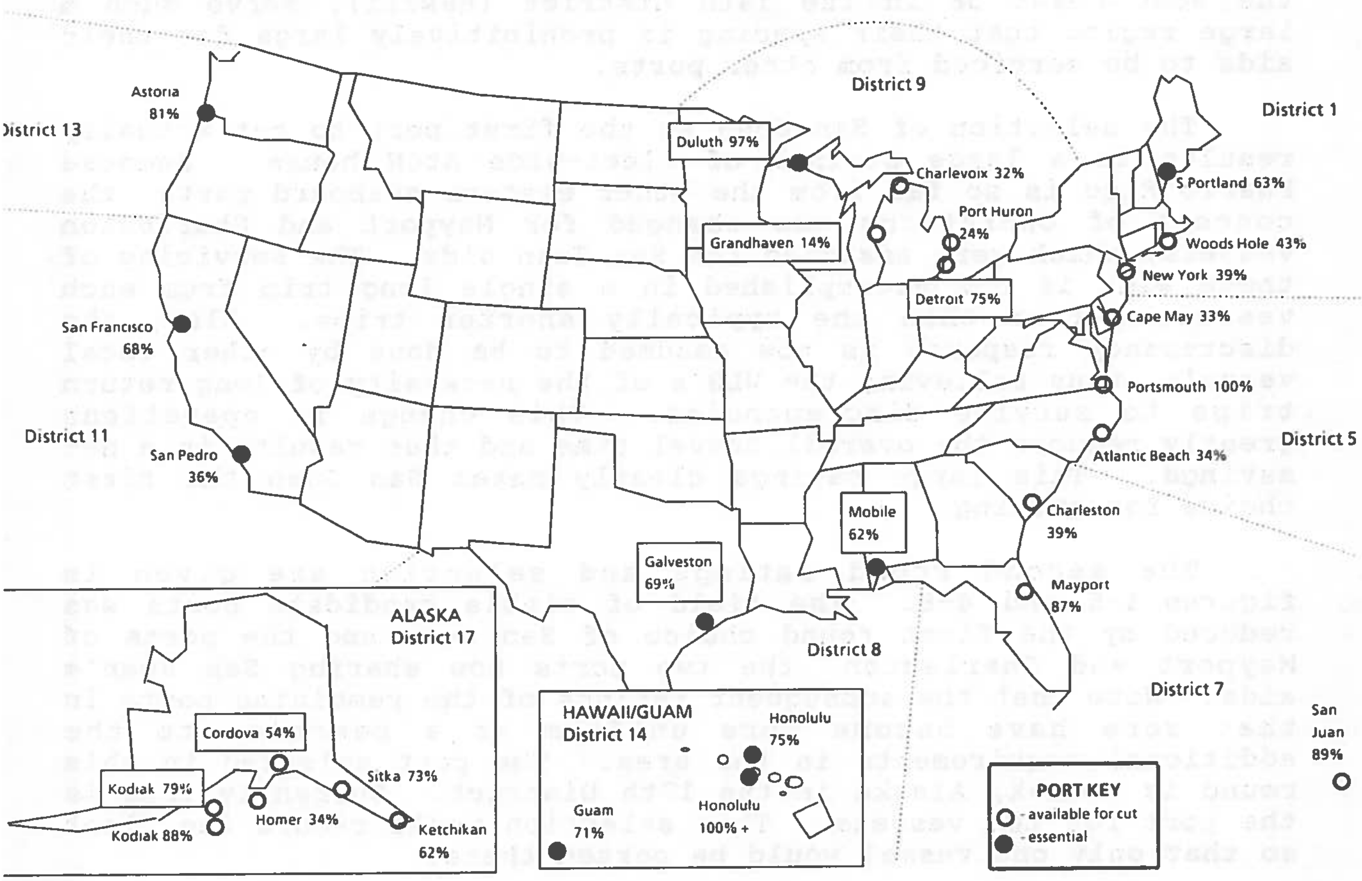

FIGURE 4-4 ROUND 1 PORT AVAILABILITY AND USE (BEFORE SELECTION)

DISTRICT	HOME PORT	VESSEL	RATINGS AND {SELECTION}
1	Woods Hole, MA	Bittersweet	D
	New York, NY	Sorrel	C
5	Cape May, NJ	Hornbeam	C
	Portsmouth, VA	Cowslip	C
	Atlantic Beach, NC	Gentian	C
9	Charlevoix, MI	Mesquite	E
	Grand Haven, MI	Acacia	C
	Port Huron, MI	Bramble	B
	Detroit, MI	Mariposa	D
17	Ketchikan, AK	Planetree	E
	Sitka, AK	Woodrush	E
	Cordova, AK	Sweetbrier	B
	Homer, AK	Sedge	C
	Kodiak, AK	Firebush	D
	Kodiak, AK	Ironwood	{B+}

VIABLE CANDIDATES

FIGURE 4-5 ROUND 2 RATINGS AND SELECTION FOR VIABLE PORTS

VIABLE CANDIDATES			RATINGS AND {SELECTION}
DISTRICT	HOME PORT	VESSEL	
1	Woods Hole, MA	Bittersweet	D
	New York, NY	Sorrel	C
5	Cape May, NJ	Hornbeam	C
	Portsmouth, VA	Cowslip	C
	Atlantic Beach, NC	Gentian	C
9	Charlevoix, MI	Mesquite	E
	Grand Haven, MI	Acacia	C
	Port Huron, MI	Bramble	{B}
	Detroit, MI	Mariposa	D

FIGURE 4-7 ROUND 3 RATINGS AND SELECTION FOR VIABLE PORTS

The fifth round cuts, shown in figures 4-11 and 4-12 show that the prior selection of Grand Haven removes all other Great Lakes ports from consideration. That is no further cuts can be accommodated within the Great Lakes. This round is the first time a selection is to be made among several candidates with equal ratings. New York, Cape May, Portsmouth, and Atlantic Beach all have a rating of C. Since any of these ports may be selected, considerations external to this analysis should determine the most desirable of the four. When examining a possible sixth cut (refer to the next section), selecting the port of Atlantic Beach as a fifth cut allows the most sixth cut options to remain open. Thus, although the four listed ports are equivalent choices, Atlantic Beach is shown as the selection. Figures 4-13 through 4-16 show the final results for each of these options.

4.3. Additional ports

The objective of this analysis is to determine the most effective set of ports for the remaining fleet when five WLB's are decommissioned. The analysis suggests that the mid-Atlantic area could marginally tolerate one additional cut. Cutting an additional mid-Atlantic port consumes most of the excess fleet capacity as represented by the SFM model. Because of the overview nature of the SFM model analyses, the results are too close to state confidently that a sixth cut can be accommodated under current operating conditions. It may well be that changes in operations may be needed to actually eliminate the additional port. These changes could be achieved by two methods. More vessel availability could be provided by further concentrating vessel activities on servicing aids to navigation, to as much as 85% of a vessel's employment. Alternatively, the vessel workload could be reduced somewhat by selectively reassigning WLB aids to other vessels.

The viability of the sixth cut is dependent upon the prior mid-Atlantic port selection (the fifth cut). If Atlantic Beach is the fifth selection, then it is possible to select either Woods Hole or New York as the additional port, although Woods Hole would minimize the impact on the remaining fleet. The only remaining fifth-sixth port pair would be the Portsmouth and Woods Hole combination. While the model shows that this combination is not technically feasible, it is so close to the line of feasibility that if operations are changed as described above, this combination will be accommodated. It has about the same impact as the Atlantic Beach-New York combination. All other pairs of ports produce clearly unfeasible results.

VIABLE CANDIDATES			RATINGS AND {SELECTION}
DISTRICT	HOME PORT	VESSEL	
1	Woods Hole, MA	Bittersweet	D
	New York, NY	Sorrel	C
5	Cape May, NJ	Hornbeam	C
	Portsmouth, VA	Cowslip	C
	Atlantic Beach, NC	Gentian	C
9	Charlevoix, MI	Mesquite	E
	Grand Haven, MI	Acacia	{C}

FIGURE 4-9 ROUND 4 RATINGS AND SELECTION FOR VIABLE PORTS

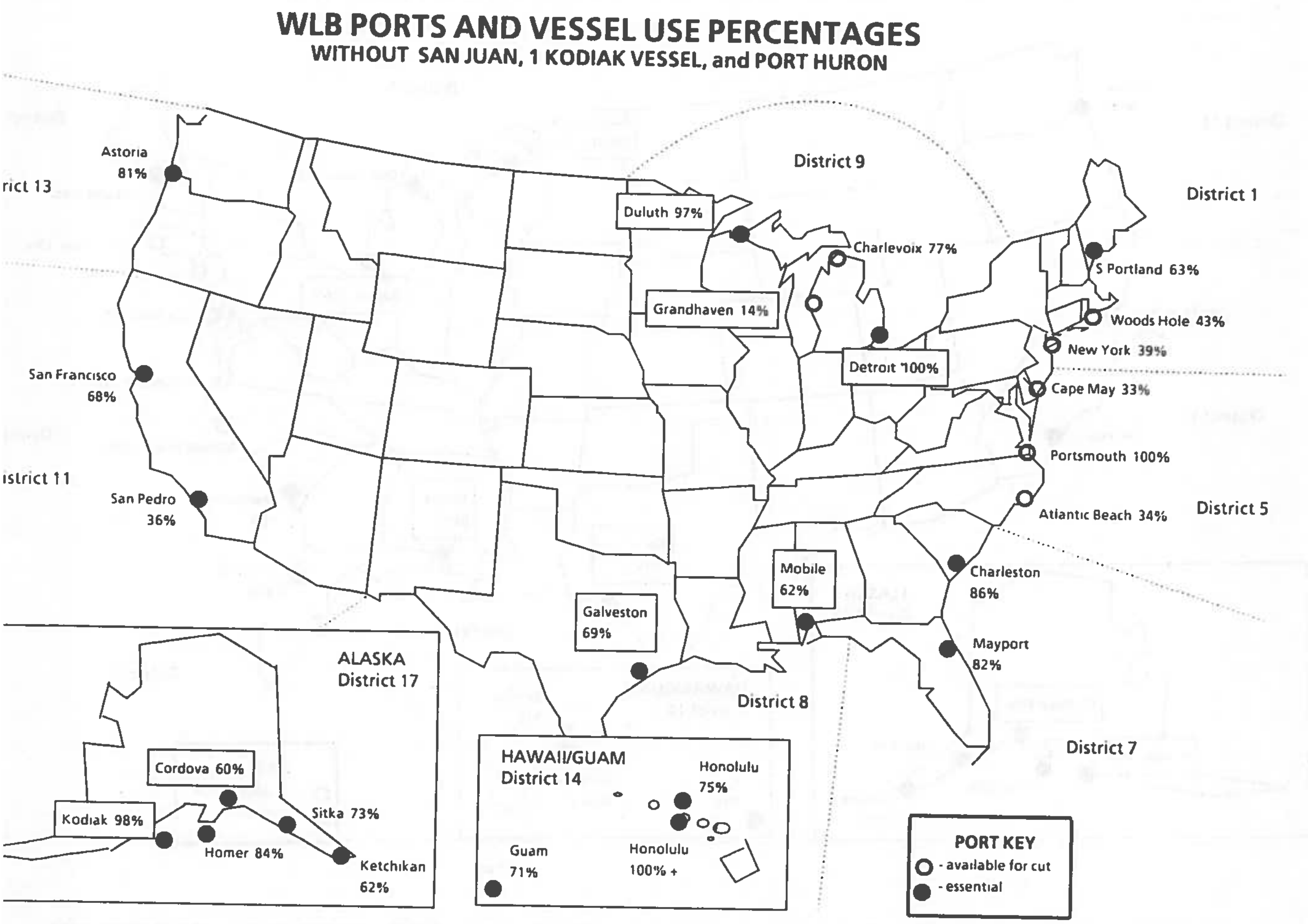

FIGURE 4-10 ROUND 4 PORT AVAILABILITY AND USE (BEFORE SELECTION)

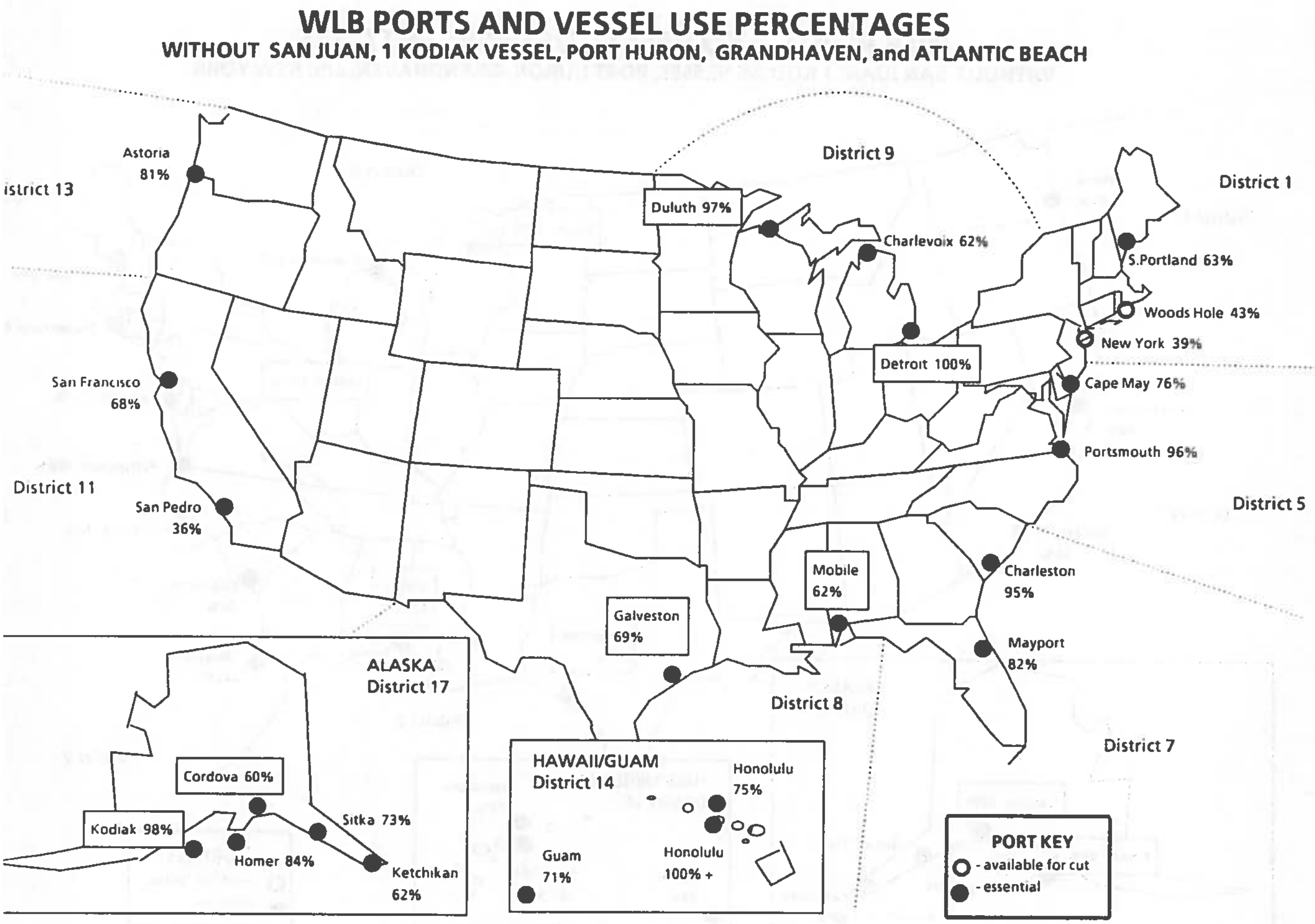

FIGURE 4-13 FINAL AVAILABILITY AND USE-ATLANTIC BEACH OPTION

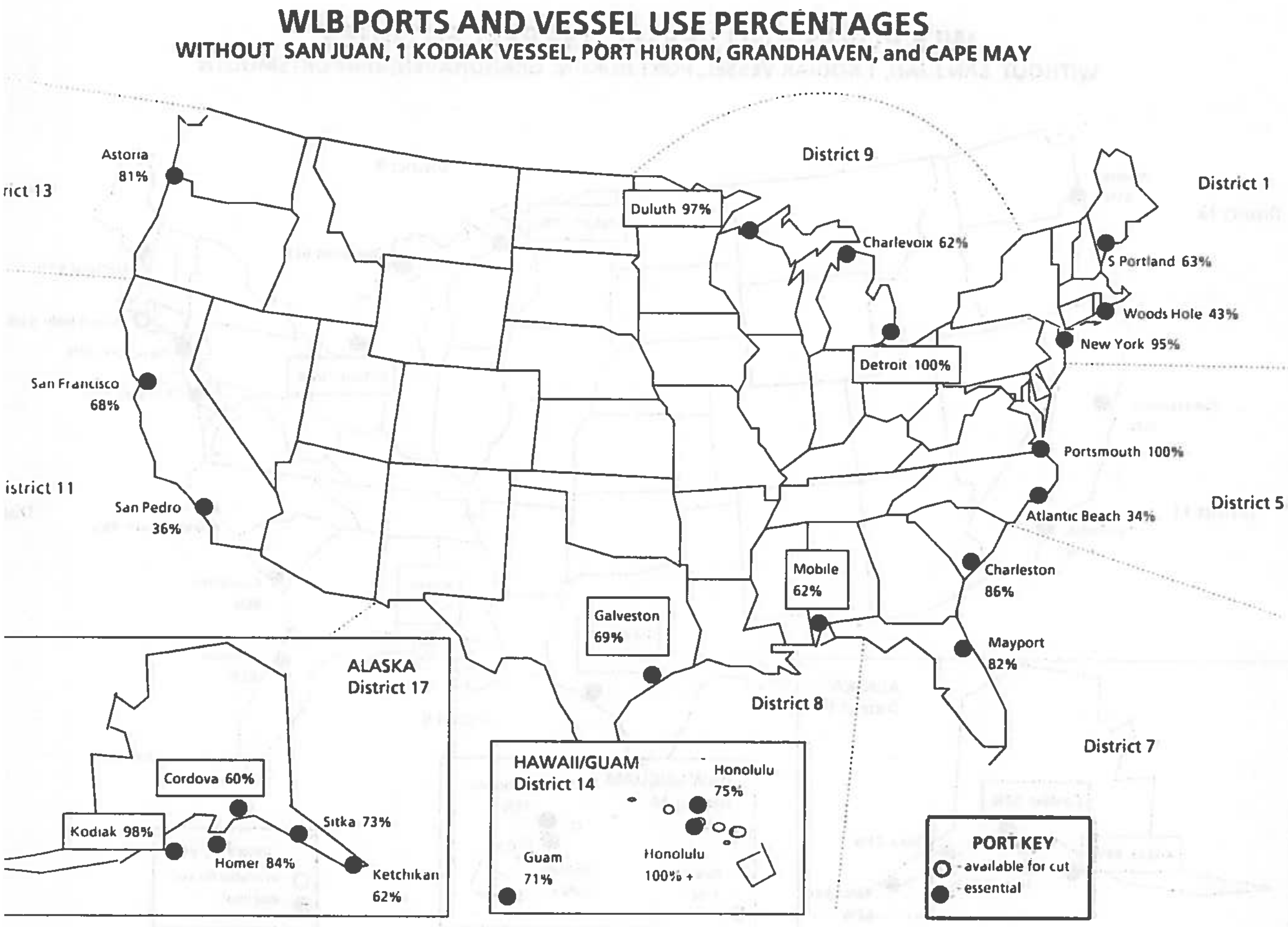

FIGURE 4-15 FINAL AVAILABILITY AND USE-CAPE MAY OPTION